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Assessment of archaeometallurgical  
materials from land off Culmstock Road,  
Hemyock (LEB24)

Dr Tim Young  
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Dr T.P. Young

## Abstract

*This excavation produced evidence for a substantial medieval iron smelting operation. Two early furnaces were overlain by a large slag dump, estimated to contain, very approximately, 60-65 tonnes of residues within the investigated area, presumably derived from the use of furnaces outside that area.*

*A very high proportion of the residues within the dump was present as large fragments (by one estimate approximately 60%), including large tapslag flows which in some cases retained their fragile margins. This can therefore be interpreted as a primary dump of waste, deposited straight from the bloomery. Below the slag dump, two poorly-preserved furnaces were discovered (their remains were, as far as possible, block lifted for examination during post-excavation analysis), but these cannot be the source of the majority of slag in the dump and further furnaces must have lain outside the excavated area, probably below the modern road.*

*The residue assemblage shows that the furnaces generated tapslags, which cooled within the tapping pits outside the furnace to form blocks of 8kg to 15kg. The blocks present in the dump were typically fractured obliquely from the slag remaining within the tapping hole, although some fractured at a point within, or even inside the hole. The base of the tapslag blocks may show little or no change across the line of the tapping hole and be a continuous level with the slag remaining inside the furnace.*

*The slag left inside the furnace formed a plano-convex block, approximately 200mm in diameter and 50mm - 65mm deep, often with somewhat lobate margins and typically with a rough, granular, upper surface, probably indicating material above (possibly the bloom and its adjacent slag) had been torn away during extraction. The top of the slag bowl inside the furnace was at the same level as the top of the tapslag outside. The adherence of reduced fire clay provides a hint that, at least in some examples, the blowing was from the left side of the furnace. The line of the tapping arch was marked by a zone of oxidised fired clay fused to the upper surface of the slag block. This line was confluent, in some examples, with the oxidised fired clay abutting the lateral margins of the tapslag outside the furnace. In some examples the reduced fired clay abutting the internal slag bowl also curved to form the inside of the line of the tapping arch. The channel through which the slag had apparently passed varied between 80mm and 180mm in width. Some of the blocks provide evidence for the axis of the tapslag block not being perpendicular to the front of the arch. The internal bowl of slag probably weighed around 3kg and a further 4kg of slag may have cooled in the tap arch area, inside the typical line of fracture for the tapslag cakes. These figures suggest that the slag produced in a smelt may have been in the order of 15kg to 22kg, with about 65% being fully tapped.*

*The evidence from the slags, therefore, suggests that slag was tapped from the furnace via a rather small opening, 80-180mm wide and up to 65mm tall. Removal of the bloom may have been via a larger furnace arch, blocked during the smelt, and containing the small tapping hole in its base.*

*Two of the tapslag cakes (T7 and T9) show evidence for small 'birds-foot' slags on their upper surfaces, hinting that some late slag flows may have been derived from a higher level, perhaps during opening of the main furnace arch.*

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## Methods

### Background

This assessment was commissioned by Jeremy Austin and Tim Brown of Isca Archaeology. The materials described and assessed here arise from excavations undertaken on land adjacent to Bailey Lodge, Culmstock Road, Hemyock, Devon (Isca Archaeology, Project P01-0098).

### On-site sampling

Following discussions during a site visit in October 2024, the dump deposit was sampled in various ways – most significantly through the rapid characterisation on site of the residues contained in three areas of the sondages: a total of 3.2 tonnes of material (Table 1). A representative sample totalling 159kg was set aside for further investigation during the post-excavation phase in January 2025. The dump was further sampled through a series of very small bulk samples (approximately 1kg each; informally described in this assessment as the ‘hammerscale’ samples). These were designed both to check for micro-residues (such as hammerscale and ore fines) and to provide an estimate of the proportion of the finer grained matrix to the larger residue blocks sampled on site that was formed of comminuted residue debris. These suggested that 60% of the matrix to the larger blocks was archaeometallurgical residue. The matrix was determined to make up approximately 2 tonnes of the sampled deposits (that which provided the 3.2 tonnes of coarse residue) – thus the site overall produced 5.2 tonnes of residues from the 6.1m<sup>3</sup> sampled, out of a total dump size of approximately 70m<sup>3</sup>, suggesting a figure of very approximately 60 tonnes for the demonstrated dump (although the dump probably extends significantly beyond the excavated area). An alternative calculation (Table 1) using a more detailed

breakdown by context, suggests a similar total of 64 tonnes.

Below the slag dump, two poorly-preserved furnaces were discovered, and their remains were, as far as possible, block lifted for examination during post-excavation analysis.

### Assessment

All submitted materials were examined visually in August 2025, using a low-powered binocular microscope where required. They have been catalogued and the major pieces photographed.

### Archaeological background

The site lies close to the core of medieval Hemyock – just 20m N of the castle moat and 100m NW of the church.

It lies immediately to the east of a plot (now ‘Castle Dene’) investigated by Context One Archaeological Services Ltd in 2007 and 2008 (Context One 2009). Their interventions produced evidence for medieval (12<sup>th</sup>-14<sup>th</sup> century) structures overlain by a dark slag-bearing deposit, in turn overlain by a thick red deposit. The slag-bearing deposit can be interpreted as the northern equivalent of the slag dump recorded on the present site. It produced, however, only 13kg of slag, probably lay beyond the main development of the dump. The overlying red clay was interpreted, as on the present site, as spoil from the creation of the adjacent castle moat.

The site lies within an area that has produced several other significant iron smelting sites: it lies 300m east of the Culmstock Road South site (7<sup>th</sup> – 9<sup>th</sup> century; Rainbird & Young 2015), 250m north-northwest of Churchills Farm (9<sup>th</sup>-10<sup>th</sup> century and 12<sup>th</sup> century; Smart 2018) and 250m southeast of the Culmstock Road North site (7<sup>th</sup> – 10<sup>th</sup> century; Young *et al.* 2022).

## Results

### General

A very high proportion of the residues within the dump was present as large fragments (by one estimate approximately 60%), including large tapslag flows which in some cases retained their fragile margins. This can therefore be interpreted as a primary dump of waste straight from the bloomery. Below the slag dump, two poorly-preserved furnaces were discovered (their remains were, as far as possible, block lifted for examination during post-excavation analysis), but these cannot be the source of the majority of slag in the dump and further furnaces must have lain outside the excavated area, probably below the modern road.

The residue assemblage shows that the furnaces generated tapslags which cooled within the tapping pits outside the furnace to form blocks of 8kg to 15kg. The blocks present in the dump were typically fractured obliquely from the slag remaining within the tapping hole, although some fractured at a point within, or even inside the hole. The base of the tapslag blocks may show little or no change across the line of the tapping hole and be a continuous level with the slag remaining inside the furnace.

The slag left inside the furnace formed a plano-convex block, approximately 200mm in diameter and 50mm - 65mm deep, often with somewhat lobate margins and typically with a rough, granular, upper surface, probably indicating material above (possibly the bloom and its adjacent slag) had been torn away during extraction. The top of the slag bowl inside the furnace was at the same level as the top of the tapslag outside. The adherence of reduced fire clay provides a hint that, at least in some examples, the blowing was from the left side of the furnace. The line of the tapping arch was marked by a zone of oxidised fired clay fused to the upper surface of the slag block. This line was confluent, in some examples, with the oxidised fired clay abutting the lateral margins of the tapslag outside the furnace. In some examples the reduced fired clay abutting the internal slag bowl also curved to form the inside of the line of the tapping arch. The channel through which the slag had apparently passed varied between 80mm and 180mm in width. Some of the blocks provide evidence for the axis of the tapslag block not being perpendicular to the front of the arch. The internal bowl of slag probably weighed around 3kg and a further 4kg of slag may have cooled in the tap arch area, inside the typical line of fracture for the tapslag cakes. These figures suggest that the slag produced in a smelt may have been in the order of 15kg to 22kg, with about 65% being fully tapped.

Two of the tapslag cakes (T7 and T9) show evidence for 'birds-foot' slags on their upper surfaces, hinting that some slag may have been derived from a higher level, perhaps during opening of the main furnace arch.

### Details

A representative sample totalling 159kg was set aside for further investigation during the post-excavation phase in January 2025. These have been described and catalogued in two groups:

- (1) a group of 16 pieces that are complete, or largely complete, examples of their class of residue, that can provide information on the overall morphology of the residues and the relationship between residue classes and
- (2) a collection of 36 smaller pieces which might provide an opportunity for sampling or which provide views of the internal structure of the various residue classes that is not visible in the more intact specimens.

These items Table 2, with group (1) listed by item and those in and those in group 2 by the tub in which they are stored.

Piece F3 ((from context 138)) is fragment of a curved sheet of slag rich in fine charcoal moulds. The sheet is approximately 40mm thick and it is interpreted to have formed as a lining to the lower part of the furnace shaft. The curvature suggests that the furnace was approximately 260mm by 320mm (with this piece forming on approximately one quarter of the circumference).

Three pieces (pieces F1 and F2 from context (138), together with the in-situ slag mass <13> from context (125)) show a bowl-like mass of slag at the foot of the shaft. In F1 this is a approximately 180mm in diameter and 70mm deep, F2 is irregular and slightly incomplete, but suggests the bowl may have been 170mm long and 240mm wide and for <13> the bowl appears to have been of similar size, but awaits full micro-excavation.

The outer edge of the tapping hole is seen on Samples <13> and <20>, as well as on tapslag flows T2, T7 and T8. It is shown as a smooth arc of oxidised fired clay connecting the fired clay of either side of the tapslag. Reduced fired clay passing from the side of the slag bowl probably onto the inner face of the tapping hole is visible on sample <13>.

In each case the base shows a less clear division between the tap slag and bowl on the base than on the upper surface.

Sample T8 shows the tapslag arising from a 'U'-shaped channel 50mm deep, now lined by a 30mm thick basal crust of dense slag. Additional samples could be cut to clarify the shape of the tapping hole.

T5 differs from the other tapslag cakes in showing a multi-layer structure, with a large void between two layers, suggesting an interrupted tap not seen in the other examples.

The extraction of the slag using a bar is suggested by a hot tear in the scar of T1 (with the bar inserted on the left side) and a similar hole in a 4046g fragment of slag from the tapping hole area, from context (135).

## Interpretation

The best direct evidence for the nature of the furnaces employed at this site was provided by the two in-situ furnaces:

Furnace [162] showed a cut approximately 1.8m long and perhaps as much as 0.6m wide. It contained a slag block (163) sampled as <20>, with the attached distal fired and indurated clay as <19>.

Furnace [167] was less well-defined, the cut was not identified beyond the end of the slag block and had a length of 0.8m. The slag block (165) overlay a dark deposit of up to 40mm (168) and was overlain in part by a deposit of accreted fired clay (166).

Slag block (165) is the more complete of the two, with block (163) missing the internal slag bowl. Block (165) shows an almost complete furnace bowl, with the slag passing below the remains of tap hole into the tapslag cake with its top at the same level.

The residues, both from the in-situ furnaces and the dumped material, provide considerable detail on the nature of operation of the furnace (evidence for the quantity and nature of the resources employed for the smelting should be forthcoming in other aspects of the post-excavation analysis).

The overall quantity of slag per smelt (15kg to 22kg, see above), compares with 17kg and 18kg assemblages from the cereal packed slagpit furnaces at Churchills Farm, 26.5kg for a wood-packed slagpit furnace at Langford, and 21kg and 23kg for wood-packed slagpit furnaces from Culmstock Road North. Thus, all these technologies produced rather similar total slag volumes.

Tapping of the furnace seems to have been accomplished by the opening of a small hole in the frontal wall (probably actually within the blocking of the furnace arch). The tapping hole was 50-65mm high (pending determination whether the slag rested directly

on the cut of the tapping channel at this point) and between 80mm and 180mm wide. Further clarification of the morphology of this opening can be sought through cutting relevant slag blocks and by examination of the foliation within the placed clay around the channel.

The flow of slag appears to have been generally continuous during the tapping, since most tapslag blocks show no significant internal discontinuities. The size of the tapping hole was designed so that the tapped slag would occlude the hole only at the end of the tap. None of the slags showed any evidence for removal of tapslag cakes from the system – so a single cake appears to have been generated in each smelt.

Fracturing of the tap slag cake away from the slag in the furnace for disposal seems to have been usual, with the fracture just outside the arch. Only two of the large tapslag cakes showed fracture within the arch area. The accumulation of additional slags above the level of the min tapslag flow in two examples, suggests that some minor residual flow may have occurred when the furnace arch was opened – and that in those instances at least, the tapslag cake must have still been in situ at that point.

Extraction of the bloom appears to be accomplished by opening up the upper part of a furnace arch. Ceramic debris from this process was fused to the top of the tapslag in several pieces (most notably the in-situ blocks (163) and (165)). Extraction typically left a torn upper surface to the slag bowl.

Onward processing of the blooms is not well represented in the assemblage. Just a single smithing hearth has been identified (an 800g example from context (138) and the selection of bulk matrix samples processed for the assessment produced no hammerscale.

## Discussion

The residues from this site are of importance for several reasons.

Firstly, they provide evidence for a period within the long history of iron making at Hemyock that has been poorly presented previously. Early slag tapping furnaces of late 9<sup>th</sup> to 10<sup>th</sup> century age were recorded at Churchills Farm (Smart, 2018) and later smelting slags, probably of 11<sup>th</sup>-12<sup>th</sup> century date, were also recovered from the same site but without evidence for the furnaces themselves. This assemblage provides an opportunity to examine the technology, extractive efficiency and ore provenance for a further time period at Hemyock – providing for an extension to the time range over which these factors have been examined in the town.

Secondly, the residues from this site are much more intact than is typical. The rapid burial of this primary slag dump by the red clay has protected it from any reworking. The nature of the technique of the iron smelting has also generated slag blocks that were able to be removed from the furnace to the dump with little breakage. These factors have enabled the preservation of the residues such that they are able to provide much significant detail on the technique employed by the medieval iron smelters.

Thirdly, the generation of plano-convex slag cakes within the bases of the furnaces produced a class of

residue that has not been widely recognised. Although not commonly used in that context, the concept of a 'furnace bottom' as developed in the 1980s was for those slags retained in a furnace after tapping. However, at that point understanding of non-slag tapping furnaces was poor, and as that developed so the term 'furnace bottom' became employed for the slag mass in a non-tapping furnace.

More recently, interest has grown in the process of remelting raw blooms as part of the process of producing finished iron in a process sometimes called hearth refining. The residues from this process can overlap in size and general shape with the larger slag cakes produced during smithing – in particular, during the process of working raw bloom to finished iron by conventional fold-and-weld techniques. The author's unpublished research excavations in 2010 at Rough Lawn, near Tisbury, Wiltshire, produced an in-situ example of a plano-convex slag cake in the base of an 11<sup>th</sup>-13<sup>th</sup> century slag tapping furnace and the question was raised as to whether this might be an example of hearth refining. The slag cake was in contact with the clay furnace shaft around its entire circumference (thus apparently occluding the tap hole) and showed an unusual recurved profile (i.e. one in which the centre, as well as the margins, was slightly raised) to the top of the slag, suggestive of a meniscate boundary with overlying iron. That slag cake proved too fragile to sample and the question went unanswered.

A second site, again of 12<sup>th</sup>-13<sup>th</sup> century age, that at Torr Quarry, Wanstrow, Somerset, produced similar residues in 2013. Here, furnace [131161] produced an in-situ plano-convex basal slag cake weighing 2.5kg. As with the Tisbury example, the slag cake had a smooth, slightly undulating top of 'recurved' profile, with voids below, similar in appearance to a cake produced during hearth refining. Furthermore, the cake rested in a depression on the furnace floor, apparently with a raised lip between it and the exterior tapped slag. Despite these observations, analysis of this cake and its associated residues (Young 2014a) strongly suggested that it was simply the product of primary smelting and not of any secondary process. Unfortunately, the Torr Quarry site remains unpublished because of the insolvency of the archaeological contractor (C & N Hollinrake Ltd) during the post-excavation process.

A third site, at Cutacre, Salford (Young 2015) has also produced substantial (up to 4kg) bowl-shaped slag blocks, in this instance slightly biconvex, but with the upper layer, as at Torr Quarry, overlying some large rounded tabular voids. The analysis of an example of these cakes showed that it was formed of smelting slag, but with a much larger range of olivine composition than in the tapped slag (suggesting development of the slag over a wider temperature range).

The new Hemyock material provides internal furnace slags that are incontrovertibly part of the smelting waste, but with varying degrees of development of a bowl shape. They differ from the above examples in being contiguous with the tapped slag, and in having a rough upper surface (potentially because the upper surface has torn off with the bloom). Detailed analysis of the furnace slag may both help to clarify the nature of the Cutacre, Torr Quarry and Tisbury examples as well as produce further information on the nature of the process employed at Hemyock. The analysis should also help better to discriminate such materials from plano-convex residues from both hearth-refining and bloomsmithing.

## Further work

These materials are capable of providing further information of archaeological significance.

A programme of laboratory analysis is proposed, closely following the provisional proposal – with minor adjustment now that the archive of material has been catalogued.

The recommended analytical campaign would prioritise bulk elemental analysis (by XRF/ICP-MS) of a suite of representative materials, with a lesser focus on the characterisation of the microstructure of the furnace slags (the novel component of the present assemblage) by analytical scanning electron microscopy (aSEM).

It is recommended that three tapslag cakes are investigated through three samples taken from each, and that three furnace slag cakes are similarly investigate through three samples each. Following identification of the most complete slag masses (including both internal furnace slags and the corresponding tapped flows), at least one of these should be at the core of the analytical campaign. The key example for this is <13> from (165), which includes most of both components. This piece could be sampled to provide 3 analyses of tapslag, 3 analyses of slag bowl (also to be examined by SEM) and 2 analyses of furnace ceramic. This piece will need full cleaning (micro-excavation first) so that it is fully documented before sampling.

Slag block F2 (from (138)) could provide a second example of a bowl for sampling. Additional potential bowls for sampling might include the 1192g piece in tub1, the 689g piece from tub1, the 2568g block from tub2. The final sampling selection will be made after these pieces have been sawn, to ensure the investigation of material that is representative of the range of texture revealed.

Selection of samples of tapslag should cover variation in morphology, as well as variation in stratigraphic origin. Since <13> derives from the base of the stratigraphy, then the selection might include another thin tapslag cake and one of the shorter thicker cakes, both from higher in the stratigraphy (perhaps T3 and T4 both from (135).

For the furnace ceramics, three separate analyses are proposed. Two of these could be provided by <13> as mentioned above, the third probably from the assemblage of wall fragments from (135) in tub4.

During the assessment, no hammerscale was recorded from the 'hammerscale' samples that were processed and only a single example of macroscopic smithing slag was noted. It is therefore proposed that the search of the 'hammerscale' samples is refocused onto a search for examples of iron ore. The proposal for two scatter mounts for SEM analysis could be better employed for examination of any ore located in further sample processing, rather than for characterising scale.

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## Figure Captions

Figure 1. Photographic montage of the upper (above) and lower (below) surfaces of the major blocks selected to form the basis of the analytical phase.

The horizontal tie-lines indicate the approximate location of the outer edge of the tapping hole.

Table 1: quantification of slag from selected areas and modelling of overall dump composition. Green tone: the thickness of the context has been adjusted to match that shown on the section rather than that recorded for the sampling. Yellow tone: matrix and stone were not recorded for Sondage 2 – their amounts shown here are a calculation based on the average proportion of these materials in the other sondages. \*: the percentage of the matrix that was fine grained archaeometallurgical has been set at 60% based on a small subset of the ‘hammerscale’ samples – this may be modified as other samples are processed.

| C                | Dimensions              | Volume (m3) | Furnace Slag (kg) | Tap Slag (kg) | Slag with furnace lining attached (kg) | Formed slag (kg) | fuel ash slag (kg) | matrix (kg) | stone (kg) | Total coarse residues weight (kg) | total all coarse materials | total all materials /m3 | % coarse slag | %stone | %matrix | % matrix that is fine residue * | %sample that is fine residue | coarse residue kg/m3   | fine residue kg/m3 | fine matrix kg/m3 | stone kg/m3 | total residue /m3 |     |
|------------------|-------------------------|-------------|-------------------|---------------|--|------------------|--------------------|-------------|------------|-----------------------------------|----------------------------|-------------------------|---------------|--------|---------|---------------------------------|------------------------------|------------------------|--------------------|-------------------|-------------|-------------------|-----|
| <b>Sondage 2</b> |                         |             |                   |               |  |                  |                    |             |            |                                   |                            |                         |               |        |         |                                 |                              |                        |                    |                   |             |                   |     |
| 135              | 8.1m L x 1m W x 0.36m D | 2.916       | 1133              | 504           | 36                                     | 51               |                    | 2353        | 47         | 1724                              | 4124                       | 1414                    | 42%           | 1%     | 57%     | 60                              | 34%                          | 591                    | 484                | 323               | 16          | 1075              |     |
| 138              | 5.76m L x 1m W x 0.3m D | 0.864       | 234               | 152           | 8                                      | 42               |                    | 484         | 48         | 436                               | 969                        | 1121                    | 45%           | 5%     | 50%     | 60                              | 30%                          | 505                    | 336                | 224               | 56          | 841               |     |
| 171              | 6.78m L x 1m W x 0.4m D | 1.356       | 323               | 99            | 8                                      | 21               |                    | 390         | 16         | 451                               | 857                        | 632                     | 53%           | 2%     | 46%     | 60                              | 27%                          | 333                    | 172                | 115               | 12          | 505               |     |
| <b>Sondage 3</b> |                         |             |                   |               |  |                  |                    |             |            |                                   |                            |                         |               |        |         |                                 |                              |                        |                    |                   |             |                   |     |
| 135              | 1m L x 1m W x 0.11m D   | 0.11        | 68                | 2             | 1                                      | 3                | 0                  | 101         | 2          | 74                                | 177                        | 1609                    | 42%           | 1%     | 57%     | 60                              | 34%                          | 673                    | 551                | 367               | 18          | 1224              |     |
| 138              | 1m L x 1m W x 0.26m D   | 0.26        | 168               | 3             | 0                                      | 6                | 0.2                | 203         | 4          | 177                               | 384                        | 1477                    | 46%           | 1%     | 53%     | 60                              | 32%                          | 681                    | 468                | 312               | 15          | 1149              |     |
| <b>Sondage 5</b> |                         |             |                   |               |  |                  |                    |             |            |                                   |                            |                         |               |        |         |                                 |                              |                        |                    |                   |             |                   |     |
| 138              | 1m L x 1m W X0.36m D    | 0.36        | 113               | 24            | 2                                      | 0                |                    | 149         | 28         | 139                               | 316                        | 878                     | 44%           | 9%     | 47%     | 60                              | 28%                          | 386                    | 248                | 166               | 78          | 634               |     |
| 171              | 1m L x 1m W x 0.24m D   | 0.24        | 159               | 19            | 8                                      | 13               |                    | 172         | 7          | 199                               | 378                        | 1575                    | 53%           | 2%     | 46%     | 60                              | 27%                          | 579                    | 430                | 287               | 29          | 1009              |     |
|                  |                         |             |                   |               |  |                  |                    |             |            |                                   |                            |                         |               |        |         |                                 |                              | average=               | 535                | 384               | 256         | 32                | 920 |
|                  |                         |             |                   |               |  |                  |                    |             |            |                                   |                            |                         |               |        |         |                                 |                              | for site volume = 70m3 | 37472              | 26908             | 17938       | 2243              |     |
|                  |                         |             |                   |               |  |                  |                    |             |            |                                   |                            |                         |               |        |         |                                 |                              | total residue (kg)     | 64380              |                   |             |                   |     |

Table 2: catalogue of specimens selected for further investigation. Items Tn are tapslag; Fn are furnace slags; SHCn are smithing hearth cakes; <13> and <20> are the in-situ slags from the early furnaces; Tubn are buckets holding collections of smaller items.

| item | C   | label              | weight | description   |
|------|-----|--------------------|--------|---|
| T1   | 135 | tapped slag        | 5156   | tongue of tapslag 290x210x70mm; tongue torn hot through bar inserted on left side, with some later slag flow; much deflation of last flows; base locally rough but with some well-developed lower flows that appear straight.   |
| T2   | 138 | formed slag        | 10116  | 420x270x70mm, main scar c200mm and oblique, then 100mm oblique in opposite sense; main scar has further piece of tapslag accreted or attached - unclear if this is evidence for hot deformation, but it probably is and this is a displaced block from the top of the main piece; two phase variable preservation, with clean last flows over very rough surface material below, very few small ceramic fragments; base is very rough, no lobing seen, one tiny area of fuel dimpling, a lot of small slag fragments attached and some iron rusting in places; lots of grey ceramic chips near the margins up about 10mm. |
| T3   | 135 | tapped slag        | 7876   | 390x240x65mm, base shows some rough surface near the fracture, but remainder, raised slightly above this level, show non-wetted flow lobes with some dimples, rare grey ceramic to 15mm, one probably inverted flow lobe (90mm); breakage mostly brittle with one small area of possible flow over it; upper surface good dark flow lobes, some ribbed; all margins lost, hint of slightly raised lip near fracture, but lower parts of the cake extend beyond this; largely clear of any accretion.  |
| T4   | 135 | slag with furnace? | 11529  | 340x260x100mm(main flow top)+40mm(raised mass including oxidised clay); shows inward dipping concave surface - possibly part of a larger bowl, which appears to have a fill of very dense slag; raised part probably slag full of tiny charcoal moulds; tapslag dense and deep, has some rough surfaced very bulbous lobes, particularly distally; apart from very top probably not classic tapslag; base very rough with probable tool marks; right side of base much neater than left, shows dimples proximally including below the probable bowl margin.   |
| T5   | 135 | tapped slag        | 9087   | 220x260(w)x110mm; very large fracture surface, with probably 3 or 4 more or less separate flows, with upper (2?) separated from lower 1 or 2 by large rounded void in the fracture; different flows have slightly different dips, but all show rough bases and flowed tops; upper surface not well preserved, but flows have very low convexity leading to flattish top; thickest just slightly distal to fracture.   |
| T6   | 135 | tapped             | 10204  | 355x230x100mm; thickest just 90mm from source; scar 120x70mm, but terminal is irregular and hard to interpret in detail; latest flows extend the whole length of block; base has hints of straight flows in centre, but rough laterally; some debris of fractured slag present across base, some oxidised clay in very small pieces across base also; deep section suggests source to right, but slight raised lip on top is on left.   |
| T7   | 138 | formed slag        | 13917  | 380x280x85mm main bowl of tapslag + 50mm upper birds-foot lying over distal part; suggests upper layer missing from proximal end, this area has mud directly onto tapslag, suggesting any loss is ancient, hidden tapslag surface is maroon, upper birds-foot slag is darker; proximal end is overlain by flow of at least 70mm wide; base is neatly rounded bowl with a rough surface; small area missing; base contains small slag, clay and pebble debris - hint of firing of clay along one upper lateral margin.   |

|      |     |                                       |       |   |
|------|-----|---------------------------------------|-------|---|
| T8   | 171 | formed slag                           | 11535 | 470x230x80mm (tapslag cake) + 35mm flipped-up piece on distal end; proximal end shows arcuate margin of mostly reduced ceramic 70mm from end of block; this end shows 'U'-shaped channel 50mm deep, with slag 30mm thick as curved crust, overlain by reduced ceramic continuous with orange fired clay below lateral margin of tapslag; upper most flows are thin and widespread - must have been a very fluid slag; base is rough centrally, shows sand coated flow sheets laterally, with some grey ceramic fragments and a few slag fragments; no indication that the 'U'-section passes into a bowl.   |
| T9   | 135 | tapped slag                           | 14507 | 330x290x95mm (main tapslag cake) +25mm raised birds-foot on proximal margin of upper face; the right side shows a linear face of oxidised fired clay, running about 60mm in from the right side; the other 180mm of rear face is rough and granular (upper 65mm) but there is a neat fracture of the lower 55mm; the join is just below level of top of tapslag; the upper part of the fracture face looks as if it might be heat affected; the base is evenly profile - the left side is planar the right side is steep and rounded, with possibly slightly undercut sections; the distal end is missing, but probably not by much.  |
| F1   | 138 | formed slag                           | 12148 | block with considerable surface accretion; 360mm long x 200mm wide x 260mm deep. Appears like dense plano-convex mass, 180mm diameter, linked to deeper fractured mass (presumably the root of a tapslag bock); deepens just outside join; on top, join covered by zone of variably oxidised fired clay; the interior of the bowl is covered in fine accretionary debris; external tapslag may bend obliquely?; scar from tapslag 85x170mm then 70mm more at an angle; tap and bowl tops are at more or less the same level, but with overlying ceramic between; the bowl is 70mm deep; the bowl has reduced fired clay adjacent to its sides and there is a hint that the passage to the tap arch may be just 90mm wide; the tapslag immediately outside bowl is 110mm; shows an arcuate margin 210mm from rear of bowl; the deep slag extends 90mm further obliquely below bowl; the bowl shows a partially non-wetted base; morphology hints at blowing on the left. |
| F2   | 138 | formed slag                           | 7618  | 295x280x110mm; rather irregularly shaped furnace bottom slag; one side necked at 180mm wide, widening to 225mm; extends 170mm rearwards from constrictions; slag inside is very rusty with some rust spalling away; the scar may have been 220x75mm originally, but parts missing; the top of the tapslag is level with top of the slag bowl; slag bowl typically around 65mm thick, right side shows zone with adhering reduced fired clay.  |
| F3   | 138 | formed slag (same bag as 7618g piece) | 951   | curved slag sheet, 130x160mm half axes (externally); approximately 40mm thick fine; charcoal debris-rich slag, with rusted iron inclusions,   |
| SHC1 | 138 | formed slag (same bag as 7618g piece) | 800   | 105x130x50mm; asymmetrically concavo-convex, top dished, smooth with slightly raised lobes; 1 side is slightly planar showing two layers: lower layer shows very slightly prilly/dimpled surface; the base shallows away from the planar layered side to around 20mm.   |
| <13> | 165 | block lifted                          |       | block 500x290mm overall; ceramic margin 325mm from tip of flows on left and 200mm on the right; width of tapslag flow 280mm, arch width 140mm; slag extends backwards 240mm from front of arch; slag interior to furnace rough topped and appears possibly torn; below cake, dark soft material 45mm at 170mm from tip, shallows through arch, so gravel immediately below rear of internal slag bowl.  |
| <20> | 163 | block lifted                          |       | block 450x260mm overall; ceramic has sigmoidal front from rear right corner to 160mm up left hand side; sweep of reduced fired material well seen; preserved ceramic about 35mm above top of internal cake, 25mm or so above external tap.  |

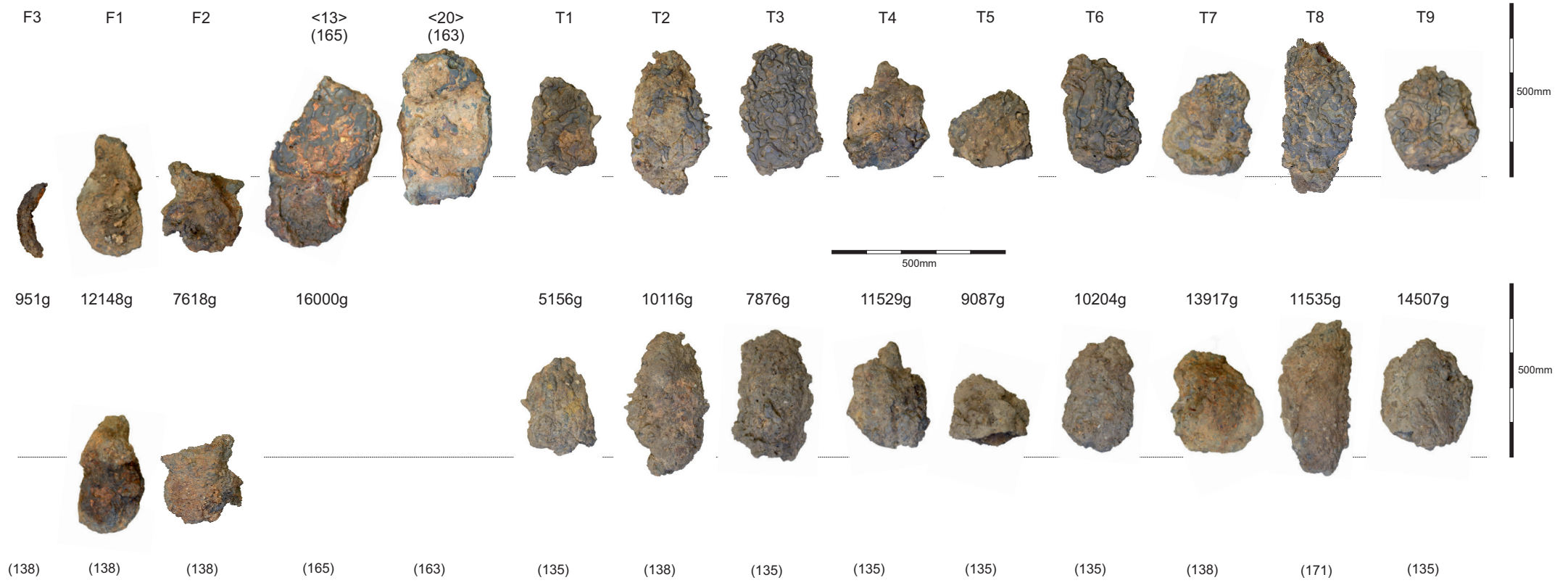
|       |         |             |   |  |
|-------|---------|-------------|---|--|
| Tub 1 | 171     | 1192        | probable internal slag cake fragment; plano-convex crudely; upper layer granular slag to 25mm, with fine charcoal; lower layer dense slag puddle to 45mm, shows healed fracture of part; probably originally c165mm across maximum width and 90mm long.   |  |
|       |         | 689         | fragment from concavo-convex dense puddle of slag, bowl to 30mm thick, probably bladed olivine; top smooth, maybe slightly reddened, base rough; 120x95mm fragment.   |  |
|       |         | 1231        | fragment from distal part of a tap slag cake; flows appear narrow; base rough, but shows constituent lobes  |  |
| Tub 2 | 138/135 | formed slag | 3730  | slab of tap slag; steep contact with reduced fired clay in one area; very irregular base in crude large lobes. |
|       |         | 1474        | concavo-convex slag, vesicular, shows lobes on base, upper surface rough, granular. Base lobate, dimpled, adhering reduced fired ceramic on one side Could be an internal slag, but not certainly so (need to check other examples for lobed bases). 180mm w, 100mm long, 75mm overall depth, crust 45mm,   |  |
|       |         | 2568        | bowl of slag, 200mm across, 130mm length, 65mm deep; base smooth, locally dimpled even microprilly; top crudely lobed, large voids below lobed top; rough adhesion, margins suggest a slightly platy internal structure.  |  |
| Tub 3 | 128/125 | 2517        | fragment of tapslag cake, thin layer of well-formed shiny lobes over more massive browner tapslag; base shows flow lobes with dimpled surfaces  |  |
|       |         | 933         | tapslag cake fragment, shows strongly wrinkled flow lobes in upper layer over more massive interior; base rough with fine slag debris and fired clay fragments  |  |
|       |         | 1082        | complex dense block with some reduced fired clay locally wrapped around almost 3 sides; probable basal dense puddle on clay, then more irregular, locally granular, locally slightly lobed material, with some dimpled surfaces at odd inclinations; presumably a fragment from with the tap arch   |  |
|       |         | 1443        | complex block probably from tap arch; shows fracture through massive slag on one side 90mm deep, away from this fracture appears more layered - possibly with sheets of slag intruded horizontally into reduced fired clay; probably another disturbed block from the tap arch area   |  |
|       |         | 1004        | distal part of a tap slag flow, lower part of break looks as if fluid flow occurred over surface - so flow broke before upper flow emplaced   |  |
|       |         | 1413        | very dense block of slag, curved margin shows contact with reduced fired clay; surface at an oblique angle and 40 degrees difference in inclination; shows lower surface of lobed flow with dimples; remainder of block massive, with one possible heat altered vertical margin? Very difficult to orientate - suggests perhaps over hanging/steep clay margin, with steeply inclined ash surface dipping towards it? |  |
|       |         | 956         | part of internal slag bowl, base rough granular, then steeper sides show indurated reduced ceramic contact, top planar, rough granular, but raised up to 40mm on main; dense bowl 50mm thick, two layers? Lower with tubular vesicles? Upper massive puddle   |  |
|       |         | 1782        | rather worn fragment of plano-convex mass; part shows flow lobes on top, partly rough granular on top; base bulbous with 30mm extremely dense crust overlain by material with more large vesicles; probably another tap arch area piece; bowl form 180mm wide and 80mm deep; precise orientation uncertain, but must be from tap arch area  |  |
|       |         | 577         | base of a small birds-foot, descends and expands in all directions, basal lobes trap small crumbs of reduced fired ceramic  |  |
|       |         | 165         | block of lining - passes from grey to orange; low degree of alteration  |  |

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|       |     |                            |      |  |
|-------|-----|----------------------------|------|--|
|       |     |                            | 639  | birds-foot; much flow was oblique down face of reduced fired ceramic   |
|       |     |                            | 638  | tap slag in very large coarse lobe   |
|       |     |                            | 667  | margin of tap slag cake; very dense; some large cavities below upper flow lobes but otherwise very little porosity   |
|       |     |                            | 132  | small fragment of tapslag or birds-foot; lobes entrap fine reduced ceramic fragments   |
| Tub 4 | 135 | slag with furnace material | 168  | section of vitrified wall  |
|       |     |                            | 186  | section of vitrified wall  |
|       |     |                            | 306  | section of vitrified wall  |
|       |     |                            | 88   | section of vitrified wall  |
|       |     |                            | 271  | section of vitrified wall  |
|       |     |                            | 185  | section of vitrified wall with rounded join in clay  |
|       |     |                            | 385  | section of vitrified wall  |
|       |     |                            | 157  | section of vitrified wall with attached dense slag   |
|       |     |                            | 1873 | tap slag fragment possibly from tapping arch; tap slag shows two flows, each of up to 45mm with massive slag between (although may be other cryptic surfaces - certainly one near base) the flow lobed surfaces; base flat, lobate, rough, passing laterally into oblique angled rough surface and then into vertical contact with reduced fired clay. that clay passes up, via a facet into clay attached to the upper flow surface. Appears to give profile of one side of the tap arch. |
|       |     |                            | 4090 | complicated large block - has very dense basal layer with lobed and dimpled basal surface; top shows an arcuate area of attached oxidised fired clay - but material between is a chaotic, presumably another tap arch lump, but details are difficult to understand.   |
| Tub 5 | 135 | formed slag                | 1000 | basal crust c30mm thick, rough and slightly porous on top, becomes more porous towards margin; on base there is a transverse band of dense slag with only a hint of lobing, but the more porous parts have small lobes and dimpled blebs; part of the dense band shows rusting so may possibly have contained metallic iron.   |
|       |     |                            | 928  | dense slag, partly with flow-lobed surface; base shows dimpled flow lobed contact; inner face of curved slag shows reduced fired clay; this can be interpreted as the slag flow through and out of a rounded tap arch margin; suggests base must rise rapidly through tap arch into the furnace.   |
|       |     |                            | 434  | fragment from arcuate margin of tap slag cake  |
|       |     |                            | 2253 | curved slab of basal crust, granular interior, basal surface is sandy, but on the rising(?) side the surface is more lobate; one margin shows a contact with a grey ceramic, equivalent to 80mm external diameter, pale grey clay on surface – it is possible that the moulded area could be contact with a ceramic tuyère.  |
|       |     |                            | 1628 | accumulation of tapslag-like material in contact with reduced fired ceramic in tight curve around one end - possibly from the proximal lateral corner of the tapping pit - so this is the undercut outer edge of the tapping arch.   |
|       |     |                            | 4046 | deep bowl-shaped fragment with arch of yellow ceramic; outside the arch, the slag has a tapslag surface and a very large internal void, internal side is a granular slag, that is cut by a possible bar hole, below which is a vertical blown surface with a maroon surface.   |

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Figure 1



# GeoArch



*geoarchaeological, archaeometallurgical & geophysical investigations*

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

*Office:* 029 20881431  
*Mobile:* 07802 413704

*E-Mail:* [Tim.Young@GeoArch.co.uk](mailto:Tim.Young@GeoArch.co.uk)  
*Web:* [www.GeoArch.co.uk](http://www.GeoArch.co.uk)