

Metallurgical Residues from Clonmacnoise

Part 1: Evaluation of material from the waste water treatment works (02E1407)

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Abstract

A total assemblage from the 2002 excavations amounting to 271kg of metallurgical residues has been examined and classified. The majority of the material was derived from a single dump of residue from the production and working of iron. No hearths or furnaces were located within the limited scope of the excavation. Of the 141kg of the assemblage greater than 50mm, some 50kg can confidently be assigned to processes of iron-working and at least 35kg to iron-smelting.

Iron smelting technology included the use of a form of slag-pit furnace, in which the pit was initially packed with large pieces of wood or charcoal. The provisional interpretation of the slag of this class is that most of the slag produced during the smelt drained into the lower part of the pit. If this interpretation is correct, it may suggest a difference with slags of Iron Age date, in which the slag seems to have been primarily retained in the upper part of the pit (as a so-called furnace bottom) with only a small proportion reaching the base of the pit in the form of small prills and blebs.

The iron-working residues are very variable, as observed on other Early Christian sites in the region. The smaller slag cakes comprise smithing hearth cakes (SHCs) with a wide range of morphology from small cakes, up to substantial masses of up to 2.5kg, with many examples, but particularly the larger ones, having good textural evidence for a substantial liquid slag pool. A second class of slag cake is larger, often sub-circular in plan, also plano-convex, but dominated by less homogeneous slag textures, and often appear to be granular, sintered or comprising tiny slag prills. This class of slag cake is represented by examples weighing up to 5.5kg, much heavier than "conventional" SHCs and well within the range of "furnace bases" (FBs).

The assemblage also contained a number of examples of fired clay tuyères. These were rather fragmentary, but are of a type commonly found on Early Christian sites in Ireland. They appear to be associated with iron-working rather than smelting, and comprise a clay tube of approximately 120mm outside diameter with an 18-22mm diameter bore. Large slabs of vitrified hearth/furnace lining are interpreted as being derived from the smelting furnaces.

The assemblage contains material similar to that from other Early Christian sites, and in particular bears close comparison with unpublished material from a probable ecclesiastic site at Clonfad, near Tyrellspass, Co. Westmeath. The potential of detailed further investigation of the assemblage for clarification of the processes represented, and for elaborating on the role of iron making and working at Clonmacnoise are discussed.

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Background

Material from the 2002 excavations along a waste water facility to the North of the visitor centre has been examined and classified. The largest sample (material originally collected as samples 20, from F14c and 21, from F14b, but subsequently mixed) comprised slags and ceramic material retrieved by hand from the excavations and mainly stored unwashed. This assemblage was washed and sorted by size. All pieces of residue above 50mm in size were hand-picked and individually described. The sorted and washed material amounted to 463 individual pieces of over 50mm, weighing 141.4kg, plus 114.7kg of material below 50mm. In addition 3.8kg of fines were retrieved by wet sieving at 200µm of a subsample of the debris from the washing of the main assemblage.

There was also a small number of samples collected during the excavation of other contexts within the same trench, amounting to a further 11.4kg. The total weight of metallurgical residue retrieved and retained from the excavation was therefore 271.4kg.

Description

Table 1 provides a complete listing of the finds from the smaller assemblages from the 2002 excavations and Table 2 provides a listing of all pieces greater than 50mm from samples 20/21.

There are several slag types within the assemblage which can, fairly easily, be differentiated. There are also an extremely large number of slag pieces for which the interpretation is far less clear.

Probable smithing slags

The dominant class of slag has a broadly plano-convex form (although some individual specimens are biconvex and others which are concavo-convex). This morphology of slag was said by Tylecote (1986) to include "furnace bottoms" (FBs) with weights of up to 25kg and "smithing hearth bottoms" (SHBs) with weights typically below 1kg. Since Tylecote's work there has been a great deal of debate and redefinition of these terms, with the term "plano-convex base" (PCB) achieving wide usage instead of SHB. Crew (1995) widened usage of the term FB to include the slags trapped in the base of a slag-tapping furnace, and used the term "slag block" for the contents of the large basal pits of slag-pit furnaces. Crew (1996) preferred the use of the term "smithing hearth cake" (SHC) to SHB or PCB, since the cakes are not always plano-convex, and do not actually form in the bottom of the smithing hearth. Crew also described the weight range of SHCs as from 100g up to about 2kg, with the largest examples possibly being confusable with FBs.

In the present collection the broad definition of SHCs could be taken to include a wide range of material, including at least 60 examples, which is capable of further subdivision:

1. smaller SHCs. The smaller SHCs are typically subcircular to slightly elongate, plano-convex to slightly biconvex examples. They have a weight range of 100g to 2.1kg, but most examples appear to lie in the 200-700g range with a length of 80-110mm. They generally have a basal crust, which ranges from 6-15mm in thickness, forming a bowl shape, which is infilled by a much more

charcoal-rich slag, which may be upstanding on the upper surface.

2. dense SHCs. The type described above appears to grade into forms in which the basal crust is thicker, and appears to have formed a liquid slag puddle. This gradation is not well understood, in the present lack of cut sections through the cakes. These dense cakes seem to have two different types of upper surface. In one the dense slag has a smooth upper surface, in the other the dense part of the cake seems to have been separated by a void from a discrete upper layer of either a thin slag crust or some porous, charcoal-rich slag. The upper surface of the dense material below the voids are characterised by the presence of visible olivine crystal terminations and sometimes almost free olivine crystals. These may either be rather equant crystals, or platy forms, often giving the surface a honeycomb texture. These textures are interpreted as the product of shrinkage of the slag puddle during the crystallisation process, drawing down the still-liquid slag from the network of first-formed crystals. They are similar in appearance to the open crystal network often found in experimental bloomery smelting in the zone between the bloom and furnace wall, but in that case the textures are assumed to be generated by crystallisation from slag which has subsequently drained to a lower level in the furnace. This presents an alternative model for generation of the SHCs, in which slag is generated at a level significantly above the top of the puddle, and drains downwards. In either case, these features indicate that the hearth was maintained at extremely high temperatures, for a prolonged period.

3. large, prilly/granular SHCs. These are large, subcircular SHCs, with a variable internal texture but frequently comprising extremely small prills of slag (mm-scale), coalescing and flowing around very fine-grained charcoal. The overall impression is of a very granular slag mass. Examples from Clonmacnoise range up to 5.5kg at a size of 250mm diameter and 70mm deep, but similar SHCs at Clonfad range up to 10kg for 320mm diameter by 120mm deep examples. These cakes fall into the size range which Tylecote referred to FBs, but despite their size there seems no compelling evidence at present to link these forms with smelting rather than smithing.

Probable smelting slags

In contrast to the plano-convex slag forms described above, there is material which can reasonably confidently be associated with smelting. The most characteristic slags in this group are those dense, well-flown slags, which surround the moulds of extremely large pieces of charcoal or wood. These charcoal/wood pieces seem to very carefully oriented to provide certainly a lining, and probably a filling, to a pit lying beneath the smelting furnace. They recall the grass packing of the pits below Iron Age smelting furnaces in Denmark. Some of the pieces show good evidence for down-wall flow of a dense fluid slag, which sometimes accumulates as a homogenous dense mass and sometimes as a layered stack of flow lobes. There are a few pieces which appear to show an upper surface to such material, and in these cases the upper surface appears to cross-cut the coarse charcoal moulds and incline inwardly downwards from

about 100mm above the base marginally, reaching the floor 160-200mm from the wall.

Isolated, more-or-less well-formed lobes of less well-flown slags are fairly common in the assemblage. Evidence from within-furnace assemblages elsewhere suggests these form commonly on the base of smelting furnace pits. Another texture seen elsewhere within the pit fills is a fine-grained, sintery-appearing material with fine-grained charcoal particles, slag blebs and a rather rusty matrix. It seems quite likely that these two textures will not be restricted to smelting furnaces.

Slags with large amounts of included charcoal may be rather undiagnostic, but particularly in examples where the charcoal is fairly coarse-grained, an association with smelting is likely.

Isolated dense slag sheets and crusts

The Clonmacnoise assemblage is particularly rich in sheets of dense slag. Some of these, possibly the majority, are probably the basal crusts from SHCs, but others may represent the base of slag accumulation within a smelting furnace.

Resinous, pale slags

The presence of these slags, with their pale colour, waxy or resinous lustre and frequent charcoal impressions (dimples) is suggestive of the presence of high-viscosity slag generated from melting of the hearth/furnace wall. A degree of input to the slag from the wall of the furnace has been well-documented for iron smelting furnaces, but is equally true for smithing hearths in which the hot-zone impinges on the wall – and is therefore more likely to occur in facilities employing a simple blowhole, rather than a protruding tuyère.

In many sites the uppermost levels of well-preserved complex SHCs may show a tongue of lining-dominated material extending into the furnace below the air blast, above the main dense part of the SHC. This tongue may be the pathway for wall material to enter the system and eventually to react with oxidised material from the workpiece, forming a more liquid slag which then drains downwards.

Tuyères

The assemblage contains numerous fragments from fired-clay tuyères. Although these artefacts are reasonably well known from Early Christian Ireland, they have not been well-studied and issues remain to be clarified.

The Clonmacnoise samples suggest an outside diameter of 90-120mm (although the tuyères may not have been perfectly circular) with an 18-22mm diameter hole. The faces of the tuyères are typically oriented at 60-70° to their axes, which is approximately the angle to which modern iron tuyères become burnt. The faces of the tuyères may show some slagging, particularly towards the base, but frequently the tips are merely glazed with a pale green glass. This vitrification may extend slightly around the angle of the face on to the sides, but the sides of the tube typically show little reaction, but often have a pale grey surface, in contrast to the dominantly oxidised sandy fabric of the tuyères.

Since the tips have been burnt back in these used and discarded examples, it is not possible to determine the original length of the tuyères. In addition, none of the examples shows its original outer face, suggesting that the tuyères were not well fired before use.

Furnace/hearth lining

The assemblage includes several large blocks of furnace lining, some with deep vitrification. Such material has not been widely recorded on Irish iron-working sites before, but the author's unpublished work on the site at Cappakeel (West), Co. Laois, has shown very similar lining debris in association with smelting slags comparable with those from Clonmacnoise.

The fines

The materials collected from the washings of the bulk collection corresponding to samples 20/21 have not been quantified but they have been inspected and qualitatively they contain a high proportion of slag fragments, many of which are magnetic, together with other debris (fired clay, charcoal, stones...), but also a high concentration of magnetic hammer scale, including both flake and spheroidal varieties (Starley, 1995). The material also contains a few slag spheroids which are less strongly magnetic, but it is unclear whether these are simply less-strongly magnetic forms of hammer scale or whether some of these are slag droplets from smelting. The fines do not appear to contain the clear smelting indicators of dense non-magnetic "coffee-bean" morphology droplets or dense small non-magnetic prills.

Interpretation

The provisional interpretation of the assemblage would indicate that both iron-smelting and smithing operations were being undertaken. Discussion of the significance and comparison of the Clonmacnoise material is hindered by the lack of full publication of material from other sites. However, the author's unpublished and in some instances on-going, investigations of other sites does provide a considerable body of comparative material. Comparative sites discussed below include Tullyallen 6 (N1, Co. Louth; Young 2003d), Celbridge (M4, Co. Kildare; Young 2003b), Carrickmines Great (SE Motorway, South Co. Dublin; Young 2003a), Clonfad (N52, Co. Westmeath) and Ballydavis A, Ballydavis B, Cappakeel, & Morrett (M7, Co. Laois). A discussion of the implications of some of these sites for the reinterpretation of some so-called bowl furnaces as slag pit furnaces also remains unpublished (Young 2003c).

Iron smelting

Iron smelting slags in the assemblage are characterised by blocks of dense slag containing the moulds of large, sometimes extremely large, pieces of wood or charcoal. There are no intact "furnace bottoms" from smelting furnaces; consequently the overall morphology of the smelting slag cakes must remain conjectural.

In some smelting slag assemblages (for instance that from Tullyallen 6), there appears to be a distinct slag cake, which might be termed a furnace bottom, with a slab-like morphology, and suspended some way above the base of the furnace pit. The base of the slag cake

at Tullyallen 6 is not well-defined, being a prilly mass with lots of included charcoal, grading downwards into a layer of charcoal with isolated slag prills and flows.

A possible sampling bias exists with the method of collection of the Clonmacnoise slags; given that the original slag material was collected by hand, the smaller slag particles (in the 5 to 30mm range) might be under-represented, or even missing, from the collection. However, notwithstanding this potential bias, it may be noteworthy that there does not appear to be any significant quantity of the prills, blebs and spheroids found in some other smelting furnaces (e.g. Tullyallen 6, but also furnaces where the main slag cake has not been preserved, such as Carrickmines Great, Celbridge, Ballydavis A and Ballydavis B). Instead, the material from Clonmacnoise is dominated by large blocks indicating down-wall flowage (presumably on the blowing wall), past carefully oriented large pieces of charcoal or wood. Similar characteristics to the Clonmacnoise smelting slags are seen in material from Cappakeel (West) and possibly from Clonfad. Material from Morrett appears intermediate between the two types of assemblage, having a rich assemblage of well-flown slags containing large charcoal pieces, but also a significant proportion of the smaller slag prills and blebs. Of the sites yielding the richly prilly assemblages from the lower part of the slag pit, most are interpreted to be of Iron Age date. Those sites with the slags indicating mass flowage to the base of the pit, forming a more coherent slag mass at the bottom, are believed to be of Early Christian date.

The significance of these differences is yet to be demonstrated, and care must be taken in separating differences in process from differences in taphonomy; it is quite likely that the nature of disposal of the large slag pieces will differ from that of the ashy, charcoal-rich material bearing the isolated prills.

The occurrence of thick slabs of vitrified lining adds to the known examples of remains of the superstructure of the slag pit furnaces and strengthens the argument for at least a short shaft.

Iron working

The occurrence of conventional SHCs, with evidence for substantial slag pools, alongside larger, less consolidated slag cakes, indicates a diversity in technology not commonly encountered in other areas or periods.

There are three significant, and not necessarily independent variables:

a. the potential variation along the process chain. Slags produced during the early stages of bloom consolidation may be more voluminous and require a higher proportion of welding operations than those produced during the later stages of bar iron production, or indeed of finished artefact production.

b. the potential variation produced by different hearth constructions. The archaeological evidence seems to indicate that there is some variability in the size and form of ground-level hearth employed. The possible existence of waist-level hearths at this period has not been confirmed. The usage, in this period, of the characteristic fired clay tuyères, is also not well understood. The chemical effect of tuyère use would very likely be a reduced input of the hearth wall to the slag forming process.

c. the potential variation produced through the use of different fuels. One avenue of investigation is the possibility that the large, less consolidated, hearth cakes, with their evidence for fine organic matter, were produced during smithing using peat, or more likely peat charcoal, as fuel. In contrast the conventional style of SHC tends to show good evidence (in the forms of moulds, dimples and sometimes inclusions) for the fuel having been wood charcoal.

It is possible that complex relationships may be at work; for instance working with fine-grained peat charcoal, rather than wood charcoal, might be enhanced by using a tuyère rather than a blowhole, and the resulting type of fire might be used preferentially for one part of the chain of operations.

The occurrence of tuyères adds to the understanding of this class of artefact. Their distribution on Early Christian sites seems to correlate with the evidence for iron-working, and they are absent from some sites with evidence purely for smelting (e.g. Cappakeel (west)). They show evidence for the same style of burning as do the iron tuyères in modern side-blast forges, and presumably were used in a similar manner, namely to bring the air blast under the fuel pile.

The context

The assemblage has considerable potential for understanding aspects of the role of iron-making and – working at Clonmacnoise. It is slightly unfortunate, from the point of view of understanding the technology, that the slag dump sampled in these excavations comprised residues from all parts of the iron processing chain, so separating the residues from the various processes is not straightforward. However, this strongly suggests that those processes were physically associated, and indeed located very close to the excavation site.

Sites of this period investigated by the author have fallen into two broad categories, although the number of sites is small, so these categories must not be considered exclusive. Firstly, there are those sites, such as Clonmacnoise, where metalworking is associated with enclosed ecclesiastical sites. Further examples of this type of site would be Clonfad and Ballykillmore, Co. Westmeath. The Clonfad assemblage (which probably totals more than 2 tonne of slag), currently under investigation, contains the same range of materials as the Clonmacnoise assemblage, although the collection contains a much smaller proportion of smelting residues. The sites reviewed by Scott (1990) also include several secular enclosures with evidence for large quantities of smithing residues. The second class of site, probably represented by several sites on the M7 in Co. Laois, but particularly including Cappakeel (West), is apparently unenclosed, and includes complexes of smelting furnaces and charcoal-production pits. This may suggest that primary iron production may commonly have been a rural activity, with secondary smithing more focused on settlement. Such a pattern is common in many periods and cultures and is a rational response to the occurrence of the natural resources of fuel and ore. However, the relative balance of smelting and smithing residues at Clonmacnoise may indicate that both parts of the process were operating together.

Despite the apparently large size of the metallurgical waste assemblage from Clonmacnoise it must be borne in mind that the excavation sample is a random one – and there is currently no evidence for the overall scale of activity. The metallurgical residues retrieved

so far probably represent a sample equivalent in size to the total losses from the production of only 20kg of finished iron. Much further work would be needed to establish the significance of the assemblage for the discussion of the site as a whole. Of other investigated sites, that at Clonfad provides the closest parallel for both the context of activity and of the residues themselves.

Further work

Table 3 lists those specimens extracted from the collection to form the basis of further investigations.

A detailed proposal for analysis is contained in a separate document. It is the purpose of this report to describe the potential of the Clonmacnoise assemblage, both within the context of furthering the understanding of this important site, but also as an assemblage capable of furthering understanding of the metallurgical technology of its period.

There are several distinct research questions to be addressed through further investigations:

1. iron smelting

Although, as discussed above, attribution of some slag textures to iron smelting within a furnace utilising a slag pit is fairly secure, the subtleties of the process are not well understood. Multiple analyses to determine the homogeneity (or otherwise) of the smelting slags are recommended. The estimation of bulk smelting slag composition is a necessary first step towards establishing a mass balance for the furnace. The mass balance may be employed, together with estimation of total slag output of the furnace, to provide an indication of bloom size (Thomas & Young 1999a, 1999b).

The discussion above also described the significant differences between various smelting slag assemblages from Irish slag-pit furnaces. The significance of these differences in terms of technological change, random variation between smelts and taphonomic controls (for instance material remaining in cleaned furnace pits compared with dumps of cleared material) also needs to be investigated. There are extremely few examples in which furnaces are left completely uncleaned after their final smelt, so careful investigation of the partial assemblages is important.

A particular issue needing to be addressed is the nature of the upper surface of the slags in the smelting furnace pit. Is the top a "free" surface of accumulated surface, with the bloom having been generated some distance higher up in the furnace? Or is the upper surface of the slag the surface from which the bloom was removed? Or is the upper surface (particularly in those cases where it dips strongly inward from the margin) a secondarily modified surface generated by bloom manipulation or bloom reheating.

2. smithing

As described above, the assemblages of residues from iron working of Early Christian age from Ireland are remarkably diverse. In order that the controls on the diversity may be addressed, a programme of detailed investigation of a range of probable smithing hearth cakes should be undertaken. This programme should include the detailed recording of the morphological and textural variation between and within the various slag

types, as well as chemical analysis to determine the components contributing to the slag and to attempt to identify evidence for the nature of the fuel.

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Table 1: Contents of small samples***t3 ext topsoil
(contaminated)***

sample 23 slag

74	granular slag with fine charcoal, bearing clasts of lining and ?limestone
788	1 surface almost planar, fine granular, fine lobes, small spheres, small charcoal, opposite face large lobed and large charcoal impressions. Uncertain whether the planar surface represents contact with the base, top or side of the slag mass
200	slab of slag with small charcoal holes one side, grading to larger on the other , curved suggesting close to a margin
392	piece probably from cake edge, fine comminuted appearing surface on curved and planar faces, 90 wide and long, 50 thick. Thickets part shows mould of v large charcoal piece
186	small plano-convex fragment, planar surface small comminuted appearance, curved face has small charcoal impressions
146	irregular piece with granular appearance on one side, but well flown between moderate charcoal on the other
68	slightly curved thin crust of dense slag approx 8mm thick
154	slab of lining with vitrified and rusty surface
214	4 pieces of slag with large charcoal impressions, plus some debris
2222	total

sample 27 fired clay

3155	40 pieces of fired clay fired clay mainly oxidised yellow-brown, locally slightly reddish, a few patches of reduced dark grey clay supported by wattle, with diameters 9-18mm observed most pieces show only approximately parallel wattles, one shows single strand at right angles to 4 others on opposite faces. No evidence that the wattles were split. Matrix silt to fine sand dominant small organics locally present too - but probably accidentally good hard material!
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Other small samples

91	cut 2	f5.8	70	light vesicular pale lining slag attached to highly altered lining, large square to bladed pale crystals in pale grey glass
127	tr3	f44	46	1. rather weathered grey vesicular slag with very large olivines, and very large charcoal impressions
			24	2. part of rounded nub of grey slag with large charcoal inclusions
151	cut 3	f84	20	1. hard fired fine clay - looks brick like in comparison with sandy linings
			78	2. fine fired clay tempered with coarse sand, vitrified surface in dark glass with lots of part-melted quartz. Some drops of adhering black slag. Piece is convexly curved, with quartz and thick vit
139	cut 3	f74	28	small lobe of pale grey slag, flowed over a gravel substrate. Some blebs of dark iron slag in upper smooth glass surface. Generally similar to material from 91.
unlabelled bag			150	5 pieces of fired silty ceramic material similar to contaminated collection, but no visible wattling
128	cut3	f44	282	1. block 80x60x50 of moderately dense slag, One face smoothish with small dimples, other is hash of small charcoal and rust, with 1 piece of ?flake
			94	2. cake margin piece, 40 long, 50 wide, 35 deep. Very dense. Lower? hard crust 8-10, then central void and upper dimpled layer
			38	3. grey (weathered?) vesicular slag with resinous surface. Irregular piece. Adhering ashy material with charcoal
unlabelled bag			134	1. slab of pale friable lining with adhering lobes of both dense iron slag and lining material around medium charcoal voids
			206	2. irregular block of charcoal-void rich slag. 1 part of surface finely granular with cf straw impressions, rest medium to coarse charcoal
			192	3. irregular slab of slag with well-mineralised wood fragments, 1 large face smooth but lobate (wall?), rare fine organics too
			384	4. large block of slag attached to wall - adjoins 1 and probably 5, slag in crude flat sheets extending perpendicular to wall, though not quite at 90°
			12	5. small fragment of iron slag lobes in contact with wall in pale friable material with fine organics
sample 26	cut 3	f77	522	1. broadly plano-convex block of low density slag. Full of medium charcoal voids, particularly on lower surface
			186	2. rather curious dense pale slag flowed lobed with smooth dark purple upper surface, lower face covered in ashy fine charcoal debris
			94	3. curious curved bulge of lining material with vitrified surface and \slag. Some of surface has\ deep red glassy glaze - is this a Cu-alloy working tuyere? Ceramic is fine clay with coarse sand
			132	4. c.50 diameter ball of dense slag with charcoal impressions and ash all over. V dense
			80	5. contact between rusty dense slag with medium charcoal impressions and very sandy substrate. Slag has flow lobes/bubbles. Some ash between slag and sand
			88	6. moderately dense slag fragment with abundant med charcoal voids
			44	7. lining dominated pale slag lobes with charcoal impressions and locally with maroon bloom and some rusty patches
			30	8. pale resinous lining dominated slag with dark glassy surface
			36	9. irregular fragment of dark dense iron slag with abundant fine charcoal debris
			56	10. irregular piece of dense slag with lower surface covered in small dimples, upper surface smooth
			60	11. irregular dense fragment with crudely lobed upper surface and finely dimpled lower
			28	12. dull surfaced flow lobe similar to 11 but better developed. Has slag inch worm on upper surface! Highly vesicular flow
			4	13. small length of iron band,

- 4 14. nail point?
- 42 15. bone & stone
- 176 16. c25 slag pieces
- 30 17. corroded piece with charcoal, 1 piece scale, and other debris - probably smithing floor

F14c

- 112 1. charcoal rich iron concretion
- 46 2. charcoal rich iron concretion
- 50 3. slab of vitrified lining - vitrification extends well back into fabric. Fabric clay with quartz grains
- 10 4. stone
- 140 5. charcoal rich iron concretion with twigs, attached to pale lobate lining slag
- 456 6. slab of dense slag with abundant charcoal impressions. Top smoothish, convex lower surface with lots of small charcoal. Some large charcoal impressions on upper surface - but also a po

unlabelled bag

- 1105 1. large block from smelting furnace wall. Curve suggests 45-55dia. 100x160x90in from wall. Inner edge getting granular, good blebs nr wall
- 156 2. convex piece of wall, with adhering slag - sometimes with gap between two. Wall heavily vitrified - could be a piece from "hood" area?
- 204 3. irregular flowed spiky mass of dense slag - smelting
- 108 4. irregular mass of lobes of wall and iron slag
- 296 5. 10 smaller pieces of slag - all probably smelting

Table 2: Working list of individual specimens >50mm from samples 20/21

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
lining and associated material		
1		140 vitrified tip of tuyère, c120 diameter with c22 diameter bore, hole slightly off centre, face partly vitrified, inclined at c50° to bore, finely sandy oxidised fabric
2		206 crudely triangular piece of reduced fired lining/stone. Coarsely sandy, long side arcuate, slagged on flat and other edges
3		158 dense slags attached to convex wall with glassy slags above - a sub tuyère piece?
4		244 coarsely sandy slagged boss of lining - probably rounded base of tuyère, possibly c 130 diameter?
5		116 irregular lump of lining slag attached to small amount of oxidised lining
6		162 irregular wedge of lining slags attached to convex lining fragment - might possibly be from tuyère
7		238 irregular block of lining with broken lining, sandstone pebbles all coated in dense slag
8		246 irregular mass of dense vesicular slag attached at 70° to sandy wall fabric
9		168 good tuyère piece, 26mm hole, 75° to surviving disc part, disc has abrupt bend 35mm outside hole, disc slagged with pale lining slag, clear beyond bend, very similar to example in sample 151
10		154 slagged convex piece of lining
11		124 heavily slagged very slightly convex lining
12		148 boss like lump of slagged lining
13		114 irregular convex lump
14		108 tip of tuyère, probably from lower side, appears to be c90 diameter, slag accumulation on lower side gives a collar effect, extending back 20 from face. Tip has pale glaze, fabric fine, sandy.
15		56 overhanging lining with intense blue fuel ash colour in places, looks like above blowhole damage?
16		36 convex slag with abrupt change from smooth to rough over angle, some bright glass, fabric fine-medium sand
40		48 corner of ceramic object, surface buff, inside grey, 1 face glazed with pale greenish glaze, broadly similar to contaminated material but has more temper
41a		90 slab of reduced fired lining cf 2, slagged face has three facets, 1 more heavily altered than the other two
17-25		340 14+88+24+28+14+32+50+62+28
26-39		600 16+40+30+30+50+58+92+50+44+12+86+20+10+62
3356		
corroded iron		
41		96 dense slag with exploding iron inside

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
hearth bottoms		
42		5540 best preserved of good furnace bottoms. 250x240wx70d but with protrusions up to 110. Has smooth hollow offset from centre with more green slag, raised charcoal rich slag peripherally, lower face has hard dense rough main bowl, with signs of flowage and dimpling around periphery
43		1705 dense pcb, with good slag puddle, with crystal terminations on upper surface, with apparently rather friable thin shell roof over. Lower surface rough. 175x120x50. C75% of cake present?
44		1285 dense pcb, 150x150x55mm, although dense much of outside has a rather sintery appearance although this may in part be due to secondary minerals. Base sintery to rough, with small microprilly area. Upper surface smoothish, slightly domed with sintered looking material in central area.
45		426 150x90x35d roughly semicircular pcb/crust fragment. Lower part dense slag with tubular vesicles, upper dense in centre but coated with porous charcoal rich material, lower face smooth dimpled
46		736 roughly quarter of pcb, 150x120x45. Dense body, smooth upper centre, charcoal holes towards margin, lower rough dimpled towards margin
47		882 probable pcb but may be basal flow, trapezoidal in plan - broken both ends, 110 long, upper very rough, maybe coarse charcoal, lower dimpled with central flow lobes, narrow end 80, other 110, skewed, lower part dense, upper has large rounded vesicles
48		1030 more or less complete extremely irregular pcb, 140x160x50, but with protrusion rising extra 50, upper rough charcoal, but smooth on protrusion, lower rough with smooth micro prills
49		2105 broken piece <50% of large irregular pcb, 140x180x60d main bowl, with charcoal-rich part up to 30 on top, lower hard rough with crust up to 15, then bowl filled with charcoal rich material, lower rough, microprills, no flows
50		824 dense biconvex cake, hole in top reveals zone of well developed free crystals, top rough, bulbous, lower face microprilly, 130x90x60
51		706 slightly biconvex dense pcb with film across top broken to reveal internal void, top matt but smoothish, bottom microprilly. 119x90x40.
52		666 small biconvex pcb, 120, 110, 45 lower rough, upper as 51, rough crust over charcoal moulds, roughly symmetrically biconvex
53		416 small pcb, 110x80x45, rough lower with microprills and central flow lobe, smoothish in part on top
54		468 small biconvex hearth cake. Has small smooth depressed area with raised rim on upper surface - presumably the blown area. Raised rim has fine charcoal. Main mass is a dull biconvex lobe, rough on top and micro-prilly below. 120x110x40.
55		388 small pcb, 110x80x40, top rough with marginal flow lobes, lower rough, with raised collar around broken proximal end
56		590 problematic piece - either half of irregular pcb or burr area from furnace?, lower dense slag with tubular vesicles and big lobes on base, upper vesicular slag with large voids with large olivines 130x90x40 bowl, but much rises to 35 above - is this another biconvex cake?
57		858 biconvex cake, lower dimpled with large flow lobes on one side, upper half very irregular on the base with rounded lumps, charcoal and other debris
58		784 wide flat pcb, 120x180x35, lower rough, small lobes at edges, top smoothish, flat with rounded remains of charcoal moulds in centre, flat towards edge
59		136 tiny pcb, lower rough, crust 6mm, top irregular but flattish, 80x70x15 bowl with 15 protrusion in one small area

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
60	242	irregular folded and bent crust, to 12mm thick 110x90x40, lower smooth lobate to rough and dimpled, upper irregular, one end folded over
61	170	80x70x35 almost complete pcb, base smoothish dimpled, top concave but with charcoal moulds, basal crust to 3, above 12 of granular vesicular charcoal to 30.
62	412	110x80x35, irregular pcb- shape interrupted by major proximal hollow with big charcoal down to crust, base rough with microprills, top smooth with charcoal to 30.
63	160	pcb fragment
64	612	100x110x45 pcb with concave top filled with charcoal, base rough with charcoal
65	394	pcb fragment, 70x100x45, basal crust to 10, charcoal rich above, base rough with flowage on one end
66	404	80x85x60 small inverted pyramidal pcb, side of pyramid against wall extends below distal faces, top smooth, flowed on removal on wall side, covered in good charcoal (dating?), base rough with very small charcoal
67	348	80x80x55 small pcb - but with raised top irregularly, base rough lots of small charcoal, top covered in charcoal and rounded lumps, poor lobes on margin
68	256	90x65x40 small pcb, smooth top locally glassy, base dimpled, good flow on margins
69	222	most of small pcb but broken, smooth top, vesicular dense slag throughout, slightly dimpled base 60x75x40
70	660	110x105x55 irregular pcb, base dimpled, lobed and small charcoal, top with flow lobes, but rougher material "dumped" in centre, shows 2 possibly 3 phases of development
71	444	130x70x40 elongate lobe of slag - probably pcb, internally very dense with some tubular vesicles, top lobed with dimpled charcoal impressions, base variously rough and dimpled, might be a flow of slag from some other cause
72	350	80x80x50 prob biconvex cake, base dimpled and with moderate charcoal inclusions, top very rough and granular looking
73	254	100x55x40 semicircular distal end of cake, thin basal crust and irregular dense body with irregular cavities, upper face smooth broken through in cavities, lower face smoothly dimpled
74	224	semi conical fragment possibly from pcb, lower crust with rough surface, internally porous with very fine charcoal little top seen - if pcb then must be conical as 66
75	178	possibly pcb, base roughly sintered material attached to main lobe, which has a smooth top, could be basal smelting hearth?
76	132	80x50x30 bowl with 15 protrusion above, semicircular piece of pcb, base and top with lots of very fine charcoal
77	190	possible proximal area of pcb, semicircular ring of inward dipping smooth slag, 60x100x45 - likely proximal type for cakes cf62 etc
78	468	v dense slag puddle with flat base (stone contact?) 90x100x50, puddle to 30, tubular vesicles rare, fine vesicular nr top, overlain by irregular charcoal rich slag, fine
79	204	60x90x30 pcb fragment, base microlobed and prilled with some inclusions, top of puddle coarse outstanding olivine seen through break in separate upper rusty crust, top smooth with medium charcoal dimples slight
80	162	90x55x30 small irregular pcb, base rough top convex with spherical blobs, charcoal and other debris
81	168	irregular piece 70x60x45 comprising c4 separate crusts, thin, at different angles fused by granular slag, base with microdimples and prills, smoothish
82	124	80x60x25 small pcb, base with fine charcoal dimples, smoothish, top flattish with medium charcoal dimples, interior porous

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
pcb like material with more open structure		
83	4180	210x270x130 probably pcb but some problems, proximal end is flat face with flow, upper face lobate near margin but mainly sintery and dished in centre. Lower face smooth rounded medium charcoal moulds. Flat face, base and edge show lining- so hearth 300 wide narrowing to 230 on flat blowing wall
84	1765	160x190x60, hollow top cake, smooth in hollow, flat proximal contact 160 wide, lower face fine sintery proximal going to coarse charcoal distally - or is this vertically down smelting wall? If so hearth bowl, 450 diameter? Similar probably to 83 - but this is only part?
85	1560	140x160x100 of which 50 is good bowl, biconvex with max height proximally, app 2 phase bowl, flowage down blowing wall, finish charcoal in bowl fill and protrusion
86	1685	pcb with partially smooth top, rest charcoal, base mainly rough charcoal inclusion, 180x170x70
87	1800	120x170x90 irregular probable pcb, very lobate with flowage on one side, very coarse charcoal (more likely to be steep smelting wall with flow at base?) base if pcb is microlobate and dimpled, top rough charcoal
88	844	120x130x60 incomplete pcb, smooth blown top, base with small-medium charcoal
89	846	120x140x60 very dubious pcb, bulbous base looks ok and has slight crust, but upper part irregular with mode charcoal - no clear top
90	1170	irregularly smooth base shiny, top very irregular, lobate one end - again could be from smelting wall 140x140x50
91	834	120x120x80 again could be smelting base, base finely dimpled, but slag above contains good flow lobes and capped with layer with extremely coarse charcoal
92	522	130x100x50 probable poor example of biconvex cake, base very rough dimples, top charcoal, move above
93	462	130wx60x50, blowing wall angle with smooth to and wall side, but base is coalesced prills, very dense - could be smelting?
94	344	150x80x30 elongate probable pcb with dimpled base, top with irregular charcoal crust with voids onto coarse crystalline material below, lots of included charcoal on both sides and inside
95	416	120x70x60 very dense coalesced flow lobes with dimpled base, large internal cavities, may well be basal flows from smelting
96	420	80x110x60
97	324	90x100x50 slightly curved mass of slag broadly comparable with that in 83. Lots of dimples and fine charcoal moulds
98	218	small nub with basal dimples but otherwise charcoal rich, granular slag, prob from base of smelting furnace but broadly similar to 83
99	346	a small section of cake margin with curved edge at c30degrees to top, could be from poor pcb or from smelting cake. very large included charcoal
100	260	smooth top, curved rough base, open texture - cake like 83 or smelting wall? 70x110x25thick curved sheet
101	216	irregular cake margin with one rough charcoal rich surface and one smoother surface - not certainly pcb
102	226	100x80x50 probably small poorly formed pcb with dimpled microprill base, very irregular top with charcoal moulds and flow lobes.

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
pcb like material found later		
103	142 90	w x 40d semicircular piece of lobe - internal lots of voids of medium charcoal, base small dimples top broad lobes, biconvex - probably a smithing cake, but could just be flow lobe
104	84	60x60x25 approx 2/3 of small pcb, microdimpled base coarser dimples on flat top
105	144	50x70x25 small piece of pale slag with heavily dimpled upper surface and smooth curved base - just possibly smithing slag
106	300	100x100x35 slag of uncertain nature with roughish base and smooth top, may be pcb
107	302	80x110x40 12mm crust forming bowl, rough lower surface with dimpled and lobate slag partially filling upper bowl - top flat or concave
108	150	small irregular pcb fragment
109	168	smooth top. Microlobate base, lots of medium charcoal inclusions - just possibly a crude pcb
110	298	4 mm thick gently curving crust with microdimples, facing one side of irregular charcoal rich slag - possibly pcb but more likely to be from hearth wall? If pcb 100x100x40
111	64	60x70x25 irregular slag film from one side of large vesicle - just possible the top of a biconvex cake, outer has very irregular slag moulds
112	52	small piece of cake margin, moderately dimple base and very smooth to with very large vesicles - suggests pcb margin
113	90	irregularly lobate base and smooth top suggest this as a smithing slag but very small
114	180	v irregular slag lobes, one part has a distinct crust hinting at a pcb link - but slag origin uncertain
115	168	80x60x25 basal dense slag crust, probably pcb but could be flow, slightly vesicular dense crust has rough outside and is overlain by a highly vesicular honeycomb slag internally, top not seen
116	248	110x50x35 good pcb fragment, base rough, top smooth but with charcoal impressions
117	296	80x120x30 distal half of pcb with thin basal crust infilled with charcoal rich slag, base small dimples
118	244	irregularly lobate slag block just possibly from margin of mass like 83
119	70	irregular nub of charcoal rich slag, sub spherical, 60 diameter, just possibly from smithing hearth

47761 total possible smithing material

slab - like material

120	102	80x60x30 thin slab of curved basal crust - poss. poorly dev pcb, bottom rough top with fine charcoal 10mm thick
121	184	95x85x30 basal crust, 10mm thick, curved, top very rough sintered, base sintered with lots of fine charcoal debris
122	124	70x80x35 base prilly, top medium charcoal moulds, irregular slab
123	36	50x45x15 broken lobe of pale plastic base, coarsely crystalline honeycomb interior, top dark, mainly broken away
124	48	50x50x12 thin slab of dense material, wedge, smooth flowed base, top slightly dimpled near edge then rough
125	16	60x40x5 thin veneer of dense shiny slag, smooth one face, dimpled the other with a blob of dark vesicular slag attached

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
126		120 90x80x35 irregular slab similar to 122
127		128 80x65x25 slab of slag probably from wall , very smooth attachment surface, shiny, with <3mm sheet of veneer attached, other side irregular flowed surface
128		116 80x60x35 irregular slab 15mm thick, rather bent as well as curved, basal surface with moderate dimples, other surface probably originally flat and rough but has right angle bend in it
129		76 75x15x65 lobe of flowed slag, probably from base of furnace, lower face smooth shiny, upper face broken in places, smooth with some dimpling
130		30 50x40x10 thin slab, 6mm with tubular vesicles, bottom fine dimples, top has impressions like removed tap slag, probably basal flow lobe
131		42 50x40x15, up to 8 thick, gently curved very dense shiny slag piece - probably attached to wall, face away from wall irregular
132		144 170x70x30 as 131 and 127 but bigger, suggests furnace diameter of c400, inner face irregular slumped lobes
133		130 90x60x35 irregular slab of probable wall slag, internally arcuate surfaces and irregular shaped slag, most of slag is prob fairly low density
134		124 45x75x20 very dense piece of curved slag, smooth blown top, base smooth shiny slightly dimpled - a pcb fragment
135		88 85x60x30 irregular slab of sintered crust, lower smooth slightly dimpled, top very rough and sintered
136		60 irregular flowed lobate material - wall or floor of furnace? 55x65x20, 8 thick
137		12 sintered crust fragment
138		54 70x50x20 irregular lobe of ?flowed slag, base smoothish, top rough but mainly broken away to show coarse honeycomb interior
139		46 55x50x10 quarter circular piece of crust with strong tubular vesicles, base smooth, top missing, interior honeycomb
140		62 55x50x25 smooth on one face, but dense lobate smelting slags with very coarse charcoal.
141		68 60x45x15 very dense basal crust with strongly tubular vesicles, lower smooth shiny dimpled, upper mainly dull rough but smooth one side - pcb fragment?
142		306 150x90x30 large triangular slab of irregular basal flow lobes, probably smelting, lower dimpled shiny, upper complex of lobes, broken very large vesicles and exposed honeycomb
143		156 100x80x25 large slab of vesicular slab, , 1 face ?top mainly smooth, lower finely dimpled with some sintering
144		208 85x105x30 slab of crust to 8mm lower microdimpled face, upper supports variety of attached vesicular slags - not clear if pcb fag or basal furnace
145		32 60x55x15 curved fragment of very hard basal crust - wall of furnace?, interior face broken, coarsely crystalline, outer smooth slightly dimpled
146		110 65x70x25 squarish piece of thin6 crust, lower dimpled with charcoal moulds, top rough irregular vesicular
147		126 65x70x20 piece of vesicular slab, lower sintered with some included squashed flow lobes or prills, top, rough irregular
148		108 70x55x30, dense pale slab in several lobes, top broken to show vesicular interior, base shows three distinct smooth lobes
149		16 50x40x7 thin slightly curved dense slag veneer, outer face smooth shiny, inner fairly smooth but some attached charcoal and slag debris

2872

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
150		118 sintery slag
151		156 prilly block with fine charcoal
152		236 slag with medium charcoal
153		220 sintery slag
154		512 blown surface cutting very coarse charcoal
155		70 sintery basal material
156		832 good example of basal flow in furnace with coarse charcoal cut by sinter surface
157		264 slag with medium charcoal
158		480 dense basal flow
159		412 finely prilly material with sintery top - uncertain
160		86 low density pale with charcoal
161		548 sintery dipping surface with fine organics sitting on small lobate wedge
162		164 slag sheet with fine charcoal
163		216 slag with medium charcoal
164		154 slag with medium charcoal
165		104 slag with medium charcoal
166		90 basal layer with very fine organics
167		90 irregular slag mass with fine charcoal
168		116 irregular slag mass with fine charcoal
169		328 irregular slag mass with fine charcoal
170		820 irregular slag mass with fine charcoal
171		556 irregular slag mass with fine charcoal
172		756 irregular slag mass with fine charcoal
173		324 wall contact with medium charcoal, smoothly lobate on wall
174		180 slag mass with small flows
175		136 slag mass with sinter
176		218 basal flow with sinter
177		846 large subspherical block with blown top, whole body has fine charcoal and is microprilly
178		68 pale slag flow with honeycomb above basal lobes
179		252 slag with medium charcoal
180		186 slag with medium charcoal
181		226 slag with medium charcoal

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
182		176 dense slag nub
183		316 vv dense slag nub - could be deformed pcb???
184		100 slag with medium charcoal
185		336 slag with medium charcoal
186		86 slag with medium charcoal
187		182 slag with medium charcoal
188		76 slag with medium charcoal
189		256 wall attached dense flow lobes
190		368 blocks of dense slag set in lobate slag mass with very large vesicles, apparently earlier slag is brecciated
191		230 slag with medium charcoal
192		54 slag with medium charcoal
193		162 slag with medium charcoal
194		92 slag with medium charcoal
195		68 slag with medium charcoal
196		150 basal flow lobe
197		118 dense lobe uncertain
198		244 dense lobe with very large dimples uncertain
199		78 slag with medium charcoal
200		100 flow lobe uncertain
201		76 flow lobe uncertain
202		118 slag with medium charcoal
203		198 slag with medium charcoal
204		192 slag with medium charcoal
205		126 flow lobe uncertain
206		66 lobe/crust
207		70 slag with medium charcoal
208		82 slag with medium charcoal
209		50 basal lobe
210		18 wall
211		602 large block of slag, curved - probably base furnace. Has early large flow in more sintery material
212		318 possible pcb fragment
213		292 dense crust - pcb?
214		124 irregular piece with fine charcoal and blown top

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
215		230 dense wall slag in curved sheet, like pot, suggests diameter of c400
216		84 lobate material with sintery top
217		712 sheet of lobed wall slags with thickness of about 40,120x180
218		102 dense lobate +/- sintery
219		88 dense lobate +/- sintery
220		148 dense lobate +/- sintery
221		122 dense lobate +/- sintery
222		138 dense lobate +/- sintery
223		74 dense lobate +/- sintery
224		176 dense lobate +/- sintery
225		232 dense lobate +/- sintery
226		240 dense lobate +/- sintery
227		126 dense lobate +/- sintery
228		130 dense lobate +/- sintery
229		322 dense lobate +/- sintery
230		244 dense lobate +/- sintery
231		236 dense lobate +/- sintery
232		84 dense lobate +/- sintery
233		60 dense lobate +/- sintery
234		114 dense lobate +/- sintery
235		122 dense lobate +/- sintery
236		110 dense lobate +/- sintery
237		148 dense lobate +/- sintery
238		138 dense lobate +/- sintery
239		138 dense lobate +/- sintery
240		66 dense lobate +/- sintery
241		106 dense lobate +/- sintery
242		230 large slab of fired wall skin with this slag layer
243		72 dense lobate +/- sintery
244		180 dense lobate +/- sintery
245		80 dense lobate +/- sintery
246		94 sintery dense slags
247		112 sintery dense slags

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
248	184	sintery dense slags
249	212	sintery dense slags
250	138	sintery dense slags
251	176	sintery dense slags
252	136	sintery dense slags
253	112	sintery dense slags
254	254	dense lobe
255	116	dense sintery/lobate material
256	114	dense sintery/lobate material
257	146	dense sintery/lobate material
258	90	dense sintery/lobate material
259	158	dense sintery/lobate material
260	230	dense sintery/lobate material
261	86	dense sintery/lobate material
262	232	dense sintery/lobate material
263	92	dense sintery/lobate material
264	268	dense sintery/lobate material
265	84	dense sintery/lobate material
266	136	dense sintery/lobate material
267	160	dense sintery/lobate material
268	152	dense sintery/lobate material
269	166	dense sintery/lobate material
270	24	dense sintery/lobate material
271	54	dense sintery/lobate material
272	84	dense sintery/lobate material
273	276	dense sintery/lobate material
274	376	pcb burr
275	112	sintery and rather lump appearing slags
276	46	sintery and rather lump appearing slags
277	34	sintery and rather lump appearing slags
278	132	sintery and rather lump appearing slags
279	46	sintery and rather lump appearing slags
280	76	sintery and rather lump appearing slags

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
281		112 sintery and rather lump appearing slags
282		144 sintery and rather lump appearing slags
283		164 sintery and rather lump appearing slags
284		148 slag lip off wall?
285		304 slag lip off wall?
286		100 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
287		96 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
288		160 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
289		66 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
290		60 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
291		148 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
292		102 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
293		128 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
294		110 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
295		330 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
296		128 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
297		164 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
298		136 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
299		124 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
300		272 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
301		378 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
302		170 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
303		78 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
304		124 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
305		146 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
306		112 rather nondescript smaller slag pieces - mainly sinter but also some lobate material
307		146 very irregular slag piece, elongate, externally dull and crudely lobate, internally a large void coated with euhedral olivine
308		282 massive
309		116 massive
310		152 pcb fragment
311		72 coarsely crystalline material
312		164 wall slag with coarse charcoal
313		82 dimpled sheet

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
314	180	big lobes around very coarse charcoal
315	142	dense lobate flow of uncertain origin
316	290	probable pcb fragment, smooth dimpled lower, coarse crystals exposed on top dense
317	178	dense lobate flow of uncertain origin
318	94	descending prill
319	140	dense lobate flow of uncertain origin
320	84	low density lobes with medium charcoal
321	112	sintery slag
322	172	dense flow base of furnace wall
323	146	dense lobate flow of uncertain origin
324	268	dense lobate flow of uncertain origin, forms ball around void - may be folded up crust
325	322	dense iron rich slag block
326	108	dense lobe of uncertain origin
327	158	complex mass of small prills - probably smelting
328	452	slab with blown top over very coarse charcoal - smooth area of smelting furnace?
329	478	complexly lobed base of wall slags
330	188	v dense mass of slag - possibly part of pcb removed hot with flowage over broken edge - but not certain
331	370	dense base of wall flow
332	704	curious iron rich dense slag plate showing explosion, probably a slightly deformed pcb smooth top, rusty smooth base
333	100	v dense slag fragment - pcb/flow?
334	134	v dense angular slag fragment, probably from pcb
335	226	possible bog ore
336	158	v dense rusty slag block - massive
337	30	small piece of sediment or just possibly ore - may be rubbish
338	92	pale resinous low density slag in lobes
339	50	pale resinous low density slag in lobes
340	48	pale resinous low density slag in lobes
341	118	pale resinous low density slag in lobes
342	366	pale resinous low density slag in lobes, with iron rich sintery curved face
343	42	pale resinous low density slag in lobes
344	40	pale resinous low density slag in lobes
345	50	pale resinous low density slag in lobes
346	48	pale resinous low density slag in lobes

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
347	196	rather rubbly looking sinter iron slag with small pale blebs
348	62	pale resinous low density slag in lobes
349	82	pale resinous low density slag in lobes
350	82	pale resinous low density slag in lobes
351	64	pale resinous low density slag in lobes
352	62	pale resinous low density slag in lobes
353	162	large lump of gravelly lining slag. Possibly a sub blowhole tongue. Upper surface shows clasts and is glassy, lower face has moulds of medium sized charcoal
354	76	pale resinous low density slag in lobes
355	266	pale resinous low density slag in lobes
356	80	dimpled char mouldic iron slag faced with sheet of pale lining slag
357	148	block of lining slag with upper surface of broad lobes, and lower surface of medium sized charcoal dimples
358	166	lobe of low density slag, with smooth lower face, upper with mod large dimples
359	28	pale resinous low density slag in lobes
360	64	open mesh of slag films around slag moulds, very delicate
361	88	thin sheet of slag with small dimples, medium on upper surface
362	102	pale resinous low density slag in lobes
363	76	slag in films around coarse charcoal
364	58	pale resinous low density slag in lobes
365	98	complex of dense prills with some pale low density blebs on op
366	34	dense slag around very coarse charcoal
367	34	single dense flow lobe
368	20	pale resinous low density slag in lobes
369	224	slag with very coarse charcoal moulds
370	384	slag with very coarse charcoal moulds
371	190	slag with very coarse charcoal moulds
372	130	dense slag in lobate flow
373	170	dense slag in lobate flow
374	46	slag with very coarse charcoal moulds
375	156	slag with very coarse charcoal moulds
376	128	dense tiny pcb like form
377	152	dense flow or small pcb, strongly curved
378	64	slag with very coarse charcoal moulds

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
379		204 slag with very coarse charcoal moulds
380		302 dense flow lobes in contact with sintery material
381		146 slag with very coarse charcoal moulds
382		242 slags with med-coarse charcoal moulds and smooth upper surface
383		232 complexly lobed crust - may be pcb
384		134 nub of dense slag - may be smithing related?
385		58 slag with very coarse charcoal moulds
386		192 dense shiny slag surrounding large timber piece at base of wall
387		136 dense but pale slags with flat wall contact - very smooth, lobate, then massive internally
388		246 slag with very coarse charcoal moulds
389		232 slag with very coarse charcoal moulds
390		376 slag with very coarse charcoal moulds
391		164 slag with very coarse charcoal moulds
392		224 slag with very coarse charcoal moulds
393		180 slag with very coarse charcoal moulds
394		140 slag with very coarse charcoal moulds
395		172 sintery slag with basal flow lobes with dense material and lots of inclusions
396		90 sintery looking slag with medium charcoal moulds
397		548 slag with very coarse charcoal moulds
398		490 slag with very coarse charcoal moulds
399		352 complexly lobed dense material with rough base - pcb/floor of furnace?
400		164 slag with very coarse charcoal moulds
401		390 dense flow attached to vertical lining with superficially sintered material
402		294 possible crude burr - charcoal rich slag strongly attached to lining
403		102 slag with very coarse charcoal moulds
404		576 120x80x50, pcb like structure with flowed slag on top lobing over edge, base prilly and med/coarse charcoal, top rusty ?near blowhole in smelting furnace - doesn't look like smithing cake?
405		748 slag with very coarse charcoal moulds
406		452 possible pcb fragment - dense slag with fine charcoal with two crusts running through piece
407		402 smooth blown top above slag with coarse charcoal - probably smelt but not certain
408		88 slag with ed/coarse charcoal moulds, pale low density
409		70 slag with ed/coarse charcoal moulds, pale low density
410		468 slag with very coarse charcoal moulds

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
411		94 slag with very coarse charcoal moulds
412		134 slag with charcoal moulds and sintery base
413		140 slag with medium charcoal
414		168 slag with very coarse charcoal moulds
415		258 slag with very coarse charcoal moulds
416		134 slag with very coarse charcoal moulds
417		172 slag with very coarse charcoal moulds
418		146 slag with very coarse charcoal moulds
419		72 flow enclosing medium charcoal, low density - fantastic crystals in void
420		132 dense wall slogs with very large charcoal and very large crystals
421		218 slag with very coarse charcoal moulds
422		58 deformed low density lobe with internal honeycomb
423		160 honeycomb and large crystals in platy layer between coarse charcoal
424		162 slag with very coarse charcoal moulds
425		226 slag with very coarse charcoal moulds
426		172 slag with very coarse charcoal moulds
427		80 low density flow lobes
428		202 slag with very coarse charcoal moulds
429		92 slag with very coarse charcoal moulds
430		178 flow lobes on pit wall
431		334 slag with very coarse charcoal moulds
432		106 slag with very coarse charcoal moulds
433		114 vesicular platy flow of uncertain origin
434		206 sintery part flow lobed slag with medium charcoal internally
435		660 140x70x110 block of wall related prilly charcoal rich slag
436		2830 230x100x170 large block of slag from base of wall c500 diameter, smooth lip at 150 smoothly lobate, inward dipping curved blow area smooth, 80 in front 150 wide and 90 down, 170x40 at least horizontal timber along wall base, possibly originally radial ones inside but cut by inward dipping surface,
437		3220 250x180x110 large block of slag with lot of included small-med charcoal. Series of flow lobes on one edge suggests orientation down wall - but suggested diameter is very large - so this could be curved base essentially a slab 100 thick with a face at 70° at one end
438		1700 230x130x80 probably block from below blow, lip slightly smoothly lobate, in this orientation block 140 high, incurving 40 by base, extends in 90 at top, all with medium to large charcoal cavities, wall side define lobes, prills and dimples, if top is actually wall this could just possibly be a pcb cf 83

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
439	2875	250x200x10 large block with central funnel surface 250 diameter 100 above base, base not particularly differentiated, 30thick 100 in from top, extends back 90 from highest without seeing side. Orientation not precisely certain, if other way then c 70 diameter? with slag thickening down, base prilly in expected orientation
440	3235	250x170x100 large slab of wall charcoal, curve suggests c.500 diameter, slag 80-90 thick - slight incurve towards base. Mainly medium charcoal cavities, some larger towards base, outer wall variously dimpled, small charcoal
441	1050	large block of dense internally lobate slag with moulds of exceptionally large charcoal. Orientation of specimen is not certain, but appears to rest on a slightly convex basal surface, some large wood/charcoal arranged tangentially at foot of wall, then next layer inclined in a 45deg. Inner upper surface appears more rusty than remainder of block. Alternative orientation would have the long wood on base, a convex wall. 160x80x90.
442	908	block of dense slag. Has open textured prilly base with coarse charcoal moulds, forming a planar basal contact. Upper surface is smooth, ashy and inclined at c20° to base, 130x140x70. Slag thins to zero 160mm from margin
443	1625	190x120x70 slab of wall, with base on one end, mainly small lobes and medium charcoal, but top shows some large lobes and charcoal, interior more sintery and debris rich towards base
444	200	90x80x40 strongly small lobate slag piece with attached lining, becomes more sintery internally
445	328	130x80x40 curved slab of strongly lobate slag with attached wall - c300 diameter if wall has strong basal curve - but otherwise the diameter is less
446	2225	170x170x90 large block representing blowing wall damage, upper part I vitrified wall in embayment, below is jutting out very dense slag with lobe extending down and sideways into wall. So complicated that alignment of wall I uncertain, presumably suggests slag a long way below blowhole-tuyère.
447	432	150x50x40 curved slab of sintery wall slag with some flow lobes - cf other big wall pieces here
448	1300	180x130x50 oval pcb like slag, charcoal rich all round except for one mall rough patch - probably pcb
449	2365	240x170x130 large block of charcoal rich slag, somewhat lobate around edges (including lobes with charcoal moulds), sintery in centre, lower rough sintery. Probably a sintery-textured pcb with a slightly dished top and the proximal side missing.
450	528	120x90x50 block from top of wall slags. Wall side roughish but lobate at top, slag 25thick on smoothly lobate top, inward dipping face smoothish, slag has internal medium-large charcoal, slag >60mm thick near bottom of piece, 60-70 below top
451	928	140x140x60 block of strongly prilly slag - but with overall form like pcb and with very finely structured base. Top smooth with medium charcoal impressions - probably an odd pcb - or modified furnace slags?
452	1595	230x150x50 large block of wall/floor angle, slag extends from 100-150 up wall , suggests 500 diameter, top of slags is smoothly lobate, all slag is rich in medium charcoal, lower part very prilly with some large charcoal. Other interpretations just possible - like large odd pcb?
453	780	220x110x50 superb slab of wall slag, shiny outside with lobes, pale slag, vesicular, has vertical row of wood capped or based by horizontal piece - way up uncertain - horizontal wood >170x30x30
454	524	140x80x70 irregular block of slag with very coarse charcoal - one face has lining contact, but unclear if wall or base
455	152	small piece of slag with good flow lobes around coarse charcoal in contact with wall,

<i>specimen #</i>	<i>weight (g)</i>	<i>description</i>
456	1420	190x120x90 triangular cross section slag with medium to coarse charcoal. Wall floor contacts only rather loose but a few more lobate slags and sediment contacts visible - but not enough to get dimensions, but both contacts extend c100
457	842	180wx100x50 burr like piece with distinct angle on base - suggesting base of wall? With slightly inward curving wall base, side at c60deg, c300diam or a little more, wall is slightly rough sediment contact, floor lightly dimpled but smooth, slag with small -med charcoal, upper part strongly reddened - represents inward dipping upper surface, suggests slag only extended to maybe 90 above base - so slag has roughly triangular cross section
458	560	150x80x80 fragment from margin of cake with angle of 45° top side and diameter of c300. Top rough mainly but with smooth patches, side charcoal inclusions of medium size, internal some very large70 long
459	958	190x90x130 probably a slab of wall slag - medium charcoal inclusions, some smooth lobes visible on long face and one short, suggesting origin against a wall at 60° to base 160 high, extending 60 onto floor - if this is so then twist of piece suggests bending during hot removal
460	242	100x60x50 irregular nub of slag with medium charcoal inclusions - some layered structure so may be a smithing slag
461	430	slag with basal prilly zone, with moulds of large charcoal fragments just above, at an inclination of 20° to base, upper surface of piece is lumpy, slightly rough textured surface probably dipping right down to floor. 80x130x70
462	850	110x170x60 curved slab possibly pcb piece base lobate and with charcoal moulds/dimples, also a piece of included "hammerflat". Top finely sintered material with lot of fine charcoal, slab mainly 30 thick, one end shows some slight flow - which might be a proximal wall
463	168	small piece of slag with sintery surface and medium charcoal moulds

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Table 3. Listing of material for further examination

sample	specimen	stratigraphy	weight	notes
27		t3 ext contam.	60	fired daub, containing moulds of several withies at various angles
151		cut 3, f84	72	piece from side of tuyère. Passes from clear surface abruptly to a thick sandy slagged coating. c120 diameter.
21	1	F14b/c	126	vitriified tip of tuyère, c120dia with c22 diameter bore, hole slightly off centre, face partly vitriified, inclined at c50deg to bore, finely sandy oxidised fabric
21	14	F14b/c	100	tip of tuyère, probably from lower side, appears to be c90 diameter, slag accumulation on lower side gives a collar effect, extending back 20 from face. Tip has pale glaze, fabric fine, sandy.
20/21	40	F14b/c	42	corner of ceramic object, surface buff, inside grey, 1 face glazed with pale greenish glaze, broadly similar to contaminated material but has more temper
20/21	41	F14b/c	92	fired clay with delicate vitriified surface (42), also exploding block of vesicular slag (92)
20/21	42	F14b/c	5540	best preserved of good furnace bottoms. 250x240wx70d but with protrusions up to 110. Has smooth hollow offset from centre with more green slag, raised charcoal-rich slag peripherally, lower face has hard dense rough main bowl, with signs of flowage and dimpling around periphery
20/21	43	F14b/c	1705	dense pcb, with good slag puddle, with crystal terminations on upper surface, with apparently rather friable thin shell roof over. Lower surface rough. 175x120x50. C75% of cake present?
20/21	44	F14b/c	1285	dense pcb, 150x150x55mm, although dense much of outside has a rather sintery appearance although this may in part be due to secondary minerals. Base sintery to rough, with small microprilly area. Upper surface smoothish, slightly domed with sintered looking material in central area.
20/21	50	F14b/c	824	dense biconvex cake, hole in top reveals zone of well developed free crystals, top rough, bulbous, lower face microprilly, 130x90x60
20/21	51	F14b/c	706	slightly biconvex dense pcb with film across top broken to reveal internal void, top matt but smoothish, bottom microprilly. 119x90x40.
20/21	54	F14b/c	468	small biconvex hearth cake. Has small smooth depressed area with raised rim on upper surface - presumably the blown area. Raised rim has fine charcoal. Main mass is a dull biconvex lobe, rough on top and micro-prilly below. 120x110x40.
20/21	83	F14b/c	4180	210x270x130 probably pcb but some problems, proximal end is flat face with flow, upper face lobate near margin but mainly sintery and dished in centre. Lower face smooth rounded medium charcoal moulds. Flat face, base and edge show lining- so hearth 300 wide narrowing to 230 on flat blowing wall
20/21	190	F14b/c	368	blocks of dense slag set in lobate slag mass with very large vesicles, apparently earlier slag is brecciated
20/21	307	F14b/c	146	very irregular slag piece, elongate, externally dull and crudely lobate, internally a large void coated with euhedral olivine

<i>sample</i>	<i>specimen</i>	<i>stratigraphy</i>	<i>weight</i>	<i>notes</i>
20/21	335	F14b/c	226	piece which may be a bog ore fragment - or may just be microprilly slag mass
20/21	337	F14b/c	148	piece which may be an ore fragment - or it may be a piece of sediment
20/21	353	F14b/c	162	large lump of gravelly lining slag. Possibly a sub blowhole tongue. Upper surface shows clasts and is glassy, lower face has moulds of medium sized charcoal
20/21	357	F14b/c	355	block of lining slag with upper surface of broad lobes, and lower surface of medium sized charcoal dimples
20/21	441	F14b/c	1050	large block of dense internally lobate slag with moulds of exceptionally large charcoal. Orientation of specimen is not certain, but appears to rest on a slightly convex basal surface, some large wood/charcoal arranged tangentially at foot of wall, then next layer inclined in a 45deg. Inner upper surface appears more rusty than remainder of block. Alternative orientation would have the long wood on base, a convex wall. 160x80x90.
20/21	442	F14b/c	908	block of dense slag. Has open textured prilly base with coarse charcoal moulds, forming a planar basal contact. Upper surface is smooth, ashy and inclined at c20deg to base, 130x140x70. Slag thins to zero 160mm from margin
20/21	446	F14b/c	2225	170x170x90 large block representing blowing wall damage, upper part is vitrified wall in embayment, below is jutting out very dense slag with lobe extending down and sideways into wall. So complicated that alignment of wall is uncertain, presumably suggests slag a long way below blowhole-tuyère.
20/21	449	F14b/c	2365	240x170x130 large block of charcoal rich slag, somewhat lobate around edges (including lobes with charcoal moulds), sintery in centre, lower rough sintery. Probably a sintery-textured pcb with a slightly dished top and the proximal side missing.
20/21	453	F14b/c	780	slab from foot of furnace wall. Outer curvature suggests pit diameter of c350. Outer face strongly lobate, but in section slags have vesicles and generally resemble a pcb crust. Wood/charcoal moulds suggest major tangential piece at base with vertically oriented pieces above. basal piece at least 210 long at 20 thick, vertical pieces at least 80 long and up to 40 wide. Just possibly piece is actually other-way-up. 220x110x50.
20/21	461	F14b/c	430	slag with basal prilly zone, with moulds of large charcoal fragments just above, at an inclination of 20deg to base, upper surface of piece is lumpy, slightly rough textured surface probably dipping right down to floor. 80x130x70
20/21		1 sack	3100	slag - fine grained
20/21		1 sack	6110	slag - indet bits
20/21		1 bag	700	sieved and washed fines collected from specimen washing (contains small bag of magnetic separates)
19		f14c	1 bag	wet clay from bagged samples
	C32	s6	1676	ACS Ltd sample: oxidized metal fragments

<i>sample</i>	<i>specimen</i>	<i>stratigraphy</i>	<i>weight</i>	<i>notes</i>
C3 F14c	s18			half sample - soil sample
C39	s05		485	ACS ltd, slag

Table 4: Overall sample weights (g)

sample 20/21		259933
<i>listed slag pieces >50mm</i>	<i>141433</i>	
<i>slag pieces <50mm</i>	<i>114700</i>	
<i>fines sieved from washing mud</i>	<i>3800</i>	
contaminated samples		5377
other small samples		6053
		<i>271363 total</i>