GeoArch

Report 2019/02

Assessment of archaeometallurgical residues from Widecombe, Devon

Dr Tim Young
20th February 2019

Assessment of archaeometallurgical residues from Widecombe, Devon

Dr T.P. Young

Abstract

The submitted material comprised 6.4kg of ironworking residues from a pit fill (123), and a small quantity of probably similar material (240g) from unstratified sources, together with approximately 65g of unstratified tin slag.

The ironworking residues comprise an assemblage of 5.6kg of smithing hearth cakes from bloomsmithing, the process of working raw bloom iron to convert it into usable finished iron. The assemblage also includes 560g of hearth lining. The hearth lining probably indicates that the residues have not been transported far from their source. The SHCs bear close comparison with bloomsmithing assemblages ranging from Iron Age to medieval in date.

Evidence for early iron production in the Dartmoor area is extremely limited, so although the age of the assemblage is currently unknown it is nonetheless significant.

In addition to some scraps of probably similar iron slags, the unstratified material included a small collection (10 fragments, 65g total) of tin smelting slags. These were in the form of thin glassy sheets with the thinner examples retaining a perfectly planar surface from contact with molten tin (probably within the floatstone or forehearth). This indicates an origin in a blowing house (either water powered or an earlier manually-blown precursor). The likely age range of such material is from the 13th century (or just possibly a little earlier) to the 18th century.

A limited programme of chemical analysis of the ironworking slags is recommended.

Contents

Abstract 1

Contents 2

Methods 2

Description of the assemblage 2
Ironworking 2
Tin smelting 2

Interpretation 3
Ironworking 3
Tin smelting 3

Further work 4

References 4

Table 1. Summary Catalogue 5
Table 2. Comparative SHC assemblages 6

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. The catalogue is presented as Table 1. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

This assessment was conducted in February 2019 and was commissioned by Bryn Morris of Southwest Archaeology.

Description of the assemblage

Ironworking:

Smithing hearth cakes: the stratified assemblage from context (123) is dominated by the occurrence of examples of smithing hearth cakes (SHCs) providing at least 5.6kg of the 6.4kg assemblage. The cakes are mostly large, with weights ranging from 354g to 2215g, with one small slag mass that may be an unusual rounded SHC weighing just 98g. The lighter specimens show a high input from the hearth lining, but the heavier specimens are also very dense. They share, typically, a finely dimpled basal surface and a plano-convex to biconvex form. The two largest specimens (weighing 866g and 2215g) both show an inclined upper layer of flow lobed slags above the main bowl. Two of the medium-sized SHCs show marked ridges on the base of the cake, extending out up to 50mm from base of the bowl. Such ridges are formed by the smith's poker being employed through or under the molten slag in order to move the slag cake or to detach it from the hearth wall.

The internal structures of the SHCs were usually not visible, but one showed fine tubular vesicles in the lower part of the cake.

Several of the SHCs show an upper surface that is smooth with gentle depressions and lacking a glassy veneer (commonly seen in SHCs to which the lining was actively contributing at the time of their cooling). These same examples also show the presence of large voids just below the upper surface (locally now unroofed), indicative of formation in a situation where rising gas could not escape through the top of the cake. These features, together with tubular vesicles, have commonly seen in slag cakes formed during modern experimentation with the processes known as hearth refining or the Evenstad Process (author's unpublished research). This technique involves the melting and reforming of the bloom in a hearth with a strong air blast. This process may be used to achieve several different effects, but is most commonly applied to reduce the phosphorus content of iron (particularly in iron smelted from bog iron ore) or to recycle small iron scraps from the smelting process. The use of the process was documented by Evenstad (1790) for its use in dephosphorising iron, but similar techniques may also be used to control carbon (Jenson 1968, Sauder 2013, Wagner 1990). The earlier use of the technique remains unknown, although it has been surmised to be the reason behind the formation of some large SHCs (or SHC-like cakes) from the early medieval and medieval of Ireland (e.g. Young 2011a). The use of such a process at Widecombe is far from certain, but it remains a possibility.

Hearth lining: some 560g of slagged hearth lining (16 pieces) were recovered from context (123). The pieces were all backed by oxidised-fired hearth ceramic – typically of a silty matrix with coarse sand and granitic gravel. Some of the pieces had a suggestion of sloughed partially-melted material passing down the wall and over an overhanging margin, but the fragments were too small to determine the full geometry of such variation. None of the fragments showed evidence for a blowhole. Assemblages rich in hearth lining have rarely been deposited far from their source.

Indeterminate iron slag: some 176g (2 pieces) from context (123) and three unstratified pieces (total 242g) were strictly indeterminate. One piece, a 44g thin folded sheet from context (123) was not from a SHC, but the others were all compatible with being fragments of SHCs. The thin sheet had probably formed against the hearth wall and had been pealed from its substrate.

Tin smelting:

Tin smelting slags were only present amongst the unstratified material.

The tin slags are all dark glassy materials, although the proportion that is clear translucent glass varies between pieces; some are probably largely microcrystalline. The pieces are all fragments of sheet-like bodies. The thicker pieces show a higher degree of deformation (compatible with the scraping of highly viscous material from the surface of a float), but the thinner pieces tend to be more planar. The deformation includes both the folding of the sheets and generation of a fibrous structure caused by the elongation of a highly viscous melt.

Several of the thin pieces show an almost perfectly planar face, indicating survival of the face that was in contact with the molten tin in the float. Some of these show tiny patches of crystals on the contact surface, possibly a devitrification feature, and probably indicating the presence of particulate material (as seen on the base of the glassy sheets at Brownie Cross; Young & Taylor 2017).

Interpretation

This assemblage contains two distinct components – ironworking residues present both in fill (123) and amongst the unstratified material, and tin smelting residues, present only in the unstratified collection.

Ironworking:

The ironworking residues are mainly identifiable as smithing hearth cakes, accompanied by fragments of hearth lining. The seven examples of SHCs that are complete, or for which the original weight may be reasonably closely estimated, have a range of 98g to 2215g, with a mean of 772g. If the unusual 98g probable SHC is excluded, then the range is 354g to 2215g with a mean of 884g. Clearly an assemblage of only 6 or 7 items is not sufficient for the generation of robust statistics, but these parameters for the weight-frequency distribution are, nonetheless, striking.

SHCs with weights above 1kg are relatively rare in assemblages from Britain. They occur almost entirely on sites with a specialist bloom smithing operation. Such sites are an integral part of the iron production process and often occur in central places, fed by bloomery iron smelting in their associated hinterland.

Large SHCs are known, for instance from the Middle Iron Age site at Tregurra, Cornwall, where a small assemblage had a range of weights from 890g – 2050g (Young 2016b). The Middle Iron Age iron smelting site at Folly Court, Wokingham (Young 2018b), produced only a very small assemblage of smithing slags, but the likely range of weights was from 332g to 1120g. A Late Iron Age site at Kingstone, Herefordshire (Young 2012) produced fifteen SHCs with weights from 230g up to 1035g with a mean of 565g. A late Roman assemblage from Miskin, Glamorgan produced a large number of fragmented cakes, mostly with original weights in the 1000 – 2000g range (author's unpublished observations) and a Roman assemblage from Dymock, Gloucestershire, had examples ranging from 112g – 3885g with a mean of 1032g (Young & Kearns 2010). A large assemblage (103 examples) of SHCs from an undated but probably early medieval site at Burlescombe, Devon, ranged from 68g – 3115g with a mean of 510g (Young 2018a). A much smaller assemblage, probably of slightly later, 11th century, date than Burlescombe, from South Hook, Pembrokeshire, ranged from 756g – 1440g, with a mean of 958g (Young 2010a,b)

In contrast, for assemblages from blacksmithing sites the maximum SHC weight typically lies in the 600g – 850g range with means of 220g – 350g, except for some rural sites apparently engaged only in intermittent light work, for which the maximum SHC weight may be rather less (e.g. Young 2016a, table 3). A few later medieval assemblages supposed to be from blacksmithing do contain some larger SHCs (up to 1500 – 1800g at sites like Worcester Deansway (McDonnell & Swiss 2004) and Burton Dassett (McDonnell 1992)). It is unclear, however, to what extent the high weights of these late SHCs were due to the processing of larger pieces of iron or whether these particular forges were supplied with only partly-refined metal requiring further working by the smith.

The assemblage from Widecombe is thus almost certainly from bloomsmithing, but the date is less certain; the SHCs are compatible with an age from prehistoric to medieval. A very slight clue may be afforded by the prominent tool marks on the base of some of the SHCs; similar toolmarks are particularly common amongst Roman bloomsmithing (and sometimes blacksmithing) slags of the Bristol Channel area (e.g. at Kingswood, Young 2017, and Frocester Court, Price 2000 figure 5.3), although elsewhere they may occur more widely.

It may be significant that although eastern Dartmoor is not generally considered a signficant centre for ancient iron production, there are both suitable, exploitable resources and some evidence for exploitation. The nearest described iron ores are at Holwell, E of Widecombe, where Dines (1956, p731) listed evidence of surface working of veins with specular haematite. More extensive iron ore veins are known from the area N of Bovey Tracey (Dines 1956, Map XII), but these are probably rather too distant to be relevant here. A site of Iron Age date at Twinyeo Farm, downstream of Bovey Tracey produced evidence for iron smelting (Young 2014), but it was believed more likely that a bog iron ore source as employed than a rock ore. Iron smelting of uncertain age was represented by a slag-pit type furnace (a type employed in both the Iron Age and early medieval period) discovered near Porthworthy (Young 2011b), which also produced slags compatible with a bog ore source. Closer to the present site is the site of Kestor, excavated by Fox (1954) and although originally interpreted as Iron Age, recent reinvestigation of the finds by Peter Crew has produced a 14C date of the early medieval period (Beta-202300; Cal AD 420 – 640) for the ironworking. The residues from Kestor are problematic, but probably include iron smelting slags and iron ores of the same general type as also occur at Holwell.

Tin smelting:

The tin smelting slags are all in the form of thin glassy sheets. Some of these show a degree of deformation, but others show one perfectly flat face, indicative of cooling upon the surface of the tin. Conventional wisdom was that the use of a float to separate the tin and slag was a development that accompanied the introduction of the water-powered blowing house with its float – a development attributed to the early post-medieval period. Recent work at Brownie Cross, to the SW of Dartmoor (Taylor *et al*. 2014, Young & Taylor 2017) has provided strong evidence for the use of the floatstone from at least the 14th century and its was argued that the introduction of the use of the float may have been the reason behind 13th century legal changes. The glassy sheets of the present assemblage re very similar to examples from Brownie Cross.

The method of the collection of the tin, and its separation from the slag, from smelting furnaces prior to the 13th century remains unknown. Most early processes known for the smelting of non-ferrous metals entail gravity separation of the metal into the base of the smelting furnace, but not the tapping of the liquid metal from the furnace into the forehearth or float. In such cases, any slag resting on the surface of the metal might be expected to be in contact with the overlying fuel and therefore able to be discriminated from slags of the later process. However, in the absence of hard evidence, that remains conjecture.

The present material is therefore most likely to post-date the 13th century, although an earlier date cannot entirely be excluded. The slag is also compatible with that produced in the later blowing houses up until the 18th century, but more recent techniques produce rather different residues. The site lies downstream of the area exploited by the Birch Tor and Vitifer mines and thus the valley is likely to have been a good potential source of alluvial ores.

Further work

The stratified iron working slags are of importance, for they indicate a previously unknown location for iron production. Further work could clarify the nature of the iron being worked (i.e. the type and perhaps provenance of the ore). An investigation for this purpose should include a modest suite of bulk chemical analyses of representative SHCs and hearth lining.

A further question is raised by the possible identification of some of the SHCs as having been produced during hearth refining. This question would be partially addressed by the bulk chemical analyses, but would also require microstructural investigation by the electron microscopy.

The value of any further work on the iron slags would be greatly enhanced if they can be dated, so the extraction of charcoal would also be a priority.

The tin slags are only dateable within the broad range discussed above and because of this their further investigation would probably be of reduced value. No further action is recommended with the tin slags.

References

DINES, H.G. 1956. *The metalliferous mining region of South-West England*. British Geological Survey.

EVENSTAD, O.1790. Afhandling om Jern-Malm, som finds i Myrer og Moradser i Norge, og Omgangsmaaden med at forvandle den til Jern og Staal. Et Priisskrift, som vandt det Kongelige Landhuusholdnings-Selskabs 2den Guldmedaille, i Aaret 1782, *Det Kongelige Danske Landhuusholdnings-selskabs Skrifter,* **D.3**: 387-449 + Tab. I-II.

FOX, A. 1954. Excavations at Kestor, an early Iron Age settlement near Chagford, Devon. *Transactions of the Devon Association for the advancement of Science*, **86**, 21–62.

JENSEN, N.L. 1968. "A treatise on iron ore as found in the bogs and swamps of Norway and the process of turning it into iron and steel", Abridged translation of Evenstad 1790. *Bulletin of the Historical Metallurgy Group*, **2**, 61-65.

McDONNELL, J.G. 1992. The identification and analysis of the slags from Burton Dasset, Warwickshire, Ancient Monuments Laboratory Report, 46/92.

McDONNELL, J.G. & SWISS, A. 2004. Ironworking residues. pp. 368-378, *in:* H. Dalwood & R. Edwards, *Excavations at Deansway, Worcester, 1988-89: Romano-British small town to late medieval city*. CBA Research Report 139.

PRICE, E. G. 2000. *Frocester: A Romano-British settlement, its antecedents and successors*. Gloucester and District Archaeological Research Group.

SAUDER, L. 2013. Making steel in the 'Aristotle furnace'. *In:* D. Dungworth and R.C.P. Doonan (eds) *Accidental and Experimental Archaeometallurgy*. Historical Metallurgy Society, Occasional Publication No. 7, 107-110.

TAYLOR, S.R., JONES, A.M. & YOUNG, T.P. 2014. Smelting point: archaeological investigations along the route of the Avon Water Main Renewal, Plympton, Devon 2009. *Proceedings of the Devon Archaeological Society*, **72**, 187-276.

WAGNER, D.B. 1990. Ancient carburisation of iron to steel: a comment. *Archeomaterials*, **4**, 111-117.

YOUNG, T.P. 2009. The Iron Slag, p. 121-123, *in:* P. Manning & H. Quinnell, Excavation and field survey at the Iron Age hillfort of Berry Ball, Crediton Hamlets. *Proceedings of the Devon Archaeological Society*, **67**, 99-132.

YOUNG, T.P. 2010a. Archaeometallurgical residues from the South Hook LNG Terminal. *GeoArch Report 2010/03*, 54 pp.

YOUNG, T.P. 2010b. Archaeometallurgical Residues. Pp. 158-163 *in:* Crane, P & Murphy K., Early medieval settlement, iron smelting and crop processing at South Hook, Herbranston, Pembrokeshire, 2004–05. *Archaeologia Cambrensis*, **159,** 117-196 .

YOUNG, T.P., 2011a. Archaeometallurgical residues from the N7 Castletown to Nenagh scheme, Camlin 3 (E3580), Co. Tipperary. *GeoArch Report 2011/23*. 62 pp.

YOUNG, T.P. 2011b. Archaeometallurgical residues from field D5, near Porthworthy, Shaugh Prior, Devon (Avon SWW Pipeline). *GeoArch Report 2011/41*. 23 pp.

YOUNG, T.P. 2012. Archaeometallurgical residues from the Brecon to Tirley gas pipeline. *GeoArch Report 2012/18*, 75pp.

YOUNG, T.P. 2014. Archaeometallurgical residues from Twinyeo Farm, Devon (ACD170/ACD504). *GeoArch Report 2014-10.* 52pp.

YOUNG, T.P. 2016a. Assessment of archaeometallurgical residues from Tidworth, Wiltshire (ACW338). *GeoArch Report 2016//20*. 11pp.

YOUNG, T.P. 2017. Ironworking residues from Kingswood, Gloucestershire (ACW451). *GeoArch Report 2017/06*, 93pp.

YOUNG, T.P. 2016b. Ironworking residues from Tregurra, Truro, Cornwall. *GeoArch Report 2016/38*. 125pp.

YOUNG, T.P. 2018a. Assessment of archaeometallurgical residues from Burlescombe (ACD1753 & ACD1767). *GeoArch Report 2018/11*, 20pp.

YOUNG, T.P. 2018b. Archaeometallurgical residues from Folly Court, Wokingham, Berkshire. *GeoArch Report 2018/15*, 124pp.

YOUNG, T.P. & KEARNS, T. 2010. Evaluation of archaeometallurgical residues from Kyrleside, Dymock, Gloucestershire (32523 & 33787). *GeoArch Report 2010/19*, 5pp.

YOUNG, T.P. & TAYLOR, S.R. 2017. 'Wolf rahm': archaeological evidence for the veracity of an old term. *Historical Metallurgy,* **49** (for 2015), 96-109.

Table 1: summary catalogue of submitted materials.

Context	Item wt (g)	Piece No.	Notes
123	2215	1	170x140x90mm, rather irregular biconvex mass, base is finely dimpled with small voids, top as inclined surface of very slightly lobed smooth surface, almost certainly large SHC, but if lobed surface was originally horizontal it could just be from the margin of a FB
	650	3	120x(100)x45mm, approximately 80% of cake (original therefore 810g), top smooth with slightly eroded-appearing dimples, top smooth to locally matt, small area of unroofed cavity, other side of cake is dense and solid, vesicular areas towards base mainly, including irregularly rounded cavities and very fine tubular
	676	1	80x110x45mm, SHC deepest on proximal side where there are two parallel tool marks on base, suggesting use of a poker from slightly to RHS of axis of hearth, and inclined outwards upwards. Base rough, finely dimpled, top smooth, slightly dimpled, unroofed cavities
	866	1	115x110x60mm, asymmetric SHC, probable proximal side has raised lip of glassy sandy lining-dominated material, this passes downwards into main dense crust of the slag, 10-15mm thick, this is overlain by rather variable slag, lining influence and vesicular proximally, but apparently dense distally, overlain in turn by tap slag like dense slag dribbles. Distal end is rough - unclear if a steep termination or a fracture. Overall form shows some similarity to the 2215g block above, although even less likely to be interpretable as a smelting slag.
	560	16	fragments of similar, but only locally joinable, vitrified and slagged oxidised lining. Lining is dominantly fine grained (silty) but has some sand and locally angular gravel-grade grains of granitic origin. The thickness of slag is very variable, but some pieces indicate a high degree of down wall sloughing, with some pieces suggesting the sloughed material sliding over an overhanging lip.
	132	2	two rather strongly rusted slag fragments, origin uncertain, but both may have contained metallic iron
	98	1	small, slightly irregular mass, probably small SHC, 50x65x35mm, wall contact slightly lobate, top glassy proximally but more maroon with and grains distally,
	44	1	slightly folded thin (mostly 3mm) dense slag sheet, unclear if folded on extraction or formed around a large cavity, probable wall contact on one side.
	334	1	very irregular piece, appears to be approximately one half of SHC with a poker tool mark extending steeply down for 50mm, but attitude is not certain, base rough, finely dimpled, SHC has dense 10-20mm crust, but original form and size uncertain.
	354	1	100x90x45(55) (l x w x h(b)), SHC, rather low density, vesicular, fragmented, base dimpled finely, top mostly glassy and smooth but rather irregular (adding lining material?).
	54	1	marginal fragment from small dense SHC (closely resembles broken margin on 676g block above, but does not join)
	384	1	rather accreted block, round, probably an accreted SHC rich in metallic iron, 70x100x40mm.
u/s	216	2	slightly worn dense iron slag fragments. Neither properly identifiable but both very similar to the stratified dense SHC material
	26	1	fractured fragment of dense slag. Probably an iron slag, slightly weathered
	20.2	4	fragments of glassy slag sheets, 2-5mm thick, one surface with striations and slightly irregular, the other smooth, locally with tiny iridescent areas of devitrification in small clusters. Tin smelting slag
	39.2	4	fragments of three glass sheets, thicker than above with at least one wrinkled surface and all somewhat folded. Tin smelting slag
	5.3	2	fragments of 2-4mm thick glassy sheet with strong fibrous texture, locally with quartz grains. Tin smelting slag

Table 2: Comparison of the SHC weight-frequency distribution with that of other assemblages containing large SHCs, for discussion see text. Weights in gram.

Site:	Tregurra	Folly Court	Kingstone	Dymock	Burlescombe	South Hook	Worcester Deansway (period 8)	Worcester Deansway (period 9)	Burton Dassett	Widecombe
Reference:	Young 2016b	Young 2018b	Young 2012	Young & Kearns 2010	Young 2018a	Young 2010a,b	McDonnell & Swiss 2004	McDonnell & Swiss 2004	McDonnell 1992	This report
	MIA	MIA	RB	RB	EM?	11th	11th – 13th	13th-15th	14th- 15th	?
count	4	3	15	10	103	5	61	32	60	6
min. wt	890	361	230	112	68	756	168	144	130	354
max. wt	2050	1120	1035	3885	3115	1440	1490	1800	1670	2215
mean wt	1284	704	565	1032	510	958	492	499	550	884
% <150g	0%	0%	0%	20%	15%	0%	-	-	-	0%
% <500g	0%	33%	47%	60%	65%	0%	-	-	-	33%
% >1000g	50%	33%	7%	20%	11%	40%	-	-	-	17%
% >3000g	-	-	-	10%	2%	-	-	-	-	-

GeoArch

geoarchaeological, archaeometallurgical & geophysical investigations

Unit 6, Block C,
Western Industrial Estate,
Caerphilly,
CF83 1BQ

Office: 029 20881431
Mobile: 07802 413704

E-Mail: Tim.Young@GeoArch.co.uk
Web: www.GeoArch.co.uk