

Preliminary report on the metalworking
remains from Roscrea Town Centre,
Co. Tipperary (C325/E3991)

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1. Introduction

Excavations of a large area in the centre of Roscrea town, Co. Tipperary uncovered evidence of metalworking across the whole site (Coyne 2011). This includes waste from all the steps required for producing iron objects: smelting, bloom smithing and secondary smithing. There was also evidence for copper production, possibly copper matte refining. The ironworking remains are of exceptional importance as they give unique insights into furnace construction, bloom processing and tuyere typology. As no radiocarbon dates were yet available at the time of writing, this report should be considered preliminary.

2. Description of the features and metallurgy-related finds

Features and residues relating to metalworking were found in every part of the large excavated area. For practical reasons these are described from south to north while retaining the Area numbers from the report. Dimensions for features are only given if these are likely related to metalworking.

2.1 Features with metalworking debris in Area C

Area C, comprising the southern-most part of the excavated area, contained three furnace pits and two likely bloom processing hearths in its central part while several pits together with debris were possibly related to smithing to the east, west and north (Fig. A).

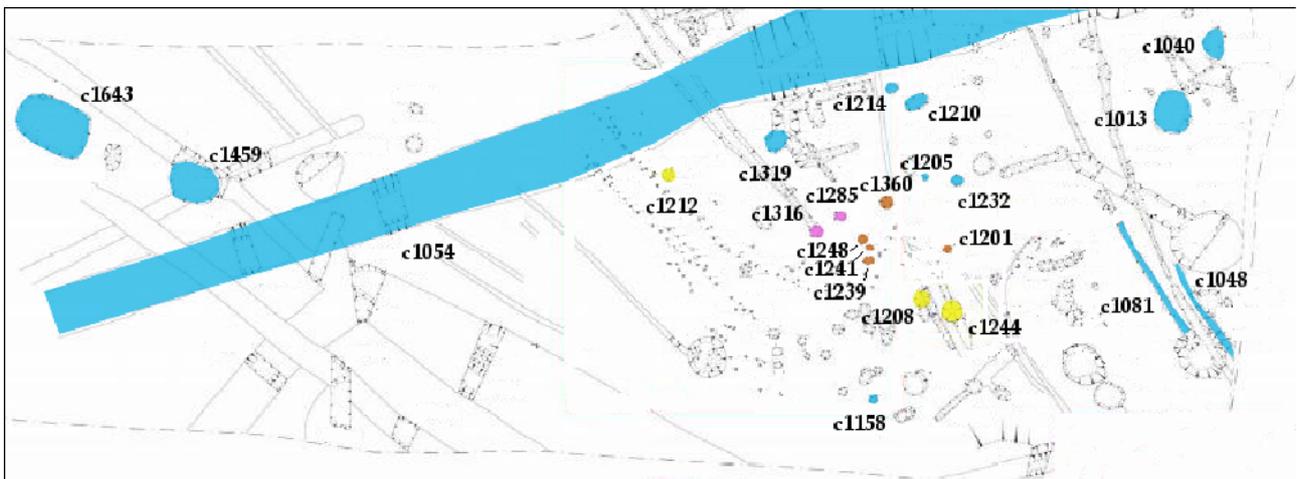


Fig. A. Features with metalworking residues in Area C. Key: light blue = smithing/undiagnostic slag, yellow = furnace pits, brown = smelting slag, pink = flat dense slag

Furnace pit c1208 was circular, with a diameter of 0.60m, and was 0.40m deep (Fig. 1). It had straight sides and a sharp break of slope at its base, which was concave. Located around the upper rim of the pit was heat-affected clay c1275 (811g). Only one of the preserved pieces shows a smoothed edge while the largest fragment suggests a minimum thickness of 50mm. The base of the pit was filled with c1207 which contained slag and ceramic material. The slag (5500g)¹ consists mostly of dense drippy pieces (Fig. 2) with also numerous fragments of brown frothy material (Fig. 3). The seven fragments of ceramic material (227g) included some pieces with smoothed surfaces. Above this, layer c1206 included further slag (1404g), nearly all dense and drippy, and thirteen pieces of heat-affected ceramics (494g). The latter material included one large fragment (276g) with a minimum thickness of 50mm which showed evidence of repair (Fig. 4).

Furnace pit c1244 was near-circular, measuring 0.70 by 0.67m, and was 0.40m deep (Fig. 5). It had stepped sides and a gradual break of slope at its base, which was concave. Although c1242 is described as 'a fire hardened gritty clay lining ... located around the top of the cut' (Coyne 2011: 212), the material preserved consists solely of drippy dense slag (1671g) (Fig. 6). One of the fragments appears to show the impression of a large fragment of wood. The base of the pit was filled with c1243 which contained drippy slag (880g) and heat-affected clay, some with adhering slag (199g). Above this, a slag-rich layer c1278 was uncovered which held mostly drippy slag (2232g) and three pieces of heat-affected clay (314g), one of which with a smoothed side. This was sealed by a further deposit c1187 with additional drippy slag (946g) and heat-affected clay (1228g). The latter includes a piece with minimum thickness of 50mm and several pieces with smoothed surfaces.

To the north of furnaces c1208 and c1244 are three more pits containing metalworking debris.

The most westerly of these is c1316. This pit was near-circular, measuring 0.43 by 0.39m, and was 0.31m deep. It had concave sides and a gradual break of slope at its base, which was tapered to a round point. It was filled with slag-rich deposit c1315, which also contained burnt bone. This deposit contained just over 2500g of slag, mostly drippy, rather dense pieces, including flat pieces, together with brown frothy material (Fig. 7). There is also about 140g of ceramic material, one piece showing what is most likely the blowing channel of a tuyere (fig. 8).

Pit c1285, to the east, was near-circular, measuring 0.40 by 0.36m, and was 0.25m deep. It had

¹ This, and other c1207 material, includes the residues labelled as c1208

irregular sides and a sharp break of slope at its flat base. It was filled with slag-rich deposit c1284. The slag from this context (1887g) is less dense than that of the furnaces and although it shows some flow structure it was much frothier and includes several flat pieces (Fig. 9). The ceramic material (165g) is recognisable as tuyere material: more orangey in colour, a fragment of flat circular surface (original diameter between 100 and 150mm) with a thin layer of vitrification on its outer side representing the tuyere front and a piece showing a blow hole with a minimum diameter of c. 20mm (Fig. 10). One piece shows two outer tuyere surfaces at a 90° angle.

A third pit c1630 (fill c1629), further east again, yielded twenty-five pieces of heavily weathered dense drippy slag (423g).

The material from deposit c1235, which was cut by furnaces c1208 and c1244 and pit c1285, consisted nearly entirely of weathered dense drippy slag, undoubtedly material from one or both of these furnaces. Deposit c1317 was located at square 230/180, so also in this general area. It consisted of relatively light frothy and drippy slag together with heat-affected clay, one fragment having a smoothed outer surface. This material is also very likely related to the same activity in that area.

In the area between the two furnaces and the three pits described above, four smaller pits contained further ironworking residues. Pit c1241 (fill c1240) contained weathered drippy slag (612g) and a fragment of heat-affected clay with a smoothed surface, while pits c1201 (fill c1200), c1248 (fill c1247) and c1239 (fill c1238) yielded small amounts (respectively 22g, 13g and 11g) of heavily weathered drippy slag.

A second area, to the north-east of pits c1316, c1285 and c1630 had a further five pits with ironworking residues. Pit c1319 (fill c1318) contained 42g of weathered, undiagnostic slag while pit c1214 (fill c1213) contained multiple small, possibly crushed, fragments of grey heat-affected ceramic material (209g). Pits c1205 (fill c1204) had 60g of slag, pit c1232 (fill c1231) had 15g and pit c1210 (fill c1209) had 23g, all weathered and undiagnostic. The latter pit also yielded two sherds of pottery.

A third furnace pit c1212 was located about 10m to the north-west of furnaces c1208 and c1244. It was near-circular, measuring 0.48 by 0.46m, and had a depth of 0.16m. It had straight sides and a sharp break of slope at its base, which was rounded. Its basal fill c1211 consisted of a large lump of

slag (3158g) with hardened clay adhering to its base (Fig. 11). The piece shows several sequences of slag flow originating from the same place (Fig. 12). The lowest, earliest flow appears to have been much more fluid than the later ones. Above this, fill c1180 contained fire-affected clay and slag. The ceramic material (172g) includes clay vitrified on adjoining near right-angled sides (Fig. 13), most likely representing a side opening or arch to the furnace. Other, non-slugged, pieces show both the smoothed interior and exterior of the furnace wall, one piece is 20mm thick, the other 30mm (Fig. 14). Two pieces also show the interior and exterior walls tapering together, undoubtedly representing the top rim of the furnace (Figs. 15). The slag (1867g) includes small fragments of drippy slag and brown frothy material, while other pieces consist of heavily slagged ceramic material representing the lower part of the inside of the furnace.

Near the eastern limits of area C more features with iron slag were uncovered. Pits c1040 (fill c1039) and c1013 (fill c1012) had weathered, undiagnostic slag, respectively 50g and 173g, the latter including a possible smithing hearth cake (SHC) fragment. Two linear features further south yielded further material. Linear feature c1048 (fill c1047) had light slag (13g), likely tuyere material (10g) and numerous slag fragments, possibly crushed material (33g) while linear feature c1081 (fill c1080) had a piece of rather dense slag, possible a SHC fragment (229g).

In the western part of area C, pit c1643 (fill c1642) yielded amorphous slag (146g), while pit c1459 (fill c1456) had a curved piece of vitrified tuyere material (87g) (Fig. 16).

Ditch 1054 (fill 1647) crossing area C from the south-west to the north-east and entering Area B yielded further weathered slag (477g), possibly including SHC material.

Finally, an isolated posthole to the south of that area c1158 (fill c1156) yielded a single weathered SHC (552g) (Fig. 17).

2.2 Features with metal working debris in Area B

Area B had three concentrations of features with ironworking debris and a fourth with evidence of both copper and ironworking (Fig. B). Ditches between and around these areas yielded further material.

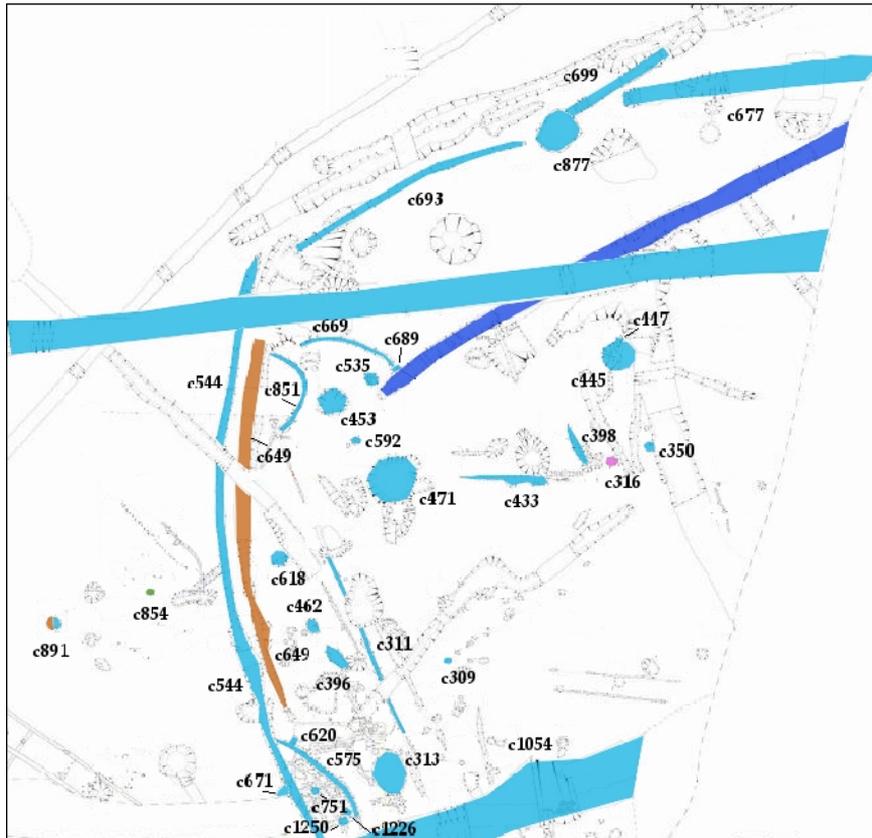


Fig. B. Features with metalworking residues in Area B. Key: light blue = smithing/undiagnostic slag, dark blue = same with SHCs over 1kg, brown = smelting slag, pink = flat dense slag, green = copper production residues

Immediately north of the central part of Area C is a group of features within Area B1 with evidence for ironworking. Several of these features cut a structure tentatively dated to the early medieval period (Coyne 2011: 195-196). These include pits c1226 (fill 1225) and c1250 (fill c1249) which held weathered SHC pieces, respectively 181g and 534g, the latter showing two indents in the upper surface caused by the air blown onto the slag by the bellows (Fig. 18). Pits c751 (fill c750), c671 (fill c670) and c612 (fill c611) all held lumps of weathered, undiagnostic slag, respectively 27g, 162g and 45g while linear feature c 575 (fill c574) four fragments of likely SHC material (1104g) and some low-density slag (133g). To the east of these pits, large pit c313 yielded an unusual double SHC (775g) in its fill c348, with the bottom one a typical dense iron-rich SHC and the upper one having a white matrix (Fig. 19), while further SHC material was recovered from its fills c340 and c337, 248g and 1072g respectively. Further north, two small pits held further ironworking debris. Pit 396 (fill c395) yielded a partially layered SHC (195g), while pit c462 (fill c461) included an elongated piece of slag with a distinctive white matrix (96g) (Fig. 20). Further north again, pit c618 (fill c617) yielded 31g of likely SHC material.

A second concentration was located further north in the vicinity of two slot trenches enclosing elongated oval areas. A large pit c453, with single fill c452 contained pieces of dense, likely SHC material (299g) and weathered iron oxide with multiple hammerscale inclusions (123g). The latter is the kind of material accumulating around the anvil during forging activities and is known as smithing pan. The same fill also yielded a late thirteenth-century coin (Edward I) and two possible whetstones. Pit c535 (fill c534) contained weathered slag, mostly SHC fragments (1484g) and seemingly also tuyere material.² Pit c689 (fill c688), which cut slot trench c669, contained further SHC material (245g), all rather flat together with some drippy slag (93g). Slot c669 (fill c668) itself yielded 1142g of SHC material and a 45g of very likely tuyere fragments. The second slot trench c851 (fill c850) held 107g of SHC material and 4g undiagnostic heat-affected clay. To the south, shallow pit c592 (fill c591), possibly a natural hollow, contained further smithing pan (11g). South again, large pit c471 (fill c484) contained several complete SHCs and fragments of the same 3984g.³ Finally, to the south-east, fill c308 of posthole c309 included a complete SCH (129g).

Several ditches linking the two previously discussed concentrations held further ironworking debris. The material from ditch c649 (fill c648) included mainly dense drippy slag (1141g) and 20g of grey heat-affected clay. The largest of the slag pieces (821g) showed multiple cavities left by pieces of timber (Fig. 21). Ditches c544 (fill c543) and c311 (fill c310) yielded SHC material (829g) and possible SCH material (296g) respectively.

To the west of these ditches, two features revealed an interesting assemblage. Feature c891 measured 1.10m by 0.84m and was 0.11m deep. It had a sharp break of slope at the top, concave sides and an uneven base. Its lower fill, c890, contained over twenty pieces of dense drippy slag (368g) (Fig. 22) while its middle (c889) and upper fill (c888) both included smithing pan (Fig. 23) and hammerscale. Feature c854 (fill c853), measuring 0.25m by 0.23m by 0.14m and about 6.5m to the north east, yielded dense drippy slag (474g), some of which showing copper-staining and even secondary copper mineralization (Fig. 24). It also contained orange to reddish clay with a thin vitrified concave outer surface and a smoothed inner surface parallel to this (Figs. 25). The minimum thickness is 4mm and the maximum thickness 10mm. Two other fragments of ceramic material were grey with a thin layer of vitrification on their outer surface, one of which had copper staining within the vitrification (Fig. 26).

² A tuyere fragment is mentioned in the preliminary report (Coyne 2011: 73, 221) which was not available for study.

³ This includes the material labelled as retrieved from c471.

To the east of the concentration with the two slot trenches is a third concentration of ironworking activity. Pit c316 was oval in plan, measuring 0.65 by 0.55m, and was 0.24m deep. It had straight sides and a sharp break of slope at its base, which was flat. It was filled with a single silty deposit c315 containing frequent charcoal and slag. The slag (1454g) consisted of twenty pieces varying between light to rather dense and including pieces with flow structure and flat specimens (Fig. 27). Nearby,⁴ an elongated feature c375, measuring 4.4m by 0.35m by 0.50m, contained copious amounts of ironworking debris. Its lower, charcoal-rich fill (c. 361) yielded nine SHCs (1708g) ranging in weight from 57g to 576g, light frothy and flat pieces (438g) (Fig. 28), white matrix slag (11g) and some more undiagnostic slag (202g). Next to this it also included tuyere material (171g),⁵ one piece showing a flat frontal surface and a rounded side, both vitrified. The upper fill of the same feature, c376, contained a further three SHCs (2576g), the largest of which weighs 1151g. Next to this, 427g of lighter, more frothy slag, a piece of heavily slagged ceramic (tuyere) material (216g) and 34 g of tuyere material were recovered from this fill. Several pits yielded further ironworking debris. Pit c445 (fill c443) had, next to some SHC material (860g), a large piece of slag (1734g) which had a thin band (10mm) at its base, on top of which was a mass of frothy material, followed by another band of dense material and more frothy material at the upper part (Fig. 29). This could represent a fusion of two similar SHCs. Pit 350 (fill c349) held small amounts of undiagnostic slag (21g) and likely tuyere material (5g), while a fragment of a dense, heavily weathered SHC was recovered from pit c571 (fill 570). A posthole c447 (fill c446), cut by pit c445 (see above) yielded an irregular SHC with white matrix (246g). Finally two linear features, c433 (fill c432) and c398 (fill c397), had respectively 20g of undiagnostic slag and a small flat lump of dense drippy slag (50g).

To the north of this last concentration, a substantial amount of ironworking debris was recovered from a series of ditches. Ditch c263 (fill c262), which extended to the concentration with the two slot trenches, held just over 10kg of SHC material, including two cakes weighing over 1.5kg (Fig 30). From the same fill, a small tuyere fragment (6g) was retrieved which showed its blow hole at an angle of about 45 degrees to its outer vitrified surface (Fig. 31). Ditch c249 (fill c248) , which cut the latter, held 1210g of SHC material and 20g of drippy slag. A deposit c335, cut by ditch c263, contained 179g of likely SHC material.

4 This features is not marked on the plans but stratigraphically described as cutting ditch c402 and under deposit c335 which is cut by ditch c263.

5 The catalogue (Coyne 2011: 221) mentions a further four tuyere fragments from this fill which were not available for study.

Further north again, ditch c699 (fill c698) yielded 1428g of slag, mostly SHC material, and a tuyere fragment (21g) with convex outer surface. Nearby ditch c677 (fill c676) held 981g of SHC material, 48g of frothy slag and a weathered tuyere fragment (69g). Ditch c693 (fill c692) had a further 68g of undiagnostic slag, while c675 (fill c674), which included modern pottery and glass, yielded 104g of SHC material. Undiagnostic slag (359g) was retrieved from pit c877 (fill 873), located between ditches c699 and c693.

2.3 Features with metalworking debris in Area A

The features containing metalworking debris in Area A, including several with important assemblages, consist mainly of linear features and two pits in its western part (Fig. C).

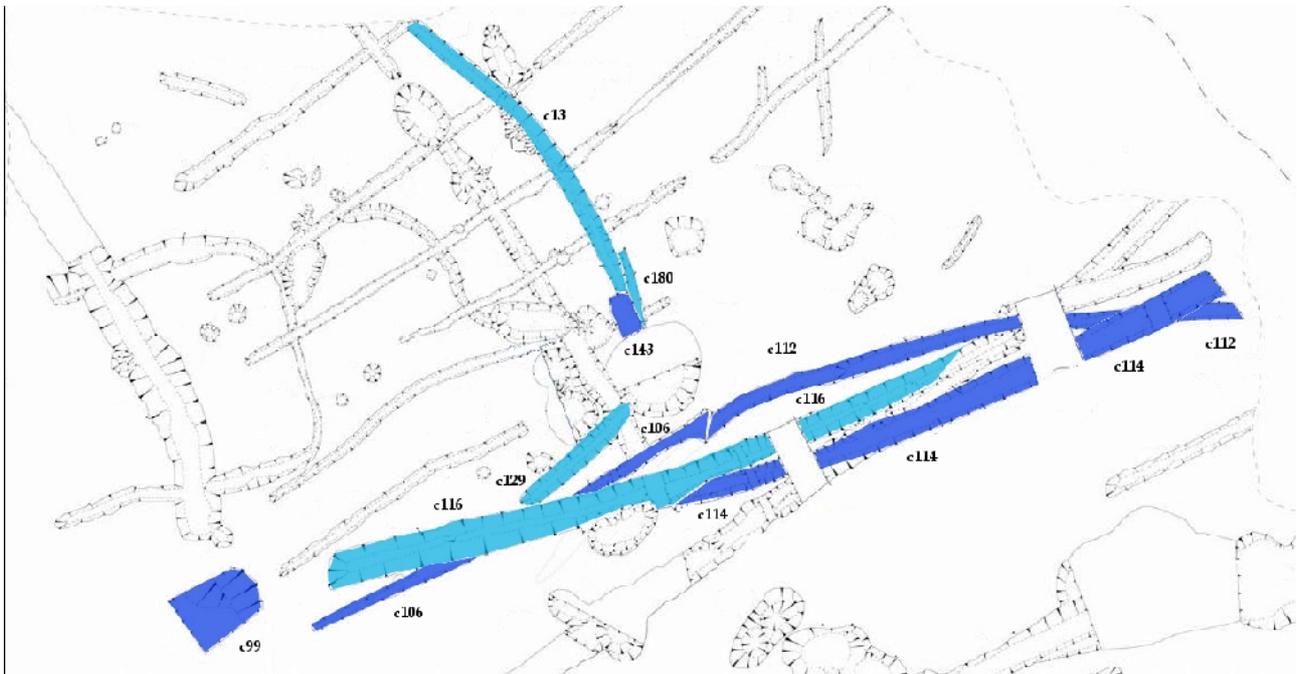


Fig. C. Features with metalworking residues in Area C. Key: light blue = smithing/undiagnostic slag, dark blue = same with SHCs over 1kg

North of the last group of ditches discussed in Area B, several more or less parallel linear features in Area A yielded ironworking debris. Linear feature c112 (fill c118) yielded 6045g of SHC material, including one large specimen (1289g) showing a hollow left by the air blown onto the liquid slag by the bellows (Fig. 32), next to 300g of more drippy, dense slag and 55g of brown frothy material. Linear feature c116, which cut c112, held, in its basal fill c145, 278g of SHC material, 55g of frothy brown slag as well as five pieces of tuyere material, one of which showing its blow hole (142g).

The same fill also included several sherds of medieval pottery. Linear feature c114, also cutting c112, had modern pottery in its lower fill c117 together with 2599g of SHC material, one cake with an unusual upstanding rim on one side (Fig. 33), 171g of dense, drippy slag and 835g of tuyere fragments.⁶ The latter included two pieces, one of which appears to have been circular with a frontal diameter of about 110mm (Fig 34), while the blow hole of the other reaches the tuyere front at an angle of about 45 degrees.

Linear feature c106, which appears to be the western extension of c112, yielded, from its single fill c105, 3813g of SHC material, 397g of dense slag with charcoal impressions and 349g of tuyere material. The tuyere material includes a nice example of a so-called 'slag beard', or slag adhering to the lower front of the tuyere (Figs. 35) and another seemingly having a circular flat front with a diameter of about 90mm. This same fill also yielded clay pipe fragments and modern pottery. Parallel to the north of the latter was linear feature c129 (fill c128) which held 573g of SHC material and 116g of tuyere material.⁷

About 2.5m north of the eastern end of linear feature c129 was pit c143. Its lower, charcoal-rich fill c182 yielded no material related to metalworking. Its middle fill c181 held 475g of SHC material and two tuyere fragments (63g). Its upper fill c142 contained 5770g of SHCs, one of which weighed 2017g, 509g of slag with white matrix, 402g of dense drippy slag and 552g of tuyere material.⁸ Linear feature c180 (fill c179), extending north along the eastern edge of pit c143, yielded 298g of SHC material and 68g of tuyere fragments. Linear c13 (fill c12), also extending north of pit c143, contained 2552g of SCH material and 495g of tuyere fragments. Three of these formed the largest part of a tuyere front with a seemingly oval front (130mm by 100mm) and showing an oval blow hole situated off-centre (Fig. 36). The same fragments also show clear evidence of fresh clay added to an already vitrified tuyere front (Fig. 37).

Just over 2m west of the western termini of linear features c106 and c116, pit c99 was uncovered. Its basal fill c140 yielded 1329g of SHC material, 640g of frothy brown slag and 170g of tuyere fragments. The next fill c139 held two pieces of slag, one a SHC fragment (395g), the other lighter brown frothy slag (87g). Fill c138, above the previous one, yielded 5938g of SHC, including one weighing 1629g, 140g of slag with white matrix, 163g of brown frothy slag, 280g of tuyere fragments and 20g of dense drippy slag. Its upper fill c98 yielded 1019g of frothy brown slag (Fig. 38), 2155g of SHC material and 549g of tuyere fragments.

⁶ A further tuyere fragment from this fill (Coyné 2011: 221) was not available for study.

⁷ Another tuyere fragment from this fill (ibid.) was not available for study.

⁸ Two more tuyere fragments from this fill (ibid.) were not available for study.

3 Discussion and interpretation

3.1 *Irish bloomery iron production*

Early Irish iron production consists of two main phases; smelting, during which the iron is removed from its ore into a bloom, and smithing or forging, during which objects are manufactured, altered and repaired. The bloom produced during smelting can undergo changes before it is ready to be forged.

Up until the Anglo-Norman period, iron was nearly exclusively smelted in so-called slag pit furnaces. These installations consisted of a clay shaft built above a pit which was filled with organic material, normally pieces of split timber but occasionally grass-like material. The shaft was filled with ore and charcoal. After firing, the non-metal parts of the ore, together with a portion of the iron, would descend into the pit under the furnace as slag and replace the packing material. The iron oxides in the ore were reduced to pure iron which formed an iron bloom just above ground level. Some early medieval furnaces had additional working hollows in front of the furnace together with evidence of an arch in the furnace wall, for example at Derrinsallagh 4, Co. Laois, where the activity was dated to the first to third century AD (Lennon 2009; Young 2009). The slag which descended into the furnace pit can vary from multiple small dense drippy slag pieces to a larger single mass of drippy slag, while some of the slag formed a spongy 'furnace cake' below the bloom. No tuyeres are known to have been used in early Irish iron smelting. After the arrival of the Anglo-Normans in Ireland in the late twelfth century, nearly all the known furnaces are of a different type with slag removal next to furnace and none are of the slag pit furnace variety (Rondelez 2014: 126, 128-129).

The bloom could still include large mounts of slag which are removed during refining. It is accepted that large slag cakes, weighing over a kilogramme and more, are likely to be the result of bloom refining. Certain types of ore, especially manganese-rich ones, produced high-carbon or steely blooms. The carbon content of the iron could also be enhanced during the smithing stages.

Early medieval Irish smithing was carried out in ground level hearths and is characterised by the widespread use of ceramic tuyeres. These implements generally consist of tubular or conical clay block with frontal diameters between 80 and 250mm. The tuyere fronts are very often covered with a thin layer of slag and in some cases a drippy accumulation of slag will be found attached to its

lower front, a so-called 'slag beard'. Typical waste products from early iron smithing are so-called smithing hearth cakes and hammer scale. The former are often bun-shaped, but can also be irregular, lumps of slag from less than 100g up to more than a kilogramme. Hammerscale, produced during forging activities, can either be globular or plate hammer scale and will accumulate, together with other iron-rich material as so-called smithing pan around the anvil.

3.2 Chronology and interpretation of the metalworking remains

The site at Roscrea, then, represents all the steps of iron production from smelting over bloom processing to smithing, together with evidence for copper production. Although it is tempting to assume this is the case, not all the steps uncovered at the site need to be contemporary. The smithing debris in the east of Area C could indicate that further activity had taken place further east. Also the occurrence of late medieval pottery and a thirteenth-century coin together with iron pan in the same fill of a feature in Area B within the concentration near the structures with curved slots potentially indicated these are late medieval. Without radiocarbon dates, we cannot date any of the activities with precision, only the features with ironworking debris cutting the likely early medieval structure in south of Area B can be said to be younger than this date.

3.2.1 The furnaces

The site at Roscrea revealed three furnace pits, all located in Area C. All three yielded broadly similar amounts of slag, that is to say between 5700 and 6900g (see Table 1).⁹ The nature of the slag differed, varying between most of it consisting of a single lump at the base of the furnace to more dispersed drippy pieces. Analysis would need to be undertaken to see if this difference in slag formation is related to the use of different technologies and/or to the intent of producing different types of iron.

In two cases, c1208 and c1244, clay rims were present around the tops of the pits and it is perhaps no coincidence that these two pits have the largest dimensions. Pit c1212 is then possibly truncated. If the furnaces are indeed early medieval in date, then their diameters are larger than what is known for furnace pits of this date, that is to say up to about 500mm (Young 2011). The preserved heat-affected clay, undoubtedly representing furnace wall fragments, suggests 50mm as the minimum wall thickness, while these same walls seemingly tapered to a point at their upper parts. From pit

⁹ Only the pure slag fragments were counted, more slag was present adhering to and fused with furnace wall material.

c1212 came also a piece of furnace wall with slag adhering on adjoining right-angled sides. This very likely represents a side opening in the furnace wall. Of interest is also the piece of furnace wall showing evidence of repair.

Furnace pit	Dimensions (length x width x depth, in mm)	Slag (in g)
c1208	600 x 600 x 400	6938
c1244	700 x 670 x 400	5729
c1212	480 x 460 x 160	5818

Table 1: Dimensions and slag weights of the three furnace pits

Only one piece of slag from the three pits shows a potential impression of a large wood fragment, while more convincing pieces were found further away in Areas A and B. As such, we are unsure of the nature of the packing material.

3.2.2 Bloom processing

Close to the furnace pits, two features (c1285 and c1316) contain slag which have characteristics of smelting slag, frothy brown material and rather drippy, but which also differs; the drippy slag often consists of flat pieces and is less dense. The same features also contain tuyere material with seemingly flat fronts with a diameter of between 100 and 150mm. As these feature contained little or no charcoal it is unsure if they functioned as hearths, but the material itself is very likely connected to some form of bloom processing.

Interestingly, the large SHCs, which are usually seen as the typical type of slag connected to bloom refining, were found away from the smelting area, mostly in the ditches in the north of Area B and the ditches and pits in Area A. Only in the north-east of Area B is likely hearth c316, which contained flat dense drippy pieces, located near a feature, c375, and a ditch, c263, which yielded SHCs weighing over 1kg.

3.2.3 Secondary iron smithing

Although smithing pan and hammerscale, the best indicators of in-situ smithing, were found in

several features, hardly any hearths related to this activity could be identified with certainty. Likely these were removed as a result of later activity. Only feature c891, in the west of the excavated area appears to have been a smithing hearth, but after it was seemingly used for depositing smelting residues. Unusually, no other iron smithing residues were uncovered in the immediate vicinity of this hearth.

Many examples of smithing hearth cakes (SHCs) were recovered from across the site, but further analysis would be needed to determine which areas were used for bloom smithing and secondary smithing and which only for secondary smithing as smaller SHCs are also known to be produced during bloomsmithing activities (Young 2012: 42, 46). Several examples of so-called double SHCs were retrieved. These are generally interpreted as being produced when a SHC from a previous smithing session was left in the hearth. Interestingly, one potential double SHC showed both were near identical, while in another case the SHC were markedly different. In the latter case, the upper cake consisted of slag with a distinctive white matrix. This unusual type of slag was encountered in various different features and areas but its nature remains unclear. Another unusual type of smithing slag, also well represented on the site, consisted of lumps of friable brown frothy material. Again, analysis would be needed to better understand these two types of slag. Two complete SHCs, one each retrieved from an isolated post hole, indicate the use of SHCs as packing material around the base of wooden posts.

Many tuyere remains were found at Roscrea. The most complete example had a flat oval front with an oval blow hole positioned off-centre within that front. At its shortest, rounded sides, the oval blow hole showed angles of about 45 degrees to the tuyere front while at its longer sides the angle was closer to 90 degrees. This would imply a rather elongated opening at the back of the tuyere, possibly intended to hold two bellow spouts. This particular tuyere front measured 130mm by 100mm. Many other fragments either showing c. 90 degree or 45 degree angles between the blow hole and the tuyere front could indicate that this type of tuyere was commonly used in relation to ironworking on the site. Other tuyeres seemingly had more circular fronts measuring 90 to 110mm.

One aspect which needs to be remarked on is the exceptional preservation of usually fragile tuyere material in ditches with medieval or modern finds material.

3.2.4 Copper production

The material related to copper production includes fragments of what appears to be cylindrical tuyeres, dense slag with Cu staining and likely grey crucible sherds. This is very similar, albeit on a much smaller scale, to the material recovered from a recently excavated site at Stradbally, Co. Waterford (Rondelez 2015). That site was interpreted as relating to matte refining or the purification of the iron-copper product from the smelting of iron-rich copper ores (chalcopyrite). The remains then represented the crucibles wherein the matte material was heated by a cylindrical tuyere. This led to the iron being removed in the dense slag which also contained some copper material. The site at Stradbally was dated to the fifth to early sixth century AD

4. Conclusions

The site at Roscrea is remarkable for the variety of its metalworking remains as well as for their preservation. The ironworking remains include three furnace pits, the remnants of typical pre-Anglo-Norman slag pit furnaces, with enough evidence to suggest a furnace shaft with a side opening with walls tapering to a pointed edge.

The bloomery processing evidence, if it is indeed contemporary with each other, suggests a first activity near the furnace whereby bellows were used and slag similar to smelting slag was produced. The main difference is that the material often formed flat pieces and is less dense. The large SHCs generally associated with bloom processing were found further afield, intermixed with the evidence for the further processing of the iron into objects.

Well-preserved tuyere material indicates that at least some had oval flat fronts with oval tapering blow holes set off-centre in the tuyere body. The tapering of the blow holes appears wide enough to propose the use of two bellows.

Finally, the rather scant remains related to copper production are near identical to recently examined fifth- to early sixth-century matte refining or the purifying of the iron-copper mix that is the product of the smelting of iron-rich copper ores.

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6. Figures



Fig. 1. Mid-ex of furnace pit c1208



Fig. 2. Drippy dense slag from c1208 (fill 1207)



Fig. 3. Brown frothy slag from c1208 (fill c1207)



Fig. 4. Furnace wall fragment from c1208 (fill c1206) showing repair (red line)



Fig. 5. Post-ex of furnace pit c1244



Fig. 6. Dense drippy slag from c1244 (fill c1242)



Fig. 7. Slag from pit c1316 (fill c1315) including rather dense flat pieces and frothy material



Fig. 8. Tuyere blow hole fragment from pit c1316 (fill c1315)



Fig. 9. Slag from pit c1285 (fill c1284) including rather dense flat pieces and frothy material



Fig. 10. Tuyere material from pit c1285 (fill c1284) the two on the left showing blow hole portions



Fig. 11. Slag lump c1211 from furnace pit c1212 after lifting



Fig. 12. Slag lump c1211 from furnace pit c1212 after cleaning



Fig. 13. Furnace wall fragment from c1212 (fill c1180) with slag on two adjoining 90° sides



Fig. 14. Furnace wall fragment from c1212 (fill c1180) showing a smoothed surface



Fig. 15a. Upper rim furnace wall fragments from c1212 (fill c1180).



Fig. 15b. Same pieces showing tapered upper rim



Fig. 16. Curved tuyere fragment from pit c1459 (fill c1456)



Fig. 17. SHC from post hole c1158 (fill c1156)



Fig. 18. SHC from pit c1250 (fill c1249) showing indents caused by air blown onto the slag



Fig. 19. Double SHC from pit c313 (fill c348)



Fig. 20. White matrix SHC from pit c462 (fill c461)



Fig. 21. Dense slag with wood impressions from ditch c649 (fill c648)



Fig. 22. Dense drippy slag from pit c891 (lower fill c890)



Fig. 23. Smithing pan from pit c891 (upper fill c888)



Fig. 24a. Dense drippy slag with copper staining from pit c854 (fill c853)

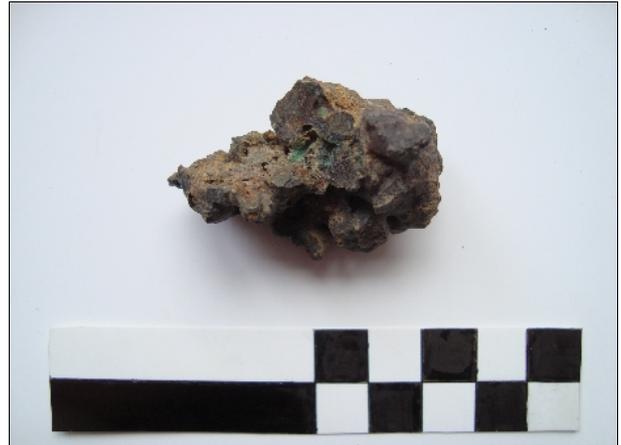


Fig. 24b. Detail of the same



Fig. 25. Likely cylindrical tuyere fragments from pit c854 (fill c853)



Fig. 26. Likely crucible fragments from pit c854 (fill c853)



Fig. 27. Rather dense slag from pit c316 (fill c315) including flat pieces



Fig. 28. Rather dense slag from feature c375 (fill c361) including a flat piece

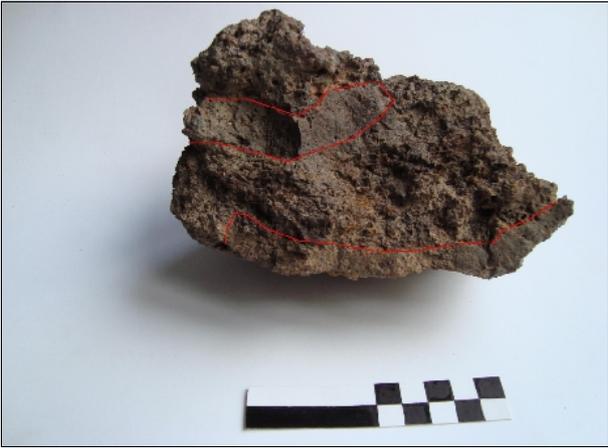


Fig. 29. Likely double SHC from pit c445 (fill c443)



Fig. 30. Large SHCs from ditch c263 (fill c262)



Fig. 31. Tuyere fragment from ditch c263 (fill c262) with blow hole at c. 45° to its vitrified front



Fig. 32. SHC from ditch c112 (fill c118) showing indent caused by air blown onto the slag



Fig. 33. SHC from ditch c114 (fill 117) with an unusual upstanding rim



Fig. 34. Tuyere front from ditch c114 (fill c117) showing blow hole



Fig. 35. Tuyere front with 'slag beard' from ditch c106 (fill c105)



Fig. 36. Oval tuyere with off-centre oval blow hole from ditch c13 (fill c12)



Fig. 37. Same tuyere front showing evidence of repair



Fig. 38. Light frothy brown SHC from pit c99 (fill c98)

7. Catalogue

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
NA	Topsoil	Topsoil	Three pieces of heavily weathered dense drippy slag (smelting?).	792
NA	1	Topsoil	Nine pieces of heavily weathered dense drippy slag.	1098
NA	1	Topsoil	Fragment of rather light SHC.	26
13	12	Curvilinear	Dense irregular SHC	277
13	12	Curvilinear	Roughly rounded SHC with drips on lower surface.	254
13	12	Curvilinear	Elongated rather dense SHC.	218
13	12	Curvilinear	Dense flattish SHC.	213
13	12	Curvilinear	Sideways elongated rather dense SHC.	270
13	12	Curvilinear	Small roughly circular oxidised SHC.	173
13	12	Curvilinear	Small lumpy heavily oxidised SHC.	127
13	12	Curvilinear	Thirty-seven pieces of dense to rather light slag. Most, and possibly all, SHC fragments.	1020
13	12	Curvilinear	Nine piece, probably all of the same tuyere. The frontal appears oval (130 by 100mm), the blow hole is horizontally oval shaped and off centre.	440
13	12	Curvilinear	Piece of tuyere showing 90° angle perpendicular to the frontal surface and clear evidence for repair.	55
65	93	Large pit	Three small pieces of light frothy brown slag.	19
83	24	Curvilinear	Four pieces of heavily weathered slag. Possibly smithing, but could be smelting.	159
83	24	Curvilinear	c. twenty small lumps of heat affected clay.	12
99	98	Metalworking pit	Irregular rather dense SHC	438
99	98	Metalworking pit	Bun-shaped rather dense SHC	410
99	98	Metalworking pit	Bun-shaped rather dense SHC	285
99	98	Metalworking pit	Elongated bun-shaped SHC	300
99	98	Metalworking pit	Elongated rather dense SHC.	375
99	98	Metalworking pit	Small irregular probably complete SHC	198
99	98	Metalworking pit	Six pieces of rather dense SHC material	149
99	98	Metalworking pit	Seven pieces of tuyere material, some showing repair above vitrified surfaces and one piece with an unusual semi-circular section	549
99	98	Metalworking pit	Three pieces of rather light brown frothy slag	914
99	98	Metalworking pit	Three small fragments of burnt clay with charcoal inclusions.	3
99	98	<i>Metalworking pit</i>	<i>Bag with numerous pieces of brown light frothy material and some undiagnostic slag fragments.</i>	105
99	138	Metalworking pit	Large, dense pronouncedly concave SHC	1629
99	138	Metalworking pit	Rounded SHC with flat upper surface.	899
99	138	Metalworking pit	Irregular SHC possibly consisting of two smaller specimens.	431
99	138	Metalworking pit	Roughly round SHC with protrusion at the base.	928
99	138	Metalworking pit	Irregular rather light SHC	347
99	138	Metalworking pit	Small irregular SHC.	337
99	138	Metalworking pit	Small, rather light SHC	329
99	138	Metalworking pit	Small, squarish and flat SHC	297
99	138	Metalworking pit	Small irregular SHC with adhering clay.	194
99	138	Metalworking pit	Two partial dense SHC's	547
99	138	Metalworking pit	Lump of vesicular white matrix slag.	140
99	138	Metalworking pit	Eight lumps of brown light slag.	300

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
99	138	Metalworking pit	Rounded lump of iron rich natural material with fossils protruding.	78
99	138	Metalworking pit	Five fragments of vitrified ceramic material with adhering slag. One piece shows convex outer surface to ceramic material (= tuyere).	280
99	138	Metalworking pit	Small piece of weathered drippy slag.	20
99	139	Metalworking pit	Partial dense SHC with raised oxidised upper part.	395
99	139	Metalworking pit	Lump of brown light frothy slag	87
99	140	Metalworking pit	Rounded and flat SHC	253
99	140	Metalworking pit	Irregular SHC of which the outer layer is composed of white matrix slag.	600
99	140	Metalworking pit	Irregular lump of frothy brown rather light slag. Probable SHC.	729
99	140	Metalworking pit	Three pieces of brown light frothy material.	566
99	140	Metalworking pit	Three pieces of vitrified ceramic material. One of them has visible outer surface (= tuyere) but the curvature is irregular so no diameter can be deduced.	170
99	140	Metalworking pit	Three pieces of brown light frothy slag.	74
106	105	Furrow	Dense lump of slag with dome drippy parts. Also impressions of large charcoal pieces.	769
106	105	Furrow	Roughly round SHC with oxidised upper part.	663
106	105	Furrow	Well formed oval SHC.	490
106	105	Furrow	Partial dense and flat SHC.	543
106	105	Furrow	Small SCH with oxidised upper part and hollow between this and lower part.	284
106	105	Furrow	Small SHC with oxidised upper part and drippy structure on lower surface.	317
106	105	Furrow	Flat concave heavily oxidised SHC.	210
106	105	Furrow	Small lump of slag (SHC?) with adhering piece of iron.	71
106	105	Furrow	Seven pieces of relatively dense to dense slag, most if not all are SHC fragments.	443
106	105	Furrow	Five pieces of relatively dense slag with slight flow pattern and impressions of charcoal.	397
106	105	Furrow	Eleven small fragments of slag, possibly fragments of SHC's.	23
106	105	Furrow	Piece of vitrified tuyere with adhering slag. The blow hole is partially preserved and the remaining sides of the tuyere show this to have been cylindrical (frontal face c. 90mm diam.). The curvature of the cylinder is visible under the slag tongue, i.e. the base of the tuyere.	148
106	105	Furrow	Piece of vitrified tuyere with adhering slag. The blow hole is partially preserved and was either of a decreasing diameter towards the front of the tuyere or had its blow hole at an angle. The distance between the centre of the blow hole and the visible edge of the tuyere varies between 40 and 60mm at a 90° angle.	159
106	105	Furrow	Two pieces of heavily heat affected ceramic material showing convex curvature (= tuyere material).	42
106	105	Furrow	Fragment of probable heat affected clay.	46
108	107	Ditch	Small piece of vitrified ceramic material with adhering slag. Probably tuyere material.	2
112	118	Ditch/drain	Large, dense well-formed SHC showing 'blowing hollow'.	1289
112	118	Ditch/drain	Roughly rectangular SHC with well formed convex base.	1225
112	118	Ditch/drain	Elongated dense SHC.	1581

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
112	118	Ditch/drain	Irregular SHC with some flow structure on one side.	836
112	118	Ditch/drain	Irregular dense SHC.	812
112	118	Ditch/drain	Small, rounded and partially oxidised SHC.	302
112	118	Ditch/drain	Two pieces of relatively light drippy slag, one with adhering clay. Both are weathered.	300
112	118	Ditch/drain	Fragment of rather light brown frothy slag.	55
114	117	Ditch/drain	Large dense broadly triangular SHC with upstanding rim at one end.	1412
114	117	Ditch/drain	Large lumpy dense SHC.	861
114	117	Ditch/drain	Two fragments of rather dense SHC material.	326
114	117	Ditch/drain	Piece of rather dense drippy slag. Weathered.	171
114	117	Ditch/drain	Sixteen pieces of tuyere material. Three pieces show blow hole. One seems to have been cylindrical (diam. c. 110mm), while another appears tapered towards the blow hole.	835
116	145	Ditch/drain	Roughly circular heavily weathered SHC (fractured).	278
116	145	Ditch/drain	Small lump of brown frothy and light slag.	55
116	145	Ditch/drain	Five pieces of vitrified tuyere material, one piece showing blow hole.	142
116	145	Ditch/drain	Small lump of oxidised iron	7
129	128	Curvilinear	Small, rather dense SHC with partial white matrix.	188
129	128	Curvilinear	Eight fragments of rather dense SHC.	385
129	128	Curvilinear	Four fragments of vitrified ceramic material. Very likely tuyeres.	116
143	142	Pit	Large partial dense SHC	2017
143	142	Pit	Roughly half circular dense SHC.	729
143	142	Pit	Flattish irregular SHC with unusual black smooth surface on upper face, impression of material during cooling?	791
143	142	Pit	Smallish half circular SHC.	369
143	142	Pit	Small lumpy rather light SHC.	268
143	142	Pit	Small lumpy rather dense SHC.	367
143	142	Pit	Small lumpy rather dense SHC.	302
143	142	Pit	Small irregular heavily oxidised SHC.	152
143	142	Pit	Small irregular SHC.	194
143	142	Pit	Seventeen pieces of rather dense slag, most if not all fragments of SHC's.	581
143	142	Pit	Ten pieces of light to dense slag with complete or partial white matrix.	509
143	142	Pit	Fourteen pieces of rather dense to dense drippy slag. Weathered to heavily weathered.	402
143	142	Pit	Three lumps of heavily oxidised slag.	75
143	142	Pit	Fourteen pieces of vitrified ceramics with adhering slag. Several pieces show outer surface (= tuyeres). One piece has sharp angle perpendicular to the front of the tuyere.	552
143	181	Pit	Small dense lumpy SHC.	225
143	181	Pit	Small light SHC, probably influenced by tuyere material.	145
143	181	Pit	Partial rather dense SHC	105
143	181	Pit	Two pieces of vitrified ceramics with adhering slag, one piece showing convex outer surface (= tuyere).	63
148	147	Pit	Five pieces of heat affected clay. One showing possible blow channel, other a smoothed outer surface (probably tuyere).	26
148	147	Pit	Small iron nail.	1

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
180	179	Linear	Seven pieces of rather light to rather dense slag. Weathered. Most if not all SHC fragments.	298
180	179	Linear	Four fragments of weathered vitrified ceramics. Very likely tuyere fragments.	68
249	248	Ditch	Partial heavily weathered SHC.	181
249	248	Ditch	Ten pieces of dense partial and near complete SHC's.	1029
249	248	Ditch	Small piece of drippy slag.	20
249	248	Ditch	Small lump of heat-affected clay.	15
249	248	Ditch	Seven nails and a padlock	143
249	248	Ditch	Lump of heavily oxidised iron.	40
263	262	Ditch	Heavily encrusted and weathered dense SHC.	1588
263	262	Ditch	Heavily encrusted and weathered dense SHC.	1512
263	262	Ditch	Heavily encrusted and weathered dense roughly circular SHC.	1147
263	262	Ditch	Heavily encrusted and weathered dense lumpy SHC.	725
263	262	Ditch	Heavily encrusted and weathered rather dense lumpy SHC.	510
263	262	Ditch	Small weathered rather dense SHC.	222
263	262	Ditch	Forty-two pieces of dense to rather dense slag. Most, if not all, partial SHC's.	4342
263	262	Ditch	Piece of reddish vitrified ceramic material with blow hole visible strongly tapered towards the outer surface.	6
263	262	Ditch	Six pieces of heat affected yellowish clay. Probably not metallurgy-related	116
309	308	Post hole	Small dense, roughly triangular SHC	129
311	310	Furrow	Irregular lump of slag with some drippy texture. SHC?	296
311	310	Furrow	Small piece of light brown frothy slag.	5
313	337	Large pit	Dense irregular SHC heavily encrusted by clayey material.	1072
313	340	Large pit	Fragment of weather very likely SHC	248
313	348	Large pit	Double SHC. At least one is dense. The upper one consisting of an unusual white fabric (calcium rich?).	775
316	315	Furnace	Twenty pieces of drippy to slightly drippy slag. Mostly rather dense, but some light fragments are included. Some pieces are flat but still show flow structure.	1454
NA	335	Deposit	Three pieces of weathered rather dense slag. Likely SHC fragments.	179
350	349	Pit	Small lump of rather oxidised slag.	22
350	349	Pit	Small piece of drippy, vesicular slag	16
350	349	Pit	Small piece of vitrified ceramic material.	5
350	349	Pit	<i>c. twenty small slag fragments, many thin and cup-shaped, probably smithing.</i>	6
375	361	Poss. Kiln	Rather dense, roughly circular SHC with irregular upper surface.	576
375	361	Poss. Kiln	Dense irregular SHC	264
375	361	Poss. Kiln	Fragment of dense round SHC	120
375	361	Poss. Kiln	Rather dense lumpy SHC	125
375	361	Poss. Kiln	Rather irregular light frothy SHC	155

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
375	361	Poss. Kiln	Lumpy light frothy SHC	157
375	361	Poss. Kiln	Irregular light frothy SHC	106
375	361	Poss. Kiln	Irregular light frothy SHC	148
375	361	Poss. Kiln	Small irregular light frothy SHC	57
375	361	Poss. Kiln	Thirteen pieces of light frothy slag, most are unusually flat.	438
375	361	Poss. Kiln	Small piece of slag, partially with white matrix.	11
375	361	Poss. Kiln	Two pieces of rather light tuyere influenced slag.	100
375	361	Poss. Kiln	Seven small lumps of rather light slag.	102
375	361	Poss. Kiln	Small piece of yellow clay with charcoal inclusions	7
375	361	Poss. Kiln	Seven pieces of vitrified ceramics with adhering slag. Tuyere fragments. The largest piece shows a 90° angle of the outer surface.	171
375	376	Poss. Kiln	Large piece of irregular slag. Multiple impressions of large wood/charcoal on lower surface. Likely SHC	837
375	376	Poss. Kiln	Large dense SHC elongated side-ways.	1151
375	376	Poss. Kiln	Nine pieces of relatively dense slag. Most, if not all, SHC fragments.	588
375	376	Poss. Kiln	Five pieces of light frothy slag.	370
375	376	Poss. Kiln	Two pieces of slag with glassy, white matrix	57
375	376	Poss. Kiln	Large piece of vitrified ceramic material with adhering slag. Strongly deformed by heat. Clay is light grey with little inclusions.	216
375	376	Poss. Kiln	Five pieces of reddish, heat affected vitrified clay. One piece has a convex outer surface.	34
375	376	Poss. Kiln	Strongly corroded iron object.	43
382	381	Pit	Small piece of rather dense slag	8
396	395	Pit	Partial layered SHC	190
396	395	Pit	Piece of elongated corroded iron	18
398	397	Linear	Lump of dense drippy slag.	50
433	432	Furrow	Small flat lump of vesicular slag.	20
445	443	Pit	Large lump of slag consisting of a thin (c. 10mm) layer of dense slag at the base, followed by frothy material, next another layer of dense material and frothy material at the top. Possibly combination of two SHC's?	1734
445	443	Pit	Irregular SHC with oxidised upper part.	554
445	443	Pit	Small dense lump of vesicular slag, probably SHC.	306
447	446	Post hole	Irregular SHC with white matrix.	246
453	452	Pit	Small irregular SHC.	241
453	452	Pit	Pieces of relatively dense slag, likely SHC fragment.	58
453	452	Pit	Concretion of weathered iron oxide with many visible flake hammerscale particles (+ smithing pan)	123
453	452	Pit	c. 20 pieces of heat-affected clay. Interesting, but likely not metallurgy related	208
462	461	Pit	Elongated piece of white matrix slag.	96
471	484	Pit	Dense, roughly half-circular SHC	761
471	484	Pit	Round, concave SHC showing direction of blowing.	398
471	484	Pit	Round concave SHC with impression of large charcoal fragment on upper surface.	492
471	484	Pit	Partial dense SHC	381
471	484	Pit	Smallish slightly elongated SHC	193
471	484	Pit	Part of rather dense SHC	80
471	?	Pit	Circular heavily weathered SHC	400
471	?	Pit	Lumpy dense heavily weathered SHC.	459

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
471	?	Pit	Partial dense weathered SHC	820
471	?	Pit	Fragment of brown frothy light slag.	54
472	486	Pit	Heavily corroded iron object (nail?).	34
472	995	<i>Pit</i>	<i>Bag with several lumps of heat affected clay.</i>	16
500	559	Kiln	Several pieces of heat affected clay, one with smoothed outer surface.	12
500	559	<i>Kiln</i>	<i>Several pieces of natural iron oxides, a few pieces of uncharacteristic slag and four specimens of probable hammerscale (weathered).</i>	2
500	560	Kiln	Piece of heat affected clay.	29
535	534	Pit	Heavily weathered SHC lump.	311
535	534	Pit	Nineteen pieces of heavily weathered dense slag. Most, if not all, are SHC fragments.	842
535	534	Pit	Eight pieces of weathered dense drippy slag.	331
535	534	Pit	'Tuyere'	
535	534	Pit	Piece of heavily oxidised curved iron.	9
544	543	Ditch	Fourteen pieces of rather dense to dense drippy slag. Heavily weathered. Likely SHC fragments.	829
571	570	Pit	Fragment of dense heavily weathered SHC.	209
575	574	Ditch	Four lumps of heavily encrusted possibly complete SHC's.	1104
575	574	Ditch	Lump of brown frothy light slag.	133
592	591	Pit/natural hollow	Two small lumps of concreted iron rust with inclusions of flake hammerscale (= smithing pan).	11
NA	593	Deposit	Two pieces of heat affected clay.	5
612	611	Pit	Piece of heavily weathered rather drippy slag.	45
618	617	Pit	Piece of rather light vesicular slag, probably SHC fragment.	31
649	648	Ditch	Large piece of dense slag showing multiple hollows after large wood fragments. Weathered.	821
649	648	Ditch	Four pieces of heavily weathered rather drippy slag.	300
649	648	Ditch	Two small pieces of rather dense drippy slag.	20
649	648	Ditch	Piece of dense grey heat affected clay.	20
669	668	Curvilinear	Thirty-two pieces of fragmented and mostly weathered SHC's.	1022
669	668	Curvilinear	Fragment of vitrified ceramic material showing convex edge (= tuyere).	4
669	668	Curvilinear	Four pieces of weathered slag SHC fragments.	120
669	668	Curvilinear	Piece of vitrified ceramic material with adhering slag. Very likely tuyere.	41
671	670	Pit	Small dense and drippy piece of slag, heavily weathered.	162
675	674	Ditch	Partial vesicular SHC	104
677	676	Linear	Rather light lumpy SHC. Weathered.	291
677	676	Linear	Small irregular heavily weathered SHC.	175
677	676	Linear	Rather dense SHC with rusty upper surface. Weathered.	254
677	676	Linear	Six SHC fragments. Weathered.	261
677	676	Linear	Two pieces of light frothy brown slag.	48
677	676	Linear	Piece of weathered convex tuyere fragment.	69
689	688	Pit	Seven pieces of dense flattish slag. Most probably from the same SHC.	245
689	688	Pit	Two pieces of weathered drippy slag.	93
693	692	Ditch	Two small rounded and heavily weathered pieces of slag.	68
693	692	Ditch	Small iron nail.	2

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
699	698	Ditch	Three fragments of rather dense SHC material.	331
699	698	Ditch	Large, fairly well formed dense SHC.	767
699	698	Ditch	Very irregular rather light SHC.	190
699	698	Ditch	Heavily weathered drippy slag.	140
699	698	Ditch	Vitrified ceramic fragment with convex outer surface (tuyere).	21
751	750	Pit	Three small lumps of heavily weathered slag. Two are somewhat drippy	27
851	850	Slot trench	Two fragments of rather dense SHC material.	107
851	850	Slot trench	Lump of heavily oxidised iron.	23
851	850	Slot trench	Fragment of heat affected clay.	4
854	853	Pit/posthole	Thirty pieces of rather dense to dense drippy slag (smelting).	415
854	853	Pit/posthole	Two pieces of dense drippy slag with Cu crystallisation!	59
854	853	Pit/posthole	Two fragments of vitrified grey ceramic material. One has Cu staining on the outer surface. Likely crucible material	34
854	853	Pit/posthole	Six pieces of reddish vitrified ceramic material, all showing concave outer surface, three pieces seem to have an inner surface which is smooth and lighter coloured. This would make the wall c. 10mm thick. (crucible? Or cylindrical tuyere).	30
854	853	Pit/posthole	Tiny piece of slag with copper oxide in one of the vesicles.	1
854	853	Pit/posthole	Eight pieces of heat affected clay with some having smoothed outer surface and one also inner surface (crucible? Or cylindrical tuyere).	5
854	853	<i>Pit/posthole</i>	<i>Three tiny pieces of probable slag, undiagnostic.</i>	<i>1</i>
877	873	Pit	Two lumps (one fractured) of dense weathered slag, one is somewhat drippy.	359
891	888	Hearth	Bag with a number of fragments of concreted crushed slag, iron oxide and flake hammerscale (=smithing pan).	993
891	889	<i>Hearth</i>	<i>Bag with small slag fragments, hammerscale (both flake and globular) and smithing pan.</i>	<i>115</i>
891	890	Hearth	20+ fragments of dense and rather light drippy slag	368
911	910	Pit	Two pieces of compact (heat affected?) clay. Probably not metallurgy related. Concrete?	64
913	912	Pit	Small lump of amorphous brown frothy slag	21
925	924	<i>Stake hole</i>	<i>Bag with several pieces of undiagnostic slag fragments.</i>	<i>5</i>
925	924	<i>Stake hole</i>	<i>Small piece of rather light slag (smithing?).</i>	<i>3</i>
988	987	<i>Stake hole</i>	<i>Tiny piece of probable natural iron oxide.</i>	<i>1</i>
992	991	<i>Pit</i>	<i>Bag with numerous pieces of probable natural iron oxides, also several slag pieces which seem to be smelting slag.</i>	<i>8</i>
1013	1012	Pit	Fragment of dense probable SHC	170
1013	1012	Pit	Small piece of rather light slag.	3
1013	1012	<i>Pit</i>	<i>Piece of brown rather light slag with numerous charcoal inclusions.</i>	<i>30</i>
1017	1016	Pit	Piece of heat affected clay with adhering slag (tuyere?).	10
1040	1039	Pit	Heavily weathered piece of rather light slag. SHC fragment?	50

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
1048	1047	Linear	Two small rather light pieces of slag, one is rather drippy	13
1048	1047	Linear	Fragment of convex vitrified ceramic material. Occasional rounded quartz in clay matrix.	10
1048	1047	Linear	<i>Bag with numerous pieces of crushed slag, probably smithing.</i>	33
1054	1647	Ditch	Eight pieces of heavily weathered pieces of slag. Most, if not all, SHC fragments.	477
1081	1080	Linear	Three fragments of rather dense. Weathered. The largest appears to be a SHC fragment	229
1155	1154	Pit	<i>c. twenty small pieces of mostly slag, some could be smelting.</i>	4
1158	1156	Post hole	Dense concave heavily encrusted SHC	552
1175	1171	Pit	<i>Bag with several pieces of natural iron oxides and three pieces of uncharacteristic slag</i>	1
1184	1183	Poss. Furrow	Three pieces of very weathered drippy slag.	209
1184	1183	Poss. Furrow	Highly oxidised lump of iron object. Likely iron object.	133
1186	1185	Poss. Furrow	Two pieces of vitrified ceramics, the larger one is slightly concave.	76
1201	1200	Pit	Four small lumps of heavily weathered drippy slag.	20
1205	1204	Pit	Three pieces of heavily weathered drippy slag.	60
1205	1204	Pit	Two lumps of heavily oxidised probable iron.	35
1208	1206	Furnace	Thirteen pieces of dense drippy slag.	1308
1208	1206	Furnace	Ten pieces of light frothy brown slag.	96
1208	1206	Furnace	Large piece of grey clay (furnace wall). Additional clay, less well sorted was added to the original outer surface. The original thickness was minimum 50mm.	276
1208	1206	Furnace	Twelve pieces of grey (some slightly pink) pieces of clay, some with smoothed surface.	218
1208	1207	Furnace	Eight pieces of drippy slag, the largest with adhering burnt clay	407
1208	1207	Furnace	Eleven pieces of brown, light, frothy slag (furnace cake).	130
1208	1207	Furnace	Seven pieces of grey clay with occasional rounded stone inclusions. Some with smoothing (furnace wall).	132
1208	1207	Furnace	Two pieces of light slag.	15
1208	1207	Furnace	Bag with numerous small pieces of slag. Mostly drippy prills with some more frothy pieces. Also some ceramic inclusions.	1410
1208	1275	Furnace	Twenty-eight pieces of heat-affected clay	811
1208	?	Furnace	Thirty-five pieces of dense drippy slag (smelting).	3244
1208	?	Furnace	Seven pieces of light frothy brown slag (furnace cake). Two pieces remarkably flat.	328
1208	?	Furnace	Five pieces of grey heat affected clay, one piece with smoothed outer convex surface (furnace wall).	95
1210	1209	Pit	Small lump of weathered slag.	23
1210	1209	Pit	Two sherds of pottery	
1212	1180	Furnace	50+ small pieces of drippy slag	417
1212	1180	Furnace	Thirteen pieces of light brown frothy slag.	255
1212	1180	Furnace	c. 30 small pieces of unclassifiable slag.	121
1212	1180	Furnace	Eleven fragments of heat affected grey clay, some with adhering slag.	122
1212	1180	Furnace	Bag with numerous fragments of heat affected clay. Many show at least one smoothed surface. Thicknesses: > 30mm, 20mm and several pieces with both surfaces tapering together.	510

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
1212	1180	Furnace	Eleven pieces of slag with grey clay inclusion. Pieces from interior of furnace.	689
1212	1180	Furnace	Bag with numerous small slag fragments, many drippy pieces (= smelting).	385
1212	1211	Furnace	Slag piece showing several sequences of slag flow originating from the same place. The lowest, earliest flow appears to have been much more fluid than the later ones.	3158
1214	1213	Pit	Bag of smallish (crushed?) fragments of grey heat-affected clay	209
1226	1225	Pit	Fragment of heavily weathered SHC.	181
1230	1229	Pit	Probably piece of heavily corroded iron.	20
1232	1231	Pit	Small lump of oxidised slag	15
NA	1235	Deposit	Sixty-one pieces of drippy, mostly dense slag. Heavily weathered.	5424
NA	1235	Deposit	Roughly rounded rather light SHC with small bit of oxidised material on the upper surface. Weathered.	324
NA	1235	Deposit	Lump of iron oxide, black colour possibly indicating high manganese content.	29
1239	1238	Pit	Two small pieces of heavily weathered slag, one drippy.	11
1241	1240	Pit	22 pieces of weather drippy slag (= smelting)	612
1241	1240	Pit	Piece of heavily heat affected grey clay with one smoothed side (furnace wall).	64
1244	1187	Furnace	Three small pieces of dense drippy slag, two with adhering clay.	104
1244	1187	Furnace	Two pieces of dense slag, one very drippy, the other with adhering clay (furnace wall).	842
1244	1187	Furnace	Twenty-two pieces of heat-affected grey clay, some with smoothed surface (furnace wall).	505
1244	1187	Furnace	Seven pieces of grey clay with adhering slag. Minimum thickness of 50mm.	713
1244	1242	Furnace	Six pieces of dense smooth drippy slag (smelting slag). One possible indication of wood impression.	1671
1244	1243	Furnace	Five pieces of dense to rather light slag with drippy structure.	880
1244	1243	Furnace	Six pieces of grey heat-affected clay. The two larger ones have adhering slag.	199
1244	1278	Furnace	Thirty-one pieces of dense, drippy slag, some with adhering burnt clay.	1315
1244	1278	Furnace	Bag with numerous small pieces of slag. Mostly drippy prills with some more frothy pieces. Also some ceramic inclusions.	799
1244	1278	Furnace	Two pieces of brown light frothy slag (= furnace cake).	118
1244	1278	Furnace	Three pieces of heat affected clay, two are mixed with slag, other showing smoothed outer surface (= furnace wall).	314
1248	1247	Pit	Three small pieces of heavily weathered drippy slag.	13
1250	1249	Pit	Heavily encrusted SHC with impression formed by forced air.	534
1285	1284	Hearth	Fifty-one pieces of rather dense slag with some drippy structure	1169
1285	1284	Hearth	Five flat pieces of rather dense slag. Probably smelting slag	443
1285	1284	Hearth	Six pieces of rather light frothy slag with numerous small charcoal inclusions. Furnace cake).	275

Cut	Fill	Feature description	Description of the metalworking waste	Weight (g)
1285	1284	Hearth	Piece of vitrified ceramic material tapering towards on side. Likely tuyere with blow hole of min. diam. of c. 20mm	29
1285	1284	Hearth	Piece of red oxidised ceramic material showing part of blow channel (min. diam. c. 20mm), slightly vitrified at one corner.	9
1285	1284	Hearth	Piece of heat affected ceramic material showing convex outer surface. Original diameter c. 100 to 150mm.	24
1285	1284	Hearth	Piece of vitrified ceramic material with adhering slag. Shows a more or less 90° angle perpendicular to the front of the object (tuyere).	61
1285	1284	Hearth	Five pieces of vitrified ceramic mater, very likely tuyere.	52
1316	1315	Hearth	Bag with numerous small pieces of slag. Mostly drippy prills with some more frothy pieces. Also some heat affected clay inclusions.	705
1316	1315	Hearth	Bag with numerous small pieces of slag. Mostly drippy prills with some more frothy pieces. Also some heat affected clay inclusions.	1853
1316	1315	Hearth	Twelve piece of oxidised clay, one piece showing blow channel, others smoothed outer edge.	114
1316	1315	Hearth	Bag with multiple pieces of heat affected clay, probably furnace wall.	28
NA	1317	Layer	Nine pieces of light to relatively light brown frothy slag.	374
NA	1317	Layer	Three pieces of drippy, light drippy slag.	144
NA	1317	Layer	Three pieces of vitrified ceramic material. Furnace wall fragments?	82
NA	1317	Layer	Fragment of grey clay with smoothed side.	3
1319	1318	Pit	Three small pieces of heavily weathered slag.	42
1459	1456	Pit	Piece of vitrified ceramics showing clear convex curvature (tuyere).	87
1459	1572	<i>Pit</i>	<i>Four tiny pieces of probable natural iron oxide, one fragment of undiagnostic slag.</i>	<i>1</i>
1501	1500	<i>Stake hole</i>	<i>Two tiny pieces of probable natural iron oxides.</i>	<i>1</i>
1592	1591	<i>Post hole</i>	<i>Lump of heavily weathered slag, probably smelting. Also four pieces of probable natural iron oxides.</i>	<i>21</i>
1606	1605	Post hole	Small piece of near crystalline iron oxide	8
1630	1629	Pit	Twenty five pieces of heavily weathered drippy dense slag (smelting).	423
1635	1634	<i>Stake hole</i>	<i>Bag with several pieces of heavily weathered slag, possibly smelting.</i>	<i>3</i>
1637	1636	<i>Stake hole</i>	<i>Seven small pieces of probable slag</i>	<i>1</i>
1643	1642	Pit/posthole	Piece of heavily weathered undiagnostic slag.	146