GeoArch

Report 2010/19

Evaluation of archaeometallurgical residues from Kyrleside, Dymock, Gloucestershire (32523 & 33787)

Dr Tim Young & Thérèse Kearns

27th July 2010

Evaluation of metallurgical residues from Kyrleside, Dymock, Gloucestershire (32523 & 33787).

Dr T.P. Young & T. Kearns

Abstract

Despite being a fairly small assemblage (38.6kg), the residues from site revealed a wide range of metallurgical activities, including iron smelting, iron smithing, the casting of copper-alloy artefacts and the small-scale extraction of silver from base metals. It is argued that this range can be resolved into two areas of activity: the primary production of iron, including both smelting and bloomsmithing, and the casting of copper-alloy artefacts, probably with a silvered finish.

Iron smelting was undertaken in a slag-tapping furnace, although the proportion of slags tapped to those which cooled within the furnace appears quite low. The site lacks the abundant dense tapslag seen in other places. Iron smithing is evidenced by large smithing hearth cakes, some of which are controversially large. This suggests the smithing was bloomsmithing, the refining of the smelted blooms, rather than blacksmithing, the production of finished artefacts.

One pit produced evidence for non-ferrous metalworking in the form of moulds for casting small artefacts and cupels (or heating trays), probably used to extract silver from copper-containing materials, perhaps coins. A previous excavation some 250m from the present site has already produced evidence for the casting of brooches, some of which appeared to have been silvered. The present material meshes well with that account, despite the distance between the locations. Most of the material was contained within a small number of cut features, none of which appears to have been of directly metallurgical origin. It is therefore not known with certainty whether the metalworking was undertaken within or close to the present site.

Material from medieval contexts was biased towards small fragments of dense tapslag, which are very resistant to physical and chemical weathering, so are probably residual.

Contents

Methods

All investigated materials were examined visually using a low powered microscope where necessary. All materials were summarily described and recorded to a database (Table 1). As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Results

Description of the residues

The slag from this site was generally rather poorly preserved. This makes identification of the materials rather difficult, for not only is the slag degraded, but the iron released by that weathering has allowed the formation of secondary concretionary growths coating the surfaces of much of the much of the assemblage.

Iron Smelting Residues

Iron smelting is represented by approximately 14kg of material. The residues from smelting fall into two classes: those which cooled inside the furnace and those which cooled outside.

The slags that were tapped from the furnace to cool outside are typically in the form of solidified rivulets, often amalgamated into larger bodies, often formed of dense slag with a maroon-purple surface, indicative of the formation of a haematite veneer to the flow under the oxidising conditions after the slag left the furnace. The present assemblage, however, actually contains rather little of what is often considered "typical" dense tapslag. Here instead the prills are wide, often of rather high convexity, with a large internal porosity giving them a low overall bulk density. There are no substantial tapslag cakes as found on other sites. There are a large number of small crude "runners" of slag, which may indicate tapping of the furnace through rather small channels, or may just reflect the rather limited quantity of slag being tapped.

The slags which solidified inside the furnace are apparently represented by a variety of slags with various textures ranging from dense, homogeneous slags with low vesicularity, through lobate materials suggestive of flow down through the fuel bed, to slags with a very high proportion of charcoal.

A large (240x190x120mm; 5250g) slag block from c112 shows a markedly more angular and more coarsely prilly lower surface than in those large slag blocks identified as smithing hearth cakes. If the most prilly face is oriented horizontally, then the piece may have formed a wedge-like block against the wall below the blowhole and the back wall of the furnace. This sort of large slag block forming in this position is sometimes termed a "furnace bottom" (although that term is probably not used, because of confusion with the residues in non-slag tapping furnaces). Another smaller fragment of a similar block may be represented by a 950g block from c121.

Iron Smithing Residues

Material derived from possible smithing activity is less well defined within this assemblage. There are ten certain or possible smithing hearth cakes (SHCs). This assemblage is too small for meaningful statistical comparison with assemblages from other sites, but none the less some comment may be made.

The examples of which the identification is most certain are of moderately large size, ranging from 410-950g (410g, 444g, 450g, 475g, 686g and 950g; from contexts c121 and c132). The multiple examples in the range of 400-500g provide a hint that these were the products of a repeated activity.

Two smaller examples were recovered, one each from contexts c122 and c132. Identification of small SHCs, particularly where the cakes are rather prilly and in a rather poor state of preservation, as here, is difficult, but these appear reasonably certain. The weights of these two are 112g and 122g.

Two large cakes have also been identified as SHCs. These two examples, both from c121, are rather similar, having a broadly similar size (sub-circular, 170-200mm across and 110-130mm deep, of which the bowl comprises 80-90mm) and weight (2785g and 3885g), as well as similar textures (both showing rather prilly bases and more charcoal-rich upper parts), and both have a pad or wedge of denser slag on the upper surface. The bowl of these examples is much more symmetrical that that of the possible "furnace bottom" described above (so that interpretation of these as inclined 'foot-of-wall' wedges is not plausible), and the prilly basal parts of formed of prills that are quite small, and of a similar size to those in some of the smaller SHCs.

Incomplete SHCs are very difficult to distinguish from the furnace slags, so only a small proportion of the identified smithing residues are fragmentary, and therefore a significant proportion of the indeterminate slags are likely to be from smithing.

Smithing microresidues, including hammerscale, were not systematically sampled on the site, but were occasionally observed attached to fragments of SHC (c121 and c132). Fragments of concretion rich in hammerscale were recorded from c1038 and c1039.

Lining slag

Small fragments of iron-poor glassy slag, derived largely from the melting of the hearth or furnace wall were recovered from contexts c1038 and 1039.

Indeterminate iron slag

Approximately 8.3kg of slag has been classified as indeterminate. These are fragments with no distinctive morphology and may be derived from either smelting or smithing. This is a particularly problem with this assemblage since charcoal rich slags with a basal crust may form in both smithing hearths and smelting furnaces, and their differentiation on fragmentary material is not possible.

Technical Ceramics

Ceramic moulds
Approximately 14 mould fragments (80g) were among the assemblage. These were predominately pale grey to pale orange in colour and manufactured from fine mica-rich clay. The fragments were quite worn however three fragments retained some impression of the object to be cast.

Fired clay
Small amounts of fired clay were retrieved from different context across the site. The most substantial quantities were recovered in context 121 which also yielded the majority (18.5kg) of the residues. This included 326g of oxidised fired material which was quite friable and lightly vitrified in areas.

566g appeared to be a different type of clay and was pale grey in colour with an occasional pale green hue. Several areas had a frothy texture and a number of pieces had small quantities of slag attached.

Cupels/Heating trays
Also present were 7 fragments (104g) of possible cupels or clay-lined cupellation hearths (possibly equivalent to objects sometimes called "heating trays". These were manufactured using fine clay similar to that used in the moulds. Their upper surfaces contained a thin white layer of residue and occasional droplets of corroded copper or copper alloy. A tiny droplet of what appears to be silver was visible on the surface of two fragments.

The process of cupellation was used to recover silver from argentiferous lead or alloys containing base metals. It works on the principle of selective oxidation, whereby, lead and any other base metals oxidise forming litharge which is absorbed into the fabric of the cupellation hearth leaving silver (or gold) on the surface. To recover, for instance silver, from a copper alloy-silver mixture, the material would be melted with an excess of lead, which carries the other base metals into the litharge, leaving the silver.

They were often manufactured using an upper lining of bone-ash (calcium phosphate), which is refractory, porous and absorbent (Tylecote 1986, 60), although for small quantities of metal simple clay cupels could be used, for the litharge reacts with silica in the cupel to form a slag. It is not clear whether a distinct base of these specimens is preserved (meaning they would be cupels), or whether the clay was simply pressed into a hearth (forming a heating tray).

Cupellation in cupels may also be used, in addition to small-scale extraction of silver from base metals for practical uses, as a means of assay silver content.

Other ceramic: probable pottery
Two contexts contained ceramic material that did not appear to be of metallurgical nature. Both contexts were of porous, so probably decalcified, degraded pottery.

Context 73 yielded approximately 50g of ceramic fragments, all of which are planar in form with no diagnostic pieces present. They appear to have been reduced fired but are buff coloured on their inner surfaces. The material was highly porous which may be the result of weathering of a limestone temper. 2 fragments (9g, 5g) from the same context are better preserved and contain small black inclusions.

A further 69 fragments (251g) were retrieved from context 83. These were extremely weathered, friable and highly porous, again likely to be due to weathering of limestone temper. This material appears to be similar to the fragments from context 73 but their poor state of preservation makes this difficult to confirm.

Corroded iron and iron rich concretions

Approximately 190g of concretions surrounding corroded iron objects among the assemblage. In some cases these were recognisable as fragments of nails, however other fragments were corroded beyond recognition.

Distribution of residues

Metallurgical residues were recovered from a number of features across the site, primarily from phase 1 of the project.

Phase 1 - 32523

The majority of residues related to iron smelting and iron working (19.6kg; of which 7.7kg appears to have been from smithing) were recovered from deposits (121 & 122) in pit [129] which measured 2.7m long, 1.06m wide and 0.3 m deep. It's likely that all of this material is *ex-situ* and that the pit functioned as a disposal area for the iron smelting residues.

The northern end of [129] was cut with a small, steep sided pit [130], measuring 0.66 in diameter and 0.62m deep. This was filled with two deposits, (131 &132) which contained 107g of fired clay, 8.6kg of slag (of which approximately 4.2kg was composed of probable fragments of SHCs) as well as a small amount of flake hammerscale.

Overall, the different types of residue were recovered in very similar proportions from the fills of [129] and [130].

5.3kg of slag was recovered from deposit (112) in pit [111] which measured 0.7m in diameter and 1.06m in length, but this was just two pieces, both of furnace slag.

The ceramic mould fragments and the cupellation material were uncovered from deposits (119) within pit [113] which measured 1.52m in diameter and 0.48m deep. As well as the material seen here, the deposit also contained animal bone, waste metal including copper alloy pieces, fragments of nails, a piece of lead and a piece of waste enamel.

69.5g of weathered ceramic material was recovered from deposit [73] which was a fill of a pit [72] measuring 1m in diameter and 0.3m deep, this was cut by a smaller pit [75].

Some 251g of badly weathered pottery was retrieved from feature [82], which measured 0.24m in diameter and 0.05m deep, which was filled with the intact base of a pot. This appears to have been dug purposely to hold the pot and it was found to contain hammerscale – however quantities are unknown. .

Phase 2 – 33787

2.4 kg of residues were recovered from phase 2 contexts. Ditches [1019], [1021], [1052] and [1054] yielded a total of 2.3kg of mostly indeterminate slag and 260g of residues was recovered from a pit [1038].The material from this pit included several fragments containing hammerscale (either forming the bulk of small concretions or attached to the surface of slag specimens), and it is possible that the pit contained more smithing micro-residues than realised.

Interpretation

No certain metallurgical structures were identified, but the quantity and distribution of residues suggests that the activity was relatively local. Metallurgical activity, or at least waste disposal. appears to have been focused in two principle areas within phase 1 of the site (32523).

The slag residues are suggestive of iron smelting within a slag-tapping furnace. The quantity of slag formed within the furnace is notable. Some other investigations of smelting sites using Forest of Dean iron ores have also recorded a high ratio of furnace slags to tap slags (Fulford & Allen 1992; Young 2006).

Smithing activity is represented alongside the smelting residues. The slag cakes are relatively large. Two SHCs fall into the size range normally associated with Romano-British blacksmithing; available data (e.g. Crew 2003; Young 2005, 2006, 2009) suggest that SHCs from blacksmithing at this period have a range from approximately 80-800g, with a mean size of 230-330g. The other cakes are larger, with a range from 410g to 950g, with two outliers at 2.8kg and 3.9kg. It is suggested that these large cakes were produced during bloom refining (bloom smithing or primary smithing). Much fewer comparative data are available for bloomsmithing residues: at Caerwent (Young 2006) they were "moderately large, ranging up to about 1kg in weight", whereas at Miskin they were frequently in the 2-3kg range (author's unpublished data). Identification of the Miskin examples as smithing slags was straightforward, both because of the morphology and because of compelling trace-element chemical studies (Thomas 2000; author's unpublished data).

However, early attempts to define SHCs frequently assigned, or implied, a much lower upper limit to their size. For instance Crew (1996) described SHCs as ranging from "100g or so to more than 2kg, but the majority seem to be between 200 and 500g" and (1995) stated that furnaces bottoms weighed "from 2kg upwards". Some recent accounts may have interpreted these discussions too tightly, and recent attempts by Allen (2009, 2010) to describe non-slag tapping furnaces from the Romano-British period around the Severn Estuary are probably erroneous, for the so-called furnace bottoms of his papers (mainly with weights less than 1kg) are extremely similar to the SHCs from bloomsmithing at Miskin and elsewhere.

The two large probable SHCs from Dymock are not identical to those from Miskin, but given the wide range of morphology exhibited by smaller SHCs depending on hearth configuration, hearth wall chemistry, fuel and precise technique employed, they fall within a similar potential range of variation and may be interpreted as SHCs with reasonable confidence.

The similar proportions of the different residue classes in the deposits of contexts c121 and c132 (Table 2) suggests that both contexts are samples of waste from a similar range of processes, and the most likely interpretation is that both batches of waste derive from a workshop engaged in the smelting of iron to produce blooms and the primary refining of those blooms to bar iron. Only a small amount of material appears to potentially relate to blacksmithing (the production or repair of artefacts), and even the small SHCs might possibly relate to the late stages of finishing bar iron.

Non-ferrous activity, or at least the disposal of non-ferrous metalworking waste, appears to have been concentrated in the north-eastern section of the site, in or around pits [72], [75], [113], [115] and [117]. The material uncovered suggests that copper alloy was being cast into artefacts (the manufacture of brooches is a possibility but is not proven) and that silver was being refined by cupellation on a small scale.

Most of the mould fragments were non-diagnostic, however at least two appear very similar to some of the fragments excavated previously at the Sewage Treatment Works in Dymock. The mould fragments seen at that site may have been used in the manufacture of trumpet brooches or possibly Colchester derivative brooches (Dungworth 2007). These types of moulds are likely to have been two piece moulds, however not enough material remains to allow reconstruction.

The refining of silver may also have been connected to brooch manufacture. Previous studies at the Sewage Treatment Works in Dymock (Catchpole 2007) uncovered evidence that some brooches were being coated with white metal (possibly silver) which may explain the use of cupellation here. While cupellation is often used on a larger scale to retrieve silver from argentiferous lead, the presence of copper in the cupellation hearth material suggests that a copper/silver rich alloy was being refined and one possibility is that silver was being extracted from coins. Another alternative possibility is that cupellation was used to recover silver from sub-standard products, for recycling. The piece of lead found among the scrap metal and other material in context (c119) may also have been associated with the cupellation process, although other purposes are, of course, possible.

The use of cupels in this manner is very well known from the early medieval onwards (e.g. Soderberg 2004), but has not been widely recognised in Romano-British contexts, although comparable material has been described from Germany (Rehren & Klaus 1999).

For a small site, the Kyrleside locality yielded evidence for a wide range of metallurgical activities. There was no certain evidence that any of the activities were undertaken within the bounds of the site, although that may have been the case. Alternatively, the site may have been purely employed for the disposal of waste from activities elsewhere. The relatively low density of the residues on the site may, perhaps, fit best with the site being used sporadically for disposal of waste produced elsewhere.

The two metallurgical industries represented are, therefore, the primary production of iron (smelting and bloom refining to bar iron) and copper alloy artefact casting (possibly also involving sliver coating). The first of these means that Dymock can be related to a very large number of sites, lying in a hinterland extending as much as 50km way from the Forest of Dean iron ore sources, at which iron was produced during the Roman period. This diffuse hinterland may reflect various economic factors, including the pre-existing location of settlement and the distribution of managed woodlands. The copper-alloy based industries, on the other hand, do not represent utilisation of a local resource, for the metals all need importing from other areas. Indeed, it is quite likely that such an industry would have relied heavily on the recycling of material. It is therefore not clear why such an industry should be established in Dymock. The evidence for such activity at Kyrleside is remarkable, for it is over 250m from the related activity at the sewage works (although the dispersed nature of industrial activity at other sites, including nearby *Ariconium* is noted).

Evaluation of potential

The ferrous metallurgical residues contain an interesting suite of materials, apparently representative of both smelting and bloomsmithing. Such material are capable of providing considerable nature about the production and efficiency of the processes involved, and normally further detailed analysis of the specimens would be recommended. A usual recommendation in such circumstances would be for a suite of analyses of both groups of materials, so that a firm relationship between them can be confirmed and quantified. A further possible use for analysis would be to investigate the possible relationship between the smelting materials and the piece of iron ore recovered, and to attempt to provenance the iron ore.

In this case, however, the rather poor preservation of the slags renders it uncertain whether they could provide sufficiently unaltered analytical data to support such an investigation. If such fresh slag is contained, however, within the weathered exterior of the blocks (and only cutting the blocks can confirm this), then analysis (both chemical and microstructural) of a suite of the materials is recommended.

Investigation of the cupels should be continued with a typological investigation of the sherds, which should be illustrated in any published report. Further detailed analysis of the cupel fragments is also certainly recommended, to confirm the nature of the refined metal and to evaluate the likely composition of the initial alloy. Although there is only a small amount of material, this process is unusual for Roman Britain (or at least it is unusual to have been recognised), and particularly in view of the data from the Sewage Works site, there is great potential to throw light on an interesting industry.

References

Allen, J.R.L. 2009. Romano-British iron-making on the Severn Estuary: towards a metallurgical landscape. *Archaeology in the Severn Estuary*, **19**, 73-79.

Allen, J.R.L. 2010. The alkali-metal ratio in Roman British bloomery slags. *Archaeology in Severn Estuary*, **20**, 41-45.

Catchpole, T. 2007, Excavations at the Sewage Treatment Works, Dymock 1995, *Transactions of the Bristol and Gloucestershire Archaeological Society*, **125**, 137-219.

Crew, P. 1995. *Bloomery iron smelting, slags and other residues*. Historical Metallurgy Society, Archaeology Datasheet No. 5.

Crew, P. 1996. *Bloom refining and smithing, slags and other residues*. Historical Metallurgy Society, Archaeology Datasheet No. 6.

Crew, P. 2003. Slags and other iron-working residues. pp. 333-340 *in:* H. James, *Roman Carmarthen: Excavations 1978-1993*. Britannia Monograph Series 20, Society for the Promotion of Roman Studies 2003.

Dungworth, D. 2007. Slags and Moulds. *In:* Catchpole, T. 2007, Excavations at the Sewage Treatment Works, Dymock 1995, *Transactions of the Bristol and Gloucestershire Archaeological Society*, **125**, 183-186.

Fulford, M.G. and Allen, J.R.L. 1992. Iron-making at the Chesters villa, Woolaston, Gloucestershire: survey and excavation 1987-91. *Britannia*, **23**, 159-215.

Rehren, T. & Kraus, K. 1999. Cupel and crucible: the refining of debased silver in the Colonia Ulpia Traiana, Xanten. *Journal of Roman Archaeology,* **12**, 263-272.

Söderberg, A. 2004. Metallurgic ceramics as a key to Viking Age workshop organisation. *Journal of Nordic Archaeological Science,* **14**, 115–124.

Thomas, G.R. 2000. *A chemical and mineralogical investigation of bloomery iron-making in the Bristol Channel Orefield, UK* . Unpublished PhD Thesis, University of Wales Cardiff

Tylecote, R. F. 1986. *The Prehistory of Metallurgy in the British Isles*,The Institute of Metals, London.

Young, T.P. 2005. Evaluation of metallurgical residues from Marsh Leys Farm. *GeoArch Report 2005/07*. 10pp.

Young, T.P. 2006. Archaeometallurgical residues from the Caerwent Forum-Basilica. *GeoArch Report 2006/01.*

Young T.P. 2009. Archaeometallurgical residues from Crickhowell Road, Trowbridge, Cardiff. *GeoArch Report 2009/02*. 11pp.

Table 1: Summary catalogue of residues from Kyrleside, Dymock.

Context	***Weight (g)***	***Description***
32523 - phase 1		
5	12	1 fragment of flowed tapslag
7	32	3 fragments of flowed tapslag
11	300	4 fragments of indeterminate slag, all rather dimpled (208g); 4 fragments of flowed tapslag (56g); 1 piece (36g) of maroon, dense, tapslag-like material in very thin layer adhering to grey fired clay or rotten stone
15	207	1 fragment of tapslag, flowed on upper surface, vesicular base
21	250	5 fragments of tapslag, flowed upper surfaces with purple to red tinge, one of which suggest flow around charcoal; 5 fragments of indeterminate slag; 1 concretion around corroded iron (in 2 pieces)
73	50	c.24 fragments of ceramic, reduced fired on one side, buff colour on the other, they appear to have been tempered with limestone which has weathered out leaving tiny voids in the fabric, also very occasional quartz - all fragments are more or less planar - no diagnostic pieces present. Probably domestic pottery.
73	9.5	2 small ceramic fragments with small black inclusions. Probably domestic pottery.
73	10	2 small fragments of oxidised fired clay; one side has thin veneer of grey smooth micaceous clay, but bulk is formed of irregular siltstone fragments in breccia fabric (cf. material from c119).
83	251	c. 69 fragments of reduced fired ceramic. The fragments are extremely weathered and friable - highly porous fabric possibly the result of weathering of limestone temper. The thickness varies from 8.6mm - 10.5mm. No diagnostic fragments. Probably domestic pottery.
112	375	1 fragment of slag with medium sized charcoal moulds, rusty appearance on one side, rather cavernous, opposing side has extremely flat surface – could be a flow not a stone surface, but possibly this is a hammered surface, perhaps during removal of slag adhering to bloom.
112	5250	1 large asymmetric cake of slag (240x190x120mm), convex base with prilly texture, prills less marked on sides. This cake is probably best interpreted as a wedge shape from the foot of the blowing wall, nestling into the back angle of the furnace. Suggests relatively angular furnace base with sides of at least 240mm. Top of the cake has blebs and impressed charcoal, not unlike top of an SHC but shows a very dense rim c.35mm thick on what is interpreted as the proximal side.
118	380	1 concretion surrounding corroded fragment of iron (20g), apparently in the form of a narrow strip, perhaps 8mm wide with about 40mm preserved as hole; 1 possible fragment of SHC? (360g), has lobate lower layer (10mm) overlain by vesicular massive material (50-60mm). Most likely a furnace slag
119	104	c. 7 fragments of possible cupellation hearth material - the bases are manufactured from fine clay which appears to be similar to mould material. Upper surfaces are occasionally rough with thin layer of white residue probably lead oxide (litharge). corroded copper/copper alloy visible on the surface of several fragments and two fragments have a small tiny droplet of what appears to be silver
119	80	14 fragments of clay moulds mainly pale grey, occasionally pale orange – very fine mica-rich fabric
119	77	2 concretions around corroded fragments of iron, the largest is almost complete nail; 7 smaller fragments of corroded iron
119	32	1 fragment of oxidised fired clay, 1 surface is relatively smooth and slightly paler in colour than the rest, which is formed of siltstone breccia (cf. material from c73)
121	2785	1 large plano-convex slag cake (200x170x110mm, bowl 80mm). Slag appears vesicular, where seen, with finely prilly base, top slightly concave with abundant charcoal. Top has possible "pad" of slag offset from centre. Probably but not certainly an SHC
121	3885	1 large dense slag cake, 180x180x130mm bowl 90mm. Bowl formed of small prills, interior of slag not well seen. Top has raised wedge shaped block, which may have been deformed. Possibly an SHC
121	326	fragments of oxidised fired clay - quite friable, lightly vitrified in places
Context	***Weight***	***Description***

Context	Weight (g)	Description
121	566	fragments of fired clay - pale grey in colour with occasional pale green hue - frothy texture in places, small amounts of slag attached to a few pieces
121	10	fragment slag with rough clay rich lower surface, upper surface has flat centre with slightly upturned edge - possibly remains of a tool mark
121	1345	3 large blocks of variable charcoal-rich to dense slag, probably furnace slags
121	478	2 blocks of slag with a crust, one with lining attached, in neither case is it clear if these are SHC fragments or furnace slags
121	950	1 large fragment of slag cake (130x120x40mm), appears wedge shaped – so may be foot of wall slag – putative base is slight lobed, the supposed wall has a thicker crust with outer laminated zone, alternatively the whole cake may be may be other way round and this is the bowl section
121	640	fragment of dense slag with oxidised lining attached, lining has vitrified convex surface, probably same as piece below, dense slag protrudes as dense cylindrical form, 60x40mm, on one side; for both this piece and 470g piece below, the slag near the wall comprises small prills, becomes massive but weathered into furnace
121	470	fragment of dense slag with oxidised lining attached, lining has vitrified convex surface. Textures similar to 640g piece above.
121	52	fragment of slag with small quantity of reduced fired lining attached, prilly near contact
121	450	Neat SHC, charcoal moulds on base, upper surface blebby, irregular, 120x90x50mm (bowl 30mm).
121	475	fragment of slag cake, blebby upper surface, multiple fine charcoal moulds on lower surface, very heavily weathered, possibly an SHC (90x120x60mm)
121	710	Block of massive slag – presumably a furnace slag, but heavily accreted in material rich in charcoal and hammerscale – just possibly a block of “smithing floor"??)
121	884	6 fragments of indeterminate slag with development of a dense crust
121	70	Slag with well developed basal prills
121	122	1 dense fragment of slag, possibly a small SHC or part of
121	114	Worn fragment of goethite ore. Smoothed surface means internal structure hard to see – apparent concentric banding, very unusual surface effect with pale yellow/brown rosettes and dendritic structure in dark dense ore – just possibly an oxidised claystone ore rather than a Dean goethite?
121	1850	23 fragments of flowed slag, mainly in the form of rather narrow, deep, prills, tubular flows and intersections of tubular flows with more charcoal-rich material. Pores in tubes are mainly large – so little typical dense tapslag
121	2390	48 fragments of indeterminate slag, mainly rather blebby of prilly internally.
122	1130	90g iron-rich concretion; 122g, probable small SHC 80x60x50mm (bowl 25mm), lobate bowl with dense wedge on top; 52 g small runner; 766g, 25 pieces of indeterminate slag; 2g oxidised fired vitrified lining
131	750	12 fragments of slag, the largest (150g) has well developed flow structures and large vesicles (vesicles present in all larger fragments); 4 fragments of reduced fired lining, possibly stones or lining caught up within tap slag flow, one piece of slag shows two such fragments within its body; 1 fragment of indeterminate rusty slag
132	107	10 fragments of oxidised fired clay, more highly fired on one side
132	796	20 pieces of indeterminate slag, variably dense to charcoal-rich, but no distinguishing features
132	554	25 fragments of flowed dense slag; tapslag
132	950	1 large SHC (130x120x60mm, bowl 45mm), with deep slag impressions on upper surface, bowl has well-flowed protuberance in centre of base
132	686	1 lump of slag, charcoal rich on upper surface, part or all of hot deformed SHC
132	410	105x90x40mm medium sized SHC, concavo-convex shape, very weathered possibly microprilly base
132	444	90x110x45mm medium sized concavo-convex SHC with prilly base
132	290	3 fragments of narrow dense slag runners, none is good example of a tap arch flow
132	198	Most of small prilly SHC, (80)x70x30mm proportion of original size uncertain
132	610	2 pieces of dense irregular slags, formed partly of flowed material partly massive. Very porous, probably furnace slags
132	198	Tap slag with largely hollow flows, of overall rather low density
132	160	fragment of slag with occasional charcoal inclusions and flow lobes on margin, furnace slag?
132	112	Small irregular SHC, 60x80x40mm (30mm bowl)
132	1355	9 pieces of slag with overall form suggesting they are parts of SHCs, none certainly so.
132	512	9 fragments of complex slags with charcoal, dense areas and some flows, suggesting these may be furnace slags, but none certainly so
132	548	5 fragments of indeterminate slags with internally prilly texture.
146	16	1 small fragment of indeterminate slag; 1 iron rich concretion
150	43	1 small concretion around corroded fragment of iron (15g); 5 small fragments of flowed slag

	(g)	
156	44	4 fragments of flowed slags , all rather worn
160	107	8 fragments of flowed slag, some with purple tinge. The largest piece (42g) flowed texture on upper surface, relatively flat base; 2 small fragments of indeterminate slag
164	128	3 fragments of indeterminate slag, all dense and flowed – probably all tapslag
33787 – phase 2		
1019	1380	1 large lump of concretion on furnace slag/possible runner (586g); 1 fragment of very highly weathered slag with a basal crust, may be part of SHC or a furnace slag, probably the former (375g); 5 fragments of dense flow slag (234g), 2 pieces of rather irregular runner, no good flow surfaces (196g)
1021	876	1 large lump of dense slag (775g), thin gravel-rich crust fired onto base, weathered on top face with few charcoal moulds (10-20mm), if this is an SHC burr then it is very large - so might possibly be smelting burr, but seems too regular for that; 3 small fragments of slag with flowed texture.
1038	176	26g tapslag fragment; 102g indeterminate microprilly slag with abundant hammerscale adhering; 50g 3 pieces of lining slag
1039	84	12 fragment of lining slag in glassy sheet with charcoal impressions; 72 g 4 pieces of concretion with extremely abundant hammerscale
1052	9.8	2 small dense fragments of slag
1054	41	2 fragments of indeterminate slag

Table 2: Distribution of residue classes by context

Context	Spot date	Tap slag	Furnace slag	Indet. slag	SHC	Lining slag	Lining	Mould	Cupel/ tray	Iron/ concretion	Iron ore	Pottery?	Total
32523 - phase 1													
5	***C1***	12											*12*
7	***C12 - C14***	32											*32*
11	***C12 - C14***	92		208									*300*
15	***C12 - C14***	207											*207*
21	***C1***	114		114						23			*250*
73	***?***											70	*70*
83	***?***											251	*251*
112	***C1***		5625										*5625*
118	***C1***		380							20			*400*
119	***C1- eC2***						32	80	104	77			*293*
121	***C1***	1850	2295	5652	7717		892				114		*18520*
122	***C1***	52		766	122		2			90			*1032*
131	***C1***	740		10									*750*
132	***C1***	1042	1282	1344	4155		107						*7930*
146	***?***			8						8			*16*
150	***C1+***	28								15			*43*
156	***?***	44											*44*
160	***Med***	85		22									*107*
164	***?Roman***	128											*128*
33787 – phase 2													
1019	***e-m C2***	430	586		375								*1391*
1021	***C2***	101			775								*876*
1038	***C1***	26		102		50							*178*
1039	***C1***					12				72			*84*
1052	***Med***	10											*10*
1054	***C13-C15***			41									*41*
	totals	*4993*	*10168*	*8267*	*13144*	*62*	*1033*	*80*	*104*	*305*	*114*	*321*	***38590***

GeoArch

geoarchaeological, archaeometallurgical & geophysical investigations

Unit 6,
Western Industrial Estate,
Caerphilly,
CF83 1BQ.

Phone:	029 20881431
Mobile:	07802 413704
Fax:	08700 547366
E-Mail:	Tim.Young@GeoArch.co.uk
Web:	www.GeoArch.co.uk