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Evaluation of archaeometallurgical residues from the Galway-Mayo pipeline: Killocorraun 1 (06E0057) and Doonbreedia 1 (06E0302)

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Evaluation of metallurgical residues from the Galway-Mayo pipeline: Killocorraun 1 (06E0057) and Doonbreedia 1 (06E0302)

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Abstract

The slag assemblage from Killocorraun 1 comprises 19kg of mainly rather large pieces of slag, which accumulated in a secondary location in the upper fills of probable charcoal production pits. The residues are dominated by material derived from large smithing hearth cakes (SHCs) produced as waste during bloomsmithing; the primary working of raw blooms down to billet or bar. Smaller amounts of slag are attributable to iron smelting, being slag flows from the basal pit of a slagpit iron smelting shaft furnace. The associated sherds of tuyère are from particularly large examples, which may suggest a later medieval to post-medieval age.

At Doonbreedia 1 samples of slag were retrieved from two of three pits which may have functioned as smithing hearths. Soil attached to the slags was rich in microresidues of flake hammerscale. The slags comprised five specimens of smithing hearth cakes (SHCs) of medium size, which are probably more likely to represent iron-working, rather than being residues of bloomsmithing from the iron production process.

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Killocorraun Site 1

Methods

All materials were examined visually, using a low-powered binocular microscope where necessary. All materials were weighed and recorded to a database.

As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Results

Slag was recovered from Killocorraun in two samples: S1 from C004 and S6 from C009. S1 yielded 13.4kg and S5 4.6kg of slag. The assemblage from C004 comprised 98 fragments with an average weight of 137g, and a maximum weight of 2055g. The assemblage from C009 comprised just 6 pieces, with an average weight of 767g and a maximum weight of 1190g. It is unclear whether these are full slag collections from those contexts or merely hand-picked samples.

Most of the slag from the site is not completely diagnostic of process. A single piece (C004: 196g) is of a dense slag with flow lobes penetrating between the moulds of large fragments of charcoal or wood. This piece is reasonably certainly a piece from the basal pit of a slag-pit iron smelting furnace. Six further smaller piece of slag (C004: total weight 708g) show dense flows associated with fuel moulds, and are possibly also smelting slags.

The most abundant (9.0kg) slag morphology in the material from the site is a massive porous slag rich in

included charcoal fragments. These pieces are not assignable to a process with any degree of certainty, but several pieces show characteristics suggestive of their being fragments of smithing hearth cakes (SHCs).

A further 3.8kg of slags bearing abundant charcoal fragments have a texture of agglomerated tiny prills, particularly forming a marked basal surface to the slag block. This "microprilly" texture is common on the very large slag cakes interpreted as SHCs several early medieval sites, particularly Clonfad 3 (Young 2006a). In the present material the microprilly slags are present as large fractured blocks. Even the largest (C004: 2055g) is not a complete SHC, but a fragment of a cake likely have been about 100mm thick and over 250m in diameter. Complete cakes of this size would weigh approximately 6-7kg.

In addition to the charcoal-rich slags there were about 3.5kg of slag fragments of a rather less porous nature and therefore rather denser. Some of these fragments show a smooth surface, and are therefore extremely likely to be fragments of SHCs.

The assemblage also includes two fragments of tuyère (C004, 98g and C009, 754g). Both of these fragments show an external lateral surface suggestive of a very large radius of curvature, probably in excess of 100mm. The sherd from C004 shows a particularly highly grit-tempered fabric.

Interpretation

Features

The archaeometallurgical residues from Killocorraun 1 comprised relatively large blocks of both smelting and smithing slag associated with large stones in the upper fills of two large, shallow pits (C003 and C008) interpreted as charcoal production pits. Sieving of the deposits released through the washing of the slag specimens revealed no associated micro-residues.

Three lines of evidence therefore point to the secondary nature of these deposits (the co-occurrence of large slag pieces and large stones, the absence of micro-residues and the mixed origins of the deposit in iron smelting and smithing). The residue-containing deposits are therefore of material derived from processes being undertaken nearby, but not directly within the features within which they were deposited. Deposition of slags within the later fills of charcoal production pits on iron-working sites can be paralleled on many other sites (e.g. Young 2005b)

Iron Smelting

The assemblage contains only a small proportion of material which can be firmly or tentatively identified as being from iron smelting. All of this material comprises dense slag which has flowed between moderately large pieces of charcoal or wood. Such textures are typical of slags formed within the basal pit of a slagpit furnace. This type of furnace is a shaft furnace, which continues below ground into a basal pit, into which flows most of the slag generated during the smelt, and is the principal variety of iron smelting furnace employed in Ireland from the Iron Age to post-medieval times (for the European distribution of such furnaces see Pleiner 2000). These basal pits often appear to have packed with material distinct from the main fuel of the furnace; in Irish examples the packing appears typically to have been of large pieces of (probably) wood, rather than charcoal, sometimes with a distinct and regular stacking (e.g. Clonmacnoise; Young 2005a). At the current state of understanding of Irish slagpit furnaces it is not possible to assign an age to slag assemblages on their morphology, although it is hoped that subtle temporal variation will be revealed as more examples become well-dated.

Smithing

The smithing slags from Killocorraun are all fragmented, but the dominant material appears to have been derived from very large slag cakes, with a prilly texture to the basal layer. Cakes of this form have been described from several sites (e.g. Clonmacnoise, Young 2005a; Clonfad 6, Young 2006a; Ballykilmore, Young 2006b; Carrigoran, Young 2006c and Woodstown, Young 2006d). In absence of more complete examples it is difficult to be certain the Killocorraun specimens are smithing hearth cakes (SHCs), but the presence of a smooth, minutely prilly, base is typical of large SHCs with this texture elsewhere. In contrast furnace bottoms from slagpit iron smelting typically show a rather poorly-defined base.

The larger specimens suggest an original weight of 6-7kg for at least some of the material. It has been argued (e.g. for the Clonfad assemblage, Young 2006a) that such large cakes are the residues from bloomsmithing (the initial compaction and refining of the raw bloom down to a billet or to bar iron).

Some of the smaller fragments of rather more dense slag are suggestive of derivation from smaller SHCs, which are likely to be from a later stage of the production of iron (perhaps smithing from billet to bar) or from working of the final iron product. Such material is fairly small proportion of the assemblage and the overwhelming impression is that the Killocorraun residues derive from smelting and bloomsmithing, in other words the production of iron from ore, rather than the working of iron artefacts.

Tuyères

Tuyères are a characteristic feature of Irish iron working from the early medieval period onwards. Contrary to some early interpretations (e.g. Scott 1990), the tuyères seem to be associated with a particular style of smithing hearth, and are not associated with iron smelting. The two sherds of tuyère in the assemblage both appear to be from tuyères with a low-degree of external curvature. Although a full appraisal of the variety of tuyère morphology through time has not yet been completed, there are clear variations present. Early medieval tuyères at Clonfad, for instance, had apparent radii of curvature from 55-100mm (Young 2006a) and at Clonmacnoise (Young 2005a) were recorded as being typically 60mm. In contrast, those from Ballykilmore (late medieval to post-medieval; Young 2006b) showed apparent radii of curvature from 100-150mm. The present examples also share with the Ballykilmore material a more-heavily tempered fabric than is typical for the earlier examples.

Conclusions

The Killocorraun residue assemblage appears to be dominantly from bloomsmithing, with a small component of slag from iron smelting in a slagpit shaft furnace. The assemblage comprises mainly large blocks of slag either dumped or reworked into the

upper fills of charcoal pits. The slag indicates iron smelting and primary bloomsmithing was undertaken nearby. The bloomsmithing hearths need not have very been substantial structures, and might even be represented by hearths/charcoal deposits elsewhere on the site.

The archaeometallurgical assemblage is not particularly diagnostic of age (Iron Age to post-medieval), but the apparent large size of the tuyères is likely to indicate a younger medieval to post-medieval age on current understanding.

Evaluation of potential

The further analysis (chemical and textural) of slags from this collection would help to clarify the identification of the slags, but would be unlikely significantly to alter the interpretation offered here. Further analysis of the smelting slag specimens would assist in clarification of the type of ore being smelted, although lack of detailed understanding of the chemical composition of bog iron ores limits the ability to provide provenance information where these ores were employed.

The occurrence of the Killocorraun residues in secondary contexts also limits the significance of the assemblage.

It is therefore recommended that further analysis is probably not justifiable at this stage. Revision of this recommendation once the date of the assemblage is clarified is advised however. Retention of this assemblage is recommended however, since there is currently a lack of understanding of early iron-making in this part of the country, and an analysis of the assemblage might prove useful in the future.

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Doonbreedia Site 1

Methods

All materials were examined visually, using a low-powered binocular microscope where necessary. All materials were weighed and recorded to a database.

As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Results

The slag assemblage from Doonbreedia site 1 comprises three specimens from sample 7, C5 (total 2.9kg) and two pieces from sample 8, C7 (total 2.0kg).

Some uncertainty is attached to the samples. Sample 7, was labelled C5, but also that it was the slag from the whole of the "furnace". The site description mentions slag from the upper fill of pit C003 (C004) but not from the lower charcoal-rich fill (C005). Similarly Sample 8 is labelled as being from C007 (the upper fill of pit C009) and the site description lists slag from this context, but the sample list describes sample 8 as being from C008 (the lower fill of the pit). It seems likely that the slag was derived from the upper fills of the two pits (C004 and C007). The upper fill of Pit C009 (C010) is also listed in the site description as bearing slag, but this does not appear to have been retrieved. The proportion of the slag in the features which was retained in samples 7 and 8 is not known – the site description appears to indicate that slag was a common inclusion in some of the contexts.

The slag assemblage comprises five pieces of slag, each a complete, or mostly complete example of a smithing hearth cake (SHC). The probable original size range of the SHCs represented by these pieces is 700g to at least 1700g. Four of the five examples show deformation (tearing or twisting) during extraction from hearth, showing that they removed hot.

Interpretation

Features

The archaeometallurgical residues from Doonbreedia were present in the fills (C004/5, C007/8 and C010) of three adjacent pits: C003 (1.42x1.42x0.42m), C006 (1.10x0.95x0.63) and C009 (1.12x1.16x0.51m). Only the slags from C004/5 and C007/8 were sampled. In both cases there is some uncertainty over whether slag from both the upper and lower fills was included in the samples.

Both slag samples yielded abundant flake hammerscale in their washings, and both samples are likely to comprise only iron-working slags.

All three pits are recorded as having probably oxidised fired layers on their bases. Such pits are probably iron-working hearths, although the dumping of iron-working waste into features of separate origin is hard to disprove. The use of the term "bowl furnace" for such features is not appropriate. Furnaces are enclosed high temperature structures, typically used for smelting metals from their ores, whereas hearths are open structures. The term "bowl furnace" has been applied to smelting furnaces of greater diameter than height (as opposed to shaft furnaces, where the height is greater than the diameter; Tylecote 1986). In Ireland, the interpretation of early iron-smelting furnaces as having had a "bowl" morphology has persisted, although most instances if such structures are now readily interpretable as the basal sections of poorly preserved shaft furnaces. In the present instance, the structures are neither associated with evidence for iron-smelting, nor of a size likely to have had a superstructure and can be viewed as open hearths. It is recommended that use of the term "bowl furnace" is abandoned.

The question of how such hearths functioned is rather more difficult to determine. The diameter of the possible hearths (1 – 1.4m) is similar to, although slightly larger than, features interpreted as smithing h hearths at Coolamurray Site 7 (Co. Wexford; Young 2006a) and Carrigoran (Co. Clare; Young 2006b), both approximately of 10th century AD age. However, not only are the Doonbreedia examples rather larger, they are also much deeper.

The problem with interpreting relatively deep features as smithing hearths is that the heating of the iron requires a reducing atmosphere. This is achieved by heating the workpiece at a level above the air input, a level by which the combustion of the fuel has effectively removed the oxygen content of the rising air blast. There is therefore only limited benefit in the presence of a slag or ash pit below the level of the air input. Even for the large smithing hearth cakes seen in early medieval Ireland the total depth of such a pit is likely to be less than 200mm. It is conceivable that the air input to a large hearth might have been through an inclined, rather than horizontal tuyère, but there is little evidence for this.

Smithing

The slags from Doonbreedia 1 all appear to be smithing slags. The size range is somewhat difficult to interpret given the uncertainty over the nature of the slag retrieval and retention. SHCs of the 700-1700g range occur on the full range of early iron-working sites in Ireland. If the site is Iron Age, then SHCs of this size might well be indicative of bloomsmithing (the primary working of the raw bloom down to billet or bar iron), but on historic sites SHCs of this size may be included within the residues from blacksmithing (the working of iron artefacts) too. The key differentiation of process would be associated with the relative abundance of SHCs of both smaller and larger size ranges than the material present here.

Conclusion

Although additional sampling of both macro- and micro-residues would have been desirable, the most likely interpretation of the Doonbreedia pits is that they represent three smithing hearths (albeit of unusually deep form). Their fills yielded both macroscopic slags and microscopic hammerscale. The slags derive from SHCs of medium size, which were most likely to have been the product of blacksmithing.

Evaluation of potential

The detailed analysis of a small assemblage of smithing slags of this type would probably not be justifiable. However, it would possibly become justifiable if the assemblage gains additional significance once the age is clarified, should that age indicate an origin within one of the less-well understood periods (e.g. the early Iron Age).

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Sample	Weight (g)	Notes
Sample 1; C004	98	highly vitrified and slagged piece of ceramic. Very coarse, well-gritted fabric. One face is less vitrified and is slightly curved, suggesting this is a fragment from a very large tuyère
(upper fill of pit C003)	2055	block of microprilly and charcoal-rich slag. Base microprilly, curved - suggestive of a thin crust SHC rather than a smelting slag cake. Cake would be >100 thick. Some rusting, >250mm diameter
	1375	block of charcoal-rich slag with slightly flown, locally smooth basal contact. Top rather rusty. Looks like part of a very large thin crust cake
	952	block of charcoal-rich slag with one slightly flown, but very irregular side, partly rusty. Smooth may be top in which case piece is slab 60mm thick. Some of the charcoal is very coarse, and some is quite well preserved
	894	block of charcoal-rich slag with microprilly base and smoothish dimpled/lobate top. Base curved suggesting SHC.
	300	block of charcoal-rich slag with microprilly base
	375	charcoal-rich slag block with some very large charcoal and a somewhat smooth top containing the charcoal
	310	block of charcoal-rich slag with microprilly base
	286	block of charcoal-rich slag with microprilly base
	176	charcoal-rich slag with overgrowth of botryoidal rust
	196	fragment of very dense slag flown between large charcoal moulds. Probably a smelting slag.
	708	6 pieces of slag with dense flows with smooth surfaces and large charcoal moulds - these are less certainly smelting slags
	272	rusty dense vesicular slag in amorphous rounded fragment
	2385	59 pieces of charcoal rich slags without additional features
	448	3 pieces of dense rusty slag with some degree of crust formation - suggestive of an SHC origin
	498	2 pieces of dense rusty slag with crust formation and a smooth blown surface - suggestive of SHC
	1690	11 pieces of slag - mainly dense and not particularly rich in charcoal or vesicles
	30	3 small slag fragments
	238	block of charcoal-rich slag
	122	charcoal-rich slag with smooth raised lobes on top - SHC margin?
Sample 6; C009	1190	charcoal-rich slag with faint crust developed on one side, suggesting this is small part of a thin crust cake. Crust does not extend far down below rim
(upper fill of pit C006)	548	piece of charcoal-rich slag, prilly in lower part, has some platy dense sections near top - again suggests SHC
	466	possibly part or all of a small SHC twisted in extraction. Has poorly developed lower crust and has an overall very irregular shape
	1150	large and probably very deformed slag. Has a smooth lobate surface apparently folded in to centre of cake. All very charcoal-rich
	564	double crust fragment. Upper crust layer has smooth margin suggesting this may have flowed slightly
	656	small piece of a very large diameter tuyère. Curvature of this piece would suggest >200mm diameter

Table 1: Killocorraun 1 – summary slag catalogue

C4/5		
fill of furnace	894	Dense slag piece 120x70x90mm, way up partly guess, but seems to have solid top and folded thin crust micro-dimpled base, top may be a pro-tuyère slab, and piece may be whole SHC, albeit a bit pinched. Top rusty, lobate, slab 15mm thick, then charcoal-rich 20mm then twisted bowl. Overall 110x65x35mm
sample 7	875	Part of a curious hollow biconvex SHC, probably 100% preserved. Bowl crust porous, vesicular, 20mm thick, forming a bowl 125x100x65mm with hollow 40-45mm deep – probably originally a slightly hollow-topped SHC with strong pinching on extraction. Lip extends up into top partly bridging hole. Base micro-dimply, top has botryoidal overgrowth.
	1120	Dense rusty SHC fragment. Base micro-dimply with raised tool cast. Crust down-flexed at one end - might be original shape, but probably extraction damage. Crust vesicular, seen to 20mm, filled with rusty charcoal-rich material, with rusty lobate slab on part of top 120x140x70mm piece, original dimensions unknown - cannot be more than 80% of cake
C7		
Fill of furnace	712	Rather irregular SHC. One end is fairly conventional, but has long thin slag tail - possibly the result of tearing during extraction. Main bowl is 110x90x45mm. Tail extends 50mm from one end with roughly 60% of circular hole 20mm in diameter separating it from main mass on one side. Top blown smooth, base micro-dimply tending to granular.
C6		
sample 8	1280	Central part of dense cake. Base smooth. Crust vesicular to 20mm. Bowl filed with charcoal-bearing material. Top planar with large charcoal inclusions and raised lobes. (100)x145x70mm. Probably 75% remaining but not entirely clear

Table 2: Doonbreedia 1 – summary slag catalogue

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