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Assessment of bronze casting debris from Banwell, North Somerset

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Abstract

The submitted sample comprised approximately 180 fragments of casting debris (mainly technical ceramics including mould fragments, possible crucible material and also some spilt metal) weighing 856g. The material was all found ex-situ in a pit, in a highly fragmented condition and very few joins could be made between pieces, making interpretation of the assemblage rather problematic.

Four groupings of mould fragments could be identified, in two main classes of fabric. Fabric (a) was dominated by quartz-rich silt, with no coarse temper, although some examples showed coarser rounded quartz grains towards the external surface; Fabric (b) was rich in rounded quartz grains throughout and also had voids suggestive of a coarse organic temper. This second group sometimes showed evidence for a fine organic temper, possibly hair, particularly visible on the fine inner surface.

The moulds were accompanied by fragments similar to Fabric (b), sometimes with evidence for a higher degree of organic temper, which are interpreted as outer wraps for the piece moulds. Several pieces, including one substantial example, are interpreted as belong to external casting gates. A few fragments are believed to be from cores, including some suggestive of a core formed from clay-wrapped straw.

The fragmentation and abrasion makes identification of the matrix uncertain in many cases. Some of the moulds in Fabric (a) were clearly for pins and some of the moulds in Fabric (b) may also have been (though an object with raised surface ridges would be an alternative interpretation for these). One of the moulds in Fabric (a) had a matrix for an ornamented ring. Some of the thicker moulds in Fabric (b) show a matrix with evidence for a thinning and slightly flaring blade. Coupled with the presence of a substantial core, this tentatively suggested either a socketed axe or chisel. Two mould fragments had a matrix indicating an object with an arcuate margin, possibly with a co-marginal groove, of uncertain nature.

One sherd is apparently from the rim of a small crucible, but other heavily slagged oxidised-fired materials are apparently more planar wedge-shaped in cross-section. The interpretation of these is uncertain, and they may be from a heating trays rather than crucibles.

Limited portable XRF analysis of the residues suggested they had been employed for casting in a slightly leaded tin bronze, a composition compatible with a Late Bronze Age date.

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Methods

All materials were examined visually with a low-powered binocular microscope where required. To assist with the assessment, a small number of qualitative analyses were taken by portable (hand-held) XRF on a representative suite of materials from context 66 sample 19. No invasive or destructive analysis was undertaken.

The specimens were analysed on a purely qualitative basis using a Bruker Tracer III-SD portable X-Ray fluorescence spectrometer. 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 with spectra stored as pdz files and csv files. The images presented in Figure 1 are produced from the csv output.

This project was undertaken for Border Archaeology, commissioned by Caroline Rosen.

Results

Description of material

Overview
The assemblage comprised a large number of fragments (approximately 180) of technical ceramic, but most were highly abraded, with extremely few detectable joins. Some of the material had apparently been washed or sieved post-excavation, leading to further extensive abrasion and damage.

The lack of joining fragments has hindered interpretation. Identification of many of the fragments was not possible with any certainty, although the dominant friable material was mainly from moulds. Where the inner faces of moulds were identified, they were planar. Taken together with the presence of a small number of fragments of rather crude concavo-convex clay pieces, interpreted as wraps, these suggest the use of part-moulds, contained within an outer clay wrap. Some fragments interpreted as being from external casting gates and cores were also present.

Alongside the mould material, were problematic wedge-shaped fragments, moderately heavily slagged on one surface and typically with an oxidised fabric, tentatively interpreted as sherds from large crucibles, but alternatively which might be from a 'heating-tray'. A single piece of well-formed rim is interpreted to be from the lip of a crucible, but is unlike published examples of Bronze Age crucibles.

Moulds
There are four categories of mould materials described here, but these are essentially variations on just two main fabric types. Fabric (a) is a fine friable material, dominated by quartz silt and very finely micaceous; Fabric (b) contains abundant rounded quartz sand (mostly 100-200µm, but commonly up to 500µm) and most examples also have organic temper, including fine plant debris in some instances, but also very fine fibres, possibly hair, in many examples (particularly visible on the smooth inner surfaces). Fabric (b) is also that seen in all the non-mould technical ceramic present.

Type (i):
(#40/#83, #41/ #42/#163, #84 & #85)
This includes all certain examples of pin moulds. The material is in Fabric (a), with no sand inclusions except close to outer surface, sparsely and finely micaceous, buff/grey mottled, typically with a buff external (with a hint of orange yellow down the narrow outer side of the mould) and grey interior zone. The matrix surface typically has a pale adhering secondary deposit.

The largest fragment is formed by pieces #83 and #40. The overall surviving fragment is 77mm long, with a cross section of 35mm by 11mm (approximately 1mm thicker near the edges than the centre). One side #40 carries a small area of surviving outer wrap in a porous sandy fabric. This was one valve of a mould for casting two pins.

In this combined fragment the two pin heads are apparently flat topped (except for the connection to the sprue), 6mm in diameter, with a short parallel-sided section before converging to the 3.5mm diameter shaft, giving an overall height of c. 4mm. The sprues are c.4mm diameter, pinched near the heads, and convergent away from pins. The two shafts have their centres 15mm apart. One shaft is 3.5 – 4 mm wide and up to 2mm deep; the other is 2.5-3mm wide, with a marked ridge appearing within it as it widens. The grooves are approximately 11mm apart. The slab has a rectangular margin, 12mm thick, with one groove (the wider) 8mm from one edge. Approximately 43mm of the shaft matrices are preserved.

Fragment #84 is somewhat similar, with matrices for two pin heads. They are not as well-preserved as in #40/#83; the better-preserved example is 6mm in diameter and 4mm tall with 4mm diameter shaft. The matrices of the shafts have centres 10mm apart, and are impressed to different depths. The sprue arrangement is uncertain, but there is suggestion of a horizontal sprue passing above both heads. The pin matrices are closer together than in #40/#83, so they cannot be counterparts.

One small piece in this fabric shows part of the matrix for a ring, with an annular ornament (#85), of 2.5mm maximum diameter and c. 13mm radius of curvature.

Fragment #41/#42/#163 is in a rather similar fabric. It bears impressions in the form of two grooves, one not fully preserved, and the other of semi-circular section 8-10mm in diameter. This diameter appears rather large for this to be a pin mould. The fabric passes from buff to grey along the length of the fragment, as does the region of the sprues in #83, so it is possible that this piece represents paired sprues rather than large pins.

Fragment #129 is a very similar size and style of mould to the pin moulds, but is a featureless corner of a mould with no matrix.

Possible locating stud #159 is also in this fabric. It is not known if this is truly a locating stud, for it is isolated and there are no other examples, but it is the appropriate size (9mm in diameter and 2mm high).

Type (ii):
(#87, #88, #166 & #167)
These show a darker grey, harder, fine clay forming the fine, smooth matrix surface, than type (i), but the bulk of the moulds are also in Fabric (a) and similarly

sand free. The smooth inner face is probably the result of the method of clay application (as a very finely washed dilute slurry) rather than the use of a different clay. Several examples show the preservation of a distinct outer sandy layer to the mould, possibly the merged interior of an external wrap.

The matrix of three fragments appears to be an elongate cone shape (#87, #88) with lateral areas may either be simply the smooth faces of the part moulds, or thin blades. These lateral areas have a slightly concave or convex profile, reminiscent of the cross section of the moulds at Dainton (Needham 1980). The mould margins taper towards the central cone. Fragment #167 may be similar but might be more tubular. These fragments may be moulds for spearheads, but the lateral areas lack the complexity of the cross-section of the Late Bronze Age spearhead moulds from Dainton, but rather resemble the concavo-convex valve junction seen on the ferrule moulds there. Unfortunately, there is insufficient continuity of the mould fragments to determine this with any certainty.

One piece (#166) in this fabric is difficult to interpret, but appears to be a fragment of a matrix with a curved (possibly flatly conical) form, with a curved groove. The object type is unknown, but it is similar to a fragment in Mould type (iv) (see #131 below).

Type (iii):
(#89, #90, #173/ #174 & #175)
This type comprises darker, more highly altered and friable moulds in Fabric (b) with abundant quartz sand and abundant small voids. The fabric therefore has an appearance similar to that of the wraps observed on Type (i) and (ii) moulds, but is differentiated by being very strongly reduced (almost black) on the inner face.

They bear matrices in the form of curvilinear grooves possibly, but not certainly, also for pins. The grooves in the mould appear less rounded than the certain pin moulds, some examples are curved and the grooves are closer together, with a very smooth mould surface towards the margins of the mould face. The grooves themselves have faint surface striations, suggesting that the grooves may have been formed by straw or rushes. These characteristics raise the possibility, that, if moulds at all, these are not pin moulds but fragments from the mould of a larger object with a raised ridge ornament. It is also possible that, given the similarity of the fabric to pieces otherwise identified as wrap, that these might be wrap and that the impressions are of a mould binding as seen at Dainton (Needham 1980).

Piece #89 is a dark coloured fragment of sheet up to 9mm thick and uniformly reduced. It shows three parallel smooth zones – two are hollowed and might be matrices for pin shafts, the third zone is flatter and wider. All might be the matrix for a single ribbed object. The two possible pin shaft matrices are c.2mm in diameter and have 5mm between their centres. There is a 3mm wide raised zone to one side before a wide flat zone.

Fragments #173 and #174 are joining. They show a similar pattern of matrix to the item #89 above, with a width of 8mm planar surface on one side, then 4mm raised, a 2mm wide groove, another 4mm raised, a second 2mm groove, and then planar for 4mm (surviving width). The grooves are very slightly curved. There is some hint of longitudinal striation in grooves which looks like texture of a straw stem.

Item #90 is strongly and abruptly divided between reduced zone close to the inner face of the mould and an outer buff zone. The matrix is poorly preserved but there are parallel groves of c.2mm diameter and 5mm between centres.

Fragment #175 is a small piece of mould with a slightly curving, deep, asymmetrical groove, approximately 1mm wide, that is more similar to the Type (i) pin moulds in form, than to the other pieces in this group.

Type (iv):
(#86, #131?, #134, #160, #161/ #30, #163, #165, 168, #169, #170, #171)

These materials are all formed of sandy Fabric (b). Most of the fragments are buff coloured, grey parts being rather restricted, with a smooth, pale grey (lightly vitrified?) matrix surface. A few of the larger fragments show a slight orange tint to external surfaces The fragments include examples which are quite thick (up to 20mm). These properties mean there is difficulty in certain discrimination of these fragments from pieces of external wrap. Where internal impressions are present they are more suggest of mould matrices than of the impression of the impression of the external surfaces of the mould valves. The following descriptions employ the interpretation of the material as moulds.

Most fragments show a significant porosity, with several showing good impressions of vegetable matter. Most pieces show evidence for finer organic temper (hair?) on the smooth surfaces.

One group of fragments includes #134, #160, #161/#30 and #162. These are all thick (up to 20mm), show external oxidation to an orange colour and show a darker matrix surface. The matrix surface is steeply inclined with the mould. The margin of the matrix shows a slight outward curve, before an almost right-angled corner. The whole is therefore suggestive of the slightly flared blade of an axe, chisel or similar. Fragment #161 is large and together with the joining small fragment #30 shows the corner of the blade. Pieces #160, #162 and #134 are broadly similar, but do not join. These fragments show evidence for a well formed rectangular overall shape to the mould (as in Mould Type (i)), which is good supporting evidence for these being mould fragments and not wrap.

Piece #165 is fragment of a smoothly curving surface in a similar sandy fabric and so may be from the centre of a blade. Piece #86 may possibly be a blade margin, and showing a possible differentiation into two layers.

Piece #131 is in a very pale fabric and shows a rather different matrix, either showing an artefact with a curved groove parallel to its margin – or the edge of the artefact and a smooth outer field beyond a concentric ridge. It is texturally related to this group, but the form of the matrix is most closely matched by fragment #166 (which is in Type ii).

There are numerous other fragments in this group, but without clear form to the internal surface, their identification as mould rather than wrap becomes more tentative.

Wraps
(#46, #91?, #121/122?, #135, #156)
Material interpreted as deriving from external wraps to the piece moulds is dominantly, nut not exclusively, slightly oxidised fired and buff in colour. The thickness

of the sheets is variable, but up to approximately 10mm. Typically the material is in a rather sandy fabric with abundant, and occasionally moderately large voids.

A few pieces (e.g. #46, #156) are strongly concavo-convex, with a rather irregular inner surface, but a neatly smoothed outer face. The nature of the inner face demonstrates that they are not moulds, but can be interpreted as external wrap fragments.

Conjoining pieces #121/#122 are regularly curved, as if part of a tubular object, with a smooth inner face and a dark, slagged outer face similar to some of the possible 'heating tray' material. The most likely interpretation is that they are external wrap contaminated by a spill during pouring.

Gates
(#47, #50, #120)
Fragment #120 forms a substantial section of an external gate. The piece is oval in section, 30mm tall and approximately 15mm thick. It appears to be inclined outwards, so that the external diameter at the rim would have been about 70mm, but the shape is very irregular. The internal diameter at the base, where the gate is assumed to have joined to the mould is about 28mm and the external diameter about 60mm.The lower face, where the gate would have joined the mould is smoothly and gently convex. The fabric is moderately sandy (like mould Fabric B) and appears to have a low proportion of organic temper.

Two small fragments (#47 & #50) are sherds showing a rounded rim of similar profile to that of #120. Fragment #47 shows a small oxidised metal droplet and #50 bears a slag coating, partially spalling off, a largely unaltered rim below.

A tiny fragment (#51) appears to show a clay divider pinched between two holes and it just possibly represents the external openings for twin sprues, as seen on the pin moulds.

Cores
(#48, #52/#164)
Three small fragments, all strongly oxidised and all related to organic materials, are interpreted as fragments of core.

Fragment #48 appears to be part of a crudely facetted cone-shaped piece, rich in moulds of organic materials (straw?). The surviving piece is irregular in shape, broken both ends, c. 20mm tall and approximately 17mm x 14mm in maximum section, thinning to approximately 10mm x 8mm. The fabric is strongly oxidised externally, but has a reduced-fired centre.

Joining fragments #52/#164 form part of a tubular structure, externally c35x45mm, internally 13x18mm (if symmetrical) apparently formed of a clay coat applied to a bundle of grass, straw or reeds, which are is visible as a fluted impression on the inner surface. The neat outline is slightly obscured by secondary clay at one end. The fabric is strongly oxidised, moderately sandy and bears thin inclusions that were probably grass.

Crucibles

A single sherd (#45) is suggestive of a crucible. The profile shows the 10mm thick lower wall inclined outwards at about 45 degrees, before rising vertically for the last 10mm to a broad, rounded rim. The fabric has a fine cream-coloured matrix bearing very fine quartz sand. There are larger spherical voids that might just indicate lost temper, but are probably vesicles formed as a product of the heating. The surface of the sherd is mid-grey, in a thin layer on the base, but a brown-grey layer extends down from the upper surface almost to mid-thickness. A thin dark deposit adheres to the inner surface.

In plan, the midline of the rim has a radius of curvature of approximately 20mm. If the curve was representative of the whole, it would make this a very small crucible, with a shape similar to that of a later cupel, but it may simply derive from the corner of a larger, slightly angular or irregular crucible.

Crucible/tray/hearth
(#49, #53-#54, #94, #115-#119, #123-#128, #130, #137-#141, #144, #146-#152)
A large number of fragments were formed of an oxidised-fired sandy ceramic, typically fired to an orange, sometimes with a dark red surface colour on one face. The pieces typically have a wedge shape, between 10mm and 25mm in thickness, with planar upper and lower faces. Only #141 and #146 have been found to join, therefore the overall form of these materials is unknown.

Many of the pieces show a build-up of copper-bearing minerals on the (presumed) upper face. Much of this material is either granular and black, or appears as small irregular or botryoidal brassy growths. This latter material at least appears to be a result of secondary sulphidisation. Somewhat similar brown coloured mineral masses up to 1.5mm diameter occur rarely within the fabric due to penetration of the melt into the porous ceramic (and have also been observed inside the fabric of material interpreted as casting gate).

The interpretation of this material is uncertain. The planar nature of the surface, the scattered copper contamination and the lack of corners or bends, suggests that the material may be from a form of heating tray, rather than a crucible or hearth wall.

Along with the fired and/or slagged ceramic, there are numerous pieces of the slagged or drossed surface layer, ranging up in thickness to about 5mm, which have become detached from their substrate. Although most of these are planar and belong with this group of material, there are a few that show a higher degree of curvature and might have formed either inside a crucible or casting gate.

Dross/Spills
(#39, #142)

These two small greenish fragments appear to be discrete blebs of corroded metal or dross. Neither has been cleaned and the composition of the metal is unknown, although they appear heavily altered.

Distribution of material

The material is distributed between two contexts, c65 and c66, both apparently fills of the same pit. Apparently some of the material spilled from its bags during the initial transit to the pottery specialist and not all may now be correctly assigned (though none was

lost). Most of the joining fragments (#30/#161, #40/#83, #41/#42/#163, #52/#164) actually involve sherds from both contexts. This would imply either that the mis-assignment of sherds to contexts is a bigger problem than thought, or that the two pit fills were closely linked and belong, perhaps, to a single disposal episode.

Chemical analysis of the material

The pXRF traces are illustrated in Figures 1 to 3. In these, the locations of the main spectral peaks for the elements present in copper alloys are indicated. Peak heights are listed in Table 1.

(i) C66 inside surface of gate. #120
The contamination of the ceramic is largely by copper, with very low levels of tin and lead.

(ii) C66 fragment of a drossy surface #119
The contamination of the ceramic was by copper with a lower proportion of tin and very low concentrations of lead.

(iii) C66 mould surface #134
This sample shows very low levels of zinc, probably slightly less copper and a trace of tin.

(iv) C66 inside elongate curved possible 'wrap' #121
This piece shows low levels of copper and very low levels of zinc and lead.

(v) C66 thick vitrified heating tray (?) surface #128
This sample showed contamination with a high level of copper and a very small amount of tin.

Where the counts were very high ((ii) 157000; (v): 156000), the analyses were similar in having copper as the main contaminant to the ceramic, with low levels of tin and lead, but just trace levels of zinc. Specimen (ii) has higher levels of tin and lead than specimen (v).

Specimen (i) has a lower overall total but higher relative levels of lead and lower levels of tin.

Of the two specimens with very low overall counts for these elements (Sample (iii), a mould, and sample (iv) a possible wrap), lead and zinc are relatively elevated compared to copper (although at low absolute levels).

Interpretation

The assemblage forms a coherent suite of residues from the casting of copper alloy artefacts. The residues are diverse, with several distinct types of moulds, wraps, gates and cores, but with very few examples/fragments of each. This leaves considerable doubt about the details of the technology and of the artefacts being cast.

The limited amount of chemical analysis undertaken, suggests the metal being cast was a lightly leaded tin bronze, with trace levels of zinc. The zinc is relatively enriched in the mould/wrap material because the zinc vapour can penetrate the porous ceramic; lead is locally enriched because it reacts with the ceramic to form a slag (Kearns *et al*. 2010). Although it is not possible to quantify the metal composition, the proportion of zinc would appear to be very low, probably less than 0.2%, and its presence in the analysis of the moulds/wrap should not be taken as indicating a significant level in the casting metal. Levels of lead are also low, but are sufficient to suggest a deliberate additive. Leaded tin bronzes are characteristic of the Late Bronze Age, but not of the Iron Age (Dungworth 1997). Tin is present in rather low quantities in the analysed samples, but it is uncertain to what extent this reflects its actual abundance in the casting metal, rather reflect the different modes of accumulation of the metal contaminants (Kearns *et al*. 2010).

The ceramics include moulds in a fine silty fabric, Fabric (a), some of which had been used to cast pins in pairs and a ring. A particularly fine, dark, variant of this fabric was employed in moulds that show a matrix with a central elongate conical component, possibly a spearhead or ferrule. A fragment of a mould of an unknown

There is evidence for a different fabric (Fabric (b)) being employed for external wraps for the moulds. This fabric bears abundant coarse, rounded, quartz sand grains, as well as voids indicative of the former presence of a significant component of organic temper.

Some of the very fine-grained silty moulds (Types (i) and (ii)) show the presence of quartz sand grains in their outer layers, rather than merely appearing abruptly across the mould-wrap boundary. Together with the particularly fine, smooth surfaces on the possible spearhead matrices of Type (ii), this does raise a question about the identification of the moulding technology employed. These features might suggest the progressive build-up of an investment mould, rather than the use of piece moulds for the finely-surfaced matrix of the possible ferrule/spearhead/ at least. The rather rectangular blocks, with a planar, apparently original, inner face employed for the pin moulds more closely resemble piece moulds. In the presence of so few fragments of the possible ferrule/spearhead moulds, this question may remain open.

The sandy Fabric (b) also appears to have been used for some moulds. The Type (iv) fragments are reasonably confidently identified as moulds, with several fragments suggesting the casting of an artefact with a short, thick, slightly flaring blade, possibly an axe or chisel. In a somewhat similar fabric, the Type (iii) fragments are somewhat less certainly from moulds. The grooved inner faces could be interpreted as either the matrices for narrow, slightly curving, pins, or for a planar surface bearing narrow slightly curving ribs. Alternatively these pieces could be interpreted as external wraps overlying a binding keeping the inner moulds correctly aligned.

Further evidence for the casting technology comes from the fragments of casting gate and possible core. The gate appears to be an external addition to the mould in a similar fabric to that of the wraps. There is no evidence for the nature of the mould to which the gate fragments would have been attached.

A small number of pieces in a partially strongly oxidised variant of the same fabric are interpreted as core fragments. One of these forms a fragment of a crude, facetted cone, approximately 20mm tall and approximately 17mm x 14mm in maximum section, thinning to approximately 10mm x 8mm. The irregularity of this core would be appropriate for the innermost section of a socket.

A second piece, formed of two joining fragments (#52/#164) formed part of a tubular structure, externally measuring perhaps as much as c.35x45mm (but with only <50% of the section preserved, this is uncertain), is also tentatively interpreted as a core fragment. The extrapolated section of this tube appears slightly angularly sub-circular, which together with its size would make this piece appropriate, if a little larger than typical, for a core for a socketed axe. Interestingly, this piece was apparently constructed as a layer of clay applied to the outside of a bundle of straw or reeds (now forming a cuspate impression on the interior surface). If indeed this was a core, then this unusual mode of construction might facilitate its removal from the artefact after casting. Alternatively, the tubular form may have been for another purpose, such as a tuyère, which would have had an internal section of approximately 13x18mm.

If the moulding materials present considerable problems in interpretation, the mode of handling the molten metal is even less clear.

A large number of ceramic fragments, in an oxidised fabric similar to Fabric (b), have a high level of metal contamination on their surface. Although these resemble the materials employed in Bronze Age crucibles, they are mainly too planar to have formed part of a typical open, bowl-like or boat-shaped form typical of the period. A tentative alternative interpretation is that they derive from some form of 'heating tray', upon which the casting may have been conducted.

If these materials are not the remains of crucibles, the evidence for crucibles is reduced to one single sherd of rim. This piece is suggestive of small shallow vessel, perhaps more similar in form to a later cupel, than to typical published crucibles of the period. Published late Bronze Age crucibles are large, open vessels (e.g. examples from The Breiddin, Tylecote & Biek 1984), sometimes with tripod legs (e.g. the crucible from Dainton, Needham 1980). In contrast, with the casting of mainly small items in the Iron Age, the earlier Iron Age crucibles from Danebury (Cunliffe 1984), Old Oswestry (Savory 1976) and Llwyn Bryn-dinas (Musson *et al*. 1982) were small, thick-walled handled forms. For much of the Iron Age the dominant crucible form is the 'D'-shaped or triangular crucible (e.g. examples from Glastonbury, Bulleid & Grey 1911). However, none of the described Bronze Age casting assemblages seems to have specialised in small artefacts, as may be the case at Banwell.

The present example does bear some resemblance in profile, however, to small crucibles of the later Iron Age and the 'native tradition' of the Roman period (e.g. crucible 1 from Porth-y-rhaw, Young 2010).

The fabric of this crucible appears somewhat similar to Fabric (b) of the moulds. Bronze Age crucibles are typically formed of less-refractory materials then Iron Age or later examples (Bayley & Rehren 2007). This crucible would appear, therefore, to lack close parallels, but the late Bronze Age to early Iron Age has notoriously few published examples.

In summary, the development of crucibles during the late Bronze Age and early Iron Age is poorly known, which means that the morphological resemblance of the single sherd from Banwell to later Iron Age and Roman forms is of unknown significance, but hints that those forms may have had an earlier ancestry than currently recognised. The possible Iron Age affinities of the crucible are countered by both the leaded alloy and the artefact types being cast, which are both Bronze Age in character.
The significance of the assemblage as a whole is that it represents an insight into casting in the region at a period with few other equivalent assemblages. The Dainton residue assemblage (Needham 1980) is closest in age (c. 10th century BC), but is dominated by martial equipment (spearheads, swords, ferrules…). In contrast, many Iron Age assemblages (e.g. Gussage All Saints, Wainwright 1979) are dominated by horse equipment. Needham (1980) discussed the pssobility of specialism within the metalworkers and the possibility that the Banwell residues represent materials from a workshop which specialised in more domestic items should be considered.

Evaluation of potential

The assemblage is a significant one, with a good array of casting residues which could be developed further for publication. There can be no doubt that full publication of this assemblage is highly desirable.

Useful additional lines of research would be to document the petrography of the ceramic residues via thin section and/or SEM investigation, investigation of potential metallic residues with the drossy material adhering to the 'heating tray' surfaces, and further attempts to find joins within the assemblage to increase the size of the mould fragments that may be interpreted.

Further investigation of the moulds by a Bronze Age artefact specialist may also help shed light on the details of the various objects being cast. The affinities of the pins, tools, ferrules(?) and unknown roundel would benefit from specialist input.

These potential gains from further investigation, are somewhat limited in scope by the small size of the assemblage, the apparently extremely incomplete nature of each item within the assemblage and the eroded nature of the fragments (from both pre- and post-excavation damage) that limits reconstruction.

Despite these drawbacks, the assemblage is well worth further investigation and publication.

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Glossary

Bronze: an alloy of copper and tin. Typical Bronze Age alloys for casting might have 10-16% tin, but rather lower tin contents are recorded from metals intended to be worked by hammering. Small quantities of lead may be added to bronze to improve its casting properties.

Core: material forming the mould for a re-entrant section or internal void within a casting. An example would be the section of the mould forming the interior of the socket of a socketed tool or weapon. Since the casting of socketed items was usually via the socket end of the mould, the core to form the socket was frequently formed as part of the **casting gate** (e.g. Tylecote 1986, Figure 46)

Crucible: a vessel used to contain metal or glass as it is melted, or to handle such molten material. Bronze Age and early Iron Age crucibles were typically only moderately refractory and were often rather open vessels heated mainly from above. Later Iron Age crucibles were typically smaller vessels, of an increasingly refractory material and increasingly heated from below rather than above.

Gate (Casting Gate)*:* a section of a mould forming a reservoir to contain the liquid metal as it is poured. The gate may be connected to the mould itself via sprues. Casting gates may be separate ceramic components or integral to the mould.

Investment Mould: a mould formed by coating a ***pattern*** (typically of wax) with a fine clay slurry. The slurry is dried and then further coats added as required, often with later coats being of coarser clay than the first (which produces the artefact surface texture), to control strength and 'breathability' of the mould as required. The mould can then be hardened by drying and low-temperature firing, which also permits the melting and removal of the wax, to leave the mould open for pouring. Wax-based investment casting is often known as the 'lost-wax' process or *cire perdue*.

Lost-wax technique: see investment mould.

Matrix: the impression of the artefact to be cast in a mould.

Mould: a container (ceramic, stone or metal) with an inner surface forming the matrix to an object to be cast. In Bronze Age metallurgy there are three main mould types – the open mould (typically of stone and employed for single-faced or simple objects, such as flat-axes), the ***investment mould*** (of ceramic and employing the lost wax technique) and piece moulds (of ceramic, stone or metal).

Pattern: an object used to form the matrix for a casting in a mould. The pattern for an ***investment mould*** is typically formed of wax (formed either by working wax into the required shape, or casting it). The pattern for a ***piece mould*** may either be a previously formed artefact of the kind desired, or a copy of the artefact in another medium (e.g. wood). In the case of an investment casting, the pattern will also need to include any necessary ***sprues***. In a piece mould the sprues may be formed by separate carving/impression of the mould.

Piece Mould: moulds formed of separate impressions of different faces of the pattern, which can then be assembled into a complete mould (after addition of any necessary sprues). Also sometimes known as part moulds. The most common use of piece moulds in the Bronze Age would have been as two part (bivalve) moulds, with or without a core as appropriate.

Sand: classification of the Wentworth Scale (and associated schemes) for sedimentary particles of 0.0625 mm to 2 mm.

Silt: classification of the Wentworth Scale (and associated schemes) for sedimentary particles of between 0.002 mm and 0.063 mm. Silt typically comprises more-or-less equant particles of (mainly) quartz and feldspar (as in the coarser sand grade), as opposed the finer-grained material classified as clay, which includes the markedly tabular form of many clay particles.

Sprue: the tubes in a mould to allow passage of the molten metal from the gate to the mould itself.

Valve: a term used to describe one part of a two-part piece mould. For simple artefacts (e.g. the pins described here), a simple two-part, or bivalved, mould would be required.

Wrap: an outer layer of clay used to join and seal the separate parts of a piece mould and external gate (if present).

Catalogue

C65 sample 40

#1 - #29: 32g, 29 pieces of indeterminate mould material

#30: 2g, 1 piece, oxidised end of mould, joins #161

#31 - #38: 4g, 7 fragments of granular highly altered ceramic, grey, porous with slag penetrating into fabric

#39: 1g, 1 piece of botryoidally-structured copper residue, possibly on grey ceramic, but covers all sides so may be oxidised spill?

#40: 20g, 1 piece, large planar mould fragment with two grooves on one face. All grey apart from one side which is buff. One groove 3.5 – 4 mm wide and up to 2mm deep; the other is 2.5-3mm wide – with a marked ridge appearing within it as it widens. Grooves are approximately 11mm apart. The slab has a rectangular margin, 12mm thick, with one groove (the wider) 8mm from one edge. Wide groove seen for 35mm, smaller for 29mm. Broken long side of mould face may possibly show a third pin mould, but this is not certain. Fine micaceous fabric. (this piece joins #83)

#41: 4g, 1 piece, 8mm thick mould fragment with edges of similar grooves to those of #40, preserved approximately 10mm apart. Fine micaceous fabric. (joins #42 and #162)

#42: 2g, mould fragment. Fine micaceous fabric. (joins #41 and #162)

#43: 2g, mould fragment with an 8mm wide flat surface (probably mould interior surface) preserved.

#44: 2g, fragment with tiny concave mould area preserved

#45: 6g fragment of rim. Strong curved profile – more like the rim of a cupel. Some adhering deposit on inside. Dark inner ace becoming pale towards base, where it has khaki paste/buff paste with moderate rounded sand

#46: 10g, somewhat concavo-convex piece – buff mostly, slightly grey on one external surface. Fabric shows moderate sand in buff paste, and probably also some organics. Unclear what this is – mould wrapping, base of side of crude crucible? Fabric similar to #47, with which it shares its concavo-convex shape.

#47: 4g, concavo convex piece in buff fabric with moderate sand. Some missing large clasts (organic?) and also an included sulphidised (?) bleb. Some mica in fabric too. Outer surface is smoothly curved – outside of mould/gate? Fabric similar to #46.

#48: 2g, fired clay more orange than typical buff and has grey core. One end shows multiple crude external facets as if part of a hand formed ‘spike? Plenty of organic inclusions. Fabric like #49, #52.

#49: 4g, nub of buff moderately sand-rich fabric, one face has slightly concave, red altered (vitrified?) surface with thin grey layer just below – looks wrong for crucible – could be fragment from mould gate? Fabric like #48, #52

#50: 2g, Fragment with rounded termination like crucible rim or mould gate margin. Dark adhering residue layer on curve with some greying below, but otherwise oxidised fired

#51: 6g, fragment in sherd-like slightly curved sheet, buff fairly sand rich with some organics. Outer surface shows two curved slightly depressed zones, inner face slightly concave and slightly darker. If surfaces the other way round, the two curved surfaces would match the convergent sprues above the pin heads?

#52: 6g, more oxidised-fired piece. One face shows a corrugated and striated surface (formed by parallel stems of straw?) Opposite face is convex, rounded and possibly with outer applied layer. Moderately sandy – probably a mould fragment, but unclear if striated face is strengthening or part of forming of mould. Fabric like #48, #49. Joins #164. External c35x45mm, internal 13x18mm if symmetrical. Neat out line is obscured by secondary clay at one end.

#53 - #54: 2g, 2 pieces of buff/orange sandy clay with organics and large rounded brown inclusions, with slagged and sulphidised planar surface. Brown large inclusions match those seen in the 2g possible crucible/gate rim (#50). One piece is large, the other tiny

C66 sample 15

#55 - #82: 25 pieces 50g, worn mould fragments

#83: 14g 1 piece, important piece. 2 pin heads with sprues above, heads have otherwise flat top, 6mm in diameter, short straight side then converge to 3.5mm diameter shaft. Total head height c. 4mm. Sprue c.4mm diameter, pinched near head, convergent away from pins, slab c. 15mm thick. Mottled grey buff, outside locally almost white with smeared (fingerprint?) texture. Fabric fine silty, some voids for possible organic temper, micaceous, very little coarse quartz. Shaft centres 15mm apart. (joins #40)

#84: 6g, 1 piece, another important piece, 2 pin head impressions, better one 6mm in diameter and 4mm tall with 4mm diameter shaft. Shaft centres 10mm apart, one higher than the other. Similar fine silty material to example above. Sprue situation not clear – possibly a wider zone above/between both heads.

#85: 2g, 1 piece of thin sheet of fine silty mould. Possibly has one angled margin present. Impression in side is of arc of 2.5mm diameter with annular ornament and c. 13mm radius of curvature. Surface of mould is very smooth outside the curve – unclear if this a mould face join (probably) or a part of artefact (less likely).

#86: 2g 1 piece, possible two layer fragment. Inner is denser, with well-formed angular end. Inside is L shaped smooth area. Unclear if this is actual artefact mould – or just well finished surface of inner piece mould. Both inner and outer layers are in a relatively sand rich fabric. Outer surface is very markedly convex indicating proximity to mould margin.

#87: 10g 1 piece, fine micaceous fabric with very hard smooth surfaced (slightly vitrified?) elongate concave impression (c. 7mm radius). Outer field is very slightly convex. Could be spear head with central rib or similar.

#88: 6g, 1 piece, fragment very similar to that above, outer field is slightly convex – so might even be a counterpart – which would define a blade fragment. Fragment has oxidised outer surface.

#89: 4g, 1 piece, dark coloured fragment of sheet up to 9mm thick and uniformly reduced. Shows3 parallel smooth zones – 2 are hollowed and might be pin shafts, third is flatter. All might be a single ribbed object. 2 pin shafts c2mm in diameter and 5mm between centres, then 3mm gap to one side before similarly altered flat zone

#90: 6, 1 piece. Strongly divided between reduced zone around artefact mould and outer buff zone. Mould is poorly preserved but might be two pin shafts. c.2mm diameter and 5mm between centres

#91: c.0.5g, small convex ceramic fragment

#92: 4g 1 piece, fragment of relatively sand rich material, with well-formed pale outer face and rather altered looking grey fabric.

#93: 6g 1 piece, fragment from what appears to be the margin of a truncated cone – perhaps 40mm diameter at the base with a slightly hollowed base. This could be a fragment of an inner part from around the pouring cup, or it could potentially be a core fragment.

#94: 2g, 1 piece, double layer fragment in rather altered-appearing pale material. Moderately sandy. Similar textures seen in wedge-sectioned slagged material.

#95: 12g 1 piece, slab buff one side and grey the other. Various superficial markings, but two on grey side might be moulds. One is a poorly preserved straight groove, the other is curved. If pin moulds then is bent!

#80-#82, 6g, 3 pieces worn silty mould fragments

C66 sample 19 (industrial/mould)

#96 - #113: 18 mould fragments, 102g, 2 pieces showed smooth, curved external surfaces, but none with internal detail.

#114: 4g 1 buff orange/buff moderately sandy, with some organics and large brownish lumps in fabric.

#115 - #116: 38g, 2 pieces, buff, slightly orange in outer parts, grey on inner face, wedge shaped clay fragments, outer face shows strong heat alteration, inner buff/grey face planar, shows little alteration.

#117 - #119: 42g, 3 pieces, similar to above wedge shaped pieces but inner face not preserved. On most heat altered example outer faces is a slaggy layer around 8mm thick. #117 and #118 join.

#120: 20g, 1 piece – appears like irregular crucible rim with coating of botryoidal material on both inner and outer faces – but lower face is neatly rounded, not broken (unlike ends) – possibly a casting gate (cf. Tylecote 1986, Figure 46) formed separately from mould to which it was attached.

#121 - #122: 12g 2 conjoining pieces – rather pot like but in same fine silty material as other mould fragments, heat affected and grey outer part of section, inner part more buff – opposite way round to most mould fragments. Possible crucible/wrap.

#123 - #128: 42g 6 pieces, botryoidal and locally green, drossy material in sheet on mostly oxidised ceramic, drossy face is mostly planar

#129: 10g, 1 piece of mould, very fine micaceous silt, buff exterior to orthogonal corner and greyish interior

#130: 4g sherd-like fragment of over fired, porous ceramic containing large brassy botryoidal masses within fabric. Inner face is smoothly concave, no residue

#131: 20g 2 pieces fine pale grey somewhat sandy material with concentric smooth areas at slightly different levels – unclear if mould for circular? object or if these are mould faces.

#133: 4g 1 piece of dark grey very mould-rich fabric with some sand. Possible pin mould fragment.

#134: 30g of pale grey/buff moderately sandy mould material, one piece has curved embayed area, probably the object

#135 - #136: 20g 2 pieces in buff sandy fabric with rather coarse appearance to clay – outer mould layer?

#176: 1g, 1 piece of highly bloated ceramic with planar, but slightly wrinkled surface.

#132: 6g, 1 elongate grey silty mould fragment

C66 sample 19 (pottery)

#137 - #141: 34g 5 pieces (1 tiny) of slagged (and secondarily sulphidised) oxidised fired ceramic – possibly pieces from base of planar based crucible. Some appear slightly wedge-shaped, but unclear if crucible wall is preserved. #141 joins #146

#142: 2g 1 piece, uncleaned corroded irregular shape, probably casting waste corroded into surrounding sediment

#143 - #144: 8g 2 pieces silty grey mould material

#145: 4g 7 tiny piece (1 fragmented piece?), over-fired porous dark material – but no Cu residues in this group

#146 - #152: 28g 7 pieces, planar drossy, botryoidal surfaces, here substrate seen it is mainly strongly oxidised and quite coarse. . #141 joins #146

#153: 1g 1 piece, green sheet of clay with lots of organic impressions in fine material – just possibly not an artificial ceramic

#154 - #155: 1g 2pieces of dark fine sheets with abundant organics including structures on one piece – they may be clay pressed onto organic substrate, probably burnt organic material

#156: 15g 1 large piece of buff coarse mould like material with concavo-convex shape – possibly an outer clay wrapper from a mould pair?? An odd shape

#157 - #158: 14g, 2 pieces, buff fired clay with external grey surface, terminating in angular edge like rim of handmade pot with flared rim – but appears too thick to actually be pottery, although this remains a possibility, and may from the end of a flared mould.

#159: 1g, 1 piece, pale grey silty fabric, micaceous, has raised boss 9mm in diameter and 2mm high. Possibly a locating study from two-piece mould.

#160: 16g 1 piece pale grey silty fabric with large rounded quartz grains, outer face planar with margin of mould, slightly oxidised, inner face shows margin of sheet like object, smooth, reduced just over object face. Very similar to #161

#161: 16g. 1 piece, pale grey silty fabric with rounded sand grains, becoming more orange on outer margin, 1 face is planar and dark, probably lightly vitrified concave mould surface. Very similar to #160. Joins #30.

#162: 12g 1 piece, buff silt/sand usual fabric, outer face has right angled corner, 'inner' face shows rounded dark surfaced embayment – could be mould fragment of largish object?

#163: 2g, fabric similar to 12g piece above, buff dark mottled, inner face is rounded – adjoins #41/#42 to form , outer face right angled

#164: 1g 1 piece, oxidised fragment with inner complex curved shape (multiple straws?) and outward convex curved face. Joins #52

#165: 4g 1 piece, grey piece with planar outer face and fine curved inner surface.

#166: 6g 1 piece, fragment somewhat similar to preceding items, if a mould, this is a slight convex item with a c40mm radius groove c3mm wide and less then 1mm high. Alternatively this might be some sort of keying?

#167: 4g, 1 piece, grey fragment with linear concave mould detail, poorly preserved. c. 8mm diameter?

#168 - #171: 26g, 4 pieces, typical pale grey silty mould fragment with abundant sand, typically two planar surfaces not quite parallel, with one darker surface and one smooth surface with fine, possibly hair, temper showing.

#172: Piece 1 6 g, mould fragment, irregular linear groove on blackened surface- but groove ends irregularly – so possibly external mould surface not object impression

#173 - #174: 8g, 2 joining pieces, shows planar surface with supposed pin moulds defined by raised ridges: 8mm planar, 4 raised, 2 groove, 4 raised, 2 groove, then planar 4mm. Supposed pin grooves are very slightly curved. If this is for pins then it must be a two part mould. Some hint of longitudinal striation in grooves – looks like texture of a straw stem.

#175: 4g 1 piece. Small fragment with curving pin groove, 1mm wide and rather less deep with angular, asymmetrical base.

#176: 1g, 1 piece. Small grey clay fragment with two parallel embayments leading in from the end – possibly the divider between two casting jets, but too small for certainty.

Sample	CuKα 8.04 keV	ZnKα 8.64keV	ZnKβ 9.57keV	PbLα 10.55keV	SnKα 25.23keV	
i	76260	<	22	2112	698	*(i) c66 inside surface of casting gate, #120*
ii	156524	<	32	2724	6087	*(ii) c66 drossy surface (from 'heating tray'?), #123*
iii	257	572	120	310	44	*(iii) c66 mould surface, #134*
iv	1373	404	50	291	59	*(iv) c66 inner face of wrap(?), #121*
v	155298	<	78	215	2206	*(v) c66 thick vitrified surface of 'heating tray', #119*

Table 1: Peak heights for selected energies, corrected for background.

Figure 1

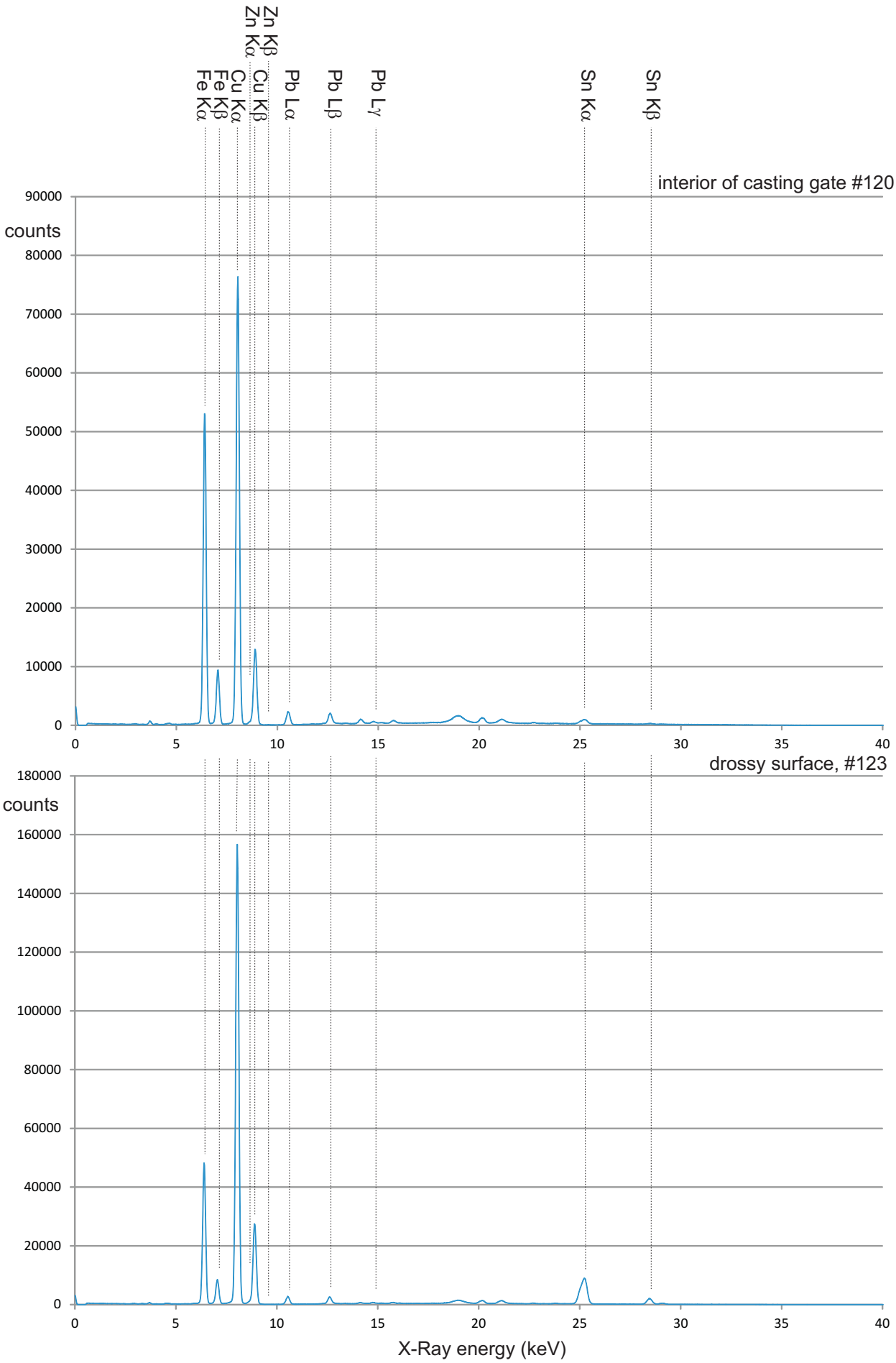

Fe Kα
Fe Kβ
Cu Kα
Cu Kβ
Zn Kα
Zn Kβ
Pb Lα
Pb Lβ
Pb Lγ
Sn Kα
Sn Kβ
interior of casting gate #120
counts
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
5
10
15
20
25
30
35
40
drossy surface, #123
counts
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
X-Ray energy (keV)

Figure 2

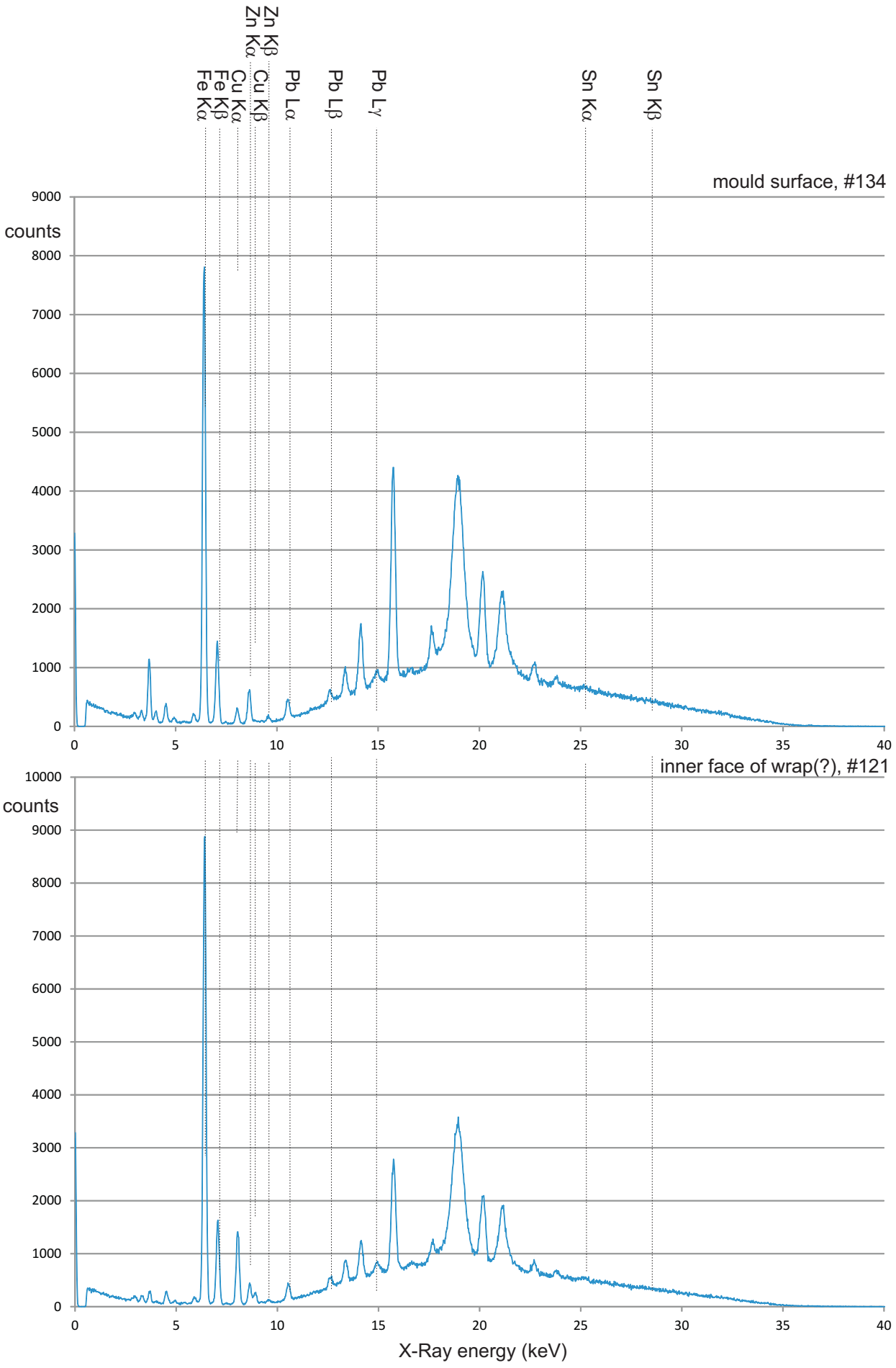
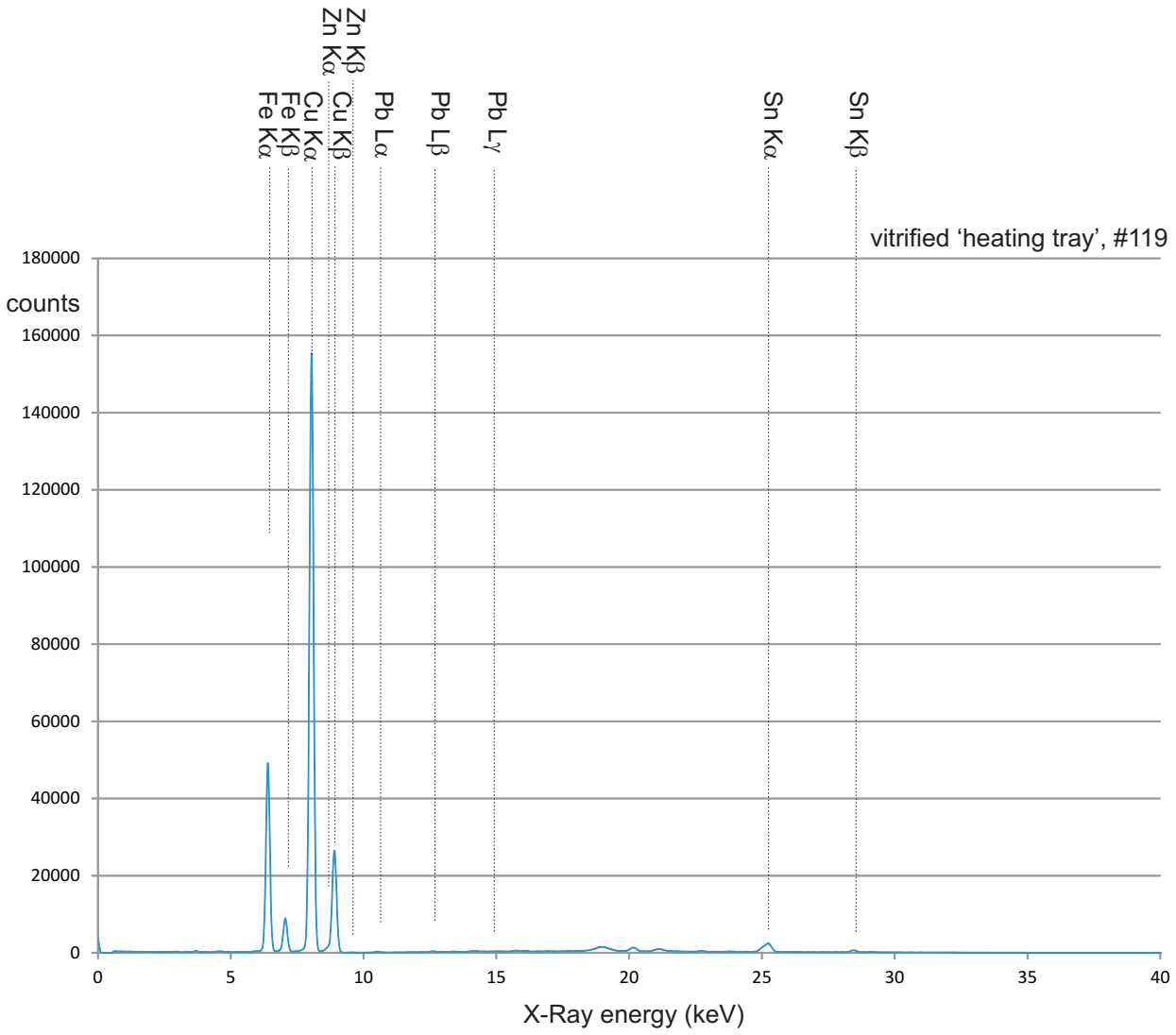

Fe Kα
Fe Kβ
Cu Kα
Cu Kβ
Zn Kα
Zn Kβ
Pb Lα
Pb Lβ
Pb Lγ
Sn Kα
Sn Kβ
mould surface, #134
counts
inner face of wrap(?), #121
counts
X-Ray energy (keV)

Figure 3


Fe Kα
Fe Kβ
Cu Kα
Cu Kβ
Zn Kα
Zn Kβ
Pb Lα
Pb Lβ
Pb Lγ
Sn Kα
Sn Kβ
vitrified 'heating tray', #119
counts
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0
5
10
15
20
25
30
35
40
X-Ray energy (keV)

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