

GeoArch

Report 2008/21

Evaluation of Archaeometallurgical
residues from the M7/M8 Contract 2:
Derrinsallagh 1 (E2177)

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12th December 2008

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Abstract

Derrinsallagh 1 yielded 12.1kg of materials for examination as possible archaeometallurgical residues. The residues are principally materials produced during iron smelting in a non-slag tapping shaft furnace, although there are just a few pieces that might possibly be from smithing. There are no certain smithing residues. Particular interest attaches to this furnace because of its late medieval 14C age.

The residues were contained in three features, pit C003, pit C011 and furnace setting ("hearth") C025. The term "furnace setting" is increasingly used for the sometimes complex sites of bloomery furnaces that may have been partly or wholly reconstructed in approximately the same location over a long period of time; it is probably the most appropriate term for C025. The details of the construction of the furnace are unclear. Below the various deposits, the natural includes two sub-parallel raised ribs of bedrock extending above the subsoil 0.60-0.90m apart and oriented NE-SW. Between the bedrock ribs the surface of the natural is oxidised fired over a distance of 1.15m NE-SW. The SW limit of the firing lies below an accumulation of large stones and the NE limit lies very close to the cut of pit C003. This scorching is interpreted as recording the footprint of the base of the furnace. The superstructure presumably used the bedrock ribs for support, but the tumbled stones now only provide a hint of its form. Detailed re-evaluation of the field records may yield further clues, but at present it would seem a fairly large diameter furnace rested on the natural surface and location of working hollows/pits C003 and C001 to the NE, beyond the gap between the bedrock ribs hints at a furnace arch on this side, so that slag and ash could be raked from the furnace into the working hollows. The slags indicate a non-slag tapping furnace, but the structural evidence suggests that this was not a slagpit furnace as seen in typical Iron Age and early medieval smelting, but that the furnace base was at ground level or only very slightly below.

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Methods

All investigated materials were examined visually, using a low-powered binocular microscope where necessary. All significant materials were summarily described and recorded to a database (Tables 1 and 2). 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

Material

The archaeometallurgical residues from Derrinsallagh 1 probably all represent waste from iron smelting in a non-slag tapping furnace. A small proportion of the material (see below) is not certainly from iron smelting, but there are no pieces which are certainly not from iron smelting.

The proportions of various classes of residue in the three slag-bearing features are indicated in Table 3. These classes are somewhat arbitrary and overlapping, but serve to indicate the general nature of the assemblages:

Floor fines: this class embraces a wide variety of small particles which are interpreted to have accumulated on the floor of a non-slag tapping furnace. The component particles include small prills and sub-spheroidal droplets of up to 10mm (often dimpled from contact with fuel particles and informally termed "coffee-bean spheroids") indicative of slags descending through the fuel bed. Other material is less clearly flowed and includes dull or resinous-appearing slag with poorly developed flow-lobe structures. Accumulations of charcoal and ore dust partly cemented by slag and secondary iron oxides are often present in such material, but did not form a significant component of the material here (rarely present in C013). This class of residue is particularly present in pit C003.

Flow slags: this class includes well-flown slags in prills and accumulations of prills, similar to the small prills which occur within the floor fines. The prills in most cases are descending (on other sites this have been demonstrated to be related to the formation of the "furnace bottom" below the bloom, which is often little more than coalesced prills) and fairly thin (diameter of 5-12mm). Rather stronger flows may occur down the blowing wall and former thicker, more massive, accumulations at the foot of the wall, and also sometimes cross-floor flows (which may mimic tap slag); there is an example of such a flow from C013. Such cross-floor flows may prove to be a feature of medieval furnaces, for material similar to tap slags has been recorded from medieval contexts at Carrickmines (Young 2006b) and Farranastack (Dowd & Fairburn 2005), without certain proof of either site possessing slag-tapping furnaces. One feature of many non-slag tapping furnaces is that the basal pit (or equivalent) may be packed with organic material that is different to the main fuel; in most cases in Ireland this appears to have been quite substantial pieces of what is probably wood rather than charcoal (sizes up to 70x50x200mm have been recorded; Young 2005a, 2005b, 2006a, 2008a). The large down-wall flows often pass around such wood pieces creating moulds (as in several pieces from C008).

crust/burr: these materials are dense slags forming curved sheets. The crusts are typically formed of coarse-grained slag with crystals oriented perpendicular to the crust margin. They may also have tubular vesicles, indicating loss of volatiles from the substrate.

They typically form where molten slag reaches a cool interface, where molten slag fills a hollow in a substrate, or where very hot slag reacts with the wall of a furnace, eating a hole back into the wall. Examples of temperature control would be where slag chills against and above the air blast into a furnace creating a slag hood over the blowhole (material from C013 may be from a hood and compares well with material from furnace C397 from Derrinsallagh 4, Young 2008c), chilling against a physical barrier is commonly seen at the base of smithing hearth cakes, but may be seen in smelting furnaces if sufficient slag flows to the base of the pit, and convex sheets from reaction are typical of the "burr" region, just below the blowhole where ponded hot slags may react with the wall in both smelting furnaces and smithing hearths (pieces of

material from C008, C013 and C020 are probably from burrs).

Distinction of small pieces of these different sorts of crust can be very difficult. None of the crust fragments from Derrinsallagh 1 has characteristics indicative of it being from a smithing hearth cake, but it is not possible to certainly exclude with certainty an origin in fragmented smithing hearth cakes for some of these pieces.

ashy concretions: this class has been used to include a variety of materials which appear (in the absence of detailed analysis) to be concretions formed of fine ashy materials, but often cored with slag particles. These materials typically form small particles (<30mm).

Low-density slags in small pieces: the fine grained slag assemblages from smelting furnaces are often rich in fragmentary material derived from the breakage of slag accumulations related to the dull and resinous-lustred material mentioned previously, as well of slag types rich in charcoal inclusions. This material will thus include both material from the furnace floor and also slags which solidified close to the bloom. The material from the floor is often in the form of rounded blebs (which if found with other classes of floor material would be placed in the floor fines class), but often the overall form of the piece is not clear.

In this assemblage such fragmentary material has been recorded from all the major contexts.

Low-density slag in large blocks: this class has been used for a single piece from C003. The fragment is of low-density charcoal-rich slag, with a top bearing a smoothish, but ropey texture. Such textures have been observed on the upper surface of "furnace bottoms" from Tullyallen (Young 2003) and Adamstown (Young 2006c), so a similar origin is tentatively suggested for this example.

Indeterminate slag: this includes slag not falling into other categories, which in this assemblage includes broken fragments of iron slag with no clear morphological traits allow assignment to a particular class, often too large to be classed as "floor fines", many are charcoal rich textures.

Ceramic: fragments of both oxidised and reduced fired clay occur. These are probably part of the furnace structure, although some firing has taken place on the base of the waste pits. The pieces in this assemblage are all too small to be diagnostic of any particular origin.

Distribution

The residues from the site derive from three areas (Table 3). Firstly, various deposits within the furnace setting (C025), although none appears to be an in-situ deposit, yielded a total of 2.0kg of archaeometallurgical residues.

Secondly pit C003, which had a single fill C008, containing 6.8kg of residues, yielded well over half the material from the site. C003 was a sub-circular pit (1.27m in diameter x .08m deep) lying immediately NE of the scorched area of the furnace setting.

The third area was the later pit (C011), which contained three fills, of which the lower fill yielded 2.9kg of residues. C011 was slightly further from the furnace than C003 (which it cut), but was elongate

(2.15m NE/SW x 1.07m wide x .22m deep) with its axis oriented towards the furnace setting.

There is no significant difference between the residue assemblages recovered from these three areas. These contexts all appear to date from a period within the mid-fourteenth to mid- fifteenth centuries (2 samples, one from C017 a fill of the furnace area and one from fill C008 of pit C003, gave identical 14C dates of Cal AD 1320 to 1340 (Cal BP 630 to 600; 2.3%) and Cal AD 1390 to 1460 (Cal BP 560 to 510; 93.3%).

Interpretation

The furnace setting C025 appear too badly damaged to be easily interpretable, although further investigation of the primary excavation records may reveal additional information.

The constraint of the furnace base within the natural rock outcrops to E and W and by a large volume of loose stone to the SW, but not to the NE, in which direction lie the two successive pits C003 and C011, suggests the likelihood of a furnace with an arch facing NE, for the extraction of the slag at the end of the smelt. The scorching below the base of C025 extends close to the lip of C003, and the site photographs suggest some scorching of the base of C003 (presumably through the raking out of hot materials from the furnace base in this direction.

The rather elaborate furnace setting and the associated waste pits resemble to some degree the medieval slag tapping furnaces in Britain, although for these the tapping channel leading to the arch is usually more pronounced. Earlier furnaces with an arch may be found in Ireland at sites such Derrinsallagh 4 (Iron Age ;Young 2008c), probably Derrinsallagh 3 (Early Medieval; Young 2008b) and rather less certainly at two sites on the M7/N7 east of Portlaoise: Morrett Site D (Iron Age) and Cappakeel West Site F (possibly Iron Age; Young 2005b). An early medieval furnace at Woodstown (Young 2006c) probably had an arch, but this may have been intended to allow slag-tapping.

Evaluation of potential

This site has produced a good suite of archaeometallurgical residues produced during iron smelting. Unfortunately all are in secondary contexts, mainly within two large working hollows into which slag was probably raked during furnace clearance. A second problem with the site is the lack of clear understanding of the nature of the furnace, although some inferences can be made.

The key interest in this site lies in its late date (mid-fourteenth to mid-fifteenth centuries), for which there is rather little evidence for iron smelting technology in Ireland so far.

The slags from the site are therefore worthy of analysis to help to document this current gap in knowledge. The programme of analysis should be accompanied by a re-evaluation of the primary field records for the site to see if any more detail can be teased-out of the record.

It is recommended that the materials from the site be retained for future study.

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Context	Sample	sample wt.	wt.	no.	notes
8	4	532	532		golden brown furnace floor material. Resinous lustre material approx 10% of which is well flowed (coffee bean spheroids and small prills), rest dull fragmentary, Some flows broken and appear glassy
8	5	2679 (3395 unwashed)	562 28 64 2025	6 15 5 c230	dense crust fragments with tubular vesicles, SHC or burr fragments dense flow slags, mainly small prills, but one larger piece with moderately large wood mould ashy, slightly concretionary, slag lumps small slag fragments, mainly dull blebby materials and associated low density slags and prills
8	6	3620 (4330 unwashed)	1396 2 12 150 74 46 1940	78 1 1 1 1 1 c240	good flow slag, quite large prills, 1 piece shows flow around large wood mould bright blue glassy slag fragment reduced fired vitrified lining massive block of low density slag with raised lobes on upper surface - possibly top of a furnace bottom dense crust fragment intimately associated with red oxidised fired lining - it would appear the slag fragment was embedded in the clay curved fragment of very dense slag, part of a crust or burr rather indeterminate slag fragments, some dull and blebby but others more massive
13	11	416 (524 unwashed)	52 1 363	1 1 c140	well-developed cross-floor slag flow reduced fired lining dull blebby slags grading into fine charcoal-rich sinter-like material, all in small slightly rounded fragments
13	16	2818 (3420 unwashed)	292 368 178 356 54 50 1520	 3 1 14 2 c200	sieved washings - includes some slag fragments and spheroids in sandy matrix Strange flowed crust-like material, slag hood? Or attached to wall? dense crust fragment - SHC or burr? charcoal rich and/or vesicular slag fragments sinter stones dull surfaced poor flow slags. No dense prills,
17	13	730 (900 unwashed)	118 24 588	1 2 45	15mm thick crust with tubular vesicles, curved, non-wetted exterior with adhering clay, micro-dimpled in places vitrified lining fragments flow slag, mainly low density tending towards vesicular masses, but a couple of pieces are more dense.
20	17	247 (326 unwashed)	128 110 8 1	10 16 1 1	dull textured, poorly developed flow slag. charcoal-rich slag fragments burnt/fired stone charcoal

Context	Sample	sample wt.	wt.	no.	notes
20	18	892	550	2	large blocks of very dense crust, c30 mm thick. Tops rather clinkery in appearance, tending to massive texture with tiny charcoal debris. Base rough to microprilly, probably from a burr
		(1010 unwashed)	252	24	dull blebby slags, moderately dense, vesicular
			44	4	fired lining
			46	3	dense flow slag
20	20	100	62	1	dense vesicular, slightly microprilly indeterminate slag fragment
		(106 unwashed)	8	4	tiny indeterminate slag fragments
			30	3	dark brown, vesicular, slightly flown slags
24	22	77	61	1	charcoal dimpled slag fragment. Internally vesicular, dense massive, rusty. Indeterminate
		(82 unwashed)	16	3	iron slag fragments

Table 1. Summary catalogue of archaeometallurgical residues by context and sample

Context	sample wt.	wt.	no.	notes
PIT 003				
8	6831	532		golden brown furnace floor material. Resinous lustre material approx 10% of which is well flowed (coffee bean spheroids and small prills), rest dull fragmentary, Some flows broken and appear glassy
		562	6	dense crust fragments with tubular vesicles, SHC or burr fragments
		28	15	dense flow slags, mainly small prills, but one larger piece with moderately large wood mould
		64	5	ashy, slightly concretionary, slag lumps
		2025	c230	small slag fragments, mainly dull blebby materials and associated low density slags and prills
		1396	78	good flow slag, quite large prills, 1 piece shows flow around large wood mould
		2	1	bright blue glassy slag fragment
		12	1	reduced fired vitrified lining
		150	1	massive block of low density slag with raised lobes on upper surface - possibly top of a furnace bottom
		74	1	dense crust fragment intimately associated with red oxidised fired lining - it would appear the slag fragment was embedded in the clay
		46	1	curved fragment of very dense slag, part of a crust or burr
		1940	c240	rather indeterminate slag fragments, some dull and blebby but others more massive
PIT 011				
13	2942	52	1	well-developed cross-floor slag flow
		1520	c200	dull surfaced poor flow slags. No dense prills,
		363	c140	dull blebby slags grading into fine charcoal-rich sinter-like material, all in small slightly rounded fragments
		368	3	Strange flowed crust-like material, slag hood? Or attached to wall?
		178	1	dense crust fragment - SHC or burr?
		356	14	charcoal-rich and/or vesicular slag fragments
		54	2	sinter
		1	1	reduced fired lining
		50		stones
		292		sieved washings - includes some slag fragments and spheroids in sandy matrix

Context	sample wt.	wt.	no.	notes
HEARTH 025				
17	730	118	1	15mm thick crust with tubular vesicles, curved, non-wetted exterior with adhering clay, micro-dimpled in places
		24	2	vitrified lining fragments
		588	45	flow slag, mainly low density tending towards vesicular masses, but a couple of pieces are more dense.
20	1239	128	10	dull textured, poorly developed flow slag.
		110	16	charcoal-rich slag fragments
		8	1	burnt/fired stone
		1	1	charcoal
		550	2	large blocks of very dense crust, c30 mm thick. Tops rather clinkery in appearance, tending to massive texture with tiny charcoal debris. Base rough to microprilly, probably from a burr
		252	24	dull blebby slags, moderately dense, vesicular
		44	4	fired lining
		46	3	dense flow slag
		62	1	dense vesicular, slightly microprilly indeterminate slag fragment
		8	4	tiny indeterminate slag fragments
		30	3	dark brown, vesicular, slightly flown slags
		24	77	61
16	3			iron slag fragments
		12111		total

Table 2. Summary catalogue of archaeometallurgical residues by feature and context

	<i>floor fines</i>	<i>flow slag</i>	<i>crust/burr</i>	<i>ashy concretions</i>	<i>low density (small)</i>	<i>indet. slag</i>	<i>low density blocks</i>	<i>ceramic</i>	<i>total</i>
PIT 003	532 8%	1424 21%	682 10%	64 1%	2025 30%	1942 28%	150 2%	12 0%	6831
PIT 011	0	1626 56%	546 19%	0	363 13%	356 12%	0	1 0%	2892
HEARTH 025	0	762 37%	668 33%	0	252 12%	287 14%	0	68 3%	2037

Table 3: Distribution of residue classes by feature. All weights in gram.

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