Centre for Archaeology Report

Analysis of Objects from Stanway, Colchester

Sarah Paynter

Summary

Five ditched enclosures and a number of burials, dating to between the 1st century BC and the 1st century AD, were discovered at Stanway, near Colchester. A large number of well preserved copper alloy and glass artefacts, and iron objects including two currency bars, were recovered from the site. Some copper alloy objects, including vessels and brooches, and also glass artefacts, such as beads and gaming counters, were examined and analysed using X-ray fluorescence spectrometry (XRF), a non-destructive technique, in order to characterise the materials and methods used in their construction. A section from one of the currency bars was examined metallographically to determine what type of iron alloy was used. The slag inclusions in the bar were analysed and the compositional data obtained will contribute to continuing research into the sources of currency bars.

Keywords

Iron Age, Roman, copper alloy, glass, technology, iron, lead-tin alloy.

Introduction

The site is situated to the southwest of modern Colchester and covers approximately $200m^2$. Planning consent was given for mineral extraction in the area in the 1960's. The excavation of the site was funded by Tarmac and English Heritage (Crummy and Crummy, 2000). Aerial photographs first revealed the existence of archaeological remains at Stanway in the 1930s. Crop marks showed 5 rectilinear, ditched enclosures, set out in two groups. Enclosures 1 and 2 are side by side and enclosures 3, 4 and 5 are in a line to the east (figure 1). Enclosure 2, the smallest and earliest of the group dating from around 200-100BC, formed the central part of a Middle Iron Age farmstead. Two iron currency bars were recovered from the enclosure ditch. Enclosure 1 followed and assumed a funerary function, although it may earlier have been used as a stock enclosure. The suggested date for enclosure 3 is 35-45 AD and enclosures 4 and 5 are thought to be Claudian. Enclosure 4 was probably constructed last, although no later than 55 AD.

Enclosures 1, 3, 4 and 5 each contained a single wooden burial chamber. A number of secondary burials were also found in the area, dating from the late 1st century BC to the late 1st century AD. Finds included an inkpot from burial BF67, a shield and spear from burial BF64 and surgical instruments from burial CF47, leading to the characterisation of these burials as the "inkpot grave", the "warrior's grave" and the "doctor's grave" in figure 1 (Crummy and Crummy, 2000). The majority of the objects examined in this report derive from the features listed in table 1, which are in enclosures 3 and 5 or nearby.

Table 1: The positions and dates of the main features discussed in this report

Enclosure	Feature	Date
3	Chamber BF006	35-45 AD
	Burial BF067	43-50AD
	Burial BF064	43-50AD
4	Chamber BF024	40-60AD
5	Burial CF072	43-54AD
	Burial CF047	43-50AD
	Chamber CF042	Post-conquest
	Burial CF115	Probably Claudian
Outside enclosure 5	Burial CF007	75-20BC

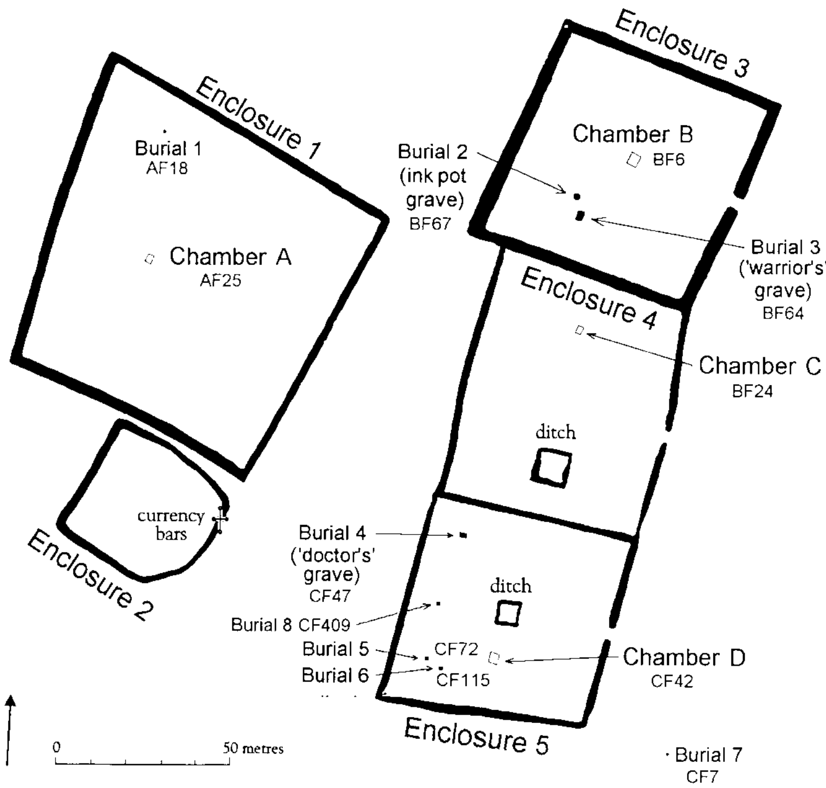

Figure 1: The location of the enclosures and burials at Stanway (from Crummy and Crummy, 2000)

Analytical Method

An EDAX Eagle II X-ray fluorescence (XRF) system was used to determine the composition of the glass and copper alloy objects. The advantages of this technique are that results can be obtained rapidly and no sampling is required, providing that the object is not too large to fit into the machine. The area analysed is less than 0.5mm in diameter and can be accurately selected and viewed using cameras within the analysis chamber. A disadvantage of the technique is that only the surface of the object is analysed, which is invariably badly corroded or weathered, and so the compositional data obtained are rarely representative of the uncorroded metal or unweathered glass beneath. The shape and large size of some of the objects from Stanway also restricted the number of areas that could be analysed, as the objects have to be positioned precisely to obtain an analysis and this was not possible for items with large protrusions, such as handles. Objects that were too large to fit into the EDAX chamber were analysed using the larger Link XR400 XRF. However with the latter system it was not possible to analyse small areas selectively, or to locate the area analysed as precisely, as with the EDAX Eagle.

During XRF analysis the object is bombarded with X-rays, which are absorbed and cause atoms in that area of the object to emit secondary X-rays. The energies of the secondary X-rays are characteristic of the elements present and so the composition of the object can be determined. It is also possible to programme the machine to analyse points at regular intervals across a large area. A map, showing the distribution of different elements over the object, can then be constructed from the individual analyses (see figure 4 later in this report).

Background

Glass

Ancient glasses were produced by reacting silica, which has a high melting point, with compounds that acted as fluxes, causing a melt to be formed at an accessible temperature (about 1000°C). The alkali oxides, soda (Na_2O) and potash (K_2O), are effective fluxes and can be derived from plant ashes or mineral sources. The ratio of soda to potash, and the concentration of other compounds present, such as magnesia and lime, varies depending on whether a mineral or plant ash source of fluxes was used, and if the latter, the type and origins of the plant. Henderson (1988) and Hartmann et al (1997) have identified glasses from c.14th century BC to 2nd century AD contexts in Europe that were produced using plant ash fluxes. These glasses consequently contain varying amounts of potash, magnesia and lime in addition to soda. However no plant ash glass was identified amongst the objects from Stanway. The great majority of glass from Iron Age and Roman Europe contains large amounts of soda (typically 15-20wt%) and some lime (about 7wt%) but little magnesia (0.5-1wt%) or potash (about 0.5wt%). This composition suggests that a relatively pure source of soda was used to make the glass, probably a soda-rich mineral such as the evaporitic deposit from Egypt known as natron (Freestone et al, 2000). This type of glass is known as soda-lime-silicate glass (Henderson, 1988).

From about the 2nd or 1st century BC, glass compositions are also characterised by small amounts of manganese oxide, added to decolourise the glass, whereas earlier glass typically contained antimony oxide as a decolouriser (Hartmann et al, 1997; Sayre and Smith, 1961; Henderson, 1985). In addition, some yellow (or more rarely white) Iron Age European glass objects contain tin colourant compounds instead of the antimony colourant compounds used in glass produced within the Roman Empire (Biek and Bayley, 1979).

Glass is susceptible to attack by water and the surface of archaeological material is often weathered. Some of the glass components are leached out, and the weathered surface becomes depleted in certain oxides, particularly soda, and relatively enriched in others, particularly silica. Henderson and Warren (1981) analysed a soda-lime-silicate Iron Age glass bead at different depths from the surface and found that soda was depleted, and potash was slightly enhanced, in the weathered surface layers.

Copper Alloys

Copper is a soft, ductile metal, which can be alloyed with other metals such as tin, zinc or lead in order to produce an alloy with a particular colour, hardness, malleability or casting fluidity. The terms used in this report to describe different archaeological alloys are based on established definitions (Bayley and Butcher, 1991). Bronze is an alloy of predominantly copper and tin. Tin levels were usually in the range of 5-12wt% and objects containing more than about 5wt% of tin have been described as bronze. Brass is an alloy of predominantly copper and zinc, normally with between about 10wt% to 25% zinc. In this report, objects containing more than about 5wt% of zinc have been described as brass. Gunmetal is a modern term but is also used to describe archaeological copper alloys with significant amounts of both tin and zinc. Objects from Stanway containing tin and zinc each at more than about 5wt% have been described as gunmetal. Lead can be added to any of these alloys and Stanway objects containing more than about 5wt% of lead have been described as leaded. The addition of lead to alloys improved the quality of castings but was detrimental if the metal was to be worked or gilded. In this report, alloys containing less than about 5wt% of total additions have been called impure copper. If several percent of an element was detected, it was recorded as a “small amount” and less than 1wt% as a “trace”.

There are considerable differences between the types of copper alloys used in Britain before the Late Iron Age compared to those used in Late Iron Age and Roman Britain. In the early and mid Iron Age bronze was the main alloy used. The lead content of Iron Age alloys was generally low, although larger, more intricate castings occasionally contained moderate amounts of lead. However in the Roman period many objects contained lead in low levels and some contained large amounts of up to 40wt% (Dungworth, 1996). Relatively high levels of the impurity arsenic have also been found in Iron Age copper alloys, but Roman alloys rarely contained more than 0.1wt% arsenic.

The earliest date for the regular production of brass in the Roman Empire is 25BC (Dungworth, 1996). Although objects made from brass began to appear in southern Britain from the early 1st century AD (Bayley, 1988), these were almost exclusively brooches, probably imported from Gaul and beyond. Although at Baldock there is evidence for the pre-conquest working of brass (Stead, 1975; Bayley, 1984), there is no evidence for the actual manufacture of the alloy in Britain until the decades following the Roman conquest, when there was a great increase in the amount of brass being used (Bayley, 1990). Brass was not regularly produced prior to the Roman period because of the difficulties associated with extracting the volatile metal zinc from its ore. Roman brass was made by the cementation process, which involved heating copper, charcoal and either zinc carbonate or zinc oxide in a lidded crucible (Bayley et al, 2001). Gunmetal was used and may have been produced by mixing scrap bronze and brass (Dungworth, 1996). However neither leaded brass nor leaded copper were normally used in Roman times and unalloyed copper was used only in certain applications (Bayley, 1988).

Copper and its alloys are prone to corrosion and different corrosion products result depending on factors such as the post-burial environment and the composition of the components making up the object. The composition of a corroded surface can differ greatly from the composition of the original metal beneath. For example zinc is more reactive than copper, and tends to be removed preferentially from brasses by corrosion in a process known as “dezincification”. Analysis of the corroded surface of a brass is therefore likely to detect lower levels of zinc, and correspondingly higher levels of the other elements present, than would be found in the original alloy. Similarly, tin-rich corrosion crusts are often formed on high tin bronzes as a result of tin oxide being insoluble and therefore immobile, relative to more mobile copper ions. Copper ions from a corroding object can be transported and deposited elsewhere, as copper compounds or, in some instances, as the metal (Cronyn, 1990). Corrosion products are often rich in elements such as chlorine or phosphorus, drawn from the surrounding environment (other elements such as carbon and hydrogen may also be present but are not detectable by XRF). As uncorroded metal surfaces were rarely accessible on the Stanway objects, the analytical data in this report have been interpreted with caution and, where possible, with reference to compositional data from studies where similar objects were sampled in order to analyse uncorroded metal.

Results

The analytical results are presented in a series of tables, grouped by material (glass, copper alloy or iron) and type of object. Where an object was particularly unusual or complex, a discussion of that object has been given in addition to, or instead of, the tabulated results. In each table the objects are listed by enclosure and then by feature.

Glass

Recent research on glass in the Roman period (Freestone et al, 2000) has developed the model that glass was produced at a number of primary production centres and then transported to workshops where it was shaped into objects. The glass used to produce the majority of Iron Age glass objects was probably produced within the Roman Empire, although glass workers outside the Empire shaped glass objects and occasionally coloured the glass themselves. All of the glass from Stanway was found to be of the soda-lime-silicate type, typical of European Iron Age and Roman glass, containing colourants and decolourisers that were also typical.

In the glass objects from Stanway, manganese oxide was used as a decolouriser and the white glass was opacified with calcium antimonate. Dark blue glass was produced by the addition of very small amounts of the strong colourant cobalt oxide, although copper oxide (also a blue colourant) was frequently detected as well. Significant quantities of iron oxide were occasionally detected in the cobalt-coloured, dark blue glasses, as is often the case, since the cobalt-rich minerals used as colourants also contained varying concentrations of iron. However in some instances iron oxide may also have been intentionally added. In previous studies (Henderson, 1991) Iron Age beads have been grouped according to the ratio of cobalt oxide to iron oxide in the glass. However none of the beads described in the literature contained such high quantities of iron oxide as detected in the dark blue counters from context F064 B1015 at Stanway (table 2). Yellow glass from Stanway was opacified with lead antimonate; no examples of the use of lead stannate, a colourant used in regions outside the Roman Empire, were found (Henderson, 1991). Traces of zinc and lead, were occasionally detected and probably entered the glass as contaminants in the colourants.

Gaming Counters

Table 2: Analytical results for glass gaming counters (see table 13)

Context	SF	Description	Results
F064 B1015	313	2 light blue and 8 black translucent counters of various sizes.	These counters, although part of the same set, had different compositions. The black counters contained in excess of 10wt% iron oxide, responsible for the darker colour, about 0.11% cobalt oxide and some copper oxide. The cobalt oxide was the dominant blue colourant. The light blue counters contained much less iron oxide and a little less cobalt oxide. The light blue counters may therefore be replacements, as they are made from compositionally different glass.
F047 C1001-C1013	98 - 109	13 opaque white counters, one very small.	Opacified by calcium antimonate.
F047 C1014 - C1026	110 – 121	13 opaque blue counters.	Opacified by calcium antimonate. Blue colour dominated by up to 0.1wt% cobalt oxide, although some copper oxide was also detected.
F042 C0597	244	Single dark blue translucent gaming counter.	Contained a small amount of cobalt oxide (the dominant colourant) some copper oxide, and a high concentration (~4wt%) of manganese oxide.

Beads and Studs

Table 3: Analytical results for glass beads and studs (see table 14)

Context	SF	Description	Results
F024 B322	147	Very small spacer bead.	This bead was likely to be faience rather than glass. It had a copper oxide coloured glaze. The surface was too weathered to determine the type of flux used.
F024 B606	251	Dark transparent green long barrel bead	This glass was coloured by copper oxide. The magnesia level was slightly higher than typical. No lead was detected.
F042 B383	255	Hexagonal transparent glass cylinder bead	Manganese decolourised.
F072 C0403	2	Large translucent blue bead with twisted opaque yellow and transparent brown cord.	The blue glass was coloured by cobalt oxide but also contained some copper. The yellow glass was coloured by lead antimonate and the brownish glass was coloured by manganese oxide.
F042 C0630	255	Translucent blue and opaque white glass stud head.	The blue glass contained high levels of manganese and iron. It was coloured predominantly by cobalt. Copper and zinc were also detected. The magnesia content of this glass was slightly higher than typical.
F042 C0723	279	Opaque blue stud head with opaque white spiral (top) and twisted opaque yellow and colourless spiral (bottom).	The blue glass contained calcium antimonate opacifier and cobalt oxide blue colourant, with some copper oxide. The yellow glass was coloured by lead antimonate. The colourless glass was decolourised by manganese oxide. The white glass was opacified by calcium antimonate.
F042 C0751	285	Translucent blue glass stud head with twisted opaque white and colourless cord and opaque yellow spiral at top.	The yellow glass was coloured by lead antimonate and the white glass by calcium antimonate. The blue glass was coloured by cobalt oxide with some copper and traces of zinc and lead detected. The colourless glass was decolourised by manganese oxide.

Bead F064 B1022 SF 377

Of the glass objects, the large blue and white bead SF 377, shown in figure 2, had the most unusual composition. The blue glass was coloured predominantly by cobalt oxide and small amounts of manganese oxide were also detected. The white glass was opacified by calcium antimonate and decolourised by several percent of manganese oxide. However the white glass also contained in excess of 20wt% lead oxide. This is atypical of the majority of white glasses of this date, as demonstrated by the compositions of the other white glass objects from Stanway, including the white gaming counters and the white decorated stud heads, which do not contain lead. Generally white glass opacified with calcium antimonate has a soda-lime-silicate glass composition with only an increased concentration of antimony clearly distinguishing it from transparent glass.

Figure 2: The large blue and white bead SF 377, shown slightly larger than actual size

However the presence of lead oxide in calcium antimonate opacified white glasses is common amongst Roman cameo glass vessels and to a lesser extent amongst mosaic glass vessels and cameo glass plaques or discs. Nearly all of the Roman cameo vessels in the British Museum, including the Portland vase (possibly late 1st century BC) and the Auldjo jug, were found to have high concentrations of lead oxide in the white glass decoration. The white glass in some of the cameo plates and plaques, although less than half of the number analysed, also contained lead oxide (Bimson and Freestone, 1983; Freestone, 1990). Similar results have been obtained in studies of other collections (Mommsen et al, 1997; Mass et al, 1998).

Cameo glass was made during two periods: the blue and white variety in the early empire 25BC to 50 or 60AD (ribbon mosaic glass is also contemporary) and a variety with a colourless background sometime between the mid-third and fourth centuries. Both varieties are rare and the distribution of finds indicates Italy as a possible main area of cameo glass production (Whitehouse, 1991 and 1997). The production process started with the formation of a cast or blown vessel consisting of a layer of white glass over a background colour glass (Whitehouse, 1991). The white glass layer was then cut to form a relief decoration (Henderson, 1996). The presence of lead oxide reduced the melting point and hardness of the white glass relative to the glass comprising the rest of the object (which contained no lead) and so facilitated the production process.

Cast cameo panels were simpler to make since the blue and white components were cast separately and then fused together, and this may be why the white glass on cameo discs and plaques is less likely to contain lead oxide.

The Stanway bead was probably formed by dabbing small blobs of heated white glass onto the blue glass bead and then marvering these into its surface; a thin strand of white glass can be seen connecting two of the white blobs. The distortion of the white decoration indicates that the glass was stretched after the white decoration had been applied, enlarging the diameter of the bead would have produced the effect seen. The white glass blobs contain small bubbles, particularly around the edges. Marvering blobs, spirals or cords of different coloured glass into the surface of a glass object was a common method of glass decoration and was successful with typical soda-lime-silicate glasses: the large, annular, cord-decorated bead (SF 2) from Stanway is an example. Thus the addition of lead oxide to the white glass in this large blue and white bead was not necessary to facilitate the production process.

Very few other examples of high lead, calcium antimonate opacified, white Iron Age glass have been identified. Lead was detected in a blue and white bead (731) with cable decoration from Hayling Island, Hants, dated to around 50AD or earlier (Bayley et al, forthcoming). This was described as a baroque example, of British origin, without exact parallel. Henderson and Warren (1981) detected 20wt% lead and some antimony oxide in the white decoration of a glass bead (described as Guido class 1 (II)) from an Iron Age context at Glastonbury Lake Village. Guido (1978) describes this class of bead as being small, blue and decorated with white rings around blue eyes. This type of bead is one of the earliest to come to Britain, in the 5th or 4th centuries BC (Guido, 1978) although it is highly unlikely that the early examples contained lead oxide as its use in white glass is unknown in Europe before the 1st century BC. The Stanway bead itself is most similar to the Group 1 beads, common on the continent, thought to have been produced in Czechoslovakia (Guido, 1978 and Crummy pers. comm.). Group 1 beads have been found in England dating to around 50BC to 50AD, although they are not widespread, but none have been analysed to determine whether any contain lead-rich white glass. Since the composition and appearance of the Stanway bead seem to be without exact known parallel, this object may be a relatively local imitation of a type of bead such as the Group 1 type. In summary the bead was probably produced between 25BC and 50AD in a workshop outside the Roman Empire, using glass derived from a Roman cameo or mosaic glass object.

Copper Alloy Objects

A large number of copper alloy objects from Stanway were analysed. Unusual objects, or complex items formed from several components, are discussed under subheadings. The remaining results have been tabulated and grouped according to the following categories: general objects, brooches and fragments.

Shield boss F064 B1006 SF 347

The boss was constructed from three parts; a cast leaded bronze knob, a bronze plate (also containing a small amount of lead) and finally an iron sheet under-layer (see table 15).

Skillet with handle with ram's head terminal F064 B1019 SF 372

The skillet was too large to be easily adjusted once in the chamber of the EDAX Eagle and so it was also analysed using the larger Link XR400. Although surface decoration, such as tinning, silvering or inlay, could not be sought since only a few areas could be accessed, examination with a binocular light microscope suggested that none of these were present. The skillet was made from two parts; a leaded bronze handle (with a small amount of zinc) and a leaded bronze body (see table 15). The lead content of the body was considerably lower than that of the handle and a small amount of zinc and traces of antimony and arsenic were also detected in the former. Both the skillet and handle had been cast and not subsequently worked, as characteristic, distinctively shaped dendritic crystals were visible on the skillet surface. The two parts had been soldered together with lead-tin solder.

Jug F064 B1020 SF 375

The jug was too large to be accommodated by the Eagle EDAX and so the Link XR400 XRF was used. The jug was constructed from three parts: the handle, the top of the jug with spout and the rounded lower body of the jug (figure 3). The handle was cast and was a leaded bronze with traces of antimony. The handle was probably attached using lead-tin solder, as some was visible where the handle was attached to the jug although this area was not accessible for analysis. The top half of the jug, including the spout, was bronze and a small amount of lead was detected. This section of the jug was cast and not subsequently worked, since small dendrites could be seen on the surface using a binocular light microscope. The metal was approximately 5mm thick at the spout. The rounded lower body of the jug was bronze, containing only a small amount of lead, and was only 1mm thick in places. This section of the jug was probably wrought although no uncorroded metal was visible to examine for evidence of dendrites or tool marks. No tinning or silvering was observed or detected analytically although it was not possible to analyse the internal surfaces of the item. Molten metal had been applied to the join between the top and bottom halves of the jug, in three areas on the inside. From its appearance and hardness this metal was probably copper alloy rather than solder. No signs of the join could be discerned on the outside of the jug where it was disguised by two parallel decorative grooves. The join was probably an overlapping, rather than butt, type but since it was still intact it was not possible to conclusively establish this.

Figure 3: The complete upper part and broken lower part of jug SF 375, still joined, with the top of the decorated handle, attached to the back, partially visible

Patera F047 C0901 SF 13

The remains of tinning were visible on the inside surface of the patera. Due to the large size of the patera it was only possible to analyse a small fragment of the handle, which had broken from the object, and this was bronze (see table 15). No lead was detected. As the object was cast in one piece the analysis of the fragment is likely to be representative of the whole. Paterae of this type were cast in moulds using the lost wax process. The characteristic grooves on the base of this type of object were turned in the wax model around which the mould was formed, rather than being cut into the metal object once cast (Poulsen, 1995).

Strainer F047 C (different context and small find numbers for each component, see table 15)

The strainer was a composite object constructed from several parts: three feet, one handle, a straining plate, a spout, a spill plate and the strainer body itself. The feet, spout and handle were all cast from leaded bronze and were tinned. The handle was attached to the body using two rivets: the hook and stud rivet was bronze and likely to be original whereas the folded strip fastening was brass and probably a repair. The strainer body was wrought from bronze and the sheet metal was less than 1mm thick, although the rim lip had a maximum thickness of about 2mm. A hole was cut in the sheet metal where the spout was to be positioned and then the spout was soldered in place with lead-tin solder. The feet were also attached to the strainer body using a lead-tin solder, as elevated levels of lead and tin were detected on the base of the feet and in certain areas on the outer surface of the strainer body. The straining plate was wrought bronze and holes had been punched in the sheet metal to form an elaborate pattern. The spill plate, which was attached to the strainer using lead-tin solder, was also wrought bronze and tinned on one surface. In several areas there was a grey / green patination on the outer surface of the strainer body, where elevated levels of tin were detected, but this was probably a result of corrosion rather than tinning. The strainer would have had a highly decorative appearance when complete. The spout, handle, spill plate and feet, which would have been silver-coloured as a result of tinning, would have contrasted with the bronze-coloured bowl.

There were occasional grey areas on the inside surface of the strainer where increased concentrations of tin and / or lead were detected. However these patches were commonly adjacent to lines of lead-tin solder and may have resulted from the corrosion of the solder rather than being evidence of tinning. Although copper alloy vessels used for food preparation were frequently tinned to inhibit the dissolution of copper in the food (see the patera discussed above), the strainer was unlikely to have held liquids for significant periods and therefore tinning may not have been required. Elevated levels of tin were also detected in the region of faint, silver-coloured, roughly semi-circular and circular marks on fragments of the strainer body. These marks may have been the remains of soldered joints, as they had a distinct shape, but because of the severely fragmented condition of the strainer body, it was not obvious whether the straining plate might have been attached to the fragments concerned.

No clear marks were visible on the outer surface of the strainer body but fine, parallel, annular scratches, following the circumference of the bowl, were visible on the inside of the body. These marks may have resulted from the finishing and polishing of the object, possibly using a pole lathe (Craddock and Lang, 1983). In other areas with more awkward contours, also inside the strainer body, fine striations were visible running in a perpendicular direction to the annular marks previously described. These striations were present near the rim, where they continued to a depth of 50mm into the bowl, on the base and also around the edges of the strainer plate, and may have resulted from hand finishing in these areas.

The strainer was crushed and fragmented when found but it was not possible to discern conclusively from examination of the strainer whether it was crushed prior to, or during, burial. The strainer body and straining plate were constructed from very thin, wrought bronze sheet, and as such are unlikely to have been unable to withstand large loads, such as might be exerted by burial. Originally, the strainer would have collapsed by bending and folding, as was observed in one large rim fragment and the straining plate. Later, as the metal corroded post-burial, brittle fracture and fragmenting of the strainer would be anticipated, and this was observed on many fragments. Some components of the strainer showed signs of heavy wear, for example the straining plate was incomplete and the spout was heavily abraded.

The analytical results for the various strainer components are summarised in table 4.

Table 4: Analytical results for strainer components (see table 15)

Context	**SF**	**Description**	**Results**
F047 C0969	67	Strainer foot	Leaded bronze, tinned on front, lead-tin solder on back
F047 C0970	68	Strainer foot	Leaded bronze, tinned on front, lead-tin solder on back
F047 C0972	70	Strainer foot	Leaded bronze, tinned on front, lead-tin solder on back
F047 C0978	76	Strainer body	Bronze with trace of lead. The solder that attached the spout, and feet, was a lead-tin solder.
F047 C		Straining plate	The plate was bronze with a trace of lead. The solder around the rim was rich in lead and tin.
		Strainer spill plate	The plate was bronze (with a small amount of lead). The front surface was tinned and lead-tin solder was detected on the back.
		Strainer spout	Leaded bronze, probably tinned,
		Handle	Leaded bronze, tinned on front. One rivet, consisting of a folded strip of copper alloy, was brass and thought to be a repair. The other rivet, consisting of a hook and stud, was bronze (with a small amount of lead).

Rods, all F047, C1030 SF 126, C1031 SF 127, C985 SF 82 and C986 SF 81

Four copper alloy rods were recovered in two pairs, with each pair containing one long and one short rod. One of the shorter rods (SF 126) was analysed (as the larger rods would not fit into the XRF sample chamber) and found to be brass (see table 15). As all of the rods were a similar colour it is likely that they all had a similar composition. Four iron rods, two long and two short, were also recovered although these were not examined.

General copper alloy objects

The analytical results for the remaining copper alloy objects, excluding the brooches and fragments, are summarised in table 5.

Table 5: Analytical results for the remaining copper alloy objects (see table 16)

Context	SF	Description	Results
F001 B075	95	Object plus fragments	Right-angled object likely to be brass. Both zinc and lead were detected in the alloy within the corner of the right-angled object. The separate lump of metal was leaded bronze.
F006 B159	118	Spout	Leaded bronze.
F006 B77	131	Pedestal	Base was leaded bronze. Lead-tin solder detected on top of base. Attached fragment appears to be leaded copper although this would be unusual.
F006 B194	141	Strap/Loop	Likely to be brass (with a small amount of lead).
F006 B226	146	Binding	Likely to be brass (small amounts of tin and lead varyingly detected, particularly on the rivet, which may indicate that solder was used).
F017 B155	115	Stud or dome headed boss	Likely to be brass (with a small amount of lead).
F028 B531	153	Plaque	Likely to be brass (with trace lead).
L041 B734	190	Fitting	Likely to be brass (with a small amount of lead).
F042 B750	231	Fitting (plaque)	Likely to be brass (with a small amount of lead).
F064 B1016	316	Board game handle	The handle was brass and is tinned.
F064 B992	319	Board corner binding	Likely to be brass (with small amounts of tin and lead also detected).
F064 B1060	348	Game board hinge	Likely to be brass (with small amounts of lead and tin also detected) plus brass rivet.
F064 B1021	376	Armlet	Impure copper (with a small amount of zinc and traces of lead and arsenic detected).
F047 C0998	94	Gaming board corner hinge	Brass.
F047 C0999	95	Gaming board hinge	Brass or gunmetal hinge and pin, as small amounts of zinc and tin were detected but the zinc may have been depleted by corrosion (trace of lead).
F047 C1049	135	Boss from tray	Bronze with a small amount of lead. Lead-tin solder on back.
F047 C1085	142	Rebated ring	Leaded bronze (with a small amount of zinc). Although very high levels of tin were occasionally detected, this may due to corrosion, since no tinning was observed. High levels of arsenic were detected.
F047 C1086	143	Plain ring	Leaded bronze (a small amount of zinc). Although very high levels of tin were occasionally detected, this may be due to corrosion, since no tinning was observed.
F047 C1041	159	Strip	Bronze.
F042 C0671	265	Spoon	The spoon was badly corroded therefore the analytical results are difficult to interpret. Small amounts of zinc, tin and lead were varyingly detected suggesting that the spoon was impure copper. However lead and tin were occasionally detected in high concentrations, particularly in a protrusion at the base of the handle. These may be lead- and tin-rich corrosion products that have formed on the spoon, which was probably tinned although no evidence survives. Alternatively lead-tin alloy from another object may have been deposited on the spoon or solder may have been used to attach something to the spoon neck or handle. No silver was detected.
F115 C0088	295	Possible mirror fragment	Leaded bronze. It cannot be conclusively determined whether the object was a mirror without sampling because of the poor condition of the object. However the tin content on one side, which was dark and smooth, was considerably higher than on the other. This is consistent with a type of Roman mirror made from a low tin bronze (containing up to about 10% tin and a few percent of lead) and tinned on one surface (Meeks, 1995). Others mirrors were made from leaded high tin bronze (c.22wt% tin).

Brooches

The analytical results for the brooches are summarised in table 6, which continues over two pages. The results are all consistent with previous analyses of these types (e.g. Bayley and Butcher, 1997 and forthcoming).

Table 6: Analytical results for brooches (see tables 17 and 18)

Context	SF	Description	Results
F067 B1071	329	Hod Hill	The brooch was likely to be brass or possibly gunmetal (small amounts of tin and zinc were detected but the zinc at the surface may have been reduced). The pin was impure copper. Large areas of the front of the brooch were tinned. The brooch was a solid casting, drilled to take the iron pegs that held the brooch pin and decorative spheres (now missing) in place.
F064 B1032	340	Nertomarus	The brooch was probably brass (with small amounts of tin and lead also detected). The surface concentration of zinc may have been depleted by corrosion. No tinning was detected.
F064 B	382	Nertomarus, four fragments	The brooch was in very poor condition but was probably brass (plus up to 5wt% lead and with a small amount of tin) with a separate brass spring. The second copper alloy object, a curved fragment, was brass (plus a small amount of lead). The third copper alloy fragment, which was decorated, was probably brass (small amounts of lead and tin were also detected, and the zinc concentration is likely to have been reduced by corrosion). The latter two fragments are unlikely to be part of the brooch (Bayley, pers. comm).
F072 C0406	5	Star brooch with blue glass centre	The brooch was brass (with some tin and a small amount of lead varyingly detected). The blue glass centre of the brooch contained manganese and was coloured mainly by cobalt with some copper. The glass centre was secured by lead-tin solder, as a high concentration of lead oxide was detected on the back of the glass centre. Lead-tin solder covered the front of the brooch, indicated by elevated tin and lead levels, suggesting that a layer of copper alloy sheet (now missing) originally covered the brooch front.
F072 C0408	6	Hod Hill Brooch	Leaded gunmetal brooch (it contained more zinc than tin) with parcel tinning. The brooch pin was impure copper. An iron axis bar secured the brooch pin and extended either side of the brooch.
F072 C0410	7	Keyhole plate brooch with red glass stud	The brooch was brass (although the amount of zinc detected is slightly low, probably as a result of corrosion) and also contained a small amount of lead). Although the foot of the brooch was decorated all over, the discoid bow was decorated only around the perimeter. A circular sheet of copper alloy was likely to have once covered this area of the brooch. As no solder was detected in this area, the red glass stud probably fixed the sheet in place. The rest of the brooch and the attached sheet may have been tinned as elevated levels of tin were detected on the front and back of the brooch, with the exception of the discoid bow (see figure 4). The setting of the glass stud and the brooch pin were impure copper. The red glass stud contained over 30wt% lead oxide, 7wt% copper oxide and also antimony oxide, consistent with other "sealing wax" red Iron Age and Roman enamels (Stapleton et al, 1999), coloured by small crystals of copper and / or cuprite (Cu_2O).

Table 6: Continued

Context	SF	Description	Results
F072 C0414	8	Lozenge brooch with blue glass centre	Brass brooch (with a small amount of tin and a trace of lead). The pin was impure copper. Elevated levels of tin, likely to be the remains of lead-tin solder, were detected on the front of the brooch except in the centre, where the glass setting was located. There was a circular rim of thicker solder around the tin-free region. A copper alloy sheet would originally have covered the entire brooch, attached with solder, with a hole for the setting to protrude through. The glass setting was coloured by cobalt and copper oxides, and also contained manganese. The glass was blue but had a red area on the base that was compositionally similar except that more copper and lower alkali levels were detected in that area. The glass was probably heated on the brooch to set it in place, and the concentration of copper in the glass increased where it was in contact with the brooch. As there was little oxygen available in the region between the brooch and glass the red colourant Cu_2O formed in the glass on the base of the setting.
F072 C0416	9	Circular brooch with lugs	The brooch was brass (with small amounts of tin and lead varyingly detected). A high concentration of tin (and some lead) was detected in the centre of the brooch front and this was probably the remains of solder used to secure a decorative central setting.
F047 C0942	40	Brooch - rear hook	Leaded bronze brooch (with a small amount of zinc) with a brass pin. No solder was accessible. Stripes of tinning.
F047 C0982	79	Langton Down brooch and ring fragment	The ring fragment was bronze (plus a small amount of lead). The level of tin detected was very high, probably due to the poor preservation of the object. The brooch was gunmetal (more zinc than tin) with an impure copper pin.
F007 C0044	198	Brooch	Brass brooch (with a small amount of tin and a trace of lead).

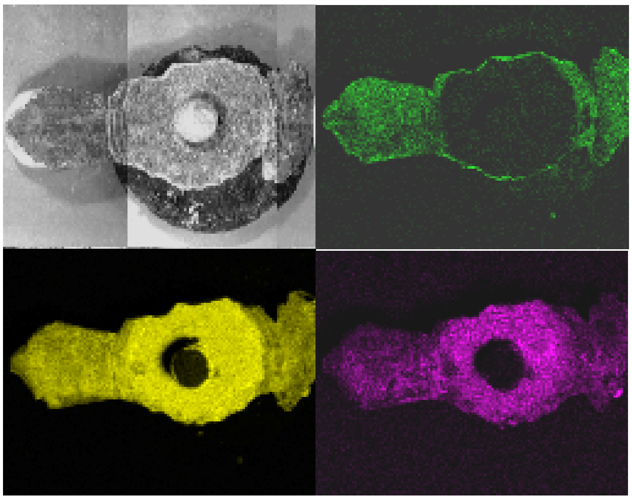

Figure 4: The distribution of tin on the surface of the brass keyhole brooch (SF7), from left to right (top) image of brooch, tin distribution, (bottom) copper distribution, zinc distribution, determined by XRF

Copper alloy fragments

A number of copper alloy fragments from Stanway were analysed and the analytical results are summarised in table 7. The fragments from context F028 B540 were atypical as they contained large concentrations of silver (up to ~37wt%) in addition to copper, tin and lead.

Table 7: Analytical results for copper alloy fragments (see table 19)

Context	SF	Description	Results
L005 B083	103	Fragments	Bronze (with a small amount of lead).
L006 B081	100	Burnt fragments including small studs	The three fragments analysed were leaded bronze and bronze.
L006 B087	101	Fitting and droplets	Impure copper.
F006 B067	90	Sheet and slag	Sheet with studs was probably brass although high levels of lead and tin in some areas may indicate the presence of solder. Other fragments were bronze (one) and leaded bronze (three).
F006 B158	109	Slaggy fragments	The two fragments analysed were bronze.
F006 B180	121	Object	Lead and copper detected.
F006 B164	123	Dribbles and fragments	Leaded bronze.
Nr F6 B025	82	Burnt / melted stud	Lead and copper detected.
F028 B540	152	Dribbles and pellets	Lead, tin and large quantities silver detected.
F042 B701	219	Fragments	Impure copper.
F042 B646	221	Sheet fragments	The four fragments analysed were all bronze with varying tin levels.
F042 B750	232	Sheet and slag	One fragment was leaded bronze. A small amount of zinc was detected in the other fragment.

Iron

Currency Bars, both F006, C201 SF 388 and C202 SF 389

The currency bars (SF 389 and SF 388) were unusual both in terms of their easterly location in Britain and their good preservation. One was complete, with a length of 0.55m including the socket and a maximum width of approximately 55mm. The weight of the bar (before cleaning) was 984g. The second bar was in three fragments, having broken twice at the socketed end. It was approximately 0.62m long and the maximum width was 60mm. Although longer than the other bar, the weight was the similar at 976g. On the broken bar, the changing cross-section along its length could be viewed. Each bar started with a flat end, continuing into a socket formed by folding both sides of the bar up at right angles. As the socket continued, the right-angled edges of the fold become rounded so that the bar was C-shaped in cross section. The bar formed a slim, flat neck and then broadened to its maximum width before tapering at the other end (see figure 5). In shape the bars are similar to two recovered from Ely, categorised as plough-share bars due to their shape. They had leaf-shaped blades, long U-shaped sockets and similar lengths and widths to the Stanway bars (Crew, 1994). However the Stanway bars are heavier by 250g and the broken Stanway bar has well-defined right angles to the sides of the socket at one point along its length.

The Stanway bars were found in the ditch of the earliest enclosure, enclosure 2, and have been approximately dated to the 1st century BC. This is consistent with other currency bars recovered in southern Britain, many of which date to the Middle Iron Age (the 1st and 2nd centuries BC) and are commonly found at settlement boundaries where they are thought to have been ritually deposited (Hingley, 1990). Although the currency bars in one group or hoard often have similar weights, as do the two Stanway bars, bars of different types tend to have different weights. It is unlikely that the weight was regulated intentionally but rather that it was determined by the smelting and smithing practices of the producer. The dimensions and weights of the bars are therefore likely to be characteristic of the producer. The bars derive their name from a passage in Caesar's account of the invasion of Britain, which appears to record the use of iron bars as currency in Iron Age southeast Britain. This has previously been at odds with the archaeological scarcity of currency bars in the southeast.

Figure 5: The Stanway currency bars

A small V-shaped section was taken from the broken bar, examined metallographically and found to be pure iron (also known as plain iron or ferrite). At the edge of the sample the microstructure was distorted (squashed) compared to the rest of the section as a result of the bar having been "upset". Upsetting involved turning the bar onto its side and striking it to obtain a flat edge, correcting the rounded edges that tended to develop on the bar during smithing (Chris Salter pers. comm). The process produced a slight lip at the edge of the bar, which unusually has been preserved on the Stanway examples and suggests that they were skilfully made. Elongated strings of slag were observed running across the width of the bar in the metallographic section showing that the metal had been worked considerably. Some of these slag inclusions were analysed using a scanning electron microscope with attached EDS analytical facility and the results are given in table 8.

Table 8: Analytical results for the slag inclusions in the fragmented currency bar, as determined by EDS, normalised wt%

Analyses	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	FeO
	0.52	0.50	5.72	23.24	5.27	0.41	1.75	4.47	0.25	0.78	56.94
	0.62	0.89	8.25	29.95	2.34	0.18	2.26	4.19	0.30	0.95	49.90
	0.85	0.61	5.56	19.24	4.17	0.26	1.34	3.53	0.24	0.54	63.54
	0.63	0.89	8.00	30.15	3.52	0.25	2.21	4.51	0.26	1.02	48.46
	0.59	0.65	6.69	25.03	4.65	0.30	1.94	4.56	0.22	0.85	54.37
Average	0.64	0.71	6.85	25.52	3.99	0.28	1.90	4.25	0.26	0.83	54.64

These results can be compared with analyses of the slag inclusions in bars from Danebury (Hants), Gretton (Northants) and Beckford (Worcestershire) (Hedges and Salter, 1979). The combination of raised phosphorus, sulphur and manganese in the Stanway bar distinguishes it from the previously analysed artefacts suggesting that the Stanway examples do not originate from the same source as any of these other bars. However the uniqueness of the composition of slag inclusions in iron artefacts from different sources has yet to be established, since the data set of published analyses with which to compare is still small. The compositional consistency of slag inclusions within bars of similar origin is also unknown. Future WDS analysis of the inclusions in the Stanway bar (using the sample already taken) will allow elements present in very small amounts to be detected and will therefore characterise the bar more fully.

Conclusions

The majority of the glass objects from Stanway were made from soda-lime-silicate glass, and a mineral source of alkali fluxes, such as natron, was probably used in the production of the glass. The glasses frequently contained significant quantities of manganese oxide and made use of antimony-based, rather than tin-based, colourants. These observations, consistent with other glass objects from Late Iron Age and Roman contexts, suggest that the glass used to produce the artefacts originated in the Roman Empire although glass workers outside the Roman Empire may then have shaped the glass into objects. The white glass used to decorate one large blue bead was found to have a lead-rich composition typical of Roman cameo and mosaic glass.

The majority of the copper alloy objects were made from bronze or leaded bronze. The exceptions were many of the brooches, assorted small fittings, the game board fittings and the rods in context CF047, which were all brass. The repair on the strainer handle was also brass. These objects are largely from enclosures 3 and 5, both post-conquest. The application of brass fittings to the game boards may suggest that these were imported. The dominance of bronze and leaded bronze in the assemblage is not unexpected. The use of leaded bronze increased at this time (Northover, 1989) and although there was a great increase in the use of brass in Britain following the conquest, its use was generally restricted to certain applications, such as military fittings and brooches (Bayley, 1988). Roman vessels are normally bronze or leaded bronze; brass is only used for a few wrought vessel types.

Acknowledgements

The author is greatly indebted to Chris Salter, both for cutting and mounting the currency bar section and for sharing his expertise on this subject, to Justine Bayley for her advice and to Nina Crummy for providing much additional information on the objects.

References

Bayley J, 1984, Roman Brass-Making in Britain, *Historical Metallurgy*, **18** (1), 42-3.
Bayley J, 1988, Non-ferrous Metal-working: Continuity and Change, *in* Slater E A and Tate J O (eds), *Science and Archaeology Glasgow 1987, Proceedings of a conference on the application of scientific techniques to archaeolo*gy, BAR British Series 196, 193-207.
Bayley J, 1990, The Production of Brass in Antiquity with particular Reference to Roman Britain, *in* Craddock P T (ed), *2000 Years of Zinc and Brass*, British Museum Occasional Paper No. 50, 7-26.
Bayley J and Butcher S, 1991, Romano-British Plate Brooches: Composition and Decoration, *Jewellery studies*, **3**, 25-32.
Bayley J and Butcher S, 1997, The Composition and Decoration of Roman Brooches, *in* Sinclair A, Slater E and Gowlett J (eds), *Archaeological Sciences 1995*, Oxbow Monograph 64, 101-6.
Bayley J and Butcher S, forthcoming, *Roman Brooches in Britain: a technological and typological study based on the Richborough collection*, London: Society of Antiquaries.
Bayley J, Dungworth D and Paynter S, 2001, *Centre for Archaeology Guidelines: Archaeometallurgy*, English Heritage.
Bayley J, Biek L, Guido M and Henderson J, forthcoming, *The glass beads from Hayling Island, Hants*, Centre for Archaeology Report.
Biek L and Bayley J, 1979, Glass and Other Vitreous Materials, *World Archaeology*, **11** (1), 1-25.
Bimson M and Freestone I C, 1983, An Analytical Study of the Relationship between the Portland Vase and other Roman Cameo Glasses, *Journal of Glass Studies*, **25**, 55-64.
Craddock P T and Lang J, 1983, Spinning, turning and polishing, *Historical Metallurgy*, **17** (2), 79-81.
Crew P, 1994, Currency bars in Britain, typology and function, *in* Mangin M (ed), *La Sidérurgie ancienne de l'Est de la France dans son contexte européen*, Besançon, 345-350.
Cronyn J M, 1990, *The Elements of Archaeological Conservation*, Routledge.
Crummy P and Crummy N, 2000, *Assessment and Updated Project Design for Analysis; Stanway, Colchester*, Colchester Archaeological Trust.
Dungworth D, 1996, The Production of Copper Alloys in Iron Age Britain, *Proceedings of the Prehistoric Society*, **62**, 399-421.
Freestone I C, 1990, Studies of the Portland Vase, *Journal of Glass Studies*, **32**, 103-107.
Freestone I C, Gorin-Rosen Y and Hughes M J, 2000, Primary Glass from Israel and the Production of glass in antiquity and the early Islamic period, *in* Nenna M D (ed), *La route du verre*, Lyon: Travaux de la Maison de l'Orient Mediterranean, 65-83.
Guido M, 1978, *The glass Beads of the Prehistoric and Roman Periods in Britain and Ireland*, The Society of Antiquaries of London.
Hartmann G, Kappel, I, Grote, K, Arndt B, 1997, Chemistry and Technology of Prehistoric Glass from Lower Saxony and Hesse, *Journal of Archaeological Science*, **24**, 547-559.
Hedges R E M and Salter C J, 1979, Source Determination of Iron Currency Bars, *Archaeometry*, **21** (2), 161-75.

Henderson J and Warren, 1981, X-Ray Fluorescence Analyses of Iron Age Glass: Beads from Meare and Glastonbury Lake Villages, *Archaeometry*, **23** (1), 83-94.
Henderson J, 1985, The Raw Materials of Early Glass production, *Oxford Journal of Archaeology*, **4** (3), 267-291.
Henderson J, 1988, Electron Probe Microanalysis of Mixed-Alkali Glasses, *Archaeometry*, **30** (1), 77-91.
Henderson J, 1991, Industrial Specialization in Late Iron Age Britain and Europe, *The Archaeological Journal*, **148**, 104-148.
Henderson J, 1996, Analysis of Ancient Glasses Part 2, Luxury Roman and Early Medieval Glasses, *Journal of Materials*, **48** (2), 62-4.
Hingley R, 1990, Iron Age "Currency Bars"; the archaeological and social context, *Archaeological Journal*, **147**, 91-117.
Mass J L, Stone R E and Wypyski M T, 1998, The Mineralogical and Metallurgical Origins of Roman Opaque Colored Glasses, *in* McCray P (ed), *The Prehistory and History of Glassmaking Technology Volume III*, Ceramics and Civilisation Volume 8, 121-44.
Meeks N, 1995, A Technical study of Roman Bronze Mirrors, *Acta of the 12th International Congress on Ancient Bronzes*, NAR 18, 179-193.
Mommsen H, Büning, Dittmann H, Hein A, Rosenberg A and Sarrazin G, 1997, *Recent Investigations of Early Cameo Glass II: Induced by Synchotron Radiation (SYXRF)*, http://www.iskp.uni-bonn.de/gruppen/mommsen/publ/cameo/cam_hp.html, Institut für Strahlen-und Kernphysik, University Bonn, Germany.
Northover P, 1989, Non-ferrous metallurgy in archaeology, *in* Henderson J (ed), *Scientific Analysis in Archaeology*, Oxford University Committee for Archaeology Monograph No. 19, UCLA Institute of Archaeology, 213-236.
Poulsen E, 1995, Remarks on Roman Bronze Skillets with Deep Grooves under the Base, *Acta of the 12th International Congress on Ancient Bronzes*, NAR 18, 59-67.
Sayre E V and Smith R W, 1961, Compositional Categories of Ancient Glass, *Science*, **133**, 1824-26.
Stapleton C, Freestone I and Bowman S, 1999, Composition and Origin of Early Medieval Opaque Red Enamels from Britain and Ireland, *Journal of Archaeological Science*, **26** (8), 913-922.
Stead I, 1975, A Roman Brooch Blank from Baldock, Herts, *Antiq. Journal*, **55**(2), 397.
Whitehouse D, 1991, Cameo Glass, *in* Newby Martine and Painter Kenneth (eds), *Roman Glass: Two Centuries of Art and Invention*, The Society of Antiquaries of London, 19-32.
Whitehouse D, 1997, *Roman Glass in the Corning Museum of Glass*, New York: The Corning Museum of Glass.

Appendix

The EDAX Eagle XRF analysis conditions were 40kV and the current was adjusted so that a deadtime of approximately 30% was obtained. EDS analysis conditions were 25kV and 1.5nA and the analytical totals were between 100 and 108wt%. All of the values in the tables that follow are given as wt% oxide or element as appropriate. For the XRF analyses of copper alloy objects the elements copper, zinc, lead and tin are given and the results have been normalised for ease of comparison, such that these elements together total 100%. When significant amounts of other elements (such as silver) were detected these elements have also been incorporated into the tabulated results. For the glasses, the normalised data given includes all of the detected oxides. However, as only the surfaces of the artefacts are analysed using XRF, and these are weathered and corroded, the compositional data are rarely representative of the uncorroded metal or glass beneath.

Aluminium = Al, Antimony = Sb, Calcium = Ca, Cobalt = Co, Copper = Cu, Iron = Fe, Lead = Pb, Magnesium = Mg, Manganese = Mn, Nickel = Ni, Potassium = K, Silicon = Si, Silver = Ag, Sodium = Na, Titanium = Ti, Tin = Sn, Zinc = Zn.

Standards

Table 9: Certified composition of copper alloy standards (BNF Metals Technology Centre, Wantage, Oxon)

Standard	**Cu**	**Zn**	**Sn**	**Pb**	**Fe**	**Ni**	**Al**
C30.25	57.2	37.9	0.0	4.7	0.0	0.0	0.0
C30.19	67.4	26.5	1.0	0.0	0.0	0.0	5.0
C50.01	75.2	0.9	9.8	11.2	0.2	1.7	0.0
C50.03	78.5	1.4	8.5	8.7	0.0	2.2	0.0
C71.31	83.2	4.0	4.0	6.2	0.1	2.0	0.0
C71.34	87.7	1.1	7.8	2.5	0.2	0.0	0.0

Table 10: Composition of copper alloy standards as determined by XRF, normalised

Standard	**Cu**	**Zn**	**Sn**	**Pb**	**Fe**	**Ni**	**Al**
C30.25	56.7	38.8	0.0	4.5	0.0	0.0	0.0
C30.19	67.7	28.2	0.8	0.1	0.1	0.0	3.1
C50.01	75.7	1.3	8.7	12.1	0.2	1.9	0.0
C50.03	78.5	2.0	7.3	9.6	0.1	2.5	0.0
C71.31	82.7	4.4	3.3	7.2	0.1	2.2	0.0
C71.34	88.1	1.7	6.4	3.3	0.3	0.1	0.1

Table 11: Known composition of glass standards

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**K_2O**	**SnO_2**	**CaO**	**TiO_2**	**MnO**	**FeO**	**CoO**	**CuO**	**PbO**	**Sb_2O_3**	**P_2O_5**	**SO_2**	**BaO**	**ZnO**
Corning A	14.5	2.8	1.0	66.6	2.9	0.3	5.3	0.8	1.0	1.0	0.2	1.2	0.1	1.6	0.1	0.1	0.5	0.0
Corning B	17.3	1.2	4.2	61.6	1.1	0.0	8.7	0.1	0.2	0.3	0.0	2.7	0.4	0.4	0.8	0.4	0.1	0.2

Table 12: Composition of glass standards as determined by XRF, normalised

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**K_2O**	**SnO_2**	**CaO**	**TiO_2**	**MnO**	**FeO**	**CoO**	**CuO**	**PbO**	**Sb_2O_3**	**P_2O_5**	**SO_2**	**BaO**	**ZnO**
Corning A	15.3	2.0	1.6	65.3	2.2	0.2	4.6	1.2	1.4	1.4	0.2	2.0	0.2	1.4	0.3	0.2	0.4	0.1
Corning B	17.9	0.4	4.3	60.3	0.8	0.1	7.5	0.2	0.3	0.4	0.1	4.4	0.9	0.3	1.0	0.7	0.0	0.4

Glass

Gaming Counters

Table 13: Composition of gaming counters as determined by XRF

Context	SF	Object	Area	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	SnO_2	CaO	TiO_2	MnO	Fe_2O_3	CoO	CuO	ZnO	PbO	Sb_2O_3
F064 B1015	313	Light blue counter	Chipped	1.9	0.8	3.6	80.5	0.6	0.0	7.9	0.1	1.1	2.3	0.1	0.2	0.0	0.0	0.0
		Small black counter		6.1	0.6	4.4	65.7	0.6	0.0	6.7	0.2	0.8	13.5	0.1	0.2	0.0	0.1	0.0
		Large black counter		6.1	0.5	4.3	66.9	1.1	0.0	7.1	0.2	1.9	10.0	0.1	0.3	0.0	0.2	0.0
		Large black counter	Chipped	6.9	0.5	3.7	67.8	0.7	0.0	6.6	0.2	1.0	10.9	0.1	0.3	0.0	0.2	0.0
		Light blue counter	White swirl	2.2	0.7	4.2	79.5	0.7	0.0	7.8	0.2	1.1	2.2	0.1	0.2	0.0	0.0	0.0
F047 C1001 - C1013	98	White gaming counters	White	2.0	0.5	5.2	75.8	0.6	0.0	7.1	0.2	0.6	1.1	0.0	0.0	0.0	0.1	5.4
	104		White	8.6	0.6	4.9	68.6	0.6	0.0	7.7	0.2	0.7	0.9	0.0	0.0	0.0	0.1	5.4
			Transparent area of white counter	4.4	0.9	5.7	76.2	0.6	0.0	8.5	0.2	0.6	0.9	0.0	0.0	0.0	0.0	0.6
	105		White	6.3	0.4	3.9	72.6	0.6	0.0	7.6	0.2	0.7	1.0	0.0	0.0	0.0	0.1	5.1
	109		White chip	5.3	0.5	4.0	74.4	0.6	0.0	7.8	0.2	0.9	1.0	0.0	0.0	0.0	0.1	4.0
F047 C1014 - C1026	110	Blue gaming counters	Spot of white opacifier	3.3	0.7	4.7	64.2	0.5	0.0	8.2	0.2	1.0	2.1	0.1	0.2	0.0	0.2	13.4
			Blue	2.9	0.7	4.6	75.6	0.7	0.0	7.4	0.1	1.1	2.1	0.1	0.2	0.0	0.2	2.6
	116		Blue	7.1	0.5	3.0	71.2	0.5	0.0	7.7	0.1	0.9	2.7	0.1	0.3	0.0	0.2	4.2
				6.4	0.3	4.3	70.8	0.5	0.0	7.6	0.1	0.9	2.9	0.1	0.4	0.1	0.2	4.0
				2.5	0.7	5.6	73.1	0.7	0.0	8.0	0.2	1.0	2.6	0.1	0.3	0.0	0.5	3.1
	111		Blue chip	2.7	0.6	3.3	77.0	0.6	0.0	7.9	0.1	1.1	2.1	0.1	0.2	0.0	0.2	3.2
			Blue	2.5	0.6	3.5	77.7	0.5	0.0	7.4	0.1	1.0	2.0	0.1	0.1	0.0	0.2	3.4
				3.4	0.5	3.3	77.4	0.5	0.0	7.3	0.1	1.0	1.9	0.1	0.1	0.0	0.2	3.3
				2.8	0.5	3.4	77.7	0.5	0.0	7.4	0.1	1.0	1.9	0.1	0.1	0.0	0.2	3.3
F042 C0597	244	Gaming counter		3.3	0.8	4.0	76.5	0.6	0.0	7.3	0.2	3.8	1.4	0.0	0.2	0.0	0.4	0.0
				1.5	0.8	3.9	79.8	0.7	0.2	7.0	0.1	3.8	1.5	0.0	0.2	0.0	0.4	0.0

Beads and Stud Heads

Table 14: Composition of beads and stud heads as determined by XRF

Context	SF	Object	Area	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	SnO_2	CaO	TiO_2	MnO	Fe_2O_3	CoO	CuO	ZnO	PbO	Sb_2O_3
F024 B322	147	Spacer bead		2.4	0.4	3.3	89.1	0.4	0.0	2.0	0.1	0.0	0.3	0.0	0.3	0.0	1.6	0.0
				0.3	0.3	2.6	89.0	0.0	0.1	1.7	0.1	0.0	0.4	0.0	4.6	0.1	0.0	0.2
				1.2	0.2	2.6	81.3	0.0	0.0	2.0	0.6	0.0	0.2	0.0	10.6	0.1	0.1	0.2
F024 B606	251	Melon bead		4.5	1.1	3.3	73.2	0.6	0.0	6.3	0.5	0.3	1.8	0.0	6.7	0.1	0.3	0.0
F024 B383	255	Cylinder bead		2.1	0.8	3.8	80.7	0.6	0.0	8.4	0.2	1.2	1.0	0.0	0.0	0.0	0.1	0.0
				0.7	0.8	3.8	83.5	0.6	0.0	7.5	0.1	1.0	0.8	0.0	0.0	0.0	0.0	0.0
			Chipped	2.3	0.8	3.6	82.3	0.5	0.0	7.4	0.1	1.0	0.8	0.0	0.0	0.0	0.0	0.0
F064 B1022	377	Blue and white bead	Blue	2.1	0.8	3.9	81.6	0.7	0.0	7.5	0.1	0.2	1.5	0.1	0.1	0.1	0.0	0.0
				1.7	0.5	3.8	82.5	0.6	0.0	7.6	0.1	0.2	1.5	0.1	0.1	0.1	0.0	0.0
			White	3.4	0.6	3.3	50.6	0.8	0.0	5.6	0.2	2.6	1.6	0.0	0.1	0.0	21.9	7.0
F072 C0403	2	Large blue bead with cord decoration	Yellow	1.2	0.0	3.6	49.8	0.7	0.0	6.6	0.3	1.9	2.0	0.0	0.1	0.0	17.2	0.7
				1.2	0.0	3.6	49.8	0.7	0.0	6.6	0.3	1.9	2.0	0.0	0.1	0.0	17.2	0.7
			Brown	1.1	0.5	5.0	70.8	0.8	0.0	7.5	0.2	4.4	1.6	0.1	0.1	0.0	2.4	0.0
				1.1	0.5	5.0	70.8	0.8	0.0	7.5	0.2	4.4	1.6	0.1	0.1	0.0	2.4	0.0
			Blue	1.8	0.6	4.6	77.0	0.5	0.0	6.3	0.2	0.5	1.5	0.2	0.2	0.0	0.0	0.0
				1.2	0.9	4.2	84.6	0.2	0.3	5.4	0.1	0.5	1.5	0.2	0.2	0.0	0.0	0.0
F042 C0630	255	Glass stud head	White	0.3	0.5	3.7	82.0	0.6	0.0	7.1	0.1	1.7	0.8	0.0	0.0	0.0	0.0	1.8
				1.3	0.9	4.3	78.8	0.8	0.0	7.5	0.2	1.9	1.1	0.0	0.0	0.0	0.0	2.0
			Blue	2.4	1.0	6.7	65.8	1.1	0.0	9.2	0.3	3.5	5.7	0.2	0.7	0.2	0.0	1.7
				3.3	0.8	5.4	69.6	0.9	0.0	8.4	0.2	3.1	4.7	0.2	0.6	0.1	0.0	1.1
F042 C0723	279	Stud head	Blue	2.2	0.6	3.8	76.2	0.9	0.0	8.3	0.1	1.6	2.9	0.1	0.2	0.1	0.1	1.5
			White	5.1	0.5	3.6	73.5	0.8	0.0	9.3	0.1	1.2	0.9	0.0	0.0	0.1	0.6	1.7
			Yellow	2.2	0.2	2.9	57.5	0.6	0.0	7.0	0.1	0.5	1.5	0.0	0.1	0.1	23.3	2.1
			Colourless	0.9	0.4	3.5	84.1	0.6	0.0	7.2	0.1	1.6	0.7	0.0	0.0	0.0	0.0	0.0
F042 C0751	285	Glass stud head	Blue chip	1.5	0.7	3.8	76.1	0.5	0.0	6.5	0.1	1.3	7.1	0.1	0.2	0.0	0.0	0.7
			Blue	1.5	0.7	3.6	78.7	0.7	0.0	7.8	0.1	1.5	2.5	0.1	0.1	0.1	0.0	1.0
			White	2.9	0.5	3.6	79.6	0.6	0.0	8.1	0.1	1.0	1.4	0.0	0.0	0.0	0.0	1.1
			Yellow	0.0	0.0	3.3	56.1	0.6	0.0	6.3	0.2	0.4	2.1	0.0	0.1	0.0	29.4	0.7
			Colourless	1.8	0.7	3.9	82.6	0.5	0.0	6.9	0.1	1.6	0.7	0.0	0.0	0.0	0.1	0.0
				2.6	0.8	4.1	78.5	0.8	0.0	7.6	0.2	1.4	2.4	0.1	0.1	0.1	0.2	0.0

Copper alloy

Table 15: Composition of large copper alloy objects as determined by XRF

Context	Object	SF	Area	Sn	Cu	Zn	Pb
F064 B1006	Shield Boss	347	Knob	55	28	0	17
				40	44	0	16
			Less corroded area of plate	24	72	1	3
				18	80	1	2
F064 B1019	Skillet	372	Handle	5	77	2	17
				19	51	1	29
			Base of bowl	5	89	1	5
				4	90	1	5
F047 C0901	Patera	13	Handle fragment	8	91	1	0
F047 C0969	Strainer foot	67	Front	14	62	0	24
			Back, less corroded area	8	71	0	20
			Back, solder	79	10	0	11
F047 C0970	Strainer foot	68	Front	29	46	0	24
			Back solder	62	20	0	18
F047 C0972	Strainer foot	70	Front	6	71	0	22
				6	66	0	28
			Back, solder	15	6	0	79
				12	5	0	84
F047 C0978	Strainer body	76	Outer surface, less corroded area	12	87	0	1
			Area with grey solder marks, high tin	64	35	0	0
			Corroded area, quite near solder mark	19	80	0	1
			Reverse, grey patination	14	80	0	6
			Outer surface, less corroded area	13	84	0	2
			Silver-coloured stripe on fragment	24	75	0	1
			Less corroded area adjacent to above	14	85	0	1
			Reverse, matt and discoloured.	19	80	0	1
			Blobs of solder potentially used to attach feet	0	1	0	99
			Solder where spout fixed	75	25	0	0
F047	Strainer spout		Dark grey area, suspected tinning	25	39	1	35
			Less corroded area	18	51	1	31
	Strainer plate		Less corroded area on outer curve	13	86	0	1
			Grey area same fragment	25	69	0	6
			Strainer plate, back, less corroded	12	87	0	1
	Handle		Front of handle	33	55	1	11
			Back of handle, less corroded area	11	82	1	6
			Back of handle	23	67	1	9
			Original rivet	10	88	1	1
			Repair rivet	1	91	8	1
F047 C1030	Rod	126		0	93	7	0

General copper alloy objects

Table 16: Composition of remaining copper alloy objects as determined by XRF

Context	SF	Object	Area	Sn	Cu	Zn	Pb
F001 B075	95	Copper alloy object and 7 fragments	Right angled object	0	94	2	4
			Alloy in corner of object	0	75	8	17
			Separate ~ spherical lump	17	66	1	16
F006 B159	118	Spout		37	43	0	20
F006 B77	131	Pedestal	Base	11	51	0	37
				16	55	0	29
			Top attached fragment	1	72	1	26
			Top attached fragment	1	74	1	25
			Top of base	25	55	0	19
			Solder on top of base	67	7	0	26
F006 B194	141	Strap / loop		0	90	3	7
				0	94	2	4
F006 B226	146	Binding	Underneath	0	98	2	1
				3	93	3	1
			Top	0	96	4	1
			Rivet from top	36	57	1	6
F017 B155	115	Stud / dome headed boss		1	93	2	4
				0	87	6	8
F028 B531	153	Plaque	Front	0	97	3	1
L041 B734	190	Fitting with corner protrusions and central rivet	Fitting	0	95	2	3
			Rivet	0	93	5	2
F042 B750	231	Copper alloy plaque	Front	0	93	4	2
			Back	0	96	2	2
F064 B1016	316	Game board handle	Tinned area	65	17	8	10
				1	85	12	2
F064 B992	319	Game board corner binding		2	94	2	2
				1	93	4	2
F064 B1006	347	Shield Boss	Knob	55	28	0	17
				40	44	0	16
			Less corroded area, second layer	24	72	1	3
				18	80	1	2
F064 B1060	348	Game board hinge	Hinge	3	91	4	2
			Hinge with iron rivets	2	92	4	3
			Head of rivet in hinge	1	95	4	1
F064 B1019	372	Skillet	Handle	5	77	2	17
				19	51	1	29
			Base of bowl	5	89	1	5
				4	90	1	5
F064 B1021	376	Armlet		0	98	2	1
				0	98	1	0

Table 16: Continued

Context	SF	Object	Area	Sn	Cu	Zn	Pb
F047 C0901	13	Patera	Handle	8	91	1	0
F047 C0998	94	Gaming board corner hinge		0	97	2	0
				0	97	3	0
				0	97	2	0
F047 C0999	95	Gaming board hinge	Part without pin	5	92	2	1
			Part with pin	4	87	8	1
			Pin	4	92	3	1
F047 C1049	135	Tray boss	Back less corroded area	14	85	1	1
			Front less corroded area	9	89	1	2
			Rim inside central depression	67	22	0	10
			Less corroded area	10	87	1	2
			Back	23	68	1	9
			Front	20	77	1	3
			Lead-rich area	2	3	0	95
F047 C0185	142	AE ring		9	75	4	12
				35	49	3	13
				25	50	3	23
				35	51	3	11
				40	39	3	18
F047 C1086	143	AE ring plain		17	67	2	14
				34	57	1	8
				0	86	4	10
F047 C1041	159	Strip		32	66	1	0
				22	76	1	1
F042 C0671	265	Spoon	Handle	0	97	2	1
				26	70	3	1
			Bowl	0	92	4	3
				9	85	3	3
			Protrusion at handle base	53	10	2	35
F115 C0088	295	Possible mirror fragment	Front	38	54	0	8
			Back	14	72	0	13

Brooches

Table 17: Composition of brooches as determined by XRF

Code	SF	Sample	Area	Sn	Cu	Zn	Pb
F064 B1032	340	Brooch	Brooch	7	83	5	5
			Front side	5	87	4	4
			Right	24	69	2	4
			Back of cross bar	11	75	9	5
			Back of cross bar	2	77	7	14
			Front of cross bar	1	88	9	2
			Pin	6	89	2	3
F064 B	382	Brooch and rod	Brooch spring	0	95	4	1
			Brooch front	14	81	2	4
				3	87	5	6
				1	88	5	5
			Brooch back	2	90	4	4
				1	89	5	5
			Curved piece, rod fragment	0	91	7	2
			Decorated fragment / rod	2	93	3	2
F067 B1071	329	Hodhill brooch	Front of brooch	27	68	4	1
				24	72	2	2
			Front of brooch, less corroded area	21	75	3	1
			Front of brooch, bottom of foot	15	81	2	1
			Side of catch plate	3	93	3	1
			Possible tinned area on brooch front	29	68	2	1
			Pin	4	91	3	2
F072 C0406	5	Star brooch	Front (tin-rich)	64	25	3	8
				45	8	2	44
			Rear	4	74	19	2
			Pin	1	72	2	25
			Reverse of glass stud	3	42	4	52
				2	83	2	13
			Brooch (soldered area)	3	42	4	52
				2	83	2	13
			Front soldered area	15	10	1	74
			Middle of brooch	82	13	1	4
F072 C0408	6	Brooch	Possible tinned area	34	56	4	6
			Front but no visible tinning	25	57	8	10
			Back of brooch head, no tinning	4	83	3	9
			Pin	0	96	3	1
			Side of catch plate	4	84	6	6
			Catch Plate	2	84	6	7

Table 17: Continued

Code	SF	Sample	Area	Sn	Cu	Zn	Pb
F072 C0410	7	Keyhole brooch	Stud holder	0	97	1	2
			Brooch	16	73	3	8
			Pin (corroded)	25	69	2	4
			Pin	1	90	7	2
			Front of brooch	0	92	3	4
			Back, bottom of brooch	17	65	5	13
				15	76	3	5
			Pin from rear	0	97	1	2
			Rear least corroded area	11	78	7	5
			Front of brooch	17	73	3	7
				21	63	5	11
F072 C0414	8	Lozenge brooch	Centre front of brooch	3	91	6	1
			Edge of solder ring in centre	92	6	2	1
			Top right front of brooch	36	62	2	1
			Pin-tip corroded plus iron residues	2	94	2	2
			Back of brooch	2	91	6	1
				3	92	3	1
F072 C0416	9	AE Brooch	Front of brooch	2	86	9	3
			Back of brooch	0	81	8	11
F047 C0942	40	AE brooch rear hook	Tinned area	40	55	1	4
			Tinned area	31	61	1	6
			Tinned area	26	66	1	7
			Back of foot, no visible tinning	37	42	1	20
			Back, top of brooch, no visible tinning	39	33	1	26
			Second area	35	38	1	26
			Pin	2	87	10	1
F047 C0982	79	Langton Down brooch	Ring fragment	45	50	0	4
			Ring fragment	47	49	0	4
			Brooch pin	8	88	2	4
			Brooch pin	2	94	4	2
			Brooch	6	84	9	1
F007 C0044	198	Brooch	Coil	6	85	6	1
				3	91	5	1
			Brooch	3	90	5	3
				3	89	6	2

Table 18: Compositions of glass centres from brooches as determined by XRF

Context	SF	Object	Area	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	SnO_2	CaO	TiO_2	MnO	Fe_2O_3	CoO	CuO	ZnO	PbO	Sb_2O_3
F072 C0406	5	Star brooch	Blue centre	2.9	0.3	4.4	74.6	0.5	0.0	7.4	0.1	1.4	3.0	0.3	0.8	0.0	0.2	0.0
F072 C0410	7	Keyhole brooch	Red stud	1.4	0.6	3.4	48.8	0.3	0.0	1.8	0.3	0.1	1.1	0.0	7.2	0.1	31.0	1.6
F072 C0421	11	Lozenge brooch	Blue area	0.0	0.6	4.4	82.3	7.4	0.1	0.8	1.4	0.1	1.3	0.0	0.0	0.0	0.0	0.0
				1.1	0.7	4.9	82.5	0.5	0.0	6.6	0.1	0.7	1.3	0.1	0.5	0.0	0.0	0.0
			Red area	0.5	0.3	5.3	80.5	0.4	0.0	4.0	0.1	0.6	1.1	0.1	6.2	0.1	0.0	0.0

Copper alloy fragments

Table 19: Composition of copper alloy fragments as determined by XRF

Context	SF	Object	Area	Sn	Cu	Zn	Pb	Ag
L005 B083	103	Fragments		59	36	0	4	
L006 B087	101	Copper alloy fitting and droplets		0	98	1	1	
L006 B081	100	Fragments	Large drop or lump	32	68	0	0	
				4	64	1	30	
			Flat fragment	37	63	0	0	
			Sphere	39	53	3	5	
F006 B158	109	Fragments		6	92	1	1	
				21	77	1	1	
F006 B180	121		Circular section	0	90	1	9	
F006 B164	123	Copper alloy sheet fragments, bad condition		27	68	0	5	
				20	76	1	4	
Nr F6 B025	82	Burnt stud / melted		0	86	1	13	
F028 B540	152	Dribble and fragment	Dribble surface	7	84	1	8	12
				29	66	1	4	37
			Broken edge	11	88	1	1	3
F042 B701	219	Fragments		2	97	1	1	
F042 B646	221	Copper alloy sheet fragments	Large lump	32	88	0	0	
			Sphere	3	96	1	0	
				1	98	1	0	
				0	99	1	0	
				6	94	1	0	
			Larger sphere	35	65	0	0	
				34	66	0	0	
			Flat fragment	35	65	0	0	
				34	66	0	0	
				16	84	1	0	
				37	63	0	0	
F042 B750	232	Dribbles and Fragments		0	98	2	1	
				12	77	1	9	
F006 B067	90	Copper alloy sheet	Raised stud	1	94	3	2	
			Flat part	6	59	6	28	
				5	69	2	24	
		Medium spherical fragment		34	49	0	17	
		Flat, medium sized fragment		5	81	1	13	
		Curved fragment		21	52	0	26	
			Lead-rich spot	3	18	0	79	
		Large fragment	High tin area	34	64	0	1	
			Low tin area	14	84	1	1	