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Assessment of archaeometallurgical residues from Twinyeo Farm, Devon

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Abstract

This report outlines an assemblage of approximately 61kg of metallurgical residues recovered during excavation at Twinyeo Farm, Devon. The assemblage derives from two areas of the site: a very small quantity of iron-working (smithing) debris from a single pit in Area 8 and the vast majority of the collection, probably entirely from iron smelting, from Area 7.

The iron smelting was undertaken in non-slag tapping furnaces of 'slagpit' type, in which the slag accumulated during the smelt in a pit at the base of the furnace shaft. Such furnaces were the dominant form of furnace across northern Europe (including Britain and Ireland) in the Iron Age. In common with most earlier forms of this furnace type, they show evidence for the use of a wood pit-packing. Most wood pieces appear to be split, rather than simple roundwood. No specimens of the iron ore were observed, but various lines of evidence suggest a bog ore may have been smelted.

The site shows three clusters of iron smelting features. In the central southern part of Area 7, a cluster of features occurs within a segmented gully, suggestive of a structure. Interpretation of these is difficult, but they may possibly include successive furnaces (1158 and 1155) with a working hollow to the SW (1160) – a combination which would suggest an arched furnace. In contrast the NW (1134 and 1136) and E (1056 and 1061) clusters show simple sub-circular pits. The potential furnaces of the central cluster, and those of the eastern, have internal working diameters of 400-500mm. Those of the NW cluster are too truncated to determine.

The residue assemblage from the central area is dominated by dense, strong, slag flows from the floor of the slagpit. These have commonly penetrated below the wood packing. Such basal flows, with or without preservation of flow textures, provided 54% of the overall collection from this area by weight, whereas smaller flow slag prills only provided 11%. Ceramic from the furnace superstructure formed 15% of this collection by weight, a high proportion and strongly suggestive of these furnaces having well-developed shafts. In contrast 100% of the slag from the NW cluster was in the form of fine flow slags. No residues appear to have been archived from the E cluster.

The material is argued to be certainly of regional and possibly of national importance, and should therefore receive further analytical investigation.

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Methods

All materials were examined visually with a low-powered binocular microscope where required. As an evaluation, the materials were not subjected to any high-magnification optical inspection, not to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional. The summary catalogue of examined material is given in Table 1 for Area 7 (ACD170) and Table 2 for Area 8 (ACD478). In addition to the material that has been assessed fully from Area 7, there is 800g of highly fragmented hearth/furnace wall material that has not been assessed in detail (this is therefore not included in Table 1, but which is included in the summary Table 3).

This project was commissioned by Naomi Payne, of AC Archaeology.

Results

Distribution of materials

The residues recovered from Area 8 were mostly recovered from contexts 272 and 285, the two successive fills of Pit F286 (Table 2). Besides these materials, a single slag lump was recovered from c100 and a fired, bloated and partially vitrified fragment of clay from c197 (this piece not necessarily of metallurgical origin).

In area 7, iron smelting residues were recovered from 10 contexts, representing fills of five features (F1134, F1136, F1145, F1150, F1165; Tables 1 and 3), but just two of those contexts actually provided 83% of the material by weight (approximately 50kg out of the 61kg total). The two rich contexts were c1159 (19.8kg) and c1176 (30.3kg), both fills of a substantial pit (cut 1160, forming part of complex feature F1145).

In total, 51.65kg of residues were recovered from pit F1145 and 5.75kg from the adjoining pit F1165. A further 1.59kg of residues were from pit F1150, which lay just outside the interrupt gully surrounding F1145 and F1165. These collections were all somewhat similar, with the proportions of the various facies of residue particularly similar for the two large collections (c1159 and c1176). In general the material from this area comprised large fragments (the average residue fragment from c1159 weighed 500g; that from c1176 weighed 398g), with a lack of small residue pieces.

In contrast, the deposits in the two heavily truncated in pits F1134 and 1136 were entirely of fine fragments of flow slag prills and fuel moulds. These two pits lie 30m NW of F1146/1165 and may represent a distinct phase of activity.

A third area of iron-smelting had two superimposed furnaces bearing slag, but this does not appear to be present in the site archive. These structures lay 40m ENE of F1145/1165. Again, the separation may mark these as being from a distinct phase of activity.

Description of materials

Iron smelting slags:

The slag from bloomery iron-making has been divided into eight facies in Table 3. These facies are not entirely distinct categories, for individual pieces may contain more than one distinct morphology or texture of slag and all the facies intergrade.

(i) Fine flow slag: this includes various morphologies of slag prill formed from slag that chilled on its passage through the fuel bed and pit packing. The typical diameter of prills ranges up to 10mm, but is generally rather less. Many of the prills show flow around fragments of charcoal or wood. The prills show a low degree of amalgamation into larger masses. The prills are typically rather brittle, resulting in their fragmentation. This material may show a gradation of properties with material placed into the following category (ii), but also with the underside of the charcoal-rich prilly material (vi).

(ii) Coarse flow slag: as (i) above but showing typically both larger prills and a higher degree of amalgamation. It is this facies that most commonly preserves evidence for the wood pit-packing, with moulds formed from amalgamated flow slag prills. The wood fragments are mainly spilt wood, although some round, or part round, sections were observed. Typical wood cross sections were around 20mm x 50mm, but some much larger material was also present. Where the orientation of the packing could be observed, material seems to be mainly flat-lying. The highest degrees of amalgamation were probably formed near locations of major down-flows from the hotzone, particularly near the blowing wall.

(iii) Flow slag forming basal sheet: some of the flow slag formed discrete sheets of amalgamated flows, typically with a tapslag-like upper surface and a prilly base. Such material is discriminated from true tapslag by maintaining a dark upper surface (i.e. there is no evidence for surficial oxidation to haematite in the air) and also by commonly having the upper surface flow texture interrupted by the moulds of overlying wood pieces (indicating that the flow had passed below the pit packing). The total thickness of such flows is typically about 50mm, thinning to 20-30mm near the margin.

(iv) Basal puddle without flow texture: these pieces are similar to those in facies (iii), but show no clear indication of flow; indeed many bear a resemblance to smithing hearth cakes (SHCs). They typically appear to be fragments of cakes of approximately 200-250mm diameter. The present interpretation of these materials is that they result from a sufficiently rapid influx of molten lag to the pit that it formed a puddle before solidifying. The formation of a molten puddle would not permit preservation of any flow structures.

(v) Indeterminate dense slag: this category embraces those dense slags which either do not display useful characteristics to enable classification (e.g. all the margins are fractured), or which show characteristics incompatible with the above facies (e.g. for dense slags formed around the upper part of the pit).

(vi) Prilly slag with fine charcoal: these slags show a charcoal-rich texture (or one that was rich in fine charcoal-moulds), but in which the slag is manly in the form of small prills. On sites where intact furnace

bottoms (FBs) have been found, this is often the characteristic texture of the main slag mass formed just below the level of the bloom (e.g. Tullyallen, Young 2003; Adamstown, Young 2006).

(vii) Charcoal-rich slag: this is similar to facies (vi) but the slag does not show a prilly structure, but is mainly in the form of this films lying between the abundant charcoal moulds.

(viii) Burr: the area immediately below the blowhole is often one of intense slag-wall interaction. The most common product of this is a dense curved slag front penetrating into and incorporating the adjacent wall, resulting in a rounded mass of dense, usually, coarsely crystalline slag, often with a skim of reduced-fired ceramic. Because of the good fluxing of the iron to form a particularly fluid slag in this area, the slag may often be seen as lobate sheets intruding into the ceramic, perhaps exploiting weaknesses in the furnace design close to ground level.

Iron smelting furnace materials

The furnace ceramics are rather abundant (14% by weight of the assemblage from the central complex of features). The assemblage has been divided (Table 3) into pieces that are dominantly oxidised fired, prices that are dominant reduced fired and 'other' material (dominantly small fragments, fragments with on vitrified face and the very small fragments that were not included in the assessment).

In general the fabric was fine, but contained a high proportion of gravel temper. Some of the most gravelly material (including pebbles of up to 80mm) may have been from the wall of the pit rather than the upstanding shaft. A low proportion of coarse organic temper was visible (as moulds) in much of the material.

As is typical (reflecting those furnace zones that require most repair) the material includes much showing the changes of curvature and oxidation that commonly occur close to the blowhole. No actual blowhole was, however, recognised in the collection.

Several fragments showed a more even curvature, suggesting an internal radius of curvature of approximately 250mm. It is not known if that is representative of the entire shaft circumference, but does tally with the observed dimensions of the certain and possible examples of basal pits (400-500mm diameter).

Iron working (smithing residues)

Contexts 272 and 285 contained a small quantity of related, manly rather small pieces of residue associated with iron-working. These ranged from microresidues (including small quantities of both flake and spheroidal hammerscale), various within-hearth residues (prills, 'coffee-bean' spheroids, slag films and droplets of lining slag), small fragments of vitrified hearth lining, and small broken fragments of more iron-rich slag. There were no definite fragments from smithing hearth cakes (SHCs), but otherwise the collection was typical of residues from smithing with a charcoal fuel.

Interpretation

The smithing residues from Area 8 are very sparse. They indicate that some smithing must have taken place in the area, but provide little evidence for its scope. Given the small amount of material retrieved, it would seem unlikely that this assemblage is associated with the compaction of the raw iron produced at the smelting sites in Area 7.

The iron smelting activity of Area 7 appears to have three separate foci, so three separate phases of smelting are likely. In-situ fine grained flow slag debris was present in each of the features 1134 and 1136, and it is likely these furnaces were not cleared after their last use.

The major part of the smelting slag collection appears to be part of a deliberate dump of coarse rubble into cut 1160. Although some sample bias against the collection of small slag pieces may have been present, the dominance of substantial slag blocks in this area (the average residue fragment from c1159 weighed 500g; that from c1176 weighed 398g) and the almost complete absence of small slag fragments in the archive, suggests these fragments may have been hand-picked to form a deliberate backfill. The use of slag blocks to fill (reinstate?) a cut feature on its abandonment has been observed at other sites (e.g. Fleethill Farm, Young 2012).

In this central area, the most likely candidate for the furnace itself is cut 1158, although 1155 is also possible (although 1155 did not have a fill of 'industrial' character). These sub-circular cuts of 400-500mm diameter lie to the NE of elongate cut 1160. There is no certainty that these features are related, but they are suggestive of a working hollow, lying adjacent to successive furnaces. Similar hollows have been recorded adjacent to non-slag-tapping 'slagpit' furnaces elsewhere (e.g. Derrinsallagh Young 2008b) and would be indicative of the presence of a furnace arch (non-slag tapping furnaces may possess an arch similar to the tapping arch of a slag-tapping furnace, but which is only used to remove the furnace contents after a smelt).

The interpretation of the other features within the central cluster is even more problematic. The large asymmetric pit (1165) bears little archaeometallurgical residue in its fills below c1163 (the lower fills again appear as a deliberate backfill, although of stone rather than slag). The overall form of this pit resembles a large slagpit furnace (c.f. Burlescombe, Reed *et al.* 2006), with an undercut blowing –wall to the SE (potentially making hollow [1190] a possible location for the bellows). If this interpretation is correct, however, it would be expected that there would be intense heat alteration of, vitrification of, and probably slag interaction with, the central part of the SE wall. Such an effect should be searched for in site records and photographs.

The furnaces of the NE cluster are superimposed, with later furnace 1056 cutting furnace 1061. Both features are highly truncated, but do appear to be indicating something close to the true diameter of the furnace bases (up to 500mm). Unfortunately, the residues from these features do not appear to be preserved in the archives. One aspect of these features that is unusual (and therefore worth pursuing through the site records and photographs) is that both features, despite the level of truncation, appear to have substantial 'vitrified' clay. Slagpit furnaces usually have insufficient maintenance of high temperatures to show actual

vitrification of pit margins – and even visible colour change on the pit base is not universal.

The NW cluster (furnaces 1134 and 1136) are even more highly truncated and show low levels of heat alteration around them (visible in 1136, but no visible alteration around 1134). The fills of these features contain residue assemblage entirely of fine grained flow slag fragments. The lack of heat alteration and the presence of only fine grained slag, would be compatible perhaps (amongst other possible interpretations) with these furnace pits having been originally deeper than those bearing substantial basal flows.

Slagpit furnace technology appears to have been the major form of early iron smelting furnace across much of northern Europe, particularly associated with the exploitation of bog iron ores. There has been some debate over the precise construction and mode of use of these furnaces, and indeed it is not entirely clear if they all functioned in the same way. Some of the earliest examples known are actually the largest, but in general their development is very poorly understood because of a lack of well dated examples.

Understanding is further complicated by the reappearance of slagpit furnaces in the early medieval period, after their replacement by a wide variety of slag-tapping furnaces during the Roman period. Slag-tapping technology again becomes the norm after, approximately, the 9th century.

As far as SW Britain is concerned, Iron Age non-slag tapping technology is known from Cornwall at, amongst other less well-known sites, the Richard Lander School in Truro (Young 2008a) and at Trevelgue Head (Dungworth 2011). In Devon, Iron Age sites have been recently investigated at Berry Ball (Crediton; Young 2009) and, possibly, Portworthy (Young 2011a).

Sites with a similar technology, but of early medieval age are known in the SW from Kestor (Fox 1954, Peter Crew pers. comm.), Burlescombe (Reed et al. 2006), probably Culmstock Road, Hemyock (currently undated - work in progress) and Churchills Farm, Hemyock (Young 2013).

Most of these sites have produced evidence for a wood pit-packing, but the Trevelgue Head assemblage appears to have been more dominated by isolated flow slag prills (as in the assemblages from 1134/1136 here) and Churchills Farm, Hemyock, employed a grass/cereals packing (Young 2013).

The iron smelting activity in Area 7 is significant for it represents the first evidence for iron-making in the area east of Dartmoor. This raises the possibility of other hitherto unsuspected iron-making in the region. The immediate area has no major known iron ore sources. Some 6km to the west, iron ores (goethite, haematite and magnetite) are present in the sedimentary rocks to the east of the granite margin around Haytor (Dines 1956, 732-734). The area 2-4km N to NE of Bovey Tracey contains several mines within the margins of the Dartmoor granite that were formerly worked for haematite for paint (Dines 1956, 726-727). A bog iron ore, rather than rock ore, source seems likely, however, for the Twinyeo smelting operation on the present evidence. The documentation of an unknown production area is important, both of itself, and for the archaeological management of other low-lying flood plain sites in the area.

Evaluation of potential

The smithing assemblage from Area 8 has little potential to produce additional useful information through further analysis. No further investigation of these residues is therefore recommended.
The iron smelting assemblage from Area 7 should be considered to be of great regional (it represents utilisation of a previously unknown iron resource and is of a period for which very few comparative sites are known) and also national (very few sites contribute to understanding of iron smelting technology and iron sourcing for the early and middle Iron Age).

Accordingly, a strong recommendation is made for further analysis of these residues and their detailed publication. The analytical campaign should include samples of a wide range of residue classes, sufficient to document variability of slag composition within different parts of the furnace. Although the main suite of samples will be drawn from the rich assemblages of the central group of features, additional data should also be acquired for slags from the NW features to establish their similarity (or otherwise) to the central group. Should samples from the eastern group be identified, then representative material should also be included.

The analytical techniques should include acquisition of chemical compositions for a wide range of major and trace elements for each sample, with a subset of the slag samples also being investigated using a scanning electron microscope for the documentation of mineral and microstructure.

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Glossary

Blacksmithing: the working of iron and steel. Often restricted to the secondary smithing – i.e. the smithing of iron to produce or repair artefacts, as opposed to the smithing involved in the production of billets or bar iron from raw iron blooms.

Bleb: a small rounded particle or textural component, often a droplet or prill.

Bloomery: a furnace for smelting iron from ore in which iron is produced as a solid material. The bloomery process was employed mainly prior to the introduction of the later blast furnace from the late 15th century.

Bloomsmithing: The process of reworking a raw bloom, through repeated reheating and hammering, to reduce its content of slag, to remove unwanted inclusions and to draw out the remaining slag into elongate inclusions. The end product may be a bar or billet. Usually taken as an alternative term for bloom-refining.

Blowhole: A hole through a furnace or hearth wall through which air is blown.

Burr: the zone of interaction between slag and the hearth or furnace wall just below the tuyère/blowhole. Typically seen as a dense lunate slag, with attached highly indurated ceramic, forming a protuberance on the margin of an SHC or FB.

Flake hammerscale (FHS): flake-like particles formed by the surficial oxidation of hot iron in air (Young 2011c). The iron oxide layer will detach from the workpiece because of differential thermal contraction or during deformation of the workpiece when hotworked at the anvil. The thin scales fall from the workpiece and will accumulate mainly close to the anvil (although some will be lost elsewhere in the forge and even in the hearth). Flake hammerscale has planar surfaces, one of which is typically very smooth and reflective, the other only slightly less so.

Flow slag: slag that has been very fluid and mobile, but which has stayed within the furnace and has not been tapped out of it.

Fuel Ash Slag (FAS): slag formed by the partial melting of hearth wall or substrate under the fluxing influence of the ash (inorganic component) of the fuel. Fuel ashes are often very rich in alkali and alkali earth elements that may lower the melting point of silicates.

Furnace bottom (FB): a rather poorly-defined term for the main slag mass formed during iron smelting in a non slag-tapping furnace. If the basal part of the furnace is shallow this may be dense, but if the bottom is deep then a rather low density FB, formed of coalesced prills, is more common. Slag escaping incorporation into the main FB forms flow slag lower in the pit. *Lining Slag*: Slag formed from the complete or partial melting of hearth or furnace lining.

Prill: a small aggregate of a material, either a spheroidal droplet or a runnel, formed from a melted liquid and either occurring as a discrete particle or as an inclusion within another material.

Slagpit furnace: a variety of non slag-tapping smelting furnace in which a pit for slag collection lies below the base of the shaft. Slag pits are commonly packed with organic material prior to smelting – which is typically split wood in NW Europe, but may be of cereals or grass (particularly in eastern Europe). Flow slags form where slag descends into the pit and a furnace bottom may form across the top of the pit.

Slag spheroids: sub-spheroidal particles, often dimpled (coffee bean spheroids), dull in lustre, and less perfectly spherical the spheroidal hammerscale. These spheroids are typically up to about 10mm in diameter. These are mainly slag droplets formed by the dripping of slag within the fuel bed of the hearth. Isolated spheroids may form in non slag-tapping smelting furnaces as a variety of sparse flow slag, but are more common in smithing hearths.

Smithing: the activity involved in forming a metal object, including, but not limited to, forging metal and joining metal by welding.

Smithing hearth cake (SHC): the slag cake formed in a smithing hearth by reaction of iron oxides lost from the workpiece with silicate material from hearth ceramic and/or fuel, below and in front of the tuyère/blowhole. They are very variable in form, but are typically plano-convex in shape (although concavo-convex and biconvex forms are common), frequently with a dense lower crust and a less well consolidated upper part. In some cases the top is formed of glassy slag.

Spheroidal hammerscale (SHS): spheroidal particles of typically less than 2mm. Often these are vesicular or hollow. Mainly formed (Dungworth & Wilkes 2009; Young 2011b) when, mainly during forge welding, the iron is heated sufficiently for the surficial oxide layer to melt; when the two sides of the weld are closed, the molten oxide is expelled. This process is often enhanced by the addition of a welding flux – particularly where quartz sand is used. The melt coalesces into droplets and chills in flight to form spheroidal hammerscale. Typically they have a shiny surface with a metallic lustre and a close to perfectly spherical shape (unless deformed by impact).

Tap slag (or *tapped slag*, sometimes *tapslag*): slag that has been *tapped* from a furnace as a liquid to solidify outside the furnace.

Tapping: the process or act of allowing a liquid to flow from a furnace. In the bloomery process it is the slag that may be tapped; in a blast furnace both slag and iron are tapped.

Vesicle: a void or pore, usually rounded and formed as a preserved gas bubble in a solidified melt.

Table 1: summary catalogue of archaeometallurgical residues and associated materials from Twinyeo Farm, Area 7, ACD170, by bag. Assm. = assemblage

Context	Item wt. (g)	Item no.	Notes
1135	934	207	small fragments of flow slag prills, both free and mould-forming
1137	1295	colln	flow slag prills as from 1135
1154	28	1	Fe-Mn mottled degraded granite
1159	1005	1	dense somewhat plano-convex slag block; accreted so details unclear, but flat side is fractured to show unusual very highly vesicular almost fuel ash slag-like material; possibly a fragment from the margin of an FB, with the FAS on upper surface; block up to 70mm thick at 100mm from margin
	1045	1	wood moulds >50x30x130mm in dense flow slag; prilly base to block (down past horizontal wood), top slightly messy, concave, forming sheet 25mm thick, dimpled with charcoal impressions - probably at marked angle to base but orientation not reconstructable fully
	682	1	fragment of dense slag sheet c60mm thick; concave top, slightly prilly base; internally vesicular with large irregular rounded vesicles
	1005	1	very dense flow slag block; wedge shaped with somewhat prilly base and upper 'tap slag'-like surface
1159	396	1	irregular very dense slag fragment; fractures are slightly blocky as if fragmental
	396	1	dense slag crust with curved base, overlain by slag with preserved charcoal fragments
	906	1	very dense thick slag sheet fragment, base rather prilly, top highly vesicular cf. fuel ash slag-topped piece recorded from the same context
	418	1	irregular mass of prilly, charcoal rich slag, with planar, prilly base with gravel
	392	1	dense slag flow reaching pit margin; flow lobes seen in places on top, base irregularly prilly, margin has large chert pebble inclusion
	272	1	irregular slag fragment with moderately large charcoal impression; vesicular, but rather too accreted to observe details
1159	2965	1	block of dense furnace base crust corroded onto large chert fragments, slag is only c1kg of this piece; slag has slightly prilly base and passes up into charcoal bearing slag over 60-70mm
	1065	1	complex block of flow slag, good lobate flows above prilly base, possibly folded
	476	1	block of complex, mainly internally prilly, slag, with incorporated crust fragment; very dense
	384	1	irregular block of weathered possible bog ore, gravelly with fragmental iron oxides
	1105	1	large block of charcoal-rich slag, some quite coarse, no original edges visible
	252	1	furnace base flow, base prilly, becomes more flow-lobed upwards, but locally truncated by the base of a large wood impression
	346	1	irregular, internally prilly, slag of indeterminate origin
	272	1	similar to 252g piece above, prilly base, wood impression on top
	258	1	another furnace floor piece with a lobate/prilly base overlain by internally prilly slags

Context	Item wt. (g)	Item no.	Notes
1159	1590	1	very dense puddle margin, several distinct flow layers, but lacking good flow textures; base prilly, but more even and consolidated than material above; wedge shaped, 160mm across, layers total 60-70mm thick. One margin looks odd - possible slag droplets adhering to fracture surface?
	852	1	reduced-fired furnace wall, with large pebble embedded (c80mm), faced with abundant glassy lining slag full of pale crystals/clasts
	550	1	margin of pit base - wedge-shaped fragment with adhering pale clay on base and includes very large wood moulds
	214	1	irregular fragment of charcoal-rich internally prilly slag
1159	362	1	dense angular slag fragment, one face shows well-developed prills, the opposite shows masses of highly bloated white FAS
	286	1	rather irregular slag fragment with some internal prills and large wood moulds
	406	1	slag with very fine texture and no vesicles or other porosity; one surface is maroon and appears to have 'blasted' style of surface texture with small worn pinnacles on mainly flat surface, the other face is more obscured, but appears to be a contact with reduced clay
	76	1	small irregular slag fragment with dense lobes associated with mass of highly vesicular froth
	90	3	broken slag fragment possibly from the same rounded nub with an open core - possibly a lost piece of iron
	28	1	dense flow slag fragment; one side prilly, the other probably a wood impression
1159	288	1	thick block of vitrified oxidised (brick red) lining
	182	1	complex block of vitrified lining; main part has thick black glaze on reduced ceramic and glazed stones; more oxidised-fired at one end
	70	1	vitrified face on reduced-fired lining; glass very sandy
	62	4	oxidised vitrified lining scraps
	166	1	oxidised vitrified lining; internally concave, brick red gravelly rear, thick slag with gravel partially fills embayment
1162	24	1	flow slag prill in kaolinite matrix
	6	1	mineralised material - possible sulphides in kaolinite with dark Fe-Mn bleb
1163	298	6	flow slag fragments in kaolinitic matrix, very fresh slag
	34	2	rock fragments with quartz and strongly cleaved dark mineral, probably pyroxene?
	668	1	large block of slag with broad rough face (from pit wall) and prilly narrow face (from foot of furnace), other faces rather accreted
	392	2	flow slags with prilly bases and hints of fuel moulds in kaolinitic accretion
	124	1	accreted lump of reduced-fired vitrified lining
	78	4	reduced-fired furnace wall fragments associated with thick black clast-rich lining slag

Context	Item wt. (g)	Item no.	Notes
1166	776	1	fragment from margin of a large slag cake (presumably FB) with upper main mass of charcoal-rich slag, prills on base and horizontal flow lobes on margin, extending 50mm out from charcoal-dominated material, typically around 50mm in thickness but variable
	258	1	fragment similar to above, and possibly originally joining, but join damaged
	158	1	rather low-density flow slags, very porous, around large fuel/wood moulds
	106	14	slag fragments, similar to main blocks
	290	1	very dense vesicle free slag in rounded mass, merging into prills on one side, probably a burr fragment
1176	234	1	planar vitrified reduced-fired lining fragment, c120mm across
	808	1	wedge-shaped mass up to 65mm thick; densely prilly to non-wetting base; top bears a couple of large moulds, but surface rather obscured by accretion
	706	1	block with c35mm of basal flows and prills, dense and shiny, then up to 50mm of more charcoal-rich material with some large curving wood moulds
	856	1	irregular, somewhat wedge-shaped, mass up to 80mm thick; prilly base, slightly separated from main more massive section, with charcoal-rich debris on top. Rare large wood impressions, one apparently vertical
1176	848	1	fragment of lip of dense slag cake up to 40mm thick, from side of cake; possibly torn and the upper charcoal-rich material may be folded over and welded on; unclear if from a very large SHC (less likely) or the margin of FB, or a margin of a basal puddle of smelting furnace (possibly most likely)
	460	1	rather irregular possible furnace floor slag; sheet-like, prilly slag, with basal surface of prills intrusive into fairly soft reduced-fired clay
	214	1	fragment of dense, but charcoal mould-bearing slag; sheet c35mm thick
	550	1	complex block of vitrified oxidised lining - shows marked overhang in vitrified surface at low end - but this possibly be a 'crevasse' rather than an actual base to something - although this remains possible; strong oxidation suggests very near blowhole
1176	926	1	irregular mass of lining slag accumulated against remnants of oxidised-fired lining; probably a major accumulation of slumped wall material fairly close to blowhole
	308	1	well vitrified but neat concave surface on oxidised-fired wall; probably from the eroded zone close to blowhole as radius of curvature appears too tight for curvature of the furnace itself
	276	1	second fragment similar to 308g piece above, but not joining
	44	2	small fragments of dense, brown-weathering porous slag, one with grey enclosed clay pellet
1176	888	1	large block of flow slag with good flow lobes and some margins of very large wood moulds
	312	1	rounded lump of very dense slag, with dimpled surface on almost all sides
	354	1	block of furnace lining; interior face slightly convex; shows slight surface reduction on top of interior oxidation. Fabric is finely gravelly clay
	548	1 (plus fragments)	brittle and fragmented piece of furnace lining; partially reduced (near surface) with oxidised deeper lining, and with at least one relining to its irregular surface; most superficial layer is rather iron-rich; geometry complex, but probably from eroding area near blowhole.

Context	Item wt. (g)	Item no.	Notes
1176	1100	1	large curving foot-of-wall block, suggests 260-20mm diameter, prilly base, lobate side largely interacted with and obscured by wall material, top and inner face with large wood moulds; very dense
	722	1	110x140x45mm, slightly concavo-convex sub-semicircular piece, could be poor SHC, but probably another furnace slag; base microprilly, well formed; top smooth with dimples where seen, but accreted and a bit messy
	1190	1	margin of a dense slag cake; roughly a quarter round, c280-300mm diameter; slightly concavo-convex; 50mm thick in centre; base accreted but prilly, top locally smooth with fuel impressions; probably mostly charcoal-bearing so less dense than some of this material
	94	1	internally prilly slag fragment with finely prilly base, rich in fine charcoal
	8	1	cemented charcoal-rich ash fragment
1176	1015	1	large irregular sheet fragment with some large raised, but not well-flown lobes, and large moulds, but orientation not determined
	950	1	fragment of large plano-convex cake; top dished with raised lip; base microprilly; could be large SHC or simply basal puddle
	334	1	dense roughly plano-convex slag piece, with deeply impressed mould-rich top; irregularly prilly base; probably basal crust from smelting furnace, but cannot exclude SHC
	710	1	irregular mass probably formed by two converging curved sheets; dense but has large amount of voids including large fuel/wood moulds
	818	1	irregular fragment of dense slag; prilly basal contact; inclined top; probably a base of wall type mass, but cannot rule out SHC
1176	1125	1	very dense slag with dark metallic-lustred surface and possible tool marks on base; alternatively and possibly more likely, these elongate convex zones are due to molten slag undercutting the pit side; way up not entirely certain
	766	1	dense slag slab; possibly lip of dense slag against burr area; one side is very rough, the other includes smooth lobes- possibly from a fuel contact; orientation uncertain
	710	1	dense block from burr area; shows small area of non-wetted lobe against angular object - possibly a stone in the wall, but elsewhere there is reaction with the wall; shows curved slag sheet within the block marking an embayed burr front
	784	1	somewhat SHC-like piece, with dished rusty asymmetric top, but appears largely formed of lobes and is probably a dished stack of furnace bottom lobes, rather too accreted for certain identification
	518	1	dense slag sheet up to 25mm thick, strongly reacted with reduced-fired ceramic behind, so probably a burr area piece rather than furnace floor; slag shows few diagnostic features
	286	1	broken piece of lobate vesicular slag with one surface formed by impression of very large wood fragment
	50	1	small slag fragment, possibly broken from same piece as above, but does not actually join
	30	1	small sheet of flow slag with wood impression both sides

Context	Item wt. (g)	Item no.	Notes
1176	848	1	large mass of accreted slag- appears to be a rather skeletal mass surrounding large wood moulds - including one with minimum of 120x70x50mm with a rounded end
	332	1	large piece of oxidised-fired furnace lining with curvature suggestive of c500mm diameter
	66	3	oxidised-fired ceramic with no vitrified surface
	76	1	oxidised-fired ceramic with weathered vesicular vitrified surface layer
	42	1	oxidised-fired vitrified lining
	212	3	irregular fragments of reduced-fired vitrified lining
1176	566	1	irregular rusty and accreted block of dense prilly flow slag in amalgamated mass
	1055	1	quadrant of 200mm diameter block, 20mm thick at edge, 60mm in centre; probably a furnace bottom puddle, but sheet-like form doesn't exclude it from being a furnace side block
	64	1	small charcoal-rich slag fragment
	808	1	irregular rusty and accreted slag block, vaguely lobate at one end, where it shows a zone of highly vesicular frothy slag, base shows probable large wood moulds, but poorly preserved
	918	1	heavily accreted, prilly base of dense slag includes moderate fuel moulds, probably the base of a furnace although strictly an SHC cannot be excluded
1176	888	1	irregular bock of rather porous slag, with one curved face with small scale prills and dimples, probably the margin of an FB
	532	1	basal flow - prilly base, impression of wood on top, very dense
	324	1	irregular block of flow slag formed of amalgamated lobes, around very large wood moulds
	594	1	very dense slag block, arcuate in plan, prilly base, accreted top, some moderate fuel moulds, probably a substantial burr fragment
	64	4	slag fragments
1176	22	1	rock
	36	2	gravelly hard clay, probably concretion rather than fired
	8	1	slagged stone/ceramic
	342	2	vitrified oxidised-fired furnace lining; larger piece is concave and has adhering rusty particles (as seen in other similar pieces)
	288	1	complexly-vitrified reduced-fired wall
	366	1	almost semicircular slag sheet with raised lip on circumference and dimpled base and top; roughly plano-convex apart from low lip; could possibly be SHC fragment, but otherwise margin of furnace bottom cake; 125x75x30mm
	910	1	large dense slag block with outer (vertical?) margin; roughly quadrant of 120mm radius; one face (bottom?) has more lobate surfaces, others rather obscured, probably a large FB fragment
	286	1	somewhat plano-convex slag lump with dimply-prilly base; strongly convex; slightly concave top is rough with charcoal debris; probably a fragment from the margin of a large within-furnace slag cake

Context	Item wt. (g)	Item no.	Notes
1176	30	6	flow slag fragments
	508	1	plano-convex charcoal-rich slag mass; no evidence if SHC or from FB, 105x80x50mm
	104	1	deeply vitrified oxidised-fired lining
1189	1165	1	broken large block; has prilly base overlain by 50mm of rather massive slag sheet with roughly planar top; whole fragment shows slight rise towards margin, which has raised top and probably fractured margin; rise probably due to lower very dark prilly zone (Mn rich?) overlain by zone of fuel ash blebs; then more constant thickness sheet which becomes charcoal-bearing near the margin and where there are larger moulds
1191	1085	1	block of iron pan/low grade bog ore - contains possible charcoal clasts - so may be post iron-working rather than the resource; mottled gravel; one large void could just have been iron artefact
	660	1	badly accreted piece, so details uncertain, but appears to be furnace bottom sheet, with smooth but wrinkled top in places, with dimpled fuel moulds; base locally prilly - appears to lift off base towards one side
	634	1	rather similar to 660g piece above, base of coalesced prills, top brown, wrinkled with impressed fuel moulds; c. 20-70mm variation in thickness across piece
	840	1	base of wall piece, has narrow stack of flow lobes with outer vertical non-wetted contact; shows 35mm thick dense crust then dipping inwards with more friable material above
	630	1	somewhat plano-convex piece; base deeply prilly; top flat irregular; probably another furnace floor piece
	346	1	irregular rounded slag mass, with finely prilly surface around much of half of exterior; broken side shows denser, less porous interior - possibly a deformed sheet fragment
	244	1	heavily accreted slag fragment with prilly base
	74	1	fragment from rounded slag ball with central fuel mould; one side may be basal clay contact?
1195	210	1	charcoal-rich iron slag with patches of highly vesicular fuel ash slag
	372	1	block of oxidised-fired wall with deep vitrification and lining slag
	272	1	vitrified oxidised-fired furnace wall
	76	2	small fragments of oxidised-fired vitrified wall
	156	1	dense flow slag lump
	192	1	slag sheet with slightly lobate/dimpled top and rough (sediment contact?) base
	172	1	as 192g fragment, possibly joining but too accreted to test
	174	2	rocks

Table 2: summary catalogue of archaeometallurgical residues and associated materials from Twinyeo Farm, Area 8, ACD478. Assm. = assemblage

context	sample	weight (g)	number	notes
100		48	1	broken nub of dense iron slag with small fuel moulds; dense; part of rounded outline may be original; of indeterminate origin
197	8	<	1	bloated and vitrified reduced-fired ceramic
272	20	46	40	assemblage of mainly very fine scale flow slags, including moulds, prills, stalked spheroids and coffee-bean spheroids, together with a three small fragments of pale FAS.
272	20 flot	<	1	tiny fragment of FAS
		<	1	lining slag in plano-convex sheet - presumably spalled from wall, stone or tool...
272	slag	60	1	poor flow of dense but vesicular slag, base finely prilly and dimpled, top has larger fuel impressions. c15mm thick
285	21	<	Assm.	small sample of hammerscale, mainly flake with a few spheroids
285	21	36	2	gravelly flowed black lining slag
		<	2	sheet-like slag films,
		<	1	charcoal-bearing slag
285		50	2	oxidised hearth lining
285	21 flots slag	<	6	fragments of glassy slag - mostly very pale
285	21 5-6mm f lining	8	5	oxidised vitrified lining fragments
		6	1	fired fine clay, laminated not gravelly
285	21	<	2	slag films with fuel moulds
		<	5	small slag fragments
295	22	18	Assm.	many fragments of FeMn mottles - not slag

Table 3: summary of archaeometallurgical residues from Twinyeo Farm, Area 7, ACD170, by facies, context and feature. Weight in grams.

CONTEXT		ARCHAEOMETALLURGICAL RESIDUES											
		slag								ceramic			*total*
Context	**Feature and fill number**	**(i) Fine flow slag**	**(ii) Coarse flow slag**	**(iiil Flow slag forming basal sheet**	**(iv) Basal puddle without flow texture**	**(v) Indet. dense slag**	**(vi) Prilly slag with fine charcoal**	**(vii) Charcoal-rich slag**	**(viii) Burr**	**Oxidised fired vitrified wall**	**Reduced-fired vitrified wall**	**Other wall**	
1135	F1134	934											*934*
1137	F1136	1295											*1295*
1159	F1145-3		1881	10829	1590	878	978	1105	476	1368	252	542	*19899*
1176	F1145-2	30	2426	12822	3130	3033	722	888	2588	3924	742		*30305*
1195	F1145-1			156		574				720			*1450*
1191	F1165-?			1714	1294	420							*3428*
1162	F1165-2	24											*24*
1163	F1165-3	298		392		668					202	445	*2005*
1173	F1165-1											297	*297*
1166	F1150-3		158			106		1034	290				*1588*

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