GeoArch

Report 2021/19

Assessment of residues from Hafod-Morfa Copperworks

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8th October 2021

Assessment of residues from Hafod-Morfa Copperworks (1057)

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Abstract

The submitted material comprised a large subset of the relevant items recovered from the site.

There were 92 items of technical ceramics, mostly scorifers, but also crucibles and cupels. These were contained within four contexts: a site-wide demolition deposit (201), a coal dust deposit (324) associated with the 19th century lab building, a demolition deposit (364) possibly from the 19th century lab building and the fill (564) of pickling pit [350] within the footprint of the pre-1840 rolling mill.

Two of those assemblages, from (324) and (564) were substantial, with 39 and 56 vessels respectively. Of these, the fill of pickling pit (564) is likely to be the earlier. The assemblage from it was dominated by 2¼ and 2½ inch scorifers produced by the 'Battersea Works England', but there were also two sizes of crucibles, two sizes of cupels, a possible large porcelain scorifer (or parting vessel?) and a single unstamped 2¼ inch scorifer.

The possibly slightly later deposit (324) associated with the 19th century laboratory building produced single examples of Battersea Works 2½ inch and 2¼ inch scorifers, but 32 examples of taller unstamped scorifers, and 5 crucibles.

There is currently no detailed dating available for the different stamps present on Battersea Works vessels. However, the Morgan Crucible Company did not commence operations at the Battersea works until 1856, which thus provides a terminus post quem for all the stamped vessels.

Analyses of the ceramics mainly show lead-rich compositions for the adhering residues. This is to be expected for materials associated with all parts of the fire assay process. Most analyses also show high levels of copper and iron and many also of zinc.

There were 27 copper-alloy objects within the assemblage; analyses were made by portable XRF of eleven of them. Three of these were copper: small finds 5, 9 and 10, an offcut of copper sheet, a nail and a cut section of pipe. The other items were of brass, the majority gave analyses of approximately 30-36% zinc content, suggesting a standard brass. Analyses of a small fragment of brass sheet (small find 76) gave analyses suggestive of a slightly lower zinc content (10-15%). The metal objects analysed are a mixture of building fixtures from demolition (e.g. pipe fragments), fragments of semi-products (e.g. clippings from brass and copper sheet) and items probably stored for recycling (e.g. the ammunition casings).

Exploratory pXRF analyses were also made of three soil samples, each with a different suite of contaminating elements.

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Methods

All materials were examined visually, using a low-powered binocular microscope where required and catalogued (Table 1).

The pXRF analyses of selected items was undertaken with a Bruker Tracer IIISD portable X-Ray fluorescence spectrometer (instrument belonging to the Department of Archaeology, Cardiff University, and the National Museum Wales). The instrument was operated with the Bruker 'yellow' filter (300µm Al + 25µm Ti), at 40kV and 9.60 µA, with a filament current of 189 µA, for 100s. The instrument was controlled by a PC running Bruker's S1PXRF software. Data were exported as text files for further imaging and processing in Bruker's Artax software. Data are presented here (Tables 3 and 4) for the technical ceramics and soil samples as the net peak area for the principal peaks as reported by Artax.

For the analyses of metals those peak area data have been converted into a semi-quantitative elemental analysis (Table 2) using a technique (Young 2015) employing a simple linear regression of data presented by Nicholas & Manti (2014) who analysed copper alloy standards using the same instrument and with the same operating conditions as for the present work. This calibration would not be expected to be fully valid for analysis of an irregular surface of weathering products, rather than smooth metal, hence it is not a fully quantitative approach.

The identifications of materials in this report, as an assessment, are necessarily limited and must be regarded as provisional.

This assessment was conducted in summer 2021 and was commissioned by Black Mountains Archaeology.

Description of the assemblage

General

The submitted material comprised a subset of the material (mostly technical ceramics and metal samples) recovered during excavations by Black Mountains Archaeology. Some material had been separated from the main collection for other studies and was unavailable for the assessment.

The catalogue of the examined material is presented in Table 1. There were 92 items of technical ceramics, mostly scorifers, but also crucibles and cupels, together with 27 copper-alloy objects and one slag brick. There were also three soil samples for exploratory pXRF analysis.

The technical ceramics

The vessels present include, most commonly, the shallow earthenware vessels known as scorifers. There are three varieties of scorifer present. There are many examples manufactured by the Morgan Crucible Co. at the Battersea Works – 11 of the 2¼ inch scorifer and 28 of the 2½ inch scorifer. There were also 36 examples of an unstamped, slightly taller design of 2¼ inch scorifer.

The 2¼ inch scorifer from the Battersea Works has a stamp reading "2¼ inch / Battersea Works / England" in horizontal lines. The vessels are 58mm diameter at the lip, 24mm tall and with a base 27mm in diameter.

The 2½ inch scorifer from the Battersea Works is stamped 'Battersea Works England' (in a ring) around 2½ (which is in a triangle). The vessels are 62mm diameter at the lip, 27mm tall, and with a base of 33mm diameter.

The unstamped 2¼ inch scorifers are taller (37mm tall), 26mm in diameter at the base and 57mm diameter at the lip, with a marked step in the profile (fr seating in a tray) 9mm above the base.

All of the scorifer types include examples where the mould producing the impression for the upper surface was not correctly aligned with the lower so that the upper dished surface is acentric.

There are just three examples of probable cupels (all from context (564)). One is a very small example 40mm diameter at the top, 35mm at base and 21mm tall. The sub-hemispherical interior shows a slight amount of cracking and there are flecks of copper corrosion products. The vessel has a low density, possibly hinting that it is unused. The other two are essentially identical, slightly larger examples of similar steep-sided shape, that are very dense and therefore used. They measure 41mm diameter at the base, 52mm at the top and are 24mm high.

A variety of crucibles are present within the assemblage, all possessing a similar fabric with a white matrix containing large quartz grains and tabular pores defining a surface parallel foliation. This suggests they are broadly of the Hessian sand type (which could be confirmed by microscopic analysis).

The most abundant crucible type is presented by five more-or-less complete examples from context (564). These vessels are fairly thin-walled, with a flat, horizontal, simply-truncated rim 84mm in diameter, the

vessels being 84mm tall and with 50mm diameter bases.

A larger variety of crucible is suggested by a base, also of 50mm in diameter, but with more strongly out-turned side immediately above the base.

Similar, but smaller crucibles also occurred with an example from context (324) being 70mm tall, 62mm in diameter at the lip and 37mm at base.

A porcelain vessel from (564) is badly heat-damaged (both cracked and deformed to that the rim is not parallel to the base –presumably it was so originally). It shows some similarity to a thick-walled scorifer, but there are significant differences. It is larger (80mm diameter approximately at the rim, and 50mm diameter at the base). It has a rounded rim profile. It has an externally beaded foot 9mm deep. It is thick-walled (up to 10mm). In the lack of a complete, undeformed example this vessel is hard to identify. It is just possible that it is an unusually large parting vessel.

Slag brick

The supplied collection included a single example of a cast slag ('scoria') sett, 5 inches square and 4 inches deep. There were two grooves across top, each 16mm wide by 6mm deep. A 40mm diameter sprue scar was present centrally on opposing faces.

The metal objects

In total 27 copper to copper-alloy artefacts were supplied.

The six objects most likely to present semi-products are all items that are presumed to have been rolled (sf76, sf77, sf173, sf174, sf175 and sf 176). These include various pieces of sheet metal and the clippings from the reduction of raw rolled metal to a regular outline. Some of these (sf75, sf175) show striations strongly indicative of rolling, the others could potentially have been fashioned by hammering, but rolling is more likely.

Several pieces are sections of pipe (sf49, sf22 (in two pieces) and sf 29 (7 pieces)). There is no evidence for these being products, so all may be either fitments or scrap.

The cartridge cases (sf77) were 110mm in length and 25mm in both body and rim diameter (i.e. they are metric calibre 20x110). They carry no headstamp. The narrow shoulder indicates a Hispano-Suiza rather than Oerlikon type. The dimensions suggest these were from ammunition for a HS-404 or similar (used as the RAF's main aircraft cannon from the late 1930s to the mid-1950s), although the weapon did have other uses. They were not examined in detail because of hydrocarbon contamination

A single copper nail (sf100) is likely to be a fitment rather than a product.

A copper alloy rod (sf13) is more problematic – it could be a fragment of stock produced by rolling or it could be a component from an artefact.

The soil samples

Sample <1>, context (432) – this sample is most heavily contaminated by zinc, although iron, copper and lead are also elevated. This pattern would be what might be expected if the contamination was largely by fumes.

Sample <2>, context (583) – this sample has a green colour and contain rounded lumps of what appear to be corroded copper-alloy metal. The analyses show exceptionally high levels of copper associated with moderately elevated zinc and lead.

Sample <3>, context (581) – this sample is red in colour, perhaps reflecting the high iron content suggested by the analysis, but a contribution from the high copper content is also possible. As so often with samples rich in iron oxides, the levels of arsenic are also somewhat elevated. Lead, zinc, and tin are also present at higher than usual levels. Such material might be interpretable as casting waste, but full determination of this would require destructive examination of the clasts.

Interpretation

The technical ceramics

The various vessels described above can be linked to their role in the process of fire assay. Later nineteenth and early twentieth century fire assay practice was described in many contemporary textbooks (e.g. Brown 1889, Bugbee 1922, Eissler 1900, Fulton 1907, Miller 1901 and Rose 1898), although none of those refers in detail specifically to the practice within the copper industry.

A typical workflow for a crucible fire assay (favoured for low-grade ores) to test for precious metals in a sample is as follows (after Miller 1901):

1. melt a sample of the material to be tested in a crucible containing a flux (including litharge.
2. when the mixture is completely molten, pour into a conical mould to cool
3. tip the material out of the mould and crush the slag with a hammer to release the lead button.
4. place the button into a pre-heated cupel in the muffle furnace and oxidise the lead to litharge
5. remove and weigh the surviving button
6. part the gold and silver in the button with acid
7. collect the gold particles and weigh.

For a scarification assay (particularly applicable to rich gold and silver ores):

1. place the sample with lead and a little borax in a pre-heated scorifer in the muffle furnace.
2. when the charge has melted add a little powdered charcoal
3 . when the fusion become quiet, pour the melt into a mould and continue from (3) above.

There were many variations on the basic technique depending on the precise nature of the materials being analysed. Scorification techniques could also be used for mattes and slags as well as ores. Crucible techniques were preferred for some ore types and for very lean ores, since they allowed for the analysis of a larger volume of ore.

The contaminants identified upon the scorifers are not particularly helpful in identifying precisely what was being analysed, beyond that they were copper-bearing, although the most likely interpretation is that ores were being sampled, rather than semi-products or waste.

Slag brick

The slag paving sett is similar to bricks recorded in-situ in a surface next to the Laboratory building in a watching brief in 2013 (https://hafodcommunitydig.wordpress.com/2013/07/12/136/).

These slag (scoria) setts are more finely finished than other slag 'bricks' found in the Swansea area and are likely to be relatively recent. Their precise origin is unknown, but at present there is no indication that they were a product of Hafod-Morfa.

The metal objects

The metals are a very mixed collection. The items likely to be directly related to the output of the works include an offcut of rolled copper sheet (sf 77), and several sheets and offcuts of brass (sf76, sf173 and sf174) or probably of brass (sf175 and sf176).

Other brass objects, particularly the collection of ammunition casings from 20mm rounds, most likely for a Hispano-Suiza 404 cannon, were probably collected for the purposes of recycling, between the late 1930s and the mid-1950s.

Still other objects are probably present as items from the demolition of structures on the site and do not necessarily have any direct connection with the metallurgical activity there (e.g. some of the pipe fragments, the nail).

Discussion

The interpretation of the analytical work represented by the scorifers, crucibles and cupels is necessarily rather superficial. A distinct difference can be seen between the analyses of the present collection and those from a broadly contemporary collection from the Sancta Maria site in Swansea investigated by GGAT (Young 2019). There, a collection of 13 unstamped 2¼ inch scorifers, similar to the present examples, a single stamped Battersea 2¼ inch scorifer and the bases of two crucibles, had apparently been dumped alongside a railway line. The Sancta Maria vessels gave analyses that were similar to but more diverse than, the present analyses. This assemblage resembles in composition that from the present context (324). As with the present collection, it was suggested that the assemblage derived from the laboratory of a copper works.

The metal samples add little to current understanding of the works, but appear to confirm that the brass handled by the works was close to the composition of 'yellow metal' (a brass with 60% copper and 40% zinc, otherwise known as Muntz Metal). The analyses suggest a slightly lower zinc content, but the instrumental calibration is inexact.

Further work

Further stages of this project should ensure all material not investigated in this report are integrated into a final account of the residues.

Although all the classes of residue material examined for this assessment would benefit from further investigation and analysis, the value of that further work must be balanced against the poor dating of much of the assemblage which occurs as residual material and in demolition contexts. Unless specific questions are raised by the post-excavation consideration of the archaeology and its interpretation and/or the currently unexamined material proves to contain residues of a markedly different character, no further analysis of the archaeometallurgical residues is currently recommended.

Similar comments apply to the metals. The most important components of the metals assemblage are the sheet fragments and offcuts. There is a higher value to improved understanding of the nature of these products. However, the value is only present for well-stratified items in a site like this with a long history of working similar metals. Where reasonably well dated examples exist, destructive analysis of samples taken from brass and copper sheet would be useful addition to knowledge.

The residues and metals should be considered as being of high potential for inclusion in the deposited site archive.

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Glossary

Crucible: a tall-sided ceramic vessel used for holding liquid contents during metallurgical reaction and for melting metals for casting.

Cupel: a small vessel, typically steep sided with a bowl-shaped depression in the top, formed of material containing a large proportion of bone ash (often with various binders). In the later post-medieval and modern periods these are typically formed by compression in a mould. The bone ash acts to absorb litharge in the cupellation process.

Cupellation: a process for separating precious metals held in lead metal, by oxidation of the lead to litharge and encouraging its absorption into a substrate (usually of bone ash), leaving the precious metals on the surface.

Fire assay: a set of techniques for the analysis, primarily, of ores. Fire assay was well developed by the late medieval period, even if full understanding of its chemistry was not achieved until the 19th century. The first stage ('fusion') may take place in a crucible ('the crucible stage'), typically mixing the ore with ***litharge***, sometimes other fluxes, and a reducing agent, or in a ***scorifer*** (the '***scorification*** stage'), typically mixing the ore with metallic lead and sometimes other fluxes. The fusion permits the uptake of silver and gold into metallic lead, while other elements enter a slag. The product of this stage is separated into a lead bead and the slag by quenching. The lead bead is then taken into a second stage ('the ***cupellation*** stage', where the lead bead is oxidised in a bone ash ***cupel***. The lead is oxidised and the litharge absorb by the cupel, leaving the gold and silver. The final stage of the process is to separate the gold and silver by a process of ***parting***.

Litharge: lead oxide, PbO.

Scorifer**:** a shallow ceramic vessel employed for scorification. These are typically thin walled, to allow them to come up to heat quickly and often have a slight basal pedestal to permit seating in a tray

Scorification: the oxidizing fusion of ore with metallic lead, producing a litharge slag and lead bead containing any precious metals, in a vessel known as a scorifer. The scorifer was often coated with ferric oxide internally to provide a basic lining to provide some protection from erosion by the slag (after Fulton 1907).

Table 1: summary catalogue of materials. Weights in g.

context	sf#	item	item description	notes	pXRF
128	100	#	38mm long nail, copper, shank 4x3mm at head, 10x9 round head		#9
201	129	#1-#7	30, 24, 29, 27, 28, 29, 28, 13mm sections of 1 inch copper-alloy tubing		#6,#7
201	13	#1	355mm length of 17mm diameter Cu-alloy rod		#15
201	132	#1	cast slag ('scoria') sett, two grooves across top, 5 inch square and 4 inches deep, groves 16mm wide by 6mm deep, 40mm diameter sprue scar centrally on opposing faces		
201	2	#1	Battersea Works England, 2¼ inch scorifer	brown glaze	#42
201	93	#1	Battersea Works England, 2½ inch scorifer	yellow/brown glaze internally	#44
201	94	#1	unstamped 2¼ inch scorifer	rich brown glaze	#39
201	3	#1	unstamped 2¼ inch scorifer	green glaze	#43
201	4	#1	unstamped 2¼ inch scorifer	apple green glaze	#41
324	22	#1	113 and c75mm sections of Cu alloy pipe, 11mm in o/d, end of short section embedded in Fe corrosion ball		#8
324	29	#2	Battersea Works England, 2¼ inch scorifer	matt black glaze, green on margins	
324	29	#1	Battersea Works England, 2½ inch scorifer	black glaze, fading to brown on one side	
324	29	#3	unstamped 2¼ inch scorifer	matt black slag glaze, eroding into fabric	
324	34	#1	unstamped 2¼ inch scorifer	yellow glaze,	#27
324	34	#11	unstamped 2¼ inch scorifer	bright green glaze	#31
324	34	#12	unstamped 2¼ inch scorifer	bright green glaze	
324	34	#13	unstamped 2¼ inch scorifer	bright green glaze	
324	34	#14	unstamped 2¼ inch scorifer	bright green glaze	
324	34	#15	unstamped 2¼ inch scorifer	rich yellow brown glaze	#33
324	34	#16	unstamped 2¼ inch scorifer	rich yellow brown glaze	#34
324	34	#17	unstamped 2¼ inch scorifer	rich yellow brown glaze	
324	34	#18	unstamped 2¼ inch scorifer	rich yellow brown glaze	
324	34	#22	unstamped 2¼ inch scorifer	clinker red brown glaze	#32
324	34	#23	unstamped 2¼ inch scorifer	clinker red brown glaze	
324	34	#24	unstamped 2¼ inch scorifer	clinker red brown glaze	

324	34	#25	unstamped 2¼ inch scorifer	clinker red brown glaze	
324	34	#26	unstamped 2¼ inch scorifer	clinker red brown glaze	
324	34	#27	unstamped 2¼ inch scorifer	clinker red brown glaze	
324	34	#28	unstamped 2¼ inch scorifer	clinker red brown glaze	
324	34	#29	unstamped 2¼ inch scorifer	poor green glaze	
324	34	#3	unstamped 2¼ inch scorifer	pale yellow/green internally with lots of erosion	
324	34	#4	unstamped 2¼ inch scorifer	no int glaze, creamish	
324	34	#5	unstamped 2¼ inch scorifer	no int glaze, creamish	
324	34	#6	unstamped 2¼ inch scorifer	no int glaze, creamish	
324	34	#7	unstamped 2¼ inch scorifer	no int glaze, creamish	
324	34	#19	unstamped 2¼ inch scorifer, base only	clinker red brown glaze	
324	34	#30	unstamped 2¼ inch scorifer, base only	poor green glaze	#35
324	34	#10	unstamped 2¼ inch scorifer, incomplete	bright green glaze	#30
324	34	#20	unstamped 2¼ inch scorifer, incomplete	clinker red brown glaze	
324	34	#21	unstamped 2¼ inch scorifer, incomplete	clinker red brown glaze	
324	34	#31	unstamped 2¼ inch scorifer, incomplete	poor green glaze	
324	34	#8	unstamped 2¼ inch scorifer, incomplete	bright green glaze	#28
324	34	#9	unstamped 2¼ inch scorifer, incomplete	bright green glaze	#29
324	34	#2	unstamped 2¼ inch scorifer, incomplete three joining sherds	yellow glaze,	
324	26	#1	crucible, 70 tall, 62 lip, 37 base, laminated fabric, quartz-rich, tall small crucible	blebs of copper corrosion	
324	26	#2	crucible, base of large crucible, 50mm base, no significant glaze, some dark on base		#38
324	40	#2	crucible, base of large thick crucible with 50mm base, splayed sides,	reddish glaze and clinkery material internally, reddish brown matt externally	#40
324	29	#4	crucible, base, laminated quartz? and voids, 46mm base, only base preserved	khaki glaze inside and out	#45
324	40	#1	crucible, spall from crucible with 50mm base	patchy green internal glaze, some brown externally	
364	67	#1	crucible base, 40mm base, laminated quartz? and voids	slightly shiny brownish interior	
564	49	#1	100mm long section of 10mm o/d copper pipe, sealed both ends by snipping		#10
564	45	#2	Battersea Works England, 2¼ inch scorifer	dark red brown dull glaze	#16
564	45	#3	Battersea Works England, 2¼ inch scorifer	some red glaze overlain by clinker, also clinker ext	#17, 18
564	91	#1	Battersea Works England, 2¼ inch scorifer	yellow glaze	

564	91	#2	Battersea Works England, 2¼ inch scorifer	yellow slaggy glaze with some erosion
564	91	#3	Battersea Works England, 2¼ inch scorifer	yellowish glaze brown where thick
564	91	#4	Battersea Works England, 2¼ inch scorifer	brown glaze
564	91	#5	Battersea Works England, 2¼ inch scorifer	brown glaze
564	91	#6	Battersea Works England, 2¼ inch scorifer	brown glaze
564	91	#7	Battersea Works England, 2¼ inch scorifer	bright blue external glaze, internal clinker blebs
564	44	#1	Battersea Works England, 2½ inch scorifer	small areas of yellow glaze inside and out
564	44	#10	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#11	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#12	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#13	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#14	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#15	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#16	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#17	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#18	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#19	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#2	Battersea Works England, 2½ inch scorifer	yellow glaze, brown where thickest
564	44	#20	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#21	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#22	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#23	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#24	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#25	Battersea Works England, 2½ inch scorifer	brown glaze
564	44	#3	Battersea Works England, 2½ inch scorifer	yellow glaze
564	44	#4	Battersea Works England, 2½ inch scorifer	yellow glaze
564	44	#5	Battersea Works England, 2½ inch scorifer	yellow glaze
564	44	#7	Battersea Works England, 2½ inch scorifer	yellow glaze
564	44	#9	Battersea Works England, 2½ inch scorifer	yellow glaze, grey material adhering
564	44	#26	Battersea Works England, 2½ inch scorifer, broken	brown glaze
564	44	#6	Battersea Works England, 2½ inch scorifer, interior acentric	yellow glaze, with black flakes on sides
564	44	#8	Battersea Works England, 2½ inch scorifer, interior acentric	yellow glaze, clear brown where ponded

564	45	#1	unstamped 2¼ inch scorifer	yellow glaze	#19
564	89	#1	crucible, top 84mm, base 50mm, 84mm tall. Laminated fabric, white with tabular cavities	white deposit in base and externally	
564	17	#1	crucible, top 84mm, base 50mm, 84mm tall. Laminated fabric, white with tabular cavities, flat rim	brown glaze internally and externally	#25
564	17	#2	crucible, top 84mm, base 50mm, 84mm tall. Laminated fabric, white with tabular cavities, flat rim	clear thick glass internally	#23?
564	17	#3	crucible, top 84mm, base 50mm, 84mm tall. Laminated fabric, white with tabular cavities, flat rim	dull reddish coating internally	#24
564	17	#4	crucible, top 84mm, base 50mm, 84mm tall. Laminated fabric, white with tabular cavities, flat rim, base only	slight external green, no internal glaze	#22
564	17	#5	crucible, lower part only, 37mm diameter base of crucible	internal patchy green glaze, externally bright blue with red patches	#21
564	47	#1	cupel, 35mm base 40mm top, 35 base, 21mm tall.	flecks of Cu-corrosion on inside	
564	46	#1	cupel, 41 base, 52 top, 24 high		#36
564	46	#2	cupel, 41 base, 52 top, 24 high		#37
564	72	#1	probable porcelain vessel, resembles think-walled scorifer, but with expanded base. Base 50mm diameter, constriction c9mm above, walls thick, up to 10mm, white porcelain? Failed, so top inclined, c80mm diameter, rounded rim in profile.	clinker externally, similar internally only in small areas	#20
564	76	#1	cu-alloy with unusual botryoidal growths around holes and along striations on surface of one side, the other side neater and smooth; 120mm long, 85mm wide; bevelled edges; probably two perforations; one side appears shear cut - is it the waste end of a rolled bar or a failed casting?		#11
564	77	#1	spike, Cu-alloy, probably from shearing edge of plate, 277mm long,10x5mm at broken end		#5
676	171	#1-#9	20mm cannon shell casings, 110mm in length and 25mm in both body and rim diameter i.e. this is metric calibre 20x110. Unmarked. The narrow shoulder indicates a Hispano Suiza rather than Oerlikon type. The dimensions suggest these were from ammunition for a HS-404 or similar (used as the RAF's main aircraft cannon from the late 1930s to the mid-1950s). Not examined in detail because of hydrocarbon contamination.		#1
u/s	128	#1	55 top, 25 tall, vessel with no pedestal (possibly cupel not scorifer lacking foot, but coated in clinker)	coated in clinker in and out so stamp and completeness not visible	#26
u/s	173	#1	Rounded end from the trimming of a brass sheet, 370mm max width, c5mm thick		#13
u/s	174	#1	trimmed brass sheet, 180x300mm, central shear cut into one narrow ide		#14
u/s	175	#1	sheet, 1 face is striated with rows of slightly raised dots. Opposite face planar, neatly rectangular, 225x490mm, narrow edges show some bevelling. Striations suggest this is a rolled sheet.		
u/s	176	#1	6-7mm thick offcut from sheet, 475mm wide, approx. 290mm long from cut end to curved face, lateral edges also appear to be cuts		

Table 2: Semi-quantitative analyses of metal samples by pXRF.

pXRF #	Sf #	Fe	Cu	Zn	Ag	Pb	metal	notes
13	143	0.3%	62.8%	36.5%	0.0%	0.5%	High-Zn brass	large sheet, analysed through bag
14	174	0.6%	67.0%	32.3%	0.0%	0.1%	High-Zn brass	large sheet, analysed through bag
15	13	0.9%	60.8%	37.1%	0.0%	1.1%	Leaded High-Zn brass?	rod
1	171	0.1%	73.8%	26.0%	0.1%	0.0%	Low-Zn brass	cartridge casing, analysed through bag
6	129	0.2%	76.1%	23.6%	0.0%	0.1%	Low-Zn brass	pipe offcut?
7	129	0.6%	70.2%	29.0%	0.0%	0.1%	Low-Zn brass	pipe offcut?
8	22	4.4%	78.8%	13.7%	0.1%	2.8%	Leaded brass?	
11	76	5.2%	83.5%	10.3%	0.1%	0.9%	Leaded brass?	sheet or plate, analysed through bag
12	76	3.9%	80.9%	14.2%	0.1%	1.0%	Leaded brass?	as #11, but area with less corrosion
5	77	2.1%	95.8%	1.2%	0.0%	0.8%	Leaded copper	sheet offcut?
9	100	1.8%	95.8%	0.6%	0.0%	1.7%	Leaded copper	nail
10	49	2.6%	95.8%	0.4%	0.0%	1.2%	Leaded copper	pipe

Table 3: net peak areas for selected elemental peaks, for pXRF analyses of technical ceramics, as reported by Artax. To avoid problems with the overlap of peaks for Pb and As, As was only included in the deconvolution where the K_B line (11.73keV) was observed to be significantly above background.

#	C	sf	item	vessel	notes	Fe K12	Co K12	Ni K12	Cu K12	Zn K12	As K12	Rb K12	Sr K12	Sn K12	Pb L1
16	564	sf45	#1	scorifer	green glaze	148465	7671	167	15777	158481		611	3008	1235	1140268
17	564	sf45	#2	scorifer	slag clinker inside very slaggy cupel	410880	11395	1612	39044	31547		2516	11166	1073	170143
18	564	sf45	#2	scorifer	rim	80571	5191	643	14365	356452		2909	3129	785	410829
19	564	sf45	#3	scorifer	thin grey deposit on rim of tall vessel	11731	0	19	12707	21576		1134	3995	2926	2078999
20	564	sf72	#1	(porcelain)	rim	654534	89045	3143	52418	115980		23142	15939	1361	12530
21	564	sf17	#1	crucible	interior poor contact	43200	6171	522	33681	17521	trace	6505	13931	939	45086
22	564	sf17	#1	crucible	glazed base	171901	22682	4638	135634	11819	trace	7848	21393	1596	35473
23	564	sf17	#2	crucible	clean large crucible base with pink/purple interior	31999	834	138	5791	5349		6006	5754	847	2205
24	564	sf17	#3	crucible	interior of fragment of typical crucible wall	41200	3900	203	32459	122324		2078	6243	2385	1318824
25	564	sf17	#5	crucible	lip of almost intact typical crucible with brown deposit	185120	9334	290	59537	198322		954	4502	1313	1003950
26	u/s	sf128	#1	scorifer?	highly slagged cupel lip	360158	9672	118	106540	3405		5339	7382	648	2254
27	324	sf34	#1	scorifer	cupel with bright yellow glaze	8877	245	51	3933	1317		822	2765	1962	1639684
28	324	sf34	#2	scorifer	apple green glaze	41054	629	131	57839	23991		1585	3813	1427	1042516
29	324	sf34	#3	scorifer	dark green glaze	18370	187	167	109437	2911		1328	3866	3009	2017466
30	324	sf34	#4	scorifer	dark green glaze	11716	149	165	109822	3795		977	2851	2463	1580380
31	324	sf34	#5	scorifer	dark green glaze	25006	757	143	141026	7711		783	4290	3543	2214222
32	324	sf34	#6	scorifer	black glaze	227882	6892	2948	117782	83319		203	2496	937	1119426
33	324	sf34	#7	scorifer	brown glassy glaze	42313	744	79	78642	11565		533	2793	2007	1606281
34	324	sf34	#8	scorifer	brown glassy glaze	165163	2627	112	95874	29143	65260	612	3094	1940	1017762
35	324	sf34	#9	scorifer	green specks on base interior	10516	160	130	18458	4544		1	651	249	255406
36	564	sf46	#1	cupel	shallow dense cupel - for blowpipe?	44830	852	215	11858	19008		435	1996	407	298146
37	564	sf46	#2	cupel	shallow dense cupel with odd residue	64908	1536	873	20400	124726		590	12052	866	583733
38	324	sf26	#1	crucible	interior of broken base of small traditional crucible	76989	2561	212	16161	15217		2421	3318	337	16553
39	201	sf94	#1	scorifer	bright brown glass glaze,	55612	954	102	30552	5861	119240	384	3163	2574	1725078
40	324	sf40	#1	crucible	interior of slagged base of large conventional crucible	600296	11009	308	58091	22006		2877	12428	2371	15623
41	201	sf4	#1	scorifer	bright green glaze	17716	212	27	27344	21002		713	3578	1097	1175836
42	201	sf2	#1	scorifer	clear brown glaze	31373	399	174	5610	28204		972	3119	2089	1681584
43	201	sf3	#1	scorifer	dark greenish dull glaze	18977	282	1	63254	6271		429	4523	1573	1420942
44	201	sf93	#1	scorifer	brownish glaze	19868	259	87	10974	11720		740	3232	1832	1554093
45	324	sf29	#1	crucible	glaze in base of large broken crucible	123160	2419	232	11970	115600		7047	6776	1207	263782

Table 4 net peak areas for selected elemental peaks, for pXRF analyses of soil samples, as reported by Artax. To avoid problems with the overlap of peaks for Pb and As, As was only included in the deconvolution where the K_B line (11.73keV) was observed to be significantly above background.

#	sample	Mn K12	Fe K12	Co K12	Ni K12	Cu K12	Zn K12	As K12	Ag K12	Ag L1	Cd K12	Cd L1	Sn K12	Sn L1	Pb L1	Pb M1
2	<1>, (432)	1271	153052	2650	281	53827	2877647	trace	3984	1403	4477	17	652	212	13825	120
3	<3>, (581), red	2195	552571	11424	1358	126714	33097	8029	5945	947	3708	31	1972	253	31263	121
4	<2>, (583), copper deposit	35623	201990	18679	8732	2273046	196706	3636	2850	1230	3416	40	693	185	10022	47

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