

## Is the Irish iron-smelting bowl furnace a myth? A discussion of new evidence for Irish bloomery iron making

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### Abstract

*Evidence from four sites recently excavated by Valerie J Keeley Ltd. in Carrickmines (South Co. Dublin), Celbridge (Co. Kildare) and Tullyallen (Co. Louth) provides new evidence for the nature of the Irish bloomery furnace. Early Irish iron-making has largely been attributed to the use of "bowl-furnace" and the present sites appear to lie within the morphologies generally attributed to that type of furnace. The furnaces, however, display a morphology (a pit 0.25 – 0.40m diameter with steep to overhanging sides) and a slag type (tabular slag cakes filling most of area of furnace, showing flowage down the blowing wall) consistent with their redesignation as slag-pit furnaces. The physical evidence for the furnaces bears close comparison with Iron Age examples from North Wales interpreted as low shaft furnaces on the basis of both excavation and experiment. The only significant difference in physical remains is the presence of an arch in the base of the wall of the Welsh examples to permit clearance of slag from the base of the furnace, rather than clearance from the top of the furnace in the Irish examples.*

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### Background

In a recent review of bloomery iron technology in Europe, Pleiner (2000) restated the view that all the evidence from Ireland indicates that bowl-furnaces were the sole furnace technology for iron smelting in Ireland before the industrial era. This synthesis leans heavily on an earlier review by Scott (1990), who indicated that the Irish Iron Age was characterized by the use of bowl furnaces "with or without superstructure". Scott relied on evidence both from a relatively small number of excavated furnaces, and from the morphology of the associated slags; of which the plano-convex cake was regularly reported. He reconstructed the furnaces as having an inverted-conical or hemispherical pit form, with forced draught applied at ground level, and possibly with a covering superstructure.

There are several problems with the recognition and interpretation of bowl furnaces. The clay superstructures of shaft furnaces are largely unfired, and so disintegrate on exposure to rain, leaving little archaeological trace. Truncated stratigraphies often preserve only the base of features such as furnaces, with the level of truncation often below original ground surface. Since the hot zone of a furnace or hearth will largely lie above the level of air input, the structure at lower levels may show rather little indication of the effects of heat. The differentiation between smelting furnaces and smithing hearths, or indeed hearths for working non-ferrous metals in crucibles, may be very difficult on such truncated remains. In general, hearths are abandoned and then may become filled with refuse from adjacent activities; they will rarely become filled with their own detritus.

In Great Britain the most usual iron smelting technology from the late pre-Roman Iron Age (in most areas certainly by the 1<sup>st</sup> century AD, but in some

areas possibly as early as 3<sup>rd</sup> century BC) involved the use of slag tapping furnaces. In some areas however, non-slag tapping technology was employed, with two recently described examples being in North Wales and in Yorkshire. These two examples provide some indication of the possible variety within non-tapping furnace technology and provide a context within which the Irish evidence might usefully be reconsidered.

## Summary of new Irish evidence

The material recently examined from several sites excavated by Valerie J Keeley Ltd. includes good examples of slag from iron smelting processes. Smelting residues have been recognised from the slag assemblages of four sites:

Tullyallen 6, Co Louth. 00E0944  
 Celbridge, Co. Kildare, 01E0306  
 Carrickmines Great, South Co. Dublin. 02E0272  
 Carrickmines Great, South Co. Dublin. 00E0525

The iron smelting slags show great similarities between the four sites, although some differences do exist. Three of the four sites have yielded evidence for the nature of the smelting furnaces, in one case (Tullyallen 6) with the last slag flow left in-situ. None of the sites currently has a well-constrained date for the iron-making activity.

### Tullyallen 6

The Tullyallen furnace was 0.47m x 0.50m and 0.18m deep. It had vertical, to very slightly undercut sides. It contained an ashy upper fill, which contained 1.7kg of mixed fragmented slag pieces (10% of the slag assemblage from the furnace), and below which lay an apparently in-situ tabular slag cake up to 0.08m thick. The cake weighs approximately 11.2kg (64% of the slag recovered from the furnace). One edge of the cake shows a greater degree of slag flowage than the remainder, and also a greater degree of slag interaction with the wall (although a large burr is not present). The opposite side of the furnace shows a decrease in intensity, and possibly absence of the subsoil reddening. The main slag cake extends approximately 60% of the width of the furnace towards this side. This side would therefore have been opposite the side of the furnace with the blowhole(s). The slag cake contains evidence for quite large pieces of charcoal (or just possibly wood). Below the main slag cake an ashy deposit contained a slag assemblage of slag prills indicating vertical slag descent through large charcoal/wood pieces and in some cases limited along-floor flowage. The prills total some 4.4kg, equivalent to 26% of the overall slag assemblage.

### Celbridge 5

Celbridge site 5 yielded evidence for three furnaces; Furnace 1 0.37m in diameter at base, 0.25m deep, and with a 0.29m diameter 0.15m above base, Furnace 2 0.29m in diameter and 0.16m deep and Furnace 3 0.29m in diameter and up to 0.26m deep. The furnaces all showed a wide (0.07-0.10m) reduced halo adjacent to the furnace wall, with an outer oxidised zone (0.06m) beyond. This alteration of the natural may have led to the interpretation of slightly larger furnace dimensions by the excavators. The stratigraphy within the three furnaces showed some similarities; they all had a basal charcoal-rich deposit, overlain by material richer in slag. Unlike Tullyallen, these slag deposits do not appear to be in-situ slag deposits, but jumbled debris. The slag material

includes prilly material embedded in ash, blocky-fractured slag bearing large charcoal clasts and vertically-descending dense flow lobes, often with a wall contact, and sometimes with evidence for an overhanging wall-floor angle.

### Carrickmines 02E0272

This site was dominantly of earlier prehistoric age, but included a "bowl-furnace" and adjacent linear pit which yielded iron-smelting slags. The furnace was heavily plough-truncated, but was 0.37m in diameter and 0.09m deep. Some slag on the base was interpreted as primary, but the main fill appears to have been charcoal- and slag-rich debris. The purpose of an adjacent large pit (2.30 x 0.59 x 0.30m deep) is unknown, but its fill also contained iron smelting slag debris. The slag assemblage is fairly small, but includes material broadly comparable to that from Celbridge.

### Carrickmines 00E0525

Unlike the other sites described above, this site produced extensive evidence for iron-working. Only one context, however, gave evidence for smelting; the fill of a ditch (F518). The material included a collection of macroscopic slags (dominated by smelting slags broadly similar to those from Celbridge, but also including a smithing-hearth cake), as well as a bulk soil sample which contained similar slags as well as plenty of lining fragments and lots of iron-rich magnetic debris.

## Discussion

Although each of the four sites mentioned above has an important slag assemblage in its own right, the group of sites taken together provides powerful new evidence for the nature of early iron making in Ireland.

Firstly, despite the use of the term by the excavators (in the lack of a real alternative) none of the furnaces from these sites actually meets the description of a bowl furnace. These structures are steep-sided pits with vertical, or undercut sides and a more-or-less flat base. Internal furnace diameters range from 0.29 – 0.47m, with some suggestion that the narrower examples may have been deeper. The evidence from the slags, and in particular from the *in-situ* slag mass at Tullyallen, is that these were furnaces blown from one side (above the level of preservation unfortunately). The fluid slags flowed down the furnace wall on the blowing side, and in some cases then flowed along the base of the furnace. The main slag mass may have been at lower temperature, but was certainly less fluid. There are minor prills across the width of the mass, and some assemblages show drops of slag as small slag spheres in the ashy deposits below the mass. The presence of the slag debris assemblages show that the furnaces were cleaned and slag removed after smelting.

The assemblages include some pieces of fired furnace lining, indicating that some superstructure must have been employed. Indeed, it is very hard to see any other way these furnaces could have been used, since the bloom must have been above the slag mass (i.e. above the present level of preservation at Tullyallen), the blowhole must have been above that, and the hotzone of the furnace would have extended upwards. Even if the furnaces were used in the "bowl" manner that, for instance, Scott (1990) interpreted, then it is hard to see how the top of the charge could be lower than about 0.4m above the preserved surface, and

given the angle of the preserved furnace sides, then this would be effectively a shaft furnace.

The interpretation of the Irish furnaces as bowls was based largely on the lack of evidence for superstructure. It is illuminating to compare this with the studies of Iron Age iron smelting in Gwynedd, North Wales, undertaken by Crew. Crew (1991) describes furnaces from sites at Crawcwellt and Bryn y Castell as surviving as "20cm deep clay lined bowls dug into the subsoil, with internal diameters of 25 to 30 cm and a surviving wall thickness of about 15cm. In two examples a blowing hole survived at ground level as a 2.5cm diameter aperture through the clay wall of the furnace. At 90° to the blowing hole there was a gap in the clay lining which was undoubtedly the remains of an arch in the superstructure. From the arch the ground level sloped down into the interior, making it clear that the slags could not have been tapped from the furnace." From this evidence Crew reconstructed these furnaces as low shaft furnaces, and in a long series of experimental smelts has very successfully smelted in the reconstruction furnaces, reproducing both good quality iron blooms and slag of identical morphology and composition to the archaeological examples. The differences between the evidence for Crew's furnaces and those of the present sites are (1) Crew has evidence for arches in the sides of the furnaces, (2) Crew's examples were clay-lined whereas the present examples are dug into a naturally clayey subsoil, (3) Crew's slag assemblages are largely broken – suggesting removal by raking of hot slag through the arch, and by fragmentation of the remainder of the slag mass when cold. There is little in the physical evidence in the two sets, Irish and Welsh, of archaeological evidence. Crew started his experiments by assuming that the evidence pointed to a bowl furnace (Crew 1991, p. 23), but found that this did not work, and that a shaft, as in the earlier experiments by Tylecote *et al.* (1971), was necessary. Crew found that increasing the bed depth (the height of the furnace above the blowhole) to 35cm allowed a reasonable bloom to form, and that the slags generated matched the archaeological finds. In later experiments Crew has increased the bed depth still more, to 50cm or greater, to allow greater control of the settling of the charge. There seems little in the field evidence to demand a bowl morphology, any more than there was in North Wales, and given Crew's experimental results it seems reasonable to reconsider the possibility of superstructure in the Irish examples.

Comparison of the present material with other sites in Ireland is not particularly easy. The literature does not contain good description of either the slag or the furnaces in older excavations. The best synthesis of the data is by Scott (1990) and his descriptions allow some comparisons to be made. There appears, however, to be continued confusion in the literature between sites involving smelting and those involving smithing (and possibly some confusion with non-ferrous metalworking hearths too). The Tullyallen slag cake compares closely in size with those from the ringfort at Lisleagh (Co. Cork), where a major iron-producing site was indicated by the 800kg of residues recovered from the ditch. The slag cakes are described by Scott as being "what by Irish standards, are exceptionally large plano-convex slag blocks (up to 35cm in diameter and 10cm in depth)". Inside the ringfort was a probable smelting furnace represented by a pit 50cm in diameter and 20cm deep. Scott (1990, p. 161) commented that this was "not of a size to have produced the mass of debris in the ditch". This comment must now be challenged in view of the recognition of the similar size of the Tullyallen slag

cake in a slightly smaller furnace. The Lisleagh site yielded uncalibrated C14 dates for this activity of AD 665 – 840. Another site quoted by Scott is the monastic settlement at Reask, Co. Kerry, where a "bowl-furnace" 45cm in diameter was associated with slag cakes up to 25cm diameter and 10cm in depth.

Scott's (1990) description of the bowl furnace is "a roughly hemispherical depression in the ground, often (but not always) clay lined, and with no provision for the removal, or *tapping*, of slag during the smelting process". This description, together with his hypothetical reconstruction (Scott, 1990, Fig 6.5.1) does not tally with the best field example he was able to illustrate, that at Rathgall, Co. Wicklow, with a C14 calibrated age of AD 180 – 540. The illustrated furnace survived as a pit 40 x 50 cm, by 25cm deep (see his text and plan, Fig. 6.5.2, not the section which erroneously shows the diameter as about 90cm). The section clearly shows the feature has steep sides and an irregular, but roughly planar base, with a strong basal angle to the walls. Although they are not so well-known, perhaps it is possible that the smithing hearths had a less planar base, and it is misidentification of these that has influenced the "bowl" interpretation.

I would suggest that it is logical to drop the term "bowl furnaces" for these structures altogether and to consider them within the broader context of shaft furnaces. There are three broad styles of non-slag-tapping furnaces: shaft furnaces in which the slag flows down past the bloom, to accumulate beneath it in a pit, shaft furnaces in which the slag descends past the bloom and can be removed through an arch (similar to a tapping arch) in the wall of the furnace and usually domed furnaces in which the slag flows internally away from the bloom towards the middle of a large furnace (this is seen in large domed furnaces with multiple blowholes, and presumably multiple blooms) and is typically removed through an arch. Of these three, the pit-like morphology of the present examples clearly excludes the possibility of removing slag through a furnace arch and they fit the concept of a slag-pit furnace, despite their small size. Slag-pit furnaces are a prominent feature of the iron age in eastern Europe. In this area they are best known as having tall narrow superstructures, over deep pits, which were probably normally used until the slag pit was full and then abandoned, and in which the slag blocks may reach 450kg. However, smaller slag pit furnaces are also known, and they, in contrast, could be cleared and used repeatedly. The examples of small slag-pit furnaces provided by Pleiner (2000) are somewhat confusing, but include examples from Nigeria, Italy, France and Austria. A British example would appear to be provided by the Iron Age and Roman smelting activity in Yorkshire (Clogg 1999, Halkon 1997), where slag masses were found on dumps (and therefore indicate a technology in which the pits were cleared) and had weights of 12-60kg. The new examples fit at the smaller end of the spectrum of known slag-pit furnaces, but there is a likelihood that similar furnaces have gone unnoticed in other areas.

In conclusion, the new material from these four sites is capable of shedding considerable new light on the nature of early Irish iron-making, and careful analysis may permit the construction of a new model for the technology involved. It seems likely that there may be much less operational difference between the Irish examples and those of Iron Age Britain, than is suggested by the present literature.

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