

GeoArch

Report 2005/15

Evaluation of archaeometallurgical
residues from Ballykilmore 6, Co.
Westmeath (A001:032)

Evaluation of archaeometallurgical residues from Ballykilmore 6, Co. Westmeath (A001:032)

Dr T.P. Young

Abstract

Archaeometallurgical residues totalling approximately 110kg were recovered from the site, mainly from the enclosure ditch (45kg), a complex pit (F1231) cut into the enclosure ditch (36kg) and a probable iron-smelting furnace (F979) cut into the ditch (9kg). The residues were dominated by slags from iron working, with approximately 48kg of smithing hearth cakes (SHCs), closely associated with 25kg of tuyères. Iron smelting was represented by approximately 10kg of slags (mainly from F979). A further 29kg of slags were not identifiable with certainty, but were probably also largely produced during smithing. The smithing assemblage is characterised by extremely dense, dark, iron-rich slags, mainly smithing hearth cakes, with an average weight of approximately 900g, a maximum observed weight of 4kg and with 26% of SHCs weighing more than 1 kg. These statistics place the assemblage very close to the early Christian assemblages from Clonfad and Clonmacnoise.

The site provides some evidence for metalworking early in its development, but most of the iron working appears to be late in the history of the site, probably 16th-18th centuries. The presence of evidence for iron smelting furnaces of this age and the similarity of the smithing slag assemblages with those from Clonfad and Clonmacnoise attributed to the working up of iron from raw primary blooms, provides good evidence that iron production from bog ore continued at Ballykilmore well into the post-medieval period, using technology based on a tradition extending back at least a thousand years.

Contents

Abstract	1
Methods	1
Results	1
Residue description	
Smithing hearth cakes	2
Iron smelting slags	2
Other slags	3
Smithing floor & hammerscale	3
Tuyères	3
Glazed stones	3
Stratigraphic distribution of residues	3
Review of the "metallurgical features"	4
Interpretation	
The nature of the residues	5
The nature of the metallurgical features ...	5
Evaluation of potential.....	6
References	6
Catalogue	7

Methods

All the macroscopic material from the collection was inspected visually (and with a low-powered stereo-microscope where necessary) and recorded to a spreadsheet. All complete, or substantial parts of, smithing hearth cakes were weighed individually and the proportion they represented of the original cake was estimated. This database is reproduced as the catalogue in this report.

Representative material from the slag collection, plus all tuyère material and all microscopic residue assemblages were retained and collated into a separate collection, for use in the Stage 2 of the investigation of archaeometallurgical activity on the site.

Results

The site yielded a total of approximately 110kg of archaeometallurgical residues, of which 48kg are slags from smithing hearth cakes (SHCs), 10kg of probable iron smelting slags, 27kg of miscellaneous and indeterminate slags and 25kg of tuyères. The site has also yielded small quantities of micro-residues (hammerscale) from soil samples, together with a few small lumps of concretionary "smithing floor".

Residue description

Smithing hearth cakes (SHCs)

SHCs comprised 47.9kg out of the 84.5kg of slag from the site (57%), and it is likely that much of the 26.8kg of "other slag" was SHC material fragmented into pieces too small to recognise as being derived from SHCs.

43 examples of SHCs (total weight 22.8kg) were sufficiently well-preserved to allow measurement or estimation of their original weight. This indicated an assemblage of weight 38.6kg with a size distribution as illustrated in Table 1 and Figure 1. This collection included 23 complete SHCs with a maximum weight of 1.35g, but the reconstructed size of the fragmentary material extends the maximum to 4.03kg.

The size distribution of SHCs from Ballykilmore is closer to that of sites interpreted as having a large component of bloomsmithing (e.g. Clonfad and Clonmacnoise) than to that of sites (e.g. Moneytucker 7) interpreted as solely concerned with blacksmithing. The SHCs from Ballykilmore are characterised by dark colour, high density and often somewhat rusty appearance. These features indicate a high iron content to these slags.

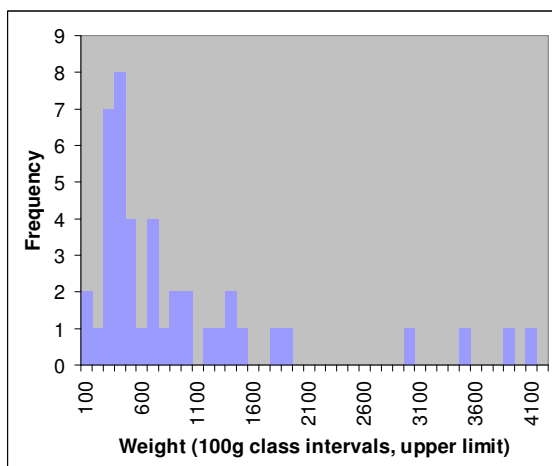


Figure 1. Size frequency histogram for 43 reconstructed SHC weights.

Iron smelting slags

Iron smelting slags occur in small quantities across the site, but are particularly well illustrated by the collection from [1201] in F979 (Table 7). This assemblage is dominated by concreterionary or sintered material in a sheet up to 70mm thick. This material may include small flows and prills indicative of a more fluid slag, and some small pieces may indicate fluid slags may be more common on the top of the concreterionary layer.

A second facies of slag is indicated by well-flown dense slags, which form brittle descending prills and flows between large pieces of wood or charcoal. These grade upwards into hollow slag masses with free crystal terminations, presumably the slag lobes that drained into the prills.

<100	2				
100-200	1				
200-300	7	0-500	22		
300-400	8				
400-500	4				
500-600	1			0-1000	32
600-700	4				
700-800	1	500-1000	10		
800-900	2				
900-1000	2				
		1000-1500	5	1000-2000	7
		1500-2000	2		
				2000-3000	1
				3000-4000	2
				4000-5000	1

Table 1. Distribution of smithing hearth cakes by weight (g). Each class interval runs from the lower limit up to, but not including the upper figure. 1000g

n	43
min	80g
max	4033g
average	898g

	number	%
<500	22	51%
<1000	32	74%
>1000	11	26%
>3000	3	7%

Table 2. Summary statistics for the 43 smithing hearth cakes for which the total weight could either be measured or estimated.

	<500	<1000	>1000	<3000	max	n	mean
1	51%	74%	26%	93%	4033	43	898
2	29%	64%	36%	93%	11000	513	1153
3	39%	68%	32%	92%	5540	38	1087
4	83%	95%	5%	100%	2588	41	386
5	77%	100%	0%	100%	824	30	333

Table 3. Comparison of summary statistics for smithing hearth cake size from Ballykilmore 6 (1), with Clonfad 3 (2; Young 2006b) and Clonmacnoise (3; Young 2005b) for which the assemblages are rather similar, together with Moneytucker site 7 (4; Young 2006a) and Marsh Leys Farm (5; Young 2005a) which have more conventional blacksmithing assemblages.

Approximately 1kg of material derives from what appears to be a spongy, thin-crust, type of hearth cake. This may be evidence for admixture of smithing slags into the assemblage, but is more likely to be part of a slag cake that formed below the bloom in a smelting furnace. These cakes are known to have formed, and have been seen in some assemblages

(e.g. Tullyallen 6; Young 2003d), but they seem to be rather fragile and may have been destroyed in most smelts during bloom extraction and furnace cleaning.

Other slags

Slag lumps, which were either non-diagnostic complete lumps, or fragments from larger pieces that were too small for certain identification, were categorised as "other slags". These materials comprised about 25% of the overall assemblage. In practice it is likely that the majority of this material is from broken SHCs. The proportion of slag from the smithing hearths that is not within the SHC or attached to the tuyère appears to be very small indeed.

Smithing floor & hammerscale

Hammerscale was recovered from sieve samples from a small number of contexts, all within area B. The majority of provisional records in context and sample descriptions proved erroneous.

Many contexts (F124, F126, F1209, F1210, F1214, F1221) within the large late pit (F1231; quadrant X) yielded hammerscale from sieved residues. Most of the samples yielded flake hammerscale only, with only a rather scant representation of spheroidal hammerscale.

The metallurgical feature F139 (also in quadrant X) yielded flake hammerscale from context F135.

Some contexts within the graveyard yielded small pieces of so-called smithing floor. This material represents hammerscale/charcoal/slag-rich material which has become cemented (concreted) after deposition. In many cases the concretion process probably results from corrosion of small associated iron particles. The material is characteristic of deposits generated on the floor of a smithy, particularly around the anvil, but may also be generated in secondary locations of dumps of fines swept from the smithy floor. This material occurred in small quantities in the graveyard soil (F413) and graves (F827, F836, F898, F1036) in the centre of the enclosure (boxes A3, A4, A5). It is likely that the concretion process must have happened elsewhere (in a primary deposit of forge material?) and the pieces reworked as clasts into the graves, rather than the concretion having occurred in a hammerscale-rich grave fill.

Tuyères

The tuyères recovered from the site are mainly extremely large blocks. They require further investigation and restoration, but appear to include fragments with apparent diameters of 200-300mm. It is possible however, that the blocks were not originally circular in section. In addition to the tuyère blocks themselves, there are several occurrences of pieces of fired-clay with a concave face that appear to have been placed to provide lateral support for the tuyère. Some of these supports have finger-impressions where the clay has been squeezed into position, and some incorporate fragments of broken used tuyères.

The fragments of tuyère from [1201], the contents of a possible basal pit of iron smelting furnace are rather different from the remainder of the material, appearing to have been approximately 140mm in diameter, with a

central hole, which tapers rapidly towards the frontal face.

Excluding the material from [1201] there was a weight of 23.5kg of tuyère material. This is a very large quantity (ratio = 0.49) in comparison with the associated 47.9kg of SHCs (for comparison Clonfad 3 yielded 17.3kg of tuyères to 711kg of SHCs, a ratio of 0.02). It is unclear at present whether this difference is related solely to the larger size of the tuyères or whether there was a more rapid turnover of tuyères at Ballykilmore.

Glazed stones

The archive shows (Table 6) nineteen examples of rock fragments, mainly small pebbles, bearing a translucent green glaze. In some cases the glaze does not coat the entire pebble, but only one face (e.g. #91, #144, #200), one shows the glaze marking a former point of contact with an adjacent rock (#548), and one shows a lobate surface, possibly indicating contact with fuel (#404).

Such glazes are produced by the reaction of elements (mainly alkalis) in fuel ash, particularly wood ash, with silica from the underlying rock substrate. As such, their origin is not specific to any particular pyrotechnological process, but the clear glaze indicates an absence of the common metals (iron, copper..), and therefore it is unlikely that glazed pebbles would be produced through metallurgical activity involving those metals.

The distribution of the glazed stones within the site shows a clear focus around the south side of the church. 4 examples derive from robber trench (F63), 2 from a deposit of loose mortared stones (F53) and 3 from a disturbed layer over F53 (F54). 1 piece was retrieved from the early accretion layer (F260) in the same area, and 2 from the overlying graveyard accretion layer (F48). 2 pieces came from grave-fills in the same area (F241 in F48 and F604 on F48). An outlying piece came from a grave fill to the north of the church (F1117). An additional four pieces were found in the topsoil.

The distribution suggests a strong link between the glazed stones and the structure. One possible explanation would be that the stones represent non-calcareous pieces fired by accident in a limekiln and subsequently incorporated within the mortar of the wall.

Stratigraphic distribution of residues

Of the 110kg of residues recovered from the site, 46kg were derived from the enclosure ditch and 36kg from the large pit F1231 that was cut into the ditch. 112kg came from various cut features, with most of the being the 9kg of material within a probable smelting furnace base cut into the upper part of the enclosure ditch.

Approximately 8kg of residues were recovered from graveyard deposits and 4kg from topsoil or other modern contexts.

It would therefore appear that the majority of the metalworking residues derive from contexts deposited late in the history of the site. Details of the distribution with the ditch and pit F1231 are shown in Table 8. The details show three types of assemblage with these contexts:

1. A sparse residue assemblage occurs in the earliest ditch fill in Area B and throughout the ditch in Area A. This suggests a background level of residue accumulation.
2. The upper levels of the enclosure ditch in Area B have a residue assemblage characterised by smithing residues with a very high proportion (30-40% by weight) of tuyère fragments. That proportion appears to decrease in the upper levels of the ditch in Quadrant X.
3. The large pit F1231 cut through the enclosure ditch in Quadrant X has a rich smithing assemblage (including fines) with a significantly lower proportion of tuyère material (21% by weight). The presence of a wide size range of material within this pit may suggest that dumping of residues took place from a closely adjacent smithy.

These data may suggest either the patterns of residue disposal change and migrate through time or that the ditch fills may not be as uniform as currently composed (i.e. might Phase B deposits in Quadrant X be coeval with Phase C deposits in Quadrant Y?). In this second possibility there would be a change in residue nature through time (with progressive decrease in the proportion of tuyère material through time), but not necessarily a migrating pattern.

The metallurgical features cut into the upper levels (probably phase B/C) of the enclosure ditch in Area A are probably smelting furnaces. Interestingly these are not accompanied by deposition of smelting slags into the ditch. Only two certain pieces of smelting slag (total weight 0.6kg) were recovered from the enclosure ditch, both from area B, and both apparently worn suggesting a degree of residuality.

Lack of stratigraphic constraints makes interpretation of the stratigraphic significance of material from inside the enclosure rather less certain. The residues from inside the enclosure mainly fall into four groups:

1. residues from individual grave fills (total 2.27kg). These are mainly from an area in and around the eastern part of the church (graves in grids 7w, 7e, 6w, 6e, 10, 11 together yielded 1.52kg) and an area in the southern part of the graveyard (boxes 37 and 36 yielded 0.69kg).
2. residues from other graveyard deposits (total 5.75kg). These are mainly from the southern part of the graveyard (post-medieval accretion layers F1131 and F1179 together yielded 4.60kg, 80% of the material from the graveyard soils).
3. residues from F137 and F139, two small probable smithing hearths in the SW of the enclosure (total 1.42kg), together with 0.30kg of material from an adjacent pit (F141).
4. isolated residues from 5 pits aligned approximately N-S adjacent to the East end of the church. F168, F194 and F860 yielded a total of 0.23kg of smithing slags. F829 and F1017 yielded 0.13kg of slags, probably mainly smelting slags. These quantities are very small, but their significance lies in the assumed early age of the pits. Detailed stratigraphic relationships are unclear at present, but it may be significant that F194 is described as below F235, which is cut by F168, F860 and F829 and also may be truncated by the SE corner of the church. This material tentatively suggests that metallurgical activity,

including both iron smelting and smithing, may have taken place on the site early in its history, in contrast to the vast bulk of the residues which date to a period late in the site's development. Other early evidence was rather lacking; none of the graves truncated by F62 yielded metallurgical residues.

There were a few pieces of smelting slags, in the otherwise smithing-dominated material from the graveyard deposits and graves within the enclosure, from the area of the church. One piece was derived from F976, a burial close to the location of the smelting furnaces in the enclosure ditch.

Review of the "metallurgical features" in the Preliminary Excavation Report

The preliminary excavation report described a number of features to which were assigned a metallurgical purpose. Recognition of the abundance of natural iron pan formations, particularly tubular concretions, rather than hammerscale, in many of these features allows a reappraisal of the significance of the features. Much of the information in this section also appears elsewhere in this report, but is organised together here to permit simpler review of the preliminary interpretation.

In the preliminary report (p.25 onwards) note is made of 22 pits associated with metallurgical activity, 13 of which were supposed to have had direct evidence for that activity. The inventory actually then lists 26 pit features.

Four of the features listed have good evidence for being associated with metallurgical activity. These occur in two geographical pairs of similar features:

In Quadrant X, on the inner side of enclosure bank:

F137: F134 yielded a good assemblage of hearth or furnace bottom fines.

F139: F135 yielded a small quantity of flake hammerscale and slag fragments as microresidues, together with a small assemblage (1.3kg) of macroscopic smithing slags.

In Area A, boxes 22/41, cut into the upper layers of the enclosure ditch:

F979: F1201 produced a large assemblage of iron smelting slags (almost 10kg; table 7), almost certainly in-situ, together with some tuyère fragments and possible smithing slags. (Cuts F162, probably ditch phase B/C - not phase A, contra Channing 2005 p 19 since F162 overlies F165)

F1183: F1183A produced a large block of concretionary or sintery material similar to that presumed to be in-situ in F979. (Cut into deposits of ditch Phase C)

Evidence was also forthcoming from the following five features, although the quality of the evidence by no means indicates a metallurgical use for the feature with any certainty (the amount of material is no more significant than that from some of the graves for instance):

F168: F171 yielded a small fragment of tuyère.

F194: F195 yielded a small fragment of tuyère (although the sieved fines did not actually contain hammerscale, contra Channing 2005 table 1).

F820: F822 yielded a small fragment (40g) of iron smelting slag.

F860: F826 yielded a small fragment (76g) of smithing slag.

F1017: F1017d yielded a small quantity (88g) of slag, at least one piece of which was probably from iron smelting.

In addition, the pit F141 (listed in the preliminary report as non-metallurgical) yielded a small assemblage (304g) of smithing slags, although these are not necessarily indicative of the usage of the feature.

No direct evidence from residues was forthcoming for the following 17 pit features to which the preliminary report ascribed a metallurgical origin:

F111
F184
F365
F445
F453
F650
F678
F903
F931
F947
F1013
F1016
F1048
F2017
F2023
F2029
F2048

The evidence for the metallurgical use of all but four of these features is thus fairly slim. Caution should be exercised in taking the small quantities of residue that some contain as indicative of the nature of the use of the features.

Interestingly, however, the limited stratigraphic evidence may suggest that the so-called metallurgical pits in the interior of the enclosure are fairly early in the history of the site. The evidence presented above casts considerable doubt on the metallurgical purpose of these features, but some of these pits do contain small quantities of metallurgical residue. In comparison the features for which a metallurgical function is better established appear to be much later. The preliminary report states:

The two small furnaces, (F137 & F139), on the southwestern side of the enclosure seem to have been cut into the inner side of the bank. The location of these features only 1.7 m inside the ditch, (F104,) cut suggests that they were constructed in a phase when the bank was still visible, though its size may have already diminished. It is possible that these furnaces are roughly contemporary with the ones (F979, F1183) cut into the enclosure ditch.

Interpretation

The nature of the residues

Much of the smithing slag from the site, both within well-formed SHCs and in amorphous hearth slags, is in the form of very dense, very dark and often slightly rusted material. These features suggest that the slags may have an unusually high iron content. This requires further investigation by chemical and mineralogical analysis and microanalysis, but would suggest that the iron lost to the hearth during working was poorly fluxed. Fluxing of the iron oxides by silicate material derived from the melting of the hearth lining in a conventional early clay-lined hearth, produces a

composition of slag that is molten, and moderately fluid, at hearth temperatures. If the supply of silicate material is restricted then the slag generated in the hearth will be more iron-rich and therefore have a much melting range. One way in which the supply of silicate material might be restricted is because of the much lower surface area of ceramic raised to high temperature when a tuyère is used instead of a solid hearth wall with a blowhole. An indication of the importance of this is provided by the evidence of small pro-tuyère slag masses and sub-tuyère slag flows which have textures indicative of much more fluid (lower iron content) slags in the localised environments within the hearth where silicate supply was elevated.

Some of the SHCs present in the collection are of the "puddle" type. These must indicate the presence of fluid slags, and accordingly must indicate either much higher temperatures, or systems in which the iron was adequately fluxed, perhaps through deliberate addition of a flux by the smith. Fluxes, typically fine quartz sand, would have routinely been used by smiths to assist in slag fluidity during fire-welding. There is some evidence that early smiths also deliberately added silicate material to the hearth to promote fluidity of the main slag mass, perhaps to assist in keeping the working part of the hearth clear of slag blebs that might otherwise adhere to the workpiece.

The smelting slag assemblage from [1201] contains examples of the dense slag flows, penetrating between large pieces of wood or charcoal, which are so characteristic of the process of bloomery iron smelting in a low shaft furnace with a basal pit, and which permit confident attribution of this feature to iron smelting (for discussion of this style of furnace see Young 2003b, 2003c, 2003d, and 2005c). The assemblage from [1201] is dominated however by a porous, sinter-like material (as is also the material from the fill [1183a/b] of adjacent furnace [1183]). This facies of residue is not well understood, but is provisionally interpreted as the result of fines percolation to the base of the furnace when smelting powdered bog ore.

The tuyères from the site are unusually large blocks, which are also unusual in the presence of lateral supporting material (both new clay and old tuyère fragments) pressed against the sides of the main blocks. The tuyères require further investigation to establish their morphology in detail, but they appear to resemble, but on a much larger scale, the tuyères which are so characteristic of smithing on Early Christian sites in the area (e.g. Clonfad and Clonmacnoise). Since the associated slags at these three sites are rather similar, it would appear unlikely that the difference in tuyère size is related to process; instead the difference in age may be significant.

The nature of the features

Iron smithing: Two possible smithing hearths were identified (F137 and F139). They are both rather small features (0.31 and 0.34m in diameter respectively and 0.10-0.12m deep) and so do not represent the entire hearth, but probably merely the central slag collecting hollow which would have lain in front of the tuyère. A hollow of this size is entirely consistent with the largest SHC recovered (estimated to have been c. 0.25m in diameter and 0.05m deep). Further investigation of the excavation records may reveal whether evidence survived for the limit of the hearth or the tuyère location. An associated charcoal spread (F1247)

survived only in patches (F127-131) scattered within an area of c.1.3 x 1.0m.

Iron smelting: The two possible smelting furnaces (F1183 and F979) were both of fairly large size (0.7m diameter and 0.7 x 1.0m respectively). Pits as large as this are not well understood at present, but have been recorded from sites such as Morrett Site D and Jamestown Site L on the Heath-Mayfield development (Young 2005c), where there is some possibility that the largest diameter furnaces are associated with the younger sites. The furnaces were accompanied by a small spread of charcoal F1186. It measured a 60 cm long, 50 cm wide and 20 cm deep

tuyères and blowholes on the one hand, and the cast iron tuyères which dominate in forges from the late 18th century. Almost nothing seems to be known about earlier post-medieval forge construction.

<i>Feature number</i>	<i>Location</i>	<i>Horizontal dimensions</i>	<i>Depth</i>
F137	Quadrant x	0.31 m in dia.	0.12m
F139	Quadrant x	0.34 m in dia.	0.10m
F979	Grid 32	1.02 x 0.70m	0.24m
F1183	Grid 41	0.7m in dia.	0.35m

Table 4. Summary of dimensions of metallurgical features.

Evaluation of potential

The assemblage from Ballykilmore 6 is a very significant assemblage for the light it may shed on the development of both smelting and smithing techniques/technology in Central Ireland in the Medieval to post-Medieval period.

The evidence from the site is, as yet, rather poorly dated, but the smelting furnaces within the ditch (probably) and the smithing assemblages from the upper levels of the ditch and the large pit [1231/5] (certainly) are late in development of the site. They would appear to date from between the 16th and 18th centuries. This is a period for which the current understanding of ferrous technology in the area is extremely poor and this site presents a very exciting opportunity for investigation.

Local tradition as gathered from discussions with local blacksmiths and historians suggests that the influx of coal with the construction of the canal network at the end of the 18th century seems to have been accompanied by a style of blacksmithing which is rather homogeneous across Britain and Ireland, and indeed much further afield. Ballykilmore appears to be indicating that in earlier post-medieval times there was a survival of a style and technology of iron-making and working which is extremely close to that of the early Christian period (e.g. Clonfad, Young 2006b) and which has its origins in the early Iron Age. The idea that bloomery processes continued in rural areas well into the post-medieval period is not new; there are historical accounts of 18th century bloomeries in Cumbria and Yorkshire for instance (Tylecote 1986), but direct archaeological evidence for the nature and context of the processes has not yet been forthcoming.

One particular aspect of the Ballykilmore assemblage is the abundance and strikingly large size of the tuyères employed. The assemblage should be capable of producing evidence for how these tuyères were used, and their influence on the chemistry of the slag-forming reactions. They provide a very important, and hitherto uninvestigated link between the earlier smaller

References

- CHANNING, J. 2005. *N6 Kinnegad to Athlone Dual Carriageway, Excavation No.: A001/032, Site No. Ballykilmore 6, Ballykilmore Townland, Co. Westmeath, Preliminary Excavation Report*. Unpublished Report, Valerie J Keeley Ltd.
- TYLECOTE, R.F. 1986. *The Prehistory of Metallurgy in the British Isles*. The Institute of Metals. 257pp.
- YOUNG, T.P. 2003b. *Evaluation of slag from Celbridge Site 5, County Kildare (01E0306)*. Geoarch Report 2003/07. 5pp.
- YOUNG, T.P. 2003c. *Is the Irish iron-smelting bowl furnace a myth? A discussion of new evidence for Irish bloomery iron making*. Geoarch Report 2003/09. 4pp.
- YOUNG, T.P. 2003d. *Evaluation of slag from Tullyallen 6, Co. Louth (00E00944)*. Geoarch Report 2003/10. 2pp. + 2 figs.
- YOUNG, T.P. 2005a. *Evaluation of metallurgical residues from Marsh Leys Farm*. GeoArch Report 2005/07.
- YOUNG, T.P. 2005b. *Metallurgical Residues from Clonmacnoise, Part 1: Evaluation of material from the wastewater treatment works (02E1407)*. GeoArch Report 2005/08.
- YOUNG, T.P. 2005c. *Evaluation of archaeometallurgical residues from the Heath-Mayfield N7 development (03E0151, 03E0966, 03E0461, 03E0603, 03E0633, 03E0679, 03E0602, 03E0635)*. GeoArch Report 2005/12. 28pp.
- YOUNG, T.P. 2006a. *Evaluation of archaeometallurgical residues from N30 Moneytucker – Jamestown, sites 1, 4, 5 and 7 (04E0329, 04E0326, 04E0325, 04E0323)*. GeoArch Report 2005/13.
- YOUNG, T.P. 2006b. *Evaluation of archaeometallurgical residues from Clonfad 3, Co. Westmeath (A001:0036)*. GeoArch Report 2005/14.

Area	Quad	Context	Feature	find/ sample	weight (g)	notes	shc	shc recon	other slag	tuyère	iron	smelting slag	smithing floor	total
Ditch F104 Phase A														
		144		1136	140	140g amorphous lump of charcoal rich rusty slag. A few dimples on one surface.; fines #939 have no scale			140					
							0		140	0	0	0	0	140
Ditch F104 Phase B														
a	4	165		1061	63	fired clay, orange, with maroon vitrified layer on one side				63				
a	7	1185		1088	112	102g, very gravelly fragment of SHC, shows tool marks on base, very strong resemblance to s1137; 10g small fragment of porous gravelly slag	112							
		116		1138	1959	844g 15 pieces of tuyère; 1055g 14 pieces of rather amorphous slag, vesicular and mostly charcoal rich			1055	844				
		116		1146	2272	1320g 14 pieces of tuyère; 462 piece (25%) of a thin crust type SHC with a smooth lobate top; 316g 6 pieces of medium density granular thin crust type debris; 174g small piece with thick crust type puddle sitting on top of lower density material.	952	1848		1320				
B	X	116		1138	3070	110x85x50, main bowl just 30 deep, 336g, SHC has charcoal dimpled top raised over charcoal moulds then pc bowl with dimpled base with fine charcoal; 110x100x45 474g, has straight proximal end a little like some of the well flown crusts, bowl 30 deep lots of upstanding charcoal rich material on top; 278g small SHC 80x80x45, bowl 30 deep lots of upstanding charcoal-rich material, charcoal dimpled base; 608g 2 blocks from tuyère tips with slag attached both show rusty material - in one area below tip is packed with it; 440g 10 pieces of tuyère and associated slag; 66g flown slag mass attached to ceramic - probable bottom of tuyère; 454g 3 pieces of charcoal rich slags - possibly contorted crust fragments; 354g irregular rusty slag mass, probably from just below tuyère tip.	1088	336, 474, 278	874	1448				
	Y	165		s1125	610	130x65x75 irregular block of internally vesicular and locally prilly slag. Top is smoothly lobate, base is microprilly. Overall form not clear, possibly been slightly rounded?			610					
							2152		2539	3675	0	0	0	8366
Ditch F104 Phase C														
a	4	160		1035	382	364g well laminated, fractured block like a dense thin crust cake, built up of many layers, a small part of a large cake, 18g small blebby piece	364		18					
a		160		1036	44	slagged tuyère, fragments with right angle bends - three pieces				44				
a	7	1184		1084	406	136g light porous sintery-looking material in several fragile pieces, contains lots of charcoal but no scale; 96g similar material but dense more blebby; 26g 4 pieces of dense flow lobes; 2g nail shank; 8g 4 small pieces of fired clay, 1 is tuyère side; 132g 4 small but very dense pieces - probably too dense to be slag inside so presumably iron lumps in forge floor concretions.			390	8	2			
a	7	1186		1081	180	assemblage of rusty sintery material, blebs, rusted iron and fine debris - looks like bottom of forge debris			180					
B	Y	160		s1120	1235	1215g 17 large diameter tuyère pieces, largest pieces 490g (photo) lower face of tuyère is eroded back in concave hollow and has ledge of Fe-slag extending in front; 10g fragment of slag, probably broken off above.			10	1215				
B	X	164		s1126	2380	256g fired clay -looks like a disk with a > shaped section, in 3 pieces, convex curved face vitrified, then turns back at an acute angle and is almost flat possible then turning out again; 232g slagged wall material; 250g vitrified and slagged clay with smooth, glazed back face. curve looks to be around 300 diameter (photos); 1000g (c80%) of neat double layer SHC, lower bowl thick 30 in centre, 8 gap with crystals, then upper flat sheet with very smooth top, overall 130 diameter, 65 thick; 558g 4 pieces of open-textured cakes; 50g well flown but fairly low density mass of blebs (sort of things seen on bottom of tuyère?)	1558	1250	50	738				

B	Y	164	s1109	1020	10 pieces of variable Fe slag. Largest is slab from base/side of hearth. No real crust, but sediment baked on to charcoal rich slag. Other material includes small pieces from denser cakes but dominated by charcoal-rich material	1020						
B	Y	164	s1122	286	48g vitrified clay, oxidised, curved outer face large diameter; 72g prilly slag with possible tuyère attachment; 86g broken nub of very dense slag; 68g charcoal-rich slag		226	48				
	Y	164	s1114	1530	688g charcoal-rich low density crude SHC in 3 pieces; 306g very complex block of vitrified wall, has pale object with right angle within- a clay block or an odd tuyère, somewhat similar to 115 material; 520g block from burr region of thick charcoal rich thin crust? Cake	1208	688	306				
						4150	874	2359	2	0	0	7385
Ditch F104 Phase D												
a	z	147	1069	364	small fragments of smithing slags, mainly rather sintery look, one piece probably was attached to tuyère (it is arcuate) other bits more filmy		364					
a	7	1181	1079	2245	incomplete thin crust cake, very porous, has internal microprilly texture in places, probable top appears to have an area of blown, more lobate surface. Piece 160x220x90. Probably 60-70% of whole	2245	3453					
a	7	1181	1079	28	twisted bleb of probably lining rich material, mainly slightly maroon tinge to black surface		28					
a	7	1181	1079	1480	1324g incomplete thinnish crust cake, in about 6 pieces, at least 190x150x50, probably 70-80%?; 48g tuyère fragment ; 8g 3 pieces of lining dominated yellow blebby material, inside with bladed olivine honeycomb; 4 pieces of more amorphous smithing slag	1324	1765	8	48			
B	X	115	914	3155	804g 4 blocks of vitrified lining; 910g 4 pieces of SHC, largest 452g c 50%? with 25mm thick dense bowl with slightly separate upper Fe-rich densish layer; 170g 3 lining dominated greenish slags; 25 pieces of vesicular slag, locally with charcoal, 1220g; 18g one rounded flowed bleb	910	904	1408	804			
B	X	115	s1115	2260	670g very complex slagged lining with bowl shaped depression (photo) - probably near blowhole; 88g smaller lining pieces; 196g very dense crystalline slag; 78g probable SHC fragment; 128g dense slag with complex flow lobes; 324g block from low density cake; 248g dense Fe-rich iron plus slag; 430g corroded SHC fragment; 40g corroded slag piece.	832	612	758				
B	X	115	s1119	3785	100g natural stones; 1275g 11 tuyère fragments and 1 piece of ?tuyère support; 296g slab of curving well-flown hard slag (cf s1124) - suggest this is not vertical but horizontal, extending in front of tuyère?; 528g small 80% complete deep SHC with protrusion on base 110x70x75; 298g slab of thin crust margin, dimpled outer face, smooth, inside fine charcoal; 90g small burr, contact 80mm wide; 274g 2 pieces of dense slightly lobate slag with wall/floor contact; 878g 12 pieces of assorted Fe-slag, non diagnostic.	916	725	1448	1275			
B	X	115	s1121	1440	382 dense charcoal-rich SHC crust fragment, but crust not well developed; 16g lining piece; 58g vitrified clay with angle - from large tuyère?; 54g blebby charcoal rich plastic slag with attachment; 930g 9 pieces of charcoal-rich slag of various textures.	382	984	74				
B	X	115	s1128	2410	934g 14 pieces of fired clay, largest shows green glazed curved surface of 300mm diameter, an iron slagged surface lies at almost 90 degrees to this, and buried surfaces suggests the outer curve may have been more bowl shaped once (photo), some of smaller pieces may be normal tuyères; 474g piece (c35%?) of dense slag bowl SHC, 40 deep, smooth top, protrusion from base; 544g 6 pieces of charcoal rich open textured cake; 272g pieces 3 from smaller SHCs; 162g strangely lobate porous piece from base of hearth/furnace, possibly contorted.	746	1354	706	934			
B	Y	115	s1124 / 924	2880	1460g 8 pieces of complex fired clay, many form glazed tubes?, ends irregular; 744g small piece of massive cake, crust thins from 30mm to almost to zero across piece so may be burr region of thin crust cake, inner face of crust has crystal terminations.s and slag remaining internally is porous; 220g 2 cake fragments; 56g 2 pieces with flown slag - sort of thing seen on tuyère tip?; 358g massive piece of dense slag with internal curving surfaces, very worn - so remnant.	964	56	1460	358			

B	Y	115	s1124 / 924	3250	1360g 12 pieces of fired clay. Smaller pieces are oxidised fired - could they be the central region of the object. Sizes and description similar to other examples, 1 piece shows the green glazing on the concave side of a curved area - but this piece is very complex!; 650g bowl side from a well-flown system, orientation uncertain but appears c. 190 deep and 300 diameter, 60 below top otherwise modest slag thickness increases and may be top of horizontal surface. side mainly 15 thick; 212g dense vesicular bowl/burr fragment; 408g 3 pieces of slag apparently with a high wall input; 562g 13 misc. Fe-slag pieces.	862	970	1360				
B	Y	147	s1129	872	732g three complexly vitrified blocks with glazed curving surfaces on at least 1 suggesting 300mm (photos); 22g iron bar; 72g 3 pieces of charcoal-rich slag.		72	732	22			
		115	1129	3420	822g 15 pieces of tuyère; 574g dense slag mass, prilly internal texture becoming coarse towards base; 316g incomplete fairly thin crust SHC with granular internal texture; 218g probably part of an odd SHC, lobate pale dense slag with very dark top surface; 298g rusty dense amorphous slag mass; 342g in two pieces - has a lobate bleb at one end with a honeycomb interior, passing into a tube with a smooth interior, tube broad circular internally but becomes 12mm square externally; 212g dense worn lump of smelting slag with very large wood - residual; 92g thin crust fragment; 198g part (most?) of small dense prilly SHC; 94g small prilly low density SHC; 58g lining slag mass; 196g 6 pieces assorted iron slag.	1258	198, 94	1126	822	212		
	Y	147	s1113	2225	604g, massive dense burr fragment; 324g 4 pieces of complexly vitrified wall; 122g corroded slag piece; 1160g large chunk/slab of slag, very Fe rich on top, dimpled and charcoal below, probably small piece of wide cake	1764		122	324			
	Y	147	s1113	270	168g complex vitrified wall; 102g fragment from thin-crust cake	102			168			
		147	1096	92	small fragment of fairly dense conventional SHC	92						
		147	1130	2970	326g small dense SHC, 90x90x30; 996g 7 pieces from a dark brown vesicular cake with a granular top, which was probably big and irregular; 114g 4 pieces of lower density charcoal-rich slag; 1290 13 pieces of large tuyère. Also of bag of fines - has magnetic slag but no scale	1322	326	114	1290			
		147	1134	1170	fines - #938, lots of mg slag but no scale; 636g dense SHC 120x100x45. Dense bowl, hollow filled with upstanding charcoal rich material to give overall biconvex form, sediment on base; 176g SHC fragment; 358g 5 pieces of more amorphous smithing hearth slag.	812	636	358				
						14531	8376	10049	22	570	0	33548
Pit F1231/5												
B	X	124	918	96	moderately abundant scale - flake							
B	X	124	s1118	4325	264g 10 small fired clay tuyère fragments; 964g large block of granular slag, twisted during extraction with rectangular iron bar so not possible to indicate proportion of cake but probably 25% of 250 diameter, 50 thick; 880g 15 pieces of charcoal rich slag; 284g small bowl shaped SHC with raised prills on one end - possibly these hung below tuyère tip? 100x70x40; 254g small rounded slag cake 70x70x50; 270g two rounded slag balls - possibly very small SHC type masses, neither complete; 1190g 57 pieces assorted Fe-slag; 42g 3 pieces dense flowed blebs	1502	3856, 284, 254	2382	264			
B	X	126	940	28	some flake present, but mainly magnetic slag and clay							
B	X	126	s1139	2325	636g 11 tuyère pieces, largest 200 diameter preserved 70 back from preserved tip; 430g part (70%?) of wide SHC 90x115x30, rather worn, bottom rough, top with medium charcoal dimples; 622g curious block of slag, probably has crust-like dense layer at top, with charcoal rich material hanging down (into pit?) below, 90x130x85; 626g 6 pieces of undiagnostic iron slags.	1052	614	626	636			
		124	1093	58	blowhole from tuyère with attached slag				58			
		125	1099	1350	1305g plus 45g bits - large friable thin crust cake, lots of sintery bits like some basal smelting furnace "sinters". 10x180x70. Concentric rings on upper surface suggest linguoid shape about 220mm wide. Very fragile.	1350	1350					

B	X	1200	s1107	2350	398g 12 stones; a few bones 25g; 258g 22 pieces of slag, mainly rather porous and granular appearing; 16g 4 pieces of oxidised fine clay with slagged curved exterior, ending at a line, beyond which the surface is striated; 60g 3 pieces of oxidised fired clay without exterior; 440g massive block of slag, dimpled base shows a slight reverse curve; slab from wall of probably thin crust type 304g; 50g melted slagged gravel sediment; 4 pieces of hollow box type slag with flowed base; 6g dense flow bleb; 574g 6 pieces of the complex fired clay material with right angle bends and boss form (1 piece has outside curve suggestive of 300 diameter,	304	698	650	
B	X	1200	s1140	2060	384g 9 pieces of large tuyère; 168g flow of dense slag underneath the tuyère extending back 70mm from tip, c300 equivalent diameter; 588g slab of thick crust SHC 100x70x40, original c 250 diameter?, probably c 20%, crust to 20mm, top seen is vesicular and has crystal terms, base rough with fine organics; 3 pieces of possible sub tuyère flow 148g; 754g 16 pieces of variable Fe-slag including several cake crust fragments.	588	2940	1070	384
B		1200	s1108	2815	470g, complete SHC, 110x85x40, base micro dimpled top rather etched; 708g large block from a massive cake, several flowed surface; 862g 13 pieces of vitrified wall, 2 pieces seem to be part of vitrified bosses up to 200 across (photos); 640g 21 pieces of varied Fe-slag, including some hollow boxes and other films. rest of weight animal bone	1178	470	640	862
		1200	1103	1634	728g 8 pieces of tuyère; 204g small dense SHC, top looks hammered 80x55x40; 126g natural stone; 566g 18 pieces of very porous, granular to charcoal rich thin-crust like slag; 90g 10 pieces of slag similar to the 566g before, but terminating in blebby flow lobes; 46g 2 rusty medium density amorphous iron slag pieces.	860	204	46	728
		1200	1104	2811	1805g massive slag piece - either a very odd thick crust SHC fragment, or otherwise part of an enormous burr. If burr then the cake must be >130mm thick, if SHC then 130x130x>100 thick, with dense layer to 70mm; 124g small thin burr with prilly material attached to 90mm width of wall; 698g 4 pieces of thinnish crust, porous slag with free olivines internally; 88g 2 pieces of amorphous charcoal rich slag; 96g dense rusty amorphous slag fragment; 256g natural stone	2627		184	
		1200	1137	1782	298g 3 large pieces of tuyère, 1 with secondary coat; 58g 11 tiny pieces of tuyère debris; 638g very dense SHC with ridges on base; 514g 12 pieces of amorphous and small slag; 410g small fragment from margin of very large granular dense cake - or just possibly a larger proportion of a smaller SHC; 220g base of SHC with open olivine honeycomb on top, rather low density.	1268	638	514	356
		1200	s1112	3650	112g fired clay fragment; 680g 5 pieces of charcoal rich slag; 1210g fragment (30%?) from amazingly dense hemispherical pale grey slag cake, 120x80x80, maybe 160mm original diameter, base with fused gravel, top rough Fe-rich; 618g small fragment of deep crust cake, crust to 50, locally crystal terms on top, base with fused gravel; 242g small SHC 90x70x15, c, 80%?; 136g stone; 632g weird piece, curved clay wedge with fired surfaces, looks like a sort of sacrificial lining (photos), wedges down from thin end to steeply inclined vitrified distal end. 180x110x55	2070	4033, 303	680	744
		1209	1090	566	this is a collection of smithing fines - taken intact but then picked for charcoal				
B	X	1210	910	16	tiny amount of flake, but mainly too coarse				
B	X	1210	s1110	1100	490g slagged and vitrified clay. This is more of the scoop-shaped clay pieces mainly well slag, burned on one side, but better preserved smooth on the other - and in one case green glazed; 22g well flown blebby dense slag; 5 pieces Fe slag 250g; well flown slightly platy piece 28g; 56g stone (remainder of bag animal bone)		272	490	
		1214	1132	2056	618g 17 fragments of large tuyère; 212g natural stone; 588g 20 pieces of low density amorphous iron slag; 244g 2 pieces med density slag; 606g 7 pieces very dense slag. Fines #936, magnetic fraction rich in slag, but only a very little scale.		1438	618	
		1214	1144	12	small lump of charcoal rich slag			12	
B	X	1214- 1203	s1106	296	6 pieces of charcoal rich slag, no form discernable			296	
B	X	1215	s1105	1690	1010g 15 pieces of slagged lining, some showing large curved surfaces, others showing right angle bends with slagging on both sides; 284g irregular prilly slag block, possibly a deformed small SHC?; 366g 9 pieces of variable Fe-slag	284	284	366	1010

B	X	1215	s1117/ 917	2685	828g complicated and irregular cake in 2 pieces, 150x110x100, cake has 3 layers, lowest is vesicular thin crust type with V shaped cross section, grading up into some slag with coarser charcoal, then oblique crust cuts this, with possibly a further oblique crust piece at high angle. Top is extremely smooth well blown surface which joins and smoothes those two crust fragments; 366g small extremely dense SHC with gravel adhering to base, 90x80x50, top probably originally domed, but broken to show void with crystal terminations; 290g 180x80x45 small SHC irregular ashy lumpy base, top covered in medium charcoal dimples; 644g 24 pieces of large tuyère and other vitrified clay, 1 pieces (photo) shows clay pressed onto side of already glazed tuyère with finger impressions; 42g 9 pieces of dense flow prills (poor) and blebs; 94g slab of moderately dense but vesicular SHC crust; 348g 52 small pieces of Fe-slag	2429	828, 366, 290	390	644				
B	X	1221	911	28	no scale - probable too coarse a fraction, lots of magnetic slag and stone with charcoal.								
B	X	1221	916	24	abundant flake, some spheroidal hammerscale								
B	X	1221	s1111	1445	998g large probably intact low density SHC, base rich in coarse charcoal, top Fe-rich and smoothish, 160x130x45 but one end folded up during extraction and breakage; 44g vitrified and slag clay with one unslagged curved surface so suggesting tuyère tip - but if so end burnt off obliquely, or even longitudinally; 14g slagged lining; 364g 12 pieces of hearth slag, one very dense suggesting included iron.	998	998	364	58				
B	X	1221	s1116	1575	50g 4 pieces dense lobate flowed material; 26g 2 pieces fired clay; 178g slab of material forming poor basal flow, firmly attached to fired clay; 102g 3 pieces of vitrified probable tuyère; 60g 4 pieces of lower density blebby flow; 716g 19 pieces of mainly charcoal rich slags; 456g 3 amorphous dense slag lumps, 1 apparently has exploding iron inside.			1460	128				
B	X	1232	s1127	112	13 pieces of corroded hearth slag, lots of accreted organics on some pieces - which might be Fe-debris			112					
							16510	11550	7630	0	0	0	35890
Other Features													
a	1	57	ditch F58	1015	88	42g worn piece of small SHC, slab like, 13mm crust. plus 46g natural stone	42						
a	1	58	ditch F58	1016	6	thin sheet of slag with botryoidal overgrowths, dense, probably a smithing fine			6				
		134	bowl/f f137	1100	68	13 pieces of rough dark material varying from blebs to charcoal rich material - looks like fines from base of hearth or furnace.			68				
B	X	135	bowl / f f139	923	28	some flake present							
B	X	135	bowl/f f139	s1123	1325	agglomerate from hearth bottom of all sorts of debris 172g; 628g piece of bowl from very dense hearth cake, slag puddle has dished top and is 20mm thick in middle, has crystal terminations around edges, has tubular vesicles, very dense and fresh looking; 12 small slag pieces, 94g; 268g part (55%?) of small SHC; 138g lip of small SHC.	1034	487	172				
		123	pit F141	1131	304	54g rusty concretionary charcoal rich floor; 250g rusty blebby lobate material around small charcoal moulds, probably poorly formed SHC; fines #934 magnetic slag no scale.	250		54				
		150	ditch f149			small piece of vitrified tuyère or hearth lining surface							
a	4	171	bowl/f f168	225	22	tuyère fragment					22		
a	4	195	bowl/f f194	1047	134	large block of oxidised fired ceramic with vitrified surface, internal fabric to clay suggests this may be a tuyère fragment - if so it must have diameter >180					134		
a	4	822	pit F820	1046	40	stack of dense prilly lobes - from a smelting furnace						40	
a	4	826	bowl/f f860	1060	152	76g 3 pieces of possible ore; 76g dimpled lobe of smithing slag, rather amorphous			76				
a	4	932	bowl/f f931	1058	8	low density charcoal rich material - is this slag or even ore? Compare 1038			8				
Z		1201	bowl/f f979	789	28	folded base of thin crust SHC	28						
		1201	bowl/f f979	1091	8707	complete suite of slag from basal part of a smelting furnace (details separate)						8707	
a		1017d	pit f1017	1062	88	7 indeterminate small lumps; 1 indeterminate dense piece; 1 prilly mass with silvery descending prills between charcoal moulds						88	
a	7	1133	ditch f1133	1072	244	irregular mass of fired clay with some slag. Clay has abundant organic temper and some fingerprints. Probably a tuyère support					244		
a	7	1183	pit f1183	1075	918	soft friable mass broken into many pieces. This is similar to some of the sinters mentioned in other contexts. It is iron rich light porous, contains small pebbles and much charcoal			918				
		a/b											

a	y	688	1031	340	2 pieces, 1 very small, of material descending between wood down wall of smelting furnace, v dense. Curvature hints at small 250mm diameter? Furnace pit						340								
a	y	689b	1032	14	small prilly piece with charcoal moulds, probably a smelting slag						14								
a	y	689b	1033	50	9 pieces of concretionary material, probably from base of smelting furnace, small prills on rusty mass of grains and charcoal fines						50								
a	3	794	1040	246	small piece, rather worn, from large dense SHC	246													
		794	331		dimpled and contorted lump of pale to green lining slag														
a	4	827b	1052	22	very dense concretionary lump full of charcoal, sufficiently dense must be lump of iron inside						22								
a	4	827b	1053	8	rusty sandy concretion around small slag fragment						8								
a	3	836	1039	18	2 small concretionary nubs around iron corrosion in smithing floor						18								
a	3	853	1043	126	2 pieces of dense dark vesicular and charcoal-rich slag. These must be from the late phase?			126											
a	1	856	1050	18	3 small nubs of smithing hearth slag			18											
a	3	898	1045	30	concretionary smithing floor						30								
a	3	908	1049	10	dark rusty lump of slag - presumably from smithing hearth			10											
a	3	921	1044	40	one lump of lining slag, two small flattish pieces of denser slags, one of which may possibly be a sub-tuyère backflow			40											
a	6	976	1068	18	2g tiny slag piece; 16g very dense blebs with charcoal impressions - almost certainly a smelting slag			2			16								
a	3	1036	1054	8	rusty fragment of lining slag			8											
a	3	1036	1055	10	3 small pieces of rusty smithing floor type material						10								
		1088	638		convex piece of green glazed vesicular ceramic with dark blebs adhering - very likely from tuyère				x										
a	3	1117	1067	4	rusty charcoal rich accretion? Attached to small piece of lining slag			4											
		1117	749		ball of glazed lining slag, probably broken in 2				x										
a	7	1169	1074	4	tiny scrap plus well flown slag bleb			4											
a	7	1192	1080	52	lump of charcoal rich iron slag - presumably smithing			52											
a	7	1307b	1083	4	irregular prilly dark slag			4											
		1317	881		very irregular lobate mass of lining slag with apparent broken contact with a more iron rich slag				x										
a	7	2004	1073	632	slab from side of very large thin crust type cake. Rusty, very dense			632											
											<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 15%;">1398</td> <td style="border: 1px solid black; width: 15%;"></td> <td style="border: 1px solid black; width: 15%;">362</td> <td style="border: 1px solid black; width: 15%;">0</td> <td style="border: 1px solid black; width: 15%;">0</td> <td style="border: 1px solid black; width: 15%;">420</td> <td style="border: 1px solid black; width: 15%;">88</td> <td style="border: 1px solid black; width: 15%;">2268</td> </tr> </table>	1398		362	0	0	420	88	2268
1398		362	0	0	420	88	2268												
Roadway																			
a	7	1171	1071	8	(bag 1 of 2) bleb with silvery base and darker top, moderate density			8											
a	7	1171	1071	14	(bag 2 of 2) 2 pieces of corroded iron bleb						14								
											<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 15%;">0</td> <td style="border: 1px solid black; width: 15%;"></td> <td style="border: 1px solid black; width: 15%;">8</td> <td style="border: 1px solid black; width: 15%;">0</td> <td style="border: 1px solid black; width: 15%;">14</td> <td style="border: 1px solid black; width: 15%;">0</td> <td style="border: 1px solid black; width: 15%;">0</td> <td style="border: 1px solid black; width: 15%;">22</td> </tr> </table>	0		8	0	14	0	0	22
0		8	0	14	0	0	22												
Modern and Topsoil																			
a	1	1	1017	14	small fragment of dense grey vesicular iron slag			14											
a	1	1	1018	30	small piece of SHC	30													
a	3	1	1028	6	corrosion around iron object						6								
a	4	1	1027	6	small piece of vitrified lining material, has dark raised zone then flat maroon zone probably tipping into hole - so presumably a blowhole or tuyère fragment					6									
a	6	1	1063	34	very dense amorphous lump of smithing hearth slag			34											
a	6	1	1065	58	18g small piece from a tuyère, 38g dense prilly rusty slag			38		18									

a	7	1	1070	288	160g piece (50%?) of small very dense rusty SHC 70w x 30d; 36g piece of iron bar/nail with accreted material; 1g nail; dense dark slag with smooth blebby exterior and coralline interior 78g; 16g 5 small pieces of vitrified orange ceramic	160	320	78	16	37				
a	7	1	1076	108	110g SHC fragment; 44g 3 corrosion balls around Fe pieces	110								44
b	6	1	1066	558	dense SHC with a v shaped profile - though may have been deformed. Probably not more than 50% of original. All surfaces bear charcoal	558	1116							
B	Y	101	s1141	732	3 pieces of v dense, slag. One shows edge of slag-bowl with moderately smooth top, other two are more charcoal-rich types of slag, with charcoal dimpled bases	732								
	1	1	1089	10	4g sandstone, 6g lobate bleb of lining slag				6					
		1	1135	1020	412g 4 pieces of tuyère; 336g dense SHC 90x90x40 flat top sediment on base; 272g 4 pieces of vesicular and charcoal-rich slag	336	336	272	412					
		128	1102	840	172g natural stone; 430g piece of dense thick crust cake - must be <30% of whole. Smooth dished top; 430g burr, probably would have been 120 wide and 47 long by 45mm deep; 74g burr, 60wide x 45 long x 25 deep, very narrow, strong burr with gravelly base. tops of both these burrs have smooth blown hollow; 22g tiny gravelly burr fragment; 68g prilly ball with smooth top - like a tiny SHC 50x40x35mm; 64g amorphous charcoal-rich slag.	956	1430	132						
		130	1097	26	low density slightly prilly material - looks like clinker but has lots of charcoal within				26					
		177	1095	25	12g corrosion spalled off large Fe object; 12g dense well flown slag prill with maroon surface; 1g small slag piece				13				12	
		178	1101	164	148g, worn piece of dense slag; 16g nail and corrosion from Fe sheet; 4g stone				148				16	
		1229	1133	84	12 pieces of thin dense flow and prills. This could be an assemblage from below the tuyère perhaps				84					
a	7	1310	1082	16	corroded iron object, folded sheet								16	
						2882		845	452	131	0	0	4310	
						shc	shc	other	tuyère	iron	smelting	smithing	total	
							recon	slag			slag	floor		
overall total						47913		26787	24565	169	9825	110	109369	

Table 5. Catalogue of archaeometallurgical residues

<i>context</i>	<i>find no.</i>	<i>number or wt. (g)</i>	<i>notes</i>	<i>deposit</i>
1	267	1	pale pebble, heated to become vesicular, coated down one side with clear to green glaze	topsoil
1	415	1	rough pale rock ,possibly a sandstone with a glaze on one side	topsoil
1	548	3	side of large boulder broken in three with thick rich glaze, can see point of contact with adjacent piece	topsoil
1	1	38g	glazed pebble	topsoil
48	138	1	limestone pebble with glaze on one side	graveyard soil in cutting 1
48	209	1	broken chip of green glazed stone or just possibly ceramic - it has become a little vesicular near the surface	graveyard soil in cutting 1
53	286	1	highly heated fissile pale coarse rock with deep green glaze on outer surface of pebble	building rubble over 48
53	592	1	glazed stone or ceramic	building rubble over 48
54	301	1	very decomposed ?limestone with deep rich glass adhering to one corner	disturbed layer over 53
54	404	1	glazed piece of ?limestone with slightly lobate appearing glaze - fuel contact maybe?	disturbed layer over 53
54	4	335g	fragment of glazed stone	disturbed layer over 53
63	200	1	small pebble of pale rock, coated in transparent green glaze on a concave side	robber trench
63	126	1	fragment of a glazed pale rock - broken to this shape - possibly spalled off larger glazed stone	robber trench
63	136	1	glazed pebble, opposing ends broken off, glaze goes all round round but has diametrically opposite thick and thin areas	robber trench
63	127	1	small piece broken from larger glazed stone	robber trench
241	91	1	cherty pebble with white glaze on one face	grave in AreaA
260	144	1	pale siliceous rock with green glaze on large side, just extending round edges on to other side	disturbed subsoil in graveyard
604	246	1	chip of green glaze	grave in AreaA
1117	750	1	small piece of pale rock as 267/200 with remains of thick green glaze on one side	grave

Table 6. Catalogue of glazed stones

<i>Weight (g)</i>	<i>Description</i>
4470	various pieces of concretionary sheet up to 70mm thick
1066	16 pieces of tuyere. Not clear if this can be assembled into a single tuyere. Two large chunks are apparent, each 130-140 in diameter. Hole appears to taper rapidly to front.
50	piece of slag from in front of tuyere
1405	extremely brittle, pale surfaced slag well flown between large pieces of wood/charcoal. Basal layer has chilled on floor and is reasonably dense. Upstanding flow lobes become increasingly vesicular upwards, eventually becoming open voids with crystal terminations inwards, just like the hemispherical lump described below.
188	4 rounded lumps which may contain iron
118	7 irregularly lumpy pieces of slag, rather sintery looking
192	3 pieces of lining dominated paleish slag. Somewhat lobate and bearing charcoal moulds, 1 piece shows small area of ceramic contact, so may be from in front of tuyere.
136	in 8 pieces, wrinkled hemispherical hollow slag body, inside is void with crystal terminations, possibly result of drip onto furnace floor.
38	5 pieces of flown blebs and prills, apparently associated with charcoal-bearing material – but not clear whether this is the charcoal-rich slag – or the concretion layer
20	2 pieces of material where the top of the concretionary later appears to have been slagged
80	2 pieces, 1 prilly and mouldic, the other massive, which seem to have come out of the concretionary layer.
1064	870g 5 large pieces and 194g c30 small pieces of charcoal rich slag in a fragmented thin crust cake. The other rim is very thin (<5mm) and granular appear, having frequent void space inside with crystal terminations. Inside is variably dense charcoal rich slag. Overall form of mass not known.

Table 7. List of materials from context 1201.

Phase	Pit 1235			BX			BY			A7			A4		
	total residue	tuyère	% tuyère	total residue	tuyère	% tuyère	total residue	tuyère	% tuyère	total residue	tuyère	% tuyère	total residue	tuyère	% tuyère
pit	35690	7630	21%												
d				12789	3845	30%	12754	4866	38%	4017	48	1%	0	0	
c				2346	738	31%	4033	1569	39%	580	8	1%	426	44	10%
b				7581	3612	48%	610	0	0%	112	0	0%	63	63	100%
a				140	0	0%	0	0		0	0		0	0	
overall	35690	7630	21%	22856	8195	36%	17397	6435	37%	4709	56	1%	489	107	22%

Table 8. Distribution of total metallurgical residue and weight of tuyère material by stratigraphic horizon (employing the terminology of Channing 2005), for the enclosure ditch and pit F1231. The totals for the ditch do not include the residues from the smaller features incised into the ditch. All weights in gram.

GeoArch



geoarchaeological, archaeometallurgical & geophysical investigations

54 Heol y Cadno,
Thornhill,
Cardiff,
CF14 9DY.

Mobile:
Fax:
E-Mail:
Web:

07802 413704
08700 547366
Tim.Young@GeoArch.co.uk
www.GeoArch.co.uk