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Ancient Monuments Laboratory
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THE EXAMINATION OF CRUCIBLE FRAGMENTS AND METALLURGICAL WASTE FROM GILBERD SCHOOL AND CULVER STREET, COLCHESTER.

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Summary

A quantity of fired clay and metallurgical waste, as well as a number of metal melting crucible fragments, recently excavated from Gilberd School and Culver Street, Colchester were submitted to the Laboratory. The material was examined and a selection of it was analysed qualitatively by x-ray fluoresence. The material provided evidence of Roman smithing on, or near to, both sites. Material from the Culver Street site also suggested the Roman working of copper alloys and possible early Roman silver melting. The Gilberd School material produced evidence of medieval bronze casting probably of one or more large objects.

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THE EXAMINATION OF CRUCIBLE FRAGMENTS AND METALLURGICAL WASTE FROM GILBERD SCHOOL AND CULVER STREET, COLCHESTER

Introduction

Approximately 10kg of metallurgical waste and fired clay were submitted for examination, as well as several soil samples. The material originated from two recently excavated Colchester sites, Gilberd School and the second phase of Culver Street. Phase 1 Culver Street material has already been examined and reported (Bayley 1983) and references are made to that report where appropriate.

A selection of the material submitted for examination was analysed qualitatively by energy dispersive x-ray fluoresence (XRF) in order to determine, where possible, what alloys were being worked. The results of these analyses and the examination of the metallurgical debris provides some evidence for Roman iron working on both of the sites. The working of copper alloys is also apparent on both sites, that at Culver Street was Roman, whilst that at Gilberd School was medieval.

As well as the metallurgical waste a total of twelve fired clay fragments, suspected of being sherds from metalworking crucibles, were included in the material submitted from Culver Street. Four of these fragments (listed in Table 2) were not thought to have originated from crucibles. A crucible sherd from Gilberd School was also examined. All of the crucible sherds were analysed qualitatively by XRF for non-ferrous metal traces. The results for the Culver Street material are presented in Table 1 and are discussed in the text.

Glossary of terms

A number of terms have been used to describe the types of metallurgical debris recovered from the two sites and these are outlined below.

Casting waste has been used here to describe the corroded dribbles and splashes of non-ferrous metals which are most likely to have derived from the accidental spillage of molten metal during casting operations.

Fuel ash slags are commonly, although not necessarily, associated with metalworking. These alkali fluxed silicate slags can be formed where silicate-rich materials, such as clay, have come into contact with alkalis (most commonly from the ash within a fire) at elevated temperatures. The silicates are fluxed by the alkali to form a vitreous slag which is usually fairly porous and light in weight. Fuel ash slags are not in themselves diagnostic of any particular process, they merely indicate a fire burning at high temperature. Metal traces within fuel ash slags can however provide clues to the processes being carried out where they were formed, for instance those described as "iron-rich" probably formed in a blacksmith's hearth. Similarly those with high levels of copper normally indicate the working of copper alloys.

Hearth lining and furnace lining are typologically indistinguishable from one another and are really specific forms of fuel ash slag where the silicate being fluxed is the clay lining of a hearth or furnace. The difference between the two forms is merely one of scale, with the higher and more sustained temperatures within a furnace producing deeper vitrification.

Smithing slag is an iron silicate (fayalitic) slag which is diagnostic of relatively low temperature working of iron in the forge or smithy. It contains a much higher proportion of iron than fuel ash slag and is therefore far denser. A further form of iron-rich waste associated with smithing is hammerscale which derives from the magnetic oxide film which forms on the surface of iron when it is heated in the forge or smithy. It can take the form of small droplets of roughly spheroidal form ("spatter") or tiny flakes ("bloom scale").

Culver Street

a) Metallurgical Waste

Periods 1 and 2: The earliest evidence for metalworking from Culver Street comes from a small group of material from three contexts probably from the North end of Building 85 (on site K, dated to Period 1 ; c44-49). It consisted of a piece of smithing slag (from the construction trench MF181) and two pieces of iron-rich fuel ash slag one of which was associated with a large coke (part burnt coal) fragment. These few finds provide some evidence for iron working, probably smithing, early in the Roman occupation, although the quantities of material produced suggest that the industrial activity was not centred on the excavated area. Site K has also produced two probable silver melting crucible sherds of Iron Age form (see section "b" below) which, although not from Pre-Boudican contexts, are almost certainly residual and are unlikely to have been in use much after the mid first century.

Other evidence for possible Pre-Boudican metalworking comes from material from eight contexts on site G associated with dumps and cultivation soil of Period 3 (c60/1-400+), but which is probably residual and of Period 1 or 2 date. Seven of these contexts produced copper alloy casting waste and XRF results suggest that in at least five of these cases the alloy is bronze which may, in at least some cases, have been deliberately leaded (ie lead was a deliberate addition to the alloy). One context produced a fuel ash slag associated with the working of a copper alloy (possibly a leaded bronze). Iron-rich fuel ash slag as well as copper alloy casting waste were found in two contexts.

No bronze waste or bronze melting crucibles have been recovered from Pre-Boudican contexts on any other part of the site although a few brass making crucibles were recovered from Pre-Boudican contexts on sites A and E (see Bayley 1983). The two pieces of iron-rich fuel ash slag recovered are not thought significant and merely suggest that some small scale iron smithing may have been going on within the Culver Street area at this time.

Period 3a: The evidence for metalworking from Culver Street in the immediate Post-Boudican period (from c60/1 to the mid second century) comes almost entirely from Site K. Twelve contexts from site K produced material related to metalworking. These contexts were all from various pits and linear features of Period 3 (c60/1-400+) date, however it was felt that the metalworking debris from the features of later Period 3 date were probably residual from Period 3a (c60/1-150). XRF results suggest that most of this material was related to bronze working.

Only two of the site K contexts produced casting waste and in each of these cases the alloy was probably a deliberately leaded bronze. The majority of the metalworking debris was in the form of fuel-ash slag which gave high XRF signals for copper, tin and lead, and is associated with bronze working. Some of this material was furnace lining and individual pieces displayed a clear gradation of firing conditions, from oxidized fired clay on the outer side through to fully vitrified inner surfaces.

Material of this type came from three features on site K, a Period 3b or 3c linear feature (KF135), and a pit (KF55) and a charcoal spread (KL80) of Period 3a date.

There is also some evidence for iron working from site K during this period. The Period 3a pit (KF55) mentioned above produced iron smithing slag and some iron-rich fuel ash slag as well as the evidence of bronze working. This pattern is repeated to some extent in another Period 3a pit (KF132) where both iron-rich fuel ash slags and fuel ash slags associated with bronze working have been recovered.

Later Roman: Evidence for metalworking is more scattered in the later Roman Period (mid second to early fourth centuries). Four soil samples were submitted from site G Buildings of this period (dated to c150-225).These were from an ash accumulation (GF1555) and an occupation layer (GL1507) in Building 117, and from occupation layers in Buildings 118 (GL3239) and 119 (GL1716). All of these samples contained fragments of shell and charcoal flecks and those from Bulidings 118 and 119 also contained fragments of fired clay and animal bone. The only evidence of metalworking was a reduced fired clay mould fragment from the ash accumulation in Buliding 117 (GF1555) and a number of tiny particles of hammerscale in the samples taken from Buildings 118 and 119. Unfortunately the morphology of the mould fragment was non-diagnostic and no detectable metal traces survived on its surface.

Site D has produced other indications of Roman metalworking activities in the period from the later second century to the later third or early fourth centuries. Only a little metalworking debris has been recovered, most of which comes from contexts related to Building 123. Occupation layers within this building have produced iron-rich fuel ash slag and fuel ash slag associated with copper alloy working. A metalled surface within the building produced a piece of reduced fired clay which has been strongly heated on one side and which may be furnace lining (XRF results indicated high levels of copper and lead). Three contexts related to the demolition of Building 123 (c275-325) have produced copper alloy casting waste, in two cases XRF results suggest a copper/lead alloy, however one has appreciable levels of copper, tin and zinc and may be a gunmetal.

Other metalworking debris from site D came from early medieval robber trenches related to Building 123. A soil sample from the robber trench DF166 produced only fired clay fragments, however a similar trench (DF30) contained bronze casting waste and iron-rich fuel ash slag, some of which was attached to fired clay and may have been furnace lining. A body sherd from a copper alloy melting crucible (Δ 3670) was also recovered from Building 123.

Two contexts from the base of the Post Roman topsoil produced small amounts of metalworking debris which are probably residual Roman. A piece of debased silver (from context H153) and a piece of copper/lead alloy casting waste (from H54) were recovered.

b) Metal melting crucible fragments

In total eight probable crucible fragments were recovered from phase 2 of Culver Street, two of which may be from crucibles of Iron Age form, and the remainder of which were probably from Roman vessels. The crucible fragments are discussed separately from the rest of the metallurgical debris since they are probably all residual and do not relate specifically to the contexts from which they came.

A number of factors suggest that the sherd Δ5093 came from a crucible of Iron Age form. It is from a hand made vessel and is made from a rather poorly refractory fabric, reduced fired to a dark grey over most of the sherd. The straight-edged rim suggests a triangular form and the sherd curves to a probable round bottom. The fact that the bottom part of the outside of the sherd is oxidized fired, and the degree of vitrification around the rim, indicate that the crucible was probably heated from the top. This corresponds to the common Iron Age practice of building the fire up around the crucible. The identification of the other possible Iron Age form sherd (Δ5206) is less certain, but it is of a similar fabric and is also hand made. Both sherds have attached corroded silver globules suggesting that both were used for silver melting.

Five of the Roman crucible sherds were of similar, highly refractory quartz tempered fabrics reduced fired to a light grey. Two of these fragments are crucible bases and both are from similar, beaker shaped vessels, typical Roman forms and similar to examples recovered from other Colchester sites (Bayley 1981). One of the bases (Δ3547) has a thin (2-3mm) added layer of less refractory clay. All of these sherds are probably associated with the melting of copper alloys with the exception of Δ3670 which has been used for gold melting. All of the sherds display some degree of vitrification.

The remaining sherd (Δ4114) is rather different from the other Roman material and is made from a rather poorly refractory fabric with a sparse mineral temper as well as considerable quantities of vegetable matter. The sherd is porous and friable and has been broken into two pieces which together form the base and part of the wall of a small pear-shaped vessel with a maximum external diameter of approximately 60mm. No extra outer clay layer has been added to the crucible, although it displays a pseudo-two-layer structure with no difference of fabric between the two layers. Similar crucible fragments, excavated from Phase 1 at Culver Street, have been interpreted as crucibles used to make brass by the cementation process (Bayley 1984). However XRF analysis of Δ4114 did not reveal the high zinc signals which were a characteristic of the Phase 1 brass making crucibles.

A number of crucible fragments from more precisely dated contexts have already been reported (Bayley 1983) from Phase 1 at Culver Street. They fall into two main categories, copper alloy melting and brass making. The bulk of the Phase 1 brass making crucibles were recovered from contexts dated to Period 3a (c60/1-150) from sites B and E. Only two brass making crucible fragments were recovered from contexts possibly dated later than the mid second century. A number of copper alloy melting crucibles were also recovered from Phase 1 of Culver Street, all of which were from site B and most of which were of Period 3 (c60/1-400+) date.

c) Discussion

In general the amount of metallurgical debris associated with iron working that was excavated from Culver Street is minimal. None of this material is suggestive of iron smelting and it probably originated from small scale smithing activities. There were no concentrations of this material which might indicate the presence of a smithy or forge, although the hammerscale from Buildings 118 and 119 on site G may indicate that one was near by. Small scale iron smithing is to be expected in virtually every settlement site of this period.

Aside from some evidence for iron smithing from site K the only evidence suggestive of metalworking prior to the mid first century is the two Iron Age form silver melting crucible sherds also from site K (although they are probably residual). They suggest some early working in precious metals, although evidence from just two finds should not be overstressed. It is possible, although not likely, that the piece of debased silver found at the base of the Post Roman topsoil (and probably residual) was connected with this activity. The only other evidence for working in precious metals is the traces of gold on one of the crucible fragments and this is almost certainly later in date and not connected.

The main evidence of Roman metalworking at Culver Street is related to the melting of copper alloys. There are some indications from site G that these activities may date back to the Pre-Boudican period, although the residual nature of the material and the small amounts recovered (site G only produced a few hundred grams of casting waste in total) should be borne in mind.

More conclusive evidence of copper alloy working comes from site K and is probably dated to between the mid first and the mid second centuries. It is notable that most of the brass making crucibles already reported (Bayley 1983) from sites B and E originate from contexts of this date, as do many of the copper alloy melting crucibles discussed in the same report. Although quantities of material recovered are relatively small, three site K contexts produced material interpreted as furnace lining and seven contexts produced fuel ash slags associated with copper alloy working. This type of material is rare elsewhere on the Culver Street site and the concentration of this material in site K and related to period 3a (c60/1-150) may indicate that of a copper alloy melting furnace was in operation here at this time. However it must be stressed that the quantities of this material recovered would only constitute a small proportion of the waste which would be produced by a metal melting furnace so that it is possible that the material may have originated from a pit or pits used to dispose of waste from a near by furnace.

Later in the Roman period there is limited evidence for working in copper alloys from site D associated with Building 123 and dated between the mid second and late third or early fourth centuries. However the quantities of material recovered do not indicate that metalworking was being carried out here, they merely suggest that working in copper alloys may have been carried out at this time somewhere on, or near to, the Culver Street site.

Table 1. The results of XRF analyses of crucible fragments from Culver Street.

SF No.	Context	Sherd type	Cu	Zn	Pb	Sn	Ag	Au	Alloy melted
5093	K50	R	+++		+++		+++		Silver
5206	K164	B	++	+	+		+		Silver
4114	G2801	Ba	+	+					?Brass making
3670	D981	B	+					+	Gold
4311	G2967	B	+	++	+				?
3547	G1024	Ba	+++	++	+				?Brass
4387	H306	Ba	+++	++	+	+			Bronze
5376	J2	B	+	+					?

Key :
+ - detected
++ - significant
+++ - major

B - body
R - rim
Ba - base

Table 2. Non - crucible material from Culver Street.

SF No.	Context	Description
3083	D82	Strongly heated pot sherd with copper alloy deposit. Sherd has probably been in a fire used for metalworking.
4082	G2560	Reduced fired clay fragments with natural fuel ash glaze.
3962	G2107	Overheated pot sherd.

Gilberd School

a) Metallurgical Waste

The metallurgical waste material excavated from Gilberd School falls into two main categories, that associated with iron working which is almost exclusively from Roman contexts, and that associated with copper alloy (probably bronze) working which comes entirely from medieval features.

The evidence for iron working consists mostly of iron-rich fuel-ash slags, although there is one piece of smithing slag (from BF159, a post hole in Building 133), and one large piece of reduced fired clay with a thick vitrified outer clay layer (from AF323, Building 131) which may be a piece of hearth lining. The Roman material comes from contexts dated between the first and third centuries although much of the later material is probably residual.

All of the copper alloy material originated from one Medieval feature, the "oven" (AF85) and its surrounding pit (AF80) with the exception of a few pieces from a post medieval sand extraction pit (AF42) and one piece of casting waste from the post medieval topsoil. All of the copper alloy material recovered which has been analysed is bronze. A few of these may be relatively high in tin and most have significant amounts of lead, although it is debatable whether they could be said to have been deliberately leaded.

A number of fired clay pieces recovered from feature AF85 have been interpreted on the basis of their form and fabric as fragments of a mould for a large casting. Three large pieces (the largest of which weighed about 1kg) from context A471 were particularly characteristic. They were of a porous, low density, fabric which would originally have contained a high proportion of finely divided vegetable matter, possibly added to the clay in the form of animal dung. The fabric was distincly divided into two bands, one oxidized fired to a light orange, and one reduced fired to a black colour. Several roughly shaped, hand made, surfaces survived and at least one of the pieces displayed a precisely shaped surface to which corroded copper alloy (probably bronze) was attached. Material of a very similar nature has come to light from a number of medieval sites, most recently from St.Georges Street, Canterbury where it has been interpreted as the remains of a medieval bell mould (Budd 1987). A further, smaller, mould fragment from AF85 (context A675) is a reduced fired fragment of a similar fabric probably from a much smaller mould. Traces of copper and lead were detected on its inner surface. A soil sample (context A385) from the pit AF80 surrounding the feature AF85 contained a number of fired clay fragments with a porous sandy fabric, which were oxidized fired to a light orange, but which featured a black reduced fired band. These may also have been mould fragments (although, if so, no original surfaces survived).

One probable crucible fragment (Δ344) was recovered from a Post Roman context (A223) which may be residual Roman. It is a small rim sherd from a fairly thin walled vessel (up to about 6mm) with an internal rim diameter of approximately 20mm. The fabric is reduced fired and was probably quartz tempered, although it is not particularly refractory and modification of the fabric by high temperatures (creating a vesicular structure throughout) has disguised the original appearance. The sherd displays some internal vitrification. XRF analysis detected traces of copper and lead. A second object (Δ490) thought to be a crucible fragment is a small piece of vesicular basalt, probably Niedermendig lava, and presumably originates from a quernstone.

b) Discussion

The only Roman metalworking for which there is evidence at Gilberd School is small scale iron smithing. This volume of material is to be expected on virtually any Roman occupation site.

The bulk of the material which is associated with metalworking comes from the medieval "oven" feature AF85 and the surrounding pit AF80. This concentration of metalworking debris, and the evidence of burning which is implied by the excavators original interpretation of the feature as an oven, suggest that the feature may have been a casting pit. It was the normal medieval practice when casting a large object by the "cire perdue" (or lost wax) method to dig a pit in which to place the mould so that the metal melting furnace could be constructed at ground level and the molten metal run directly into the mould. However if a mould of the size requiring a casting pit was constructed here only a very small proportion of it has been recovered. Furthermore since the metal melting furnace is unlikely to have been located at any great distance from the casting pit it is suprising that no fragments of furnace lining have been recovered from the site. The absence of this metalworking debris may be due to post medieval disturbance or to deliberate demolition and removal of the furnace soon after it was used. However it remains possible that the material recovered originated elsewhere and was merely dumped in the pit.

If the feature is a casting pit the fact that a pit was dug, and the dimentions of some of the mould fragments, suggest that large objects were being cast. XRF analyses of a selection of the casting waste suggested that all of the material was bronze and at least some of it was high in tin. This might suggest that the activity involved was bell-founding, however many of the pieces of casting waste contained significant quantities of lead (the presence of which would have a detremental effect on the tone of a finished bell). Other possibilities are cauldrons and skillets or even monumental castings, unfortunately the few mould fragments which have been recovered are non-diagnostic.

References

Bayley, J. (1981) Some technological finds from Lion Walk and Balkerne Lane in P. Crummy _Colchester Archaeological Report 3: Excavations at Lion Walk, Balkerne Lane and Middleborough, Colchester, Essex._

Bayley, J. (1983) Crucibles and other metallurgical debris from Culver Street, Colchester. AML Report No. 3872

Bayley, J. (1984) Roman brass making in Britain. _Historical Metallurgy_ _18_ (1) 42-3

Budd, P. (1987) The evidence for bell-founding and other metalworking activities from St.Georges Street, Canterbury. AML Report No.37/87

Appendix

The following list gives a brief summary of the type of material recovered from each context and submitted to the laboratory for examination.

Culver Street

D1961	DF1291	Copper/lead alloy casting waste.
D240	DF166	Soil sample containing fired clay fragments.
D195	DF195	Iron rich fuel ash slag.
D823	DF30	Iron rich fuel ash slag.
D869	DF30	Bronze casting waste.
D527	DF30	Large piece of iron rich fuel ash slag attached to fired clay, probably hearth lining associated with iron working.
D125	DF38	Fuel ash slag associated with copper alloy working.
D1141	DF624	Natural.
D1034	DF842	Probably natural.
D1195	DL1171	Copper/lead alloy casting waste.
D1694	DL1480	Reduced fired clay which has been heated strongly from one side vitrifiying surface, probably furnace lining, associated with copper and lead traces.
D810	DL805	(?Gunmetal) casting waste.
G1805	GF1555	Soil sample containing shell and charcoal flecks.
G1804	GF1555	Reduced fired clay mould fragment plus fired clay.
G2531	GF2363	Natural deposit.
G1457	GL1423	Leaded bronze casting waste.
G1910	GL1507	Soil sample containing shell and charcoal flecks.
G1829	GL1716	Soil sample containing solid iron fragment (?iron object), shell, fired clay fragments, animal bone, charcoal flecks, and hammer scale (bloom scale).
G2351	GL1746	Bronze casting waste / slag.
G2378	GL1746	Bronze casting waste.
G2306	GL1814	Iron rich fuel ash slag with attached copper alloy casting waste (possibly bronze).

G2172	GL2024	(?Bronze) casting waste.
G2625	GL2535	Bronze casting waste.
G3325	GL3133	Fuel ash slag associated with leaded bronze working.
G3306	GL3239	Soil sample containing shell, fired clay fragments, animal bone, charcoal flecks, hammer scale (bloom scale) and a pot sherd.
G4339	GL4331	Iron rich fuel ash slag with attached copper alloy casting waste.
H153	HF150	Piece of debased silver (green colouration due to corrosion of copper "impurity").
H54	HL3	Copper/lead alloy casting waste.
K125	KF112	Fuel ash slag associated with the working of leaded bronze.
K133	KF132	Leaded bronze casting waste / slag.
K329	KF132	Fuel ash slag, some associated with the working of leaded bronze, and some iron rich. Also a piece of charcoal.
K164	KF135	Fuel ash slag plus furnace lining associated with the working of a (high tin) bronze.
K295	KF290	Fuel ash slag associated with the working of bronze.
K433	KF390	Iron rich fuel ash slag.
K444	KF390	Fuel ash slag.
K57	KF55	Iron smithing slag.
K116	KF55	Furnace lining and fuel ash slag associated with the working of leaded bronze plus iron rich fuel ash slag and an iron fragment/object.
K86	KF84	(?Leaded bronze) casting waste.
K118	KL117	Leaded bronze casting waste.
K187	KL80	Furnace lining associated with leaded bronze.
M186	MF181	Iron smithing slag.
M331	MF315	Iron-rich fuel ash slag
M410	GL333	Iron-rich fuel ash slag plus coke.

Gilberd School

A1283	AF144	Fuel ash slag
A1339	AF180	Iron rich fuel ash slag.
A1356	AF180	Iron rich fuel ash slag and reduced fired clay.
A2409	AF323	Large piece of reduced fired clay, probably hearth lining, with added layer of deeply vitrified material.
A2535	AF338	Iron rich fuel ash slag.
A2003	AF42	Copper alloy casting waste.
A1292	AF42	(High tin) bronze casting waste.
A280	AF42	Bronze casting waste.
A473	AF80	Bronze casting waste.
A411	AF80	(High tin) bronze casting waste, some attached to fired clay.
A384	AF80	(High tin) bronze casting waste, some attached to fired clay. Some fairly large pieces. (Also copper corrosion products attached to shell fragment).
A432	AF80	Bronze casting waste mixed with fragments of solid iron (possible iron object).
A385	AF80	Soil sample containing a number of pieces of fired clay (possibly mould fragments), also charcoal fragments and hammerscale (spatter).
A489	AF80	Bronze casting waste.
A435	AF85	Bronze casting waste.
A606	AF85	?Fuel ash slag with high lead signal.
A471	AF85	Three large pieces of fired clay. Probably part of a mould for a large object. Traces of bronze or gunmetal detected.
A710	AF85	Two probable mould fragments associated with the casting of a copper alloy object.
A675	AF85	Reduced fired clay, probable mould fragment, traces of copper and lead detected.
A825	AL1	Bronze casting waste.
A676	AL24	Piece of fired and partly vitrified clay which may contain metal working waste.
A1265	AL43	Iron rich fuel ash slag.

A1264	AL43	Iron rich fuel ash slag.
A1075	AL52	Iron rich fuel ash slag.
B639	BF159	Iron smithing slag.