GeoArch

Report 2023/08

Assessment of residues from Port y Candas, German, Isle of Man

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12th April 2023

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Abstract

The submitted material comprised 7.9kg of hand-picked material and sample residues from a total of 100 separate collections (bags) from 38 contexts. This material included approximately 6.6kg of probable archaeometallurgical residues, comprising a small but diverse assemblage.

The ferrous archaeometallurgical residues are noteworthy for their particularly bad preservation; the iron slags are typically heavily weathered, soft, and often not preserving surface detail. In contrast, the more siliceous material of the hearth ceramic and associated slags may be more adequately preserved. The poor condition of the iron slag is associated with weathering under the influence of a very high, fluctuating, water-table.

Metalworking is represented in contexts currently interpreted as being of Iron Age date solely by a few sand-grade grains from a single sample. Such grains are within the size-range of material potentially moved by worm action and cannot thus be a reliable indicator of contemporary metalworking on their own. The remainder of the collection derives from contexts either interpreted to be of early medieval age, or directly dated as such by radiocarbon determinations.

The early medieval residues are dominated by those certainly or probably from ironworking (smithing). The slags are typically in small masses, with the few present as smithing hearth cakes (SHCs) showing a weight range of 94g to 242g for the three complete examples and 182g and 204g for two substantial fragments. This suggests that this evidence relates to blacksmithing, rather than bloomsmithing (the working of iron during its production).

The smithing slags are associated with a significant quantity (977g, 14% of the assemblage by weight) of vitrified hearth ceramic. Of this material, 424g was identifiable as deriving from ceramic tuyères. Ceramic tuyères are a relatively uncommon class of find in England and Wales, although rectangular-sectioned block tuyères do occur occasionally in Iron Age and Roman contexts. Tuyères with a circular or sub-semicircular section are the normal means of ventilating a smithing hearth from the sixth century onwards into the post-medieval period in Ireland. Although the evidence here is not conclusive, the tuyères are probably related to the forms seen in Ireland.

Microresidues from smithing, most notably flake hammerscale, were recovered from five contexts, the fill of hearth [1032], the fill of posthole [1029] and a fill of pit [1091), as well as a dump of smithing debris into the external ditch.

Amongst the last phases of activity on the site, a dump of waste into ditch (1008), contained a small, but significant assemblage of residues from iron smelting. The smelting had been undertaken in a non-slag tapping furnace with a basal pit that had been filled with wood. Such technology is widespread in Britain and Ireland in the early medieval period, with a long history back into the Iron Age. Several contexts produced small quantities of iron ore. The ore was present in particles of up to 10mm and included both haematite and goethite. Although these particles might have been introduced to the site as part of the iron making process, this cannot be taken for granted. The nearest sources of such minerals are probably the area around Cass-ny-Hawin, SE of Ballasalla and Maughold Head, near Ramsey. However, an origin is also possible from outside the island, with derivation, for instance, from Cumbria, perhaps by glacial transport.

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Methods

All materials were examined visually, using a low-powered binocular microscope where required. As an assessment, the materials were not subjected to any high-magnification optical inspection, not to any form of instrumental analysis.

Most of the macroscopic materials required further washing prior to examination and in some cases removal of adhering matrix by scalpel.

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

This practical assessment was largely conducted in September 2020, but reporting was not completed until March 2023. The work was commissioned by Dr Harold Mytum of Liverpool University.

Description of the assemblage

General

The submitted material comprised 7.9kg of hand-picked material and sample residues from flotation from a total of 100 separate collections (bags) from 38 contexts (Table 1).

The archaeometallurgical residues are generally noteworthy for their particularly bad preservation; the iron slags are typically very heavily weathered, commonly soft, and often not preserving surface detail. In contrast, preservation of the more siliceous material of the hearth ceramic and associated lining-influenced slags may be good. The poor condition of the iron slag is associated with weathering under the influence of a very high water-table. Iron weathered from the slags has commonly been re-precipitated as accretionary coatings on the exterior of the slag, as ferruginous cement with other sediments and commonly as tubular concretions (concretions a few millimetres in thickness that form around plant roots and occasionally worm burrows).

The poor preservation created problems with identification, not only in the details of the macroscopic material but also in the basic identification of many of the grains in the flotation residues. Because of these practical no attempt has been made to quantify the materials in the flotation residues and even for the macroresidues caution should be observed. Some slag pieces have been abraded or fractured during cleaning, indeed whole slag pieces may have been lost this way. Those pieces that have been cleaned suitably may have had mass lost through leaching or, more rarely, added, during formation of concretionary material.

Residues from iron smelting

Context (1008) contained a small, but significant assemblage of residues from iron smelting (1060g). The key pieces are rather massive, dense slags, bearing the moulds of the pieces of wood with which the furnace basal pit was packed, prior to smelting. The wood pieces are 30-40 mm across and up to 100mm in length. In one case wood, probably mineralised, is preserved within the mould. Related dense slags show evidence for internal flow lobes. There is also a dense slag prill with charcoal fuel contacts and a possible fragment of slag with flow lobes chilled against a ceramic wall (commonly a non-wetted contact is observed between the slags in the pit and the pit wall).

Although this context produced two small fragments of hearth/furnace wall neither was certainly from a tuyère and there were no fragments from the context identifiable as being from SHCs.

Residues from smithing

The early medieval macroscopic residues are dominated by those certainly or probably from ironworking (smithing) including the material on Table 2 listed as SHC (1822g) and smithing slag (42g) as well as probably most of that listed as indeterminate (2197g) and lining slag (217g). The slags are typically in rather small masses and fragments, with few even relatively complete smithing hearth cakes (SHCs). The SHCs show a weight range of 94g to 242g for the three complete examples and 182g and 204g for two substantial fragments.

As mentioned above, the weights of highly weathered slags do not necessarily correspond to closely to their original weights. To test this in the current material, the weights of SHCs (the three complete examples, plus one almost complete one) were plotted against their bounding volume (length x width x depth; L x W x h) expressed in cubic centimetres and compared wth better preserved material from a Roman site (Figure 1). Although the Port y Candas examples plot rather peripherally to the Roman examples, their regression lines are very similar. This suggests that despite the weathering the SHC weights do provide some valid information. They suggest that the iron-working activity presented by the SHCs was blacksmithing, rather than bloomsmithing (the working of iron during its production). SHCs from bloomsmithing typically show

rather greater weights than those from blacksmithing. For Iron Age assemblages, most SHCs over 800g may be from bloomsmithing, but for early medieval Irish assemblages (produced in hearths using ceramic tuyères) then most SHCs over 1200g are probably from bloom working. Thus, whatever the interpretation of the significance of the tuyères (see below) the SHCs are below this threshold.

Slag droplets (recorded from contexts (1003) and (1009) are likely to be droplets that chilled within the fuel bed of a smithing hearth. Very similar centimetre-scale droplets may form in smelting furnaces, but these did not occur in the company of other smelting residues.

Smithing microresidues (most notably flake hammerscale) were recovered from five contexts, the fill of hearth [1032], the fill of posthole [1029] and a fill of pit [1091), as well as a dump of smithing debris into the external ditch.

Technical ceramics

The smithing slags are associated with a significant quantity (977g, 14% of the assemblage by weight) of fragments of vitrified hearth ceramic. Of this material 424g was material identifiable as being from ceramic tuyères.

Ceramic tuyères are a relatively uncommon class of find in England and Wales, although rectangular-sectioned block tuyères do occur occasionally in Iron Age and Roman contexts, but tuyères with a circular, sub-semicircular or 'D'-shaped section are the normal means of ventilating a smithing hearth from the sixth century in the post-medieval period in Ireland. The precise form of these examples is therefore of considerable interest.

Fuel ash slag (FAS)

The term fuel ash slag (FAS) is used here for materials that are interpreted to have undergone partial melting (vitrification) through the fluxing influence of the wood ash from the charcoal fuel, rather than through the influence of the iron (as iron oxides) in the hearth. There are two pertinent morphologies here: firstly a highly vesicular, usually pale, slag, often carrying remnant quartz grains, typically with a clay or soil precursor (FAS, total 27g) and secondly clasts formed from individual pebbles, bloated by degassing during dehydration, dihydroxylation and decarbonation, but for which the surficial partial melt was sufficiently viscous to inhibit gas escape (bloated tsone, 22g).

FAS is particularly common where the heated substrate was already rather calcareous, adding to the effect of the calcium and potassium oxides in he fuel ash. Recent work has shown how FAS may be developed, not only in some metallurgical systems, but also in kilns (such as pottery or cereal drying kilns) and even in domestic hearths under appropriate circumstances. The presence of these materials does not necessarily indicate metallurgical activity.

FAS such as that from Port y Candas may arise from heating of the margins and floor of a metallurgical hearth away from the focus of the main slag-generating activity. Bloated stones may most commonly be seen in floor level hearths incised into a gravelly substrate, from which individual pebbles occasionally become detached into the hearth.

Iron ore

Several contexts produced small quantities of iron ore to a total of only approximately 4g. The ore was present in particles of up to 10mm and included both haematite and goethite. Although these particles might have been introduced to the site as part of the iron making process, this cannot be taken for granted. The nearest sources of such minerals are probably the area around Cass-ny-Hawin, SE of Ballasalla and Maughold Head, near Ramsey. However, an origin is also possible from outside the island, with derivation from Cumbria, perhaps by glacial transport.

Concretion

As well as the concretionary material attached to items from other classes of residue, 240g of concretionary material are listed separately in Table 2. These pieces either have the core particle entirely concealed or have not formed on a single lump of residue.

Non-metallurgical materials

240g of material (9 pieces) from context (1092) was a fragmented block of basalt.

Distribution of the assemblage

The distribution of resides by context is provided in Table 2.

Metalworking is represented in the collections derived from contexts currently interpreted as being of Iron Age date solely by a few sand-grade grains from a single sample. Such grains are within the size-range of material potentially moved by worm action and cannot thus be a reliable indicator of contemporary metalworking on their own.

The remainder of the collection (approximately 6.5kg of actual archaeometallurgical residues) derives from contexts either interpreted to be of early medieval age, or directly dated as such by radiocarbon determinations.

The early medieval residues are dominated by those certainly or probably from ironworking (smithing). The slags are typically in rather small masses, with the few present as smithing hearth cakes (SHCs) showing a weight range of 94g to 242g for the three complete examples and 182g and 204g for two substantial fragments. This strongly suggests that the activity was blacksmithing, rather than bloomsmithing (the working of iron during its production).

Several hearths were identified during excavation, of which hearth [1071] is significant, for its lower fill (1059) produced a fragment of a ceramic tuyère. As noted above, the fill of hearth [1032] produced flake hammerscale. Thus, both of these hearths may have been employed for metalworking.

A fragment of tuyère was also recovered from the deposit (1016) in ditch [1100].

Interpretation

The iron smelting was undertaken in a non-slag tapping furnace with a basal pit that had been filled with wood. Such technology is widespread in Britain and Ireland in the early medieval period, with a long history back into the Iron Age. The present material cannot provide further detail on the precise variant of this type of furnace used at the site. Suggestions by Kneale (2006) that the morphology of fired and vitrified clay fragments suggested a dome-like cover over a 'bowl' furnace can be discounted.

The context of the iron smelting in the history of the site is uncertain; although the deposit containing the modest assemblage of smelting residues (context (1008)) is late, it is possible that it relates to the clearance of earlier waste from the interior. The widespread occurrence of haematite iron ore on the site cannot be taken as evidence for the protracted undertaking of iron smelting on the site. Although this may be the case, haematite also has uses as a pigment and as a polish and its natural occurrence on the site (perhaps in the drift geology) also needs to be excluded.

The use of tuyères, probably for iron smithing (although their use in non-ferrous metalworking cannot be excluded), in the early medieval period at Port y Candas may be of great potential interest. For much early ironworking, the preferred approach in Britain appears to have been the use of a hearth with a wall with a simple perforation for a blowhole. The use of a specially prefabricated block, a tuyère, to contain the blowhole is less commonly encountered.

There appear to be two main morphological families of tuyères: one, the so-called block tuyères, typically with an approximately rectangular cross section, widely seen from the pre-Roman Iron Age of central and western Europe and the second, 'tubular' tuyères with a sub-circular section (although commonly 'D'-shaped with a flat base), associated with the early medieval and medieval periods, prior to the introduction of iron tuyères.

Within the region, rectangular block tuyères are represented by examples from the Middle Iron Age for copper smelting at Four Crosses (Young 2006, 2010; Havard *et al*. 2016, illus. 17), apparently for iron working at Gussage All Saints (Spratling 1979, 129), probably for ironworking at Mucking (Dungworth & Bayley 1999) and by a late Iron Age or early Roman assemblage from Axminster (Young 2015). A 100mm square example from Carpow in Scotland (Tylecote 1986,1999) has commonly been described as Roman, but occurred in a dump of smithing waste in the upper fills of the legionary fortress ditch and is therefore likely to post-date the abandonment of the site and be 3rd century or later (and thus probably not culturally Roman). There remains considerable doubt whether such tuyères were regularly employed for iron smithing. Several of the occurrences were certainly associated with non-ferrous metalworking and it is possible that the use of tuyères was particularly linked to temporary facilities (rather than to permanent smithies).

Tuyères of a circular or 'D' cross-section are rare from early medieval Britain, being recognised from just a few sites in Essex (Rook Hall and Mucking; Dungworth & Bayley 1999). Although no large, certainly diagnostic, pieces survived, Late Iron Age tuyère sherds from Truro (Young 2021) may also possibly have had a 'D'-shaped cross section in contrast to the other Iron Age examples. In Ireland, however, such tuyères became the almost sole form of ventilating smithing hearths from the middle of the 7th century until the early post-medieval period. This change of practice in Ireland may reflect the adoption of a central European tradition.

Unfortunately, there are very few sherds of tuyère within the present collection that shed detailed light on their morphology. A 92g sherd from context (1016) includes what appear to be a lower corner of the front face, forming an approximate right angle between the side and base and a 60g fragment from context (1009) shows a margin with a radius of curvature of approximately 60mm. These pieces are therefore ambiguous, although the curvature of the fragment from (1009) is probably more suggestive of an Irish-style 'D'-section tuyère than a rectangular block tuyère. The relative abundance of tuyère sherds in the fired/vitrified clay assemblage from this site is also more reminiscent of an early medieval Irish assemblage, than it is to assemblages from England and Wales.

Previous excavations at the site also produced archaeometallurgical residues. These received some investigation in an unpublished MA thesis (Kneale 2006). The most significant aspect of this earlier work was the assemblage of 74 crucible fragments, apparently of early medieval age. These are indicative of non-ferrous metalworking, probably mainly the casting of copper alloys. This is in marked contrast to the complete absence of such evidence from the phase of excavations reported upon here. The previous assemblage also included tuyère fragments and a moderate quantity of iron slags (probably approximately 500 pieces). A total of 1.2kg of haematite ore was recorded, with an unpublished report suggesting that the ore was quartz-bearing and comparable with a source at the Dhoon in Maughold.

The earlier work covered a much larger area of the interior of the site than the 2010 work reported here. The difference in the archaeometallurgical materials recovered partially reflects this areal difference, but also hints at some spatial separation of the craft activities.

Further work

The poor state of preservation of the ferrous archaeometallurgical residues that comprise the bulk of the materials studied here means that these are not suitable, in general, for detailed analytical investigation.

The materials from the earlier investigations include crucibles that might be worth analytical investigation to determine the nature of the metals being worked, either within the cope of the present work or as a future project.

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Table 1: summary catalogue of submitted macroscopic materials. Weights in g. Assm = assemblage.

context	find	sample	note	s. wt.	item wt.	item no.	item description
1001					62	1	thickly slagged vitrified oxidised lining
					36	5	slag scraps in accretion
					2	2	lining slag fragments
1002	6			42	42	6	rotten slag fragments, probably SHC or hearth slags; one piece shows a pale glaze around the margin of the fragment - a rounded margin like the lateral margin of an SHC
1003	1			1	assm		2 fine brown weathered slag blebs, 1 fragment of slag with schist inclusion, 1 lining slag fragment
1003	1			4	assm		stone slag lining slag, highly magnetic assemblage, particularly the stone component; some slag droplets
1003	8			48	48	1	fragment of 15mm thick sheet of charcoal-rich slag
1003	9		bag1	52	30	11	indeterminate slag fragments
					6	1	dense flow lobe
					6	1	lining slag prill
					<1	2	slag droplets
					10	1	vitrified oxidised fired lining
1003	9		bag2		56	1	fragment with two dimpled surfaces at right angles suggesting fuel contacts and another planar surface, probably from an internally prilly SHC
					12	4	slag fragments
1004	10			10	10	1	fragment of strongly concavely-curved vitrified lining face; a complex piece, possibly flap of face folded back; appears vitrified along detachment fissures as well as front
1005	11			1282	204	1	irregular slag block, probably twisted proximal end of SHC, with smooth but deeply dimpled top and neat base with accretion containing hammerscale; uncertain how much of the SHC this is, but appears tabular, 80 x 80 x 20mm thick
					78	1	fragment from margin of small SHC, top smooth but dimpled as in example above, tabular, base accreted so no detail seen
					118	1	odd piece appears to be wall contact of SHC with dimpled top and lobate base, but probable contact area is very smooth and at odd angle - deformed on extraction?
					182	1	irregular fragment, probably from an SHC, wedge-shaped, 15mm thick on one corner, thickening to 30mm along opposing curved edge
					68	3	vitrified oxidised fired ceramic
					16	1	glazed bloated stone
					4	2	FAS-like blebs
					10	1	lining slag nub
					592	60	small pieces of indeterminate iron slag, many well-accreted
					10		scraps
1005	12			44	44	1	vitrified oxidised-fired lining slag, glassy surface particularly thick, planar and pale - unlike most from iron working

1005	14		bag1	104	104	2	larger (56g) fragment similar to 56g piece from 1003 - multiple fuel contact surfaces suggesting an internally prilly SHC; block is a a nub, broken in 2, not a clear SHC shape
1005	14		bag2	38	10	1	goethite ore?
					8	1	stone - lower grade goethite?
					2	1	goethite ore?
					18	5	small indeterminate slag fragments
1006	17	1	mag				ashy charcoal fragments
1007/1010	4			54	assm		stone
1007/1010	4			<1	assm		stone, charcoal tubular concretions
1007/1010	67	4	mag				stone and indeterminate rusty material
1008				40	24	2	rotten slag fragments
					8	1	concretion with charcoal
					10	1	possible slag, hard with large charcoal clast
1008	18			1276	564	1	large block of weathered amalgamated flow slag with large wood moulds
					154	28	small fragments of iron slag, all vesicular, mostly blebby or lobed, some with suggestions of contact with grey gravelly clay
					306	1	block of massive dense slag with surface wood moulds, locally with surviving wood
					16	1	planar piece of vitrified oxidised fired lining
					72	1	flow-lobed slag in accretion- just possibly a non-wetted wall contact
					10	4	small angular fragments of pale lining slag
					24	1	very irregular sharp fragment of lining related material
					12	1	concretion
					116	2	dense, vesicular, massive slag pieces; just possibly a hint of internal lobes in one
					2	1	prill with charcoal contacts
1009	5			48	assm		dominated by lining slags, some stone and some fired clay
1009	5			14	assm		mostly lining slag in small droplets, some lining, some accretion and some other slag pieces
1009	21	5	mag				ashy charcoal material, plus some more coherent possible FAS fragments
1009	22		bag 1	198	48	4	ferruginous and charcoal-rich material attached to soft gravelly clay
					46	12	scraps of mostly charcoal-rich slag
					64	1	dense lobate sheet attached to small slag fragment below and rich in large charcoal pieces above
					18	1	fragment of vitrified oxidised fired ceramic
					6	2	fragments of curved surfaces of lining slag
					16	1	pale nub of lining slag or FAS
1009	22		bag 2		38	2	irregular twisted prills of gravelly lining slag
					18	1	vitrified oxidised lining fragment
					6	1	bloated mudstone lump
					52	4	indeterminate vesicular, charcoal-bearing iron slag

1009	22		bag3	680	60	1	sherd of vitrified oxidised-fired ceramic with concentric zonation on face and curved margin of c60mm radius; possible tuyère
					76	1	convex well finished ceramic on margin, centrally dished and burnt back; concentric zonation to glaze, cut across by linear beard of lining slag, below which wall unaltered; possible tuyère
					50	1	vitrified oxidised fired ceramic, front face planar and zoned, but on margin this overlies a surface that appears slightly angled back
					28	1	convex fragment of vitrified oxidised-fired ceramic
					284	2	slab-like piece of charcoal-rich slag 35mm thick; clay on base; probably SHC but slab like not typical form
					42	1	fragment of 10mm thick slag sheet, close to planar
					6	2	small fragments of oxidised-fired vitrified ceramic
					80	10	fragments of iron slag
					30	1	twisted scrap of lining slag
					24	1	dense slag with hard rounded margin, possible edge of very small SHC
1016	25			338	92	1	maximum of 45mm depth of right-angled corner of oxidised fired ceramic; glazed both on the slightly inset front and also the side, the likely base appears not to have been glazed, suggests lower corner of block tuyère
					144	1	highly weathered block of very charcoal-rich slag
					56	8	small fragments of charcoal rich slag
					24	3	fragments of vitrified oxidised fired hearth ceramic
					22	1	oxidised-fired hearth material with a crack over which the superficial slag layer appears to have stretched and deformed; there is also some slag attached to vitrified surface of uncertain nature; probably also a lining slag.
1017	26			278	66	1	very thickly slagged oxidised fired lining
					118	3	indeterminate weathered iron slag
					16	1	irregular lining slag lump
					78	2	extremely soft brown weathered material
1019	27			3	3	2	unclear if slag or concretion, very rich in charcoal
1020	20			<1	assm		stone and ferruginous material (including tubular concretions) but no residues
1020	20			<1		1	charcoal
1020	20			<1	assm		concretion
1022	6			172	144	assm	weathered fragmented slags, a few blebby, mostly indeterminate, 1 larger fragment of vitrified lining, 1 highly-bloated rock fragment, all very soft except lining
					28	10	stones
1022	6			70	assm		lots of accretion but rich assemblage of slag fines with some FHS
1022	30	6	mag				mostly ashy charcoal, some tiny FAS fragments (larger assemblage than others)
1023	8			2	assm		rock, charcoal, tubular concretions, couple of tiny fragments of haematite, one possible slag fragment
1023	8			<1	assm		mostly weathered slag grains, some stone
1023	8			60	assm		mixture of materials mostly lining-related; includes 3 fragments of very thick boated vitrified layer (cf brazing shroud), at least one bloated stone, but mostly more conventional pale lining

1023	12			78	assm		mostly gravel/ferricrete, but contains a significant proportion of slag, mostly dark glassy lining slags, some possible FAS and some very degraded iron slag
1023	12			4	assm		degraded slag fragments with lesser stone and concretion
1023	33		bag 2	94	94	1	70x55x20mm, small SHC with accretion on top, broken in 3
1023	31	8	mag and slag				1 c12mm diameter FAS grain, approximately 10 grains of degraded iron slag
1023	33		bag 4	246	94	3	vitrified oxidised fired hearth lining, variously curved
					96	1	large block of vitrified oxidised-fired lining, possibly block tuyère corner
					4	1	fired sandy clay
					26	2	brown soft ferruginous concretionary material
					26	1	irregular lobate mass of lining slag
1023	33		bag 1	280	158	1	very weathered SHC, 80x70x40mm, nubs of lining slag on otherwise slightly dished upper surface
					84	1	probable fragment of highly weathered accreted SHC
					48	1	vitrified oxidised hearth lining with convex surface
1023	33		bag3		48	1	accreted fragment of small wide shallow SHC
					82	23	fragments of iron slag, mostly irregular fragments, but one fragment of flow lobe
					10	1	twisted irregular scrap of lining slag
					2	4	charcoal
					4	1	vitrified oxidised hearth lining
					40	2	stones
					18	1	brown highly weathered charcoal-containing slag
1023	33			24	24	1	dimpled flow of lining slag with bloated inclusions (and potentially concealed gravel); upper face dominantly glassy, lower face with debris and more FAS-like; dimples in upper face contain remnants of charcoal
1030	7			<1	assm		slag fragments, concretionary debris and a small amount of FHS
1030	36	7	mag				mostly charcoal and charcoal-rich ferruginous grains, no certain residues
1031	37				28	4	soft ochreous fragment, largest piece appears to be completely decomposed slag, and has MD response
1033	38	9	mag and slag				FAS droplet fragment, rest indeterminate stone and ferruginous material
1033	39			190	190	15	indeterminate iron slag fragments, many with slightly lobate tops; probably more likely to be smithing than smelting slags, but exceptionally poorly reserved
1033	9			1	1	1	sand grains bound by black glass
1033	9			4	assm	17	haematite

1033	9			42	assm		mostly small weathered slag fragments and blebs, some accretion, modest quantity of FHS
1039	42	13	slag				main fragment probably goethite ore, not slag
	43				56	8	low density iron stained clay; one dark piece shows MD response
1041	10		?	4	4	28	dark brown ped-like rounded concretions?
1043	17			<1	assm		stone, charcoal, tubular concretions
1043	17			7	assm		3 fragments of lining slag amongst the stones
1043	44	17	mag and slag				four highly vesicular fragments, probably FAS
1043	45			92	22	1	oxidised-fired ceramic with dark glass
					40	3	weathered slag nubs
					30	8	small slag fragments
1045	25			2	assm		tubular concretions
1051	46			6	6	1	lobate, possibly gravelly, green glazed FAS-like material
1053	27			16	assm		mostly accretion but some very weathered slag prills and blebs
1053	27			32	assm		stone
1057	18			4	assm		stone with one FAS grain
1057	18			518		26	stones, some with traces of haematite
1057	18			<1	assm		tiny quantity of very small indeterminate grains
1058	14			104	86	1	fragment of decomposed probable SHC, columnar crystal relicts for sheet along one side (the probable planar top), rest more massive and fine; suggests a substantial fragment of a small SHC
					16	10	small fragments of decomposed iron slag
1058	15			4	assm	20	lining slag
1058	15			<1	assm		mostly stone, but chips and fragments of lining slag
1058	15			4	assm		stone and lining slag
1058	50	15	mag and slag				one lining slag bleb, couple of FAS fragments
1059	22			<1	assm		tiny quantity of material, includes grains of probable lining lag

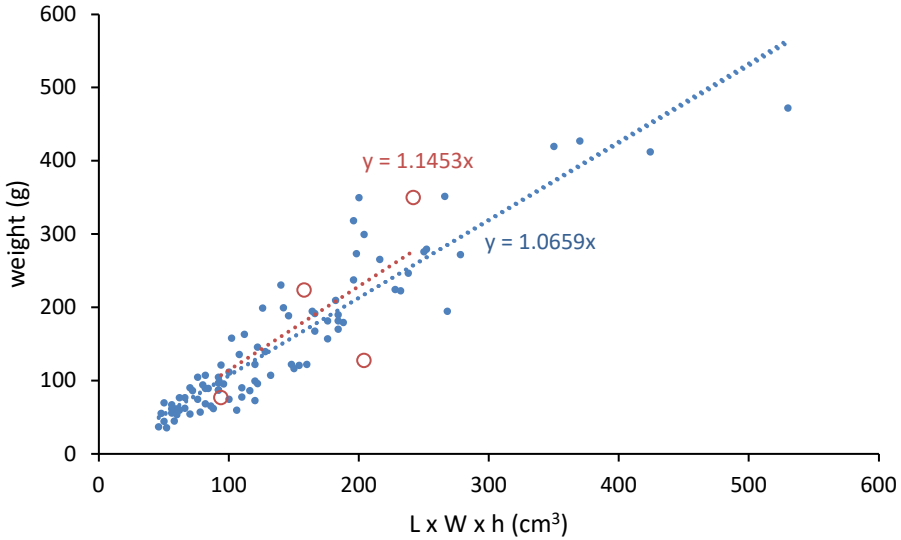
1059	52			60	19	7	fragments of rotten dark vesicular slag - SHC fragments?
					9	1	concretionary material of uncertain nature
					1	1	small prill fragment
					3	2	probable rotten slag fragments
					5	1	rotten vitrified lining fragment
1059	53			50	50	1	vitrified oxidised fired hearth wall, one corner shows part of margin of hole though glaze, but wall below shows no sign of blowhole; the furthest edge (45mm away) shows a curve away from the plane of main face; cannot exclude this is a tuyère face
1060	54			98	76	30	small fragments of slag, a few fragments of lining slag, but others are iron slag
					22	1	thickly vitrified oxidised-fired ceramic
1060	54			34	34	1	small fragment from wall attachment of small SHC - adhering sandy lining is pale grey and well fused suggesting this is a burr
1062	19			<1		1	stone
1062	19		<1		assm		stone, 1 haematite
1062	19			50	assm		stone and charcoal rich concretion
1062	19			2	assm		slag, stone
1066	21			4	assm		stone, with small fragment of vitrified lining
1066	21			16	assm		mostly rock and charcoal but moderate FAS and one piece of lining
1066	21			<1	assm		stone, concretion, lining, slag
1066	57			404	106	8	poorly preserved fragments: 4 pieces probably concretionary, 3 pieces of dimpled and lobate lining slag, 1 piece of dimpled slag sheet
					300	2	stones
1066	58	21					soft haematite in 3 pieces - 2 botryoidal crust, 1 more clay rich
1066	60	21	slag				1 small round brown ?concretion, remainder mostly FAS
1067	61			242	242	1	SHC, 70x100x50(35), biconvex SHC, very charcoal-rich; base dimpled and very slightly lobate
1069	23			<1	assm		haematite (c7 pieces)
1069	23			<1	assm		includes a few fragments of sandy glass
1069	23			<1	assm		tiny quantity of material, includes grains of probable lining lag
1072	24			<1	assm		probable FAS debris
1072	24			10	assm		mostly stone and tubular concretions, but one large shard of vitrified lining and a couple of small FAS pieces
1072	24			2	assm		stone and slag fragments

1080	26		8	assm		mostly rock grains, one burnt bone, some charcoal and single probable low-density slag fragment
1080	26		14	assm		charcoal with some stone
1080	26		<1	assm		stone
1089	29	?	2	assm		stone and dark ?peds
1090	64			6		fragmented soft ochreous material- strangely roundedly porous mass
1092	65		240	240	9	fragmented block of basalt
Gelling	68		22	2	1	concretion
1977a				1	1	glazed FAS fragment
Trench				2	1	corroded slag
				17	6	probably concretionary pieces

Table 2: distribution of residue facies by context. SHC = smithing hearth cake, FAS = fuel ash slag, conc. = concretion, FHS = flake hammerscale

context	context notes	smelting slag	SHC	smithing slag	indet slag	lining slag	hearth ceramic	tuyère	FAS	bloated stone	Iron ore	conc.	droplets	FHS	ash/charcoal	*total*
1001	topsoil				36	2	62									*100*
1002	upper bank?			42												*42*
1003	?		56		96	6	10						y			*168*
1004	deposit						10									*10*
1005	subsoil (modern)		582		602	10	68		4	16				y		*1282*
1006	internal deposit?														y	*0*
1007/1010	deposit younger than hearth 1011											y			y	*0*
1008	upper ditch fill	1060			190	34	16					20				*1320*
1009	lower ditch fill (dated) = (1060)		308		290	68	76	186	16	6			y	y	y	*950*
1016	lower ditch fill [1100]				200		46	92								*338*
1017	basal fill of ditch [1100]				118	16	66					78				*278*
1019	upper ditch fill				3											*3*
1020	fill of pit (1021) dated											y			y	*0*
1022	?(overlying deposit dated)				144							y		y	y	*144*
1023	Pit fill? (dated)		495		100	60	150	96	y	y	y	26			2	*929*
1030	fill of p/h 1029				y							y		y	y	*0*
1031	deposit cut by [1024]											28				*28*
1033	fill of hearth (1032)				190	1			y		4			y		*195*
1039	fill of p/h 1038										y	56				*56*
1041	bank revetment											4				*4*
1043	upper fill of ditch 1042? Dated				70	y	22		y			y			y	*92*
1045	middle fill of pit [1091]											y				*0*
1051	?								6							*6*
1053	lower fill of palisade trench 1076				y											*0*
1057	early build up, bank/levelling								y							*0*
1058	fill of ditch [1042]		86		16	20			y							*122*
1059	fill of burnt pit [1071] (pit overlies fills of [1042]		19		4	y	5	50				9				*87*
1060	lower ditch fill = 1009		34		30		22									*86*
1062	bank revetment				y		y				y	y			y	*0*
1066	fill of ditch 1065				106		y		y		y					*106*
1067	bank; dump of clay in NE		242													*242*
1069	fill of gully 1073 (internal structure?)					y					y					*0*
1072	lower early build-up				y		y		y							*0*
1080	overlies southern palisade cut by ditch [1065]					y									y	*0*
1089	buried turf											y				*0*
1090	?											y				*0*
1092	natural															*0*
	Gelling 1977a Trench				2				1			19				*22*
	total	*1060*	*1822*	*42*	*2197*	*217*	*553*	*424*	*27*	*22*	*4*	*240*	*0*	*0*	*2*	***6610***

Figure 1: SHC weight (g) plotted against bounding volume (L x W x h, all in cm) for examples from Port y Candas (open orange circles) and Cleevelands (filled blue circle; a Roman smithing site in Gloucestershire, Young 2018)



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