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Evaluation of archaeometallurgical residues from Dunlo, Ballinasloe, Co. Galway (08E653)

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Abstract

This site has produced an unusual residue assemblage of approximately12.3kg contained within a group of five cut features. The assemblage is unusual for it contains extremely few large pieces of slag, but has abundant fine-scale debris. In particular, context 8, the fill of Feature 4, contained 8.8kg of smithing waste. This material included small slag fragments, hammerscale, slag flats, corroded iron, vitrified small stones and fuel waste, all cemented by secondary iron oxides. Many of the slag fragments appear to be crushed. Such material is commonly found on the floor of a smithy and represents waste dropped during hearth clearance and work at the anvil. Its abundance here may reflect the smithing activity being largely bloomsmithing. The occurrence of large amounts of such material in Feature 4 is probably through redeposition. Context 6, the fill of Feature 2, also contains a hammerscale rich assemblage, similar to but slightly less accreted than that of context 8.

In contrast context 7, the fill of Feature 3, together with contexts 9 and 14, the fills of Feature 5, contain slags that are much less accreted. Context 7 contains the only example of an intact smithing hearth cake (SHC) from the site as well as some small fragments of possible smelting slag. The silty fill does not appear to resemble a primary metallurgical deposit. Context 14 contains a small amount of dense slag, including pieces in thin sheets bearing the impression of large wood pieces. These are likely to be smelting slags. Context 5 from Feature 1 contained a single piece of slag, probably part of an SHC.

Identification of the role of the features is difficult. Feature 5 may well be the basal pit of a slagpit iron smelting furnace and it contains a small amount of smelting residue. The purpose of Feature 3 is uncertain, but it may be a second slagpit furnace pit. Features 2 and 4 contain large amounts of smithing waste, but these are unlikely to be in-situ smithing hearth deposits; although the two features may possibly be smithing hearths, it is likely these fills entered the cuts on their abandonment. An alternative interpretation is that features 2 and 4 represent charcoal-making pits supplying the two smelting furnaces. Feature 1is a large shallow pit, compatible with being a smithing hearth or a charcoal-making pit. The large boulder that impinges on the pit is curious though, for it would not seem the best place to create a charcoal pit. On the other hand if the boulder were employed as an anvil stone, the close relationship with an adjacent smithing hearth might make more sense.

Contents

Methods

All materials were examined visually with a low powered binocular microscope. Larger macroscopic slag pieces were individually weighed, described and recorded to a database, but for this assemblage most of the material was in large bulk samples which prohibited the description of individual fragments within the scope of an assessment. The summary catalogue is given in Table 1. The fine debris from the specimens in the sample bags was checked with a magnet for the presence of hammerscale.

The conclusions reached in this report are therefore limited by the nature of the evaluation inspection. No chemical analysis or high-powered microscope work is attempted during an evaluation.

Results

Description of the residues

Iron smithing

Smithing residues are represented by the large quantity of fine residues in contexts 6 and 8, together with smithing hearth cakes (SHCs) from contexts 5 and 7.

The fines include abundant flake hammerscale (the spalled surface from the workpiece where is had been superficially oxidised during heating) and slag flats (thin slag veneers where slag from hearth has coated the workpiece surface). Spheroidal hammerscale appears rather uncommon, but it is possible that free spheroids were too small for the sampling technique.

Slag particles include rare sub-spheroidal droplets, small lobate slag droplets, minor prills and angular fragments broken from a variety of larger slag masses. Larger slag pieces include dull, slightly lobate slag prills, charcoal-rich agglomerations and slag sheets, some of which probably formed against a hearth floor or margin.

The deposits are also rich in charcoal debris.

The particles described do not occur often as isolated pieces; a very high proportion of the material is agglomerated into larger lumps and aggregates. In some cases this appears to be due to a thin layer of secondary iron oxides (in effect a similar coating to that seen in bog iron ores), but most commonly the aggregates seem to have formed around individual iron particles that have corroded. In many cases these aggregates are developing cracks as the corroding iron has expanded.

The significant amount of material from context 8 seems likely to be due, at least in part, to the high proportion of iron particles in this deposit, the corrosion of which has caused so much accretion of hammerscale and other very fine particles which would otherwise have been lost during sampling.

SHCs are rather poorly represented in the assemblage, with just two significant pieces:

- an apparently complete SHC from context 7 is a rather flat ,tabular cake, with a top deeply impressed with charcoal moulds and slightly dimpled base. It measures 90x80x30mm and weighs 314g.

- part of an SHC weighing 148g was recovered from context 5. It was not possible to determine what proportion of the original SHC was presented by this fragment. The SHC was rather overgrown by ferruginous accretions so surface detail was not seen.

Iron smelting

Iron smelting is represented by 256g (57 pieces) of material from context 14, together with a smaller amount of material from context 9. Some material from context 7 is less certainly associated with smelting.

The iron smelting residues are generally rather small fragments of dark, dense slag, with a very smooth surface (having an almost polished appearance). The fragments include some prills and blebs but are mainly fragments of slag sheets and films. The most diagnostic pieces have flat surfaces with the striated impressions of large pieces of wood (although the fragments are typically too small to show substantial areas of such contacts). Large pieces of wood were generally used for packing the pits of the slagpit furnaces prior to smelting and the contact surfaces of the descending slags with wood are a characteristic feature of slagpit furnace assemblages.

Other material from contexts 7 and 9 is rather more similar to that from the smithing assemblages, and contains sintered or accreted fines. In contrast to the material from contexts 6 and 8 however these accretions do not contain flake hammerscale. There interpretation as smelting residues is however tentative. At other sites sintered fines have been recorded from the base of slagpits (e.g. Cherryville, Co. Kildare, Young 2008a), with the fines being mainly fuel fines and ore dust.

Technical ceramics

The assemblage contains several pieces of vitrified clay, with contexts 7, 9 and 14 each containing two sherds. The material from context 14 is in larger sherds than the remainder of the material and is suggestive of the margin of a ceramic tuyère with a 50mm radius of curvature.

Distribution of the residues

The residues described above occur in five cut features:

Feature 1: This is a large sub-rectangular cut (C16; 1.35 x 0.95 x 0.18m) abutting a large boulder. There were two fills: upper fill C5 and lower fill C17. There was just one piece of slag from C5, an incomplete SHC. It was this context that gave the ^{14}C data of Cal AD 985-1028.

Feature 2: This was an arcuate shallow cut (C2; 1.0 x 0.30 x 0.10m) filled by dark, charcoal enriched deposit C6 with its abundant assemblage of smithing fines.

Feature 3: This was an irregular cut (C15; 0.70 x 0.42 x 0.12m) filled by C7, an orangey brown silty sand with frequent charcoal inclusions and a rather indeterminate residue assemblage including one 314g SHC, some ceramic fragments and a few pieces of dense slag that are possibly smelting debris, together with two sherds of vitrified ceramic, possibly from a tuyère.

Feature 4: This feature was elongately rectangular in shape (Cut C12; 1.25 x 0.65 x 0.15m). Its fill, C8, was a dark, charcoal-rich, deposit with 8.8kg of relatively fine-grained smithing debris.

Feature 5: This was a sub-circular cut (C13; 0.56 x 0.53 x 0.10m). The upper fill (C14) was brownish and some smelting slag together with less identifiable material and two sherds probable from a tuyère. The lower fill (C9) was of loose brown-grey sandy clay with moderate slag inclusions, which included smelting residues, together with two sherds of tuyère.

Interpretation

This assemblage is extremely unusual in being comprised of an extremely large amount of fine-grained material, with a virtual absence of the larger slag pieces that are normally found. The larger slag blocks that would have been created during smelting (together with most of the smelting fines) and the SHCs formed during bloomsmithing must have been deposited either "off-site" or in slag dumps that have since been truncated.

The fine grained nature of the assemblage makes its interpretation rather more difficult and the conclusions more tentative than when dealing with the coarse material.

The occurrence of a small quantity of smelting residues in the sub-circular Feature 5 (contexts C9 and C14) is suggestive of Feature 5 being the remains of a smelting furnace. The high degree of scorching around this pit at a high level is also supportive of this feature having been associated with particularly high temperatures. The similarly-sized Feature 3 also yielded a sparse assemblage including smelting slags.

The very high proportion of flake hammerscale and slag flats means that the assemblages from contexts 6 and 8 (features 2 and 4 respectively) may readily be identifiable as deriving from smithing. The abundant small slag blebs, small slag fragments, fuel, iron and the hammerscale are typical of the make-up of an assemblage from a smithy floor. Similar assemblages have been recovered from within smithing earths (e.g. Coolamurry, Co. Wexford, Young 2008b), but such a "dirty" hearth would not be expected to be permitted during use and the occurrence of so much waste in the hearth may be due to the transfer (deliberate or accidental) of material from smithy floor to floor level hearth on its abandonment, or perhaps a younger working floor simply covered older hearths. At Coolamurry, the fines-rich hearth deposits were associated with substantial dumps of coarser material (including the SHCs) just a short distance from the hearths – but any such deposits which may have existed at Dunlo had long since been truncated.

An alternative interpretation of the elongate features 2 and 4 is that they were charcoal pits. They are rather smaller than charcoal pits elsewhere, but their elongate form is similar to those at various sites (for instance see Carlin *et al.* 2008, illustration 5.8a-d; note the concave nature of the base of these examples, which with further truncation would have made the limits of the cuts much smaller). In this interpretation the smithing debris is purely waste which has accumulated in the abandoned pits. This interpretation has the attraction of having two charcoal pits corresponding to the two smelting furnaces, with perhaps smithing actually taking place to the west and associated with Feature 1. Distinction between the two hypotheses might be made through close examination of the scorching of the subsoil; in charcoal burning pit this will be slight and distributed over the whole pit, in a smithing hearth it may be more intense, particularly in the small area adjacent to the air supply (tuyère) – the distal end of the hearth may have a very low degree of scorching.

Feature 1contained little evidence from residues as to its purpose, with just a single SHC recovered from its fill. The feature is of an appropriate size to have either been a large smithing hearth (for instance it lies within the size range of the 7th-10th century bloomsmithing hearths at Borris; Co. Kilkenny, Young 2009b) or perhaps a small charcoal pit (it is approximately the same size as the smallest charcoal pits at Cappakeel and Ballydavis, Co. Laois; Young 2005). The digging of the feature in a location so that it was intersected by the large boulder is curious and suggests this was undertaken deliberately. One possibility is that the hearth was for smithing and was positioned to employ the boulder as an anvil. As commented above, the detailed distribution of reddening of the subsoil may provide further clues as to the nature of the feature.

A reasonable hypothesis for the interpretation of the features is thus that feature 1 may have been a smithing hearth, features 2 and 4 may have been either smithing hearths or charcoal pits and that features 3 and 5 may have been the basal pits of smelting furnaces. However, all the features are heavily truncated, and there is a lack of definitely in-situ residue, so this interpretation is likely to have to remain tentative. The identification of both smelting and smithing residues makes it extremely likely that bloomsmithing would have been a significant part of the smithing undertaken here. This may be reflected in the abundance of the smithing fines, since bloomsmithing will generate abundant small slaggy residues resulting from the removal of slag from the raw bloom through both mechanical means and liquation. Bloomsmithing would also be compatible with the high level of small metallic iron fragments in these deposits.

One interesting aspect of this assemblage is the distribution of sherds of tuyère. All the recognised possible tuyère sherds were from the fills of features 3 and 5, the possible smelting furnaces. Although the author has previously argued (for instance recently in discussing Milltown/ Ballynamorahan; Young 2009c) that tuyères were employed only in smithing hearths, there is now a growing number of sites that have yielded fragments of tuyères within structures that are believed to have been smelting furnaces. These sites include Carrigoran, Co. Clare (9th–11th century; Young 2006), Ballykilmore, Co. Westmeath (14th–15th century; Young 2009b) and Milltown/Ballynamorahan, Co. Kilkenny (7th–9th century; Young 2009c). In North Wales, Crew (1989, 1998) has demonstrated that the small non-slag-tapping smelting furnaces were sometimes re-used as smithing hearths, so the occurrence of tuyères within smelting furnaces does not prove that the tuyères were used in the smelting process. Another possible interpretation of such occurrences is that the external working pit on some of these furnaces may have also acted as a bloomsmithing hearth. Further work is required to establish the significance of these finds.

The interpretation of the site as whole is that it is most likely to be a small iron production site. The site certainly includes both smelting and smithing, so at least some, if not all, of that smithing is likely to be bloomsmithing. The two SHCs recovered were however quite small (314g for the complete example, with the part SHC probably derived from a smaller example). Such small sizes are usually associated with blacksmithing (Young forthcoming) when they are of early medieval age. Small SHCs might also however be associated with the final stages of working the bloom into usable bar iron, so these examples are not necessarily indicative of blacksmithing, particularly given the evidence that the larger slag pieces did not end up being deposited within the site.

The reason why Dunlo shows such a dominance of fines is uncertain. Presumably a smithy was usually kept clean and the sweepings from the floor tipped

away, perhaps in a nearby ditch or on the slag heap. At Dunlo, the deposits of smithing fines must either represent the places where such sweepings were dumped – or are evidence for a particularly "dirty" smithy.

Evaluation of potential

The chief value in the assemblage from Dunlo lies in the exceptionally abundant smithing fines. Although the origin of such material is understood in a general sense, the relationship between smithing fines and the nature of the smithing being undertaken is not. In the case of Dunlo, the argument that the smithing residues derive from bloomsmithing has been made above. No such assemblage has yet been examined in detail (certainly in Ireland and probably in the wider area of Europe too). The only detailed analysis of smithing fines of this period is the study at Coolamurry (Young 2008b), where the iron working seems to have been dominantly blacksmithing. A comparison of the present material with that from Coolamurry (which was contemporary with Dunlo on the basis of ^{14}C dates) would make a very significant study and may help to clarify whether Dunlo was indeed solely concerned with the process of iron production, or was engaged in more general purpose iron-working.

Such a study should analyses not only the various classes of slag and hammerscale (with bulk chemical analysis where possible, plus detailed electron microscope microanalysis and microstructural studies), but should also examine the small pieces of iron in the assemblage to determine its composition too.

The significance of this material and its research potential means that it should be regarded as having a high priority for retention by the NMI. Since amount of metallic iron in the smithing fines is both considerable and significant, care should be taken in the environmental management of the material to prevent further degradation of the iron (particularly if the recommended analysis is not pursued in the short term).

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feature	sample	context	weight (g)	quantity	notes
1	1	5	148	1	heavily accreted margin of slag cake with charcoal inclusions – almost certainly an SHC margin
2	3	6	2185	1 bag	smithing fines, typically finer-grained than the material from C8 and richer in flake hammerscale, but also has a couple of larger pieces with large charcoal moulds that might possibly be from smelting. Much of the material is bound by secondary iron oxides derived from weathering of small iron pieces.
3	4	7	314	1	90x80x30mm (+10mm concretion on upper surface) rather flat SHC, deeply impressed charcoal on top, base finely dimpled
			412	1 bag	assemblage of rather indeterminate slags. Contains 2 sherds of well vitrified tuyère/furnace lining. The matrix is sandy/ashy, not obviously rich in hammerscale
4	5	8	8775	4 bags	smithing fines with abundant hammerscale, slag flats, blebs, fuel and small amorphous slag fragments, together with large quantities of small angular fragments of broken slag. Much of the material is bound by secondary iron oxides derived from weathering of small iron pieces, which are particularly abundant.
5	6	9	318	1 bag	assemblage includes at least a dozen pieces of dense flow slags, some with hint of large charcoal moulds, some charcoal-rich dimpled blocks, some pieces of possible sinter of 1-2mm rounded particles (though the binding material might be secondary), no hammerscale in fines, also contains two sherds which may be tuyère
5	7	14	256	57	256 g of assemblage is formed of dense, very shiny flows, mainly rather small and often platy - but some show moulds indicating contact with substantial wood
			22	2	sherds of probably tuyère, c.100mm apparent diameter
			132	bulk	tiny slag fragments
			22		dust

Table 1. Summary Catalogue

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