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Evaluation of Archaeometallurgical residues from the M7/M8 Contract 2: Derryvorrigan 1 (E2193)

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Abstract

Metalworking activity is recorded from Period 3 at Derryvorrigan, tentatively dated as being somewhere within the period 4th century BC to 1st century AD. Furnace morphology is uncertain, with paired furnaces or furnaces with an arch and external working hollow both being possible reconstructions. Slags are typical of those formed in low shaft slagpit smelting furnaces. Furnace C92 appears to have been left uncleaned after its final smelt and contains a full suite of slag deposits, totalling approximately 21.5kg. This weight of slag compares closely with that of assemblages from other examples of unemptied furnaces of Iron Age date.

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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 (Table 1). 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

Residues

The residues were dominantly, possibly entirely, from iron smelting in a slagpit shaft furnace. These slags include flow slags (slags which have solidified as prills and blebs having dripped down through the fuel bed), amalgamated flow slags forming a “furnace bottom”, flow slags coalescing on the base of the slagpit to enclose large pieces of wood (seen as moulds) which formed the pit-packing, slag fines (tiny prills, blebs and spheroids formed by slags dripping to the base of the pit, together with sinter-like accumulations of ore dust, charcoal and slag) and dense slags forming a burr (a zone of interaction between the slags and the wall just below the blowhole.

Some of the slag pieces are too small, too fragmented or simply non-diagnostic for certain identification.

Only 4 pieces of slag of the identifiable material, all from C200, are possibly from iron working, rather than from smelting. These four pieces are all of a dense crust, bearing tubular vesicles. They are similar to fragments of medium sized smithing hearth cakes. However, it must be remembered that this texture is a product of interaction of a slag puddle with the underlying substrate, and although typical of smithing residues, similar circumstances may occur in a smelting furnace and a definite origin in smithing cannot be attributed to the pieces.

The pieces of fired ceramic within the assemblage were mostly uninformative, but the large piece of vitrified material from C236 shows a vitrified face with an abrupt (convex) change of angle. This might be interpretable as the top of a scooped hollow as often forms through erosion of the furnace wall above the blowhole (Crew 1991), but equally might represent the junction between the overhanging lower part of the furnace walls and a vertical shaft, as tentatively suggested for the shape Derrinsallagh 4 furnace C397 (Young 2008d).

Furnace C92 contained a large quantity of in-situ slag, representing the residues from its last use. The slag had a total weight of approximately 21.5kg, which compares closely with other similar assemblages of Iron Age (or probable Iron Age) date (Derrinsallagh 4 C397 – c21kg, Young 2008d; Tullyallen 6 – 17.5kg, Young 2003; Adamstown 1 - 18.6kg, Young 2006).

Structures

Most of the residues from Derryvorrigan 1 were recovered from a series of features identified in the field as three paired/figure-of -eight "bowl furnaces" (C064/C169, C065/C216, C085) and two individual "bowl furnaces" (C092, C157). However, C157 occurs against the baulk and C092 was associated with shallow pit C091 (and other features including pit C095); both of these might also possibly be more complex structures.

Furnaces of this type may now confidently be interpreted as low shaft slagpit furnaces, rather than bowl furnaces (the conceptual model commonly applied to such features at the time of excavation; Scott 1990). Furthermore, it is recommended that the site records are revisited to assess the possibility that these are not paired furnaces but that they may actually have been low shaft slagpit furnaces with an arch connecting the basal pit to an external working hollow. Such a furnace has recently been demonstrated in a well-preserved example from Derrinsallagh 4 (C397; Young 2008d). The basal slagpit and the working hollow of such a furnace together form a "figure of eight". Paired furnaces are not unknown, but in the plans and descriptions presented here it seems as if the two components of each structure are actually linked, rather than being simply adjacent. Such a linkage certainly suggests the presence of a furnace arch linking a slagpit and working hollow. Unfortunately the available reports and drafted diagrams do not permit a suitable level of interpretation to determine whether this was the case.

In addition the pit complex including C56, C57, C58 and C59 yielded a quantity of flow slags. Given the described figure of eight shape of pit C56, it would be worth re-evaluating the site records to ascertain whether there is any possibility this too might have been a furnace, and indeed whether any of the other pits might have been furnaces since they all have appropriate dimensions.

Detailed discussion of the furnace morphology is not possible in advance of such a re-evaluation. Tentatively, however, it is suggested that C216 may have been the working hollow for C65 (which appears to have been smaller) and C64 the working hollow for C169.

Within all the possible furnaces the recorded dimensions of lower, slag rich fills, are typically approximately 350-400mm diameter. This suggests that this figure represents the working diameter of the furnaces, and again a parallel can be found in the size of the recorded furnace C397 at Derrinsallagh 4.

Furnace C92 retained an extensive set of residues, suggesting abandonment without any clearance of slag after the last smelt. The total residues in the structure weighed 21.5kg (see above). The residues from C92 include much of the slag forming the "furnace bottom", and with appropriate site records it would be possible to reconstruct how this lay in the ground and to determine the blowing direction. Reconstruction of the blowing direction is less certain for the other furnaces but may also be possible, particularly utilising the distribution of oxidised- and reduced – fired clay.

The nature of the fired clay around these pits is also worthy of further investigation, for it remains unclear whether these pits are lined with clay (which has then been fired), or whether the fired material is the natural subsoil. In the latter case, some adjustment of the stated cut dimensions might be required.

The 14C dates for Period 3 at Derryvorrigan include a date on alder/hazel charcoal of 50BC-AD90 and AD100-AD120 for C016 and a date on oak charcoal of 370BC-150BC and 140BC-110BC for C092. Oak charcoal dates from furnaces are notorious for being too old (used charcoal fuel will rarely have preserved sapwood), but the date is very likely to be close to that for the iron smelting at Derrinsallagh 4 (apparently within the period 3rd century BC to 1st century AD).

Interpretation

The furnaces at Derryvorrigan 1 are strongly suggestive of a morphology more complex than that of a simple low shaft slag pit furnace. Either the twin features may represent paired furnaces, or they may represent furnaces with an arch and external working pit. Although the currently available data are ambiguous, arched furnaces seem very likely.

Furnaces with an arch to allow easy access to clean the basal pit of the furnace between smelts are widely known outside Ireland (e.g. Crew 1987, 1989, 1991, 1998; Pleiner 2000). The only unambiguous example from Ireland is C397 from Derrinsallagh 4 (Young 2008d). Other examples where an arch is suspected have been found locally, with possibly examples at Derrinsallagh 3 (Furnace C819 and working hollow C640; Young 2008c) and maybe at other sites on this scheme. Further east of the M7/N7 scheme other examples may occur (Cappakeel West and Morrett; Young 2005).

The furnaces appear to have had slagpits of moderate size (300-400mm diameter). This is in general agreement with developing models for somewhat larger furnaces earlier in the Iron Age(e.g. Cloncollig, Young 2008b; Cherryville, Young 2008a; and possibly also Adamstown 1, Young 2006, and Tullyallen, Young 2003) and possibly smaller ones in the Early Christian period.

Evaluation of potential

The residues from Derryvorrigan 1 have potential for enhancing understanding of Iron Age smelting technology. In particular furnace C92 was left with a full suite of residues which should be capable of shedding light on details of slag chemistry, variability

and mass balance. Detailed analysis of these slags would also be useful in comparison with the unusual slags (perhaps representing a failed smelt) present in C397 at Derrinsallagh 4.

Context C211 yielded a small quantity of bog iron ore particles, which might shed important light on the nature of the resource being exploited. Despite the abundance of smelting sites in the Irish Midlands which utilised the local bog iron ore resources, there are very few occasions on which iron ores have actually been recovered during archaeological excavations.

Detailed analysis of residues should be undertaken in parallel with a reinterpretation of the field records.

In view of the important nature of the evidence from this site, all residues are recommended for retention.

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F	find	sample	context wt	wt	no	notes
15		29	12	12	5	5 flow slag scraps
76			120	112	10	vitrified furnace lining
76			120	8	11	10 fragments of possibly sintery thin sheet, 1 small prill
94		23	54	54	5	scrappy fragments of vesicular slag
121		10	1740	1740	1	massive block of flow slag with large wood moulds
131		7	24	24	2	rusty iron slag fragments
141		30	350	350	15	flow slag
143		13	2510	1030	35	flow slag, grading into massive, slightly granular-appearing slag
143		13	2510	1480	c160	flow slag
150		20	20	28		spheroids and prill fragments in gravelly residue (wt slag only)
154		24	216	216	10	vitrified oxidised fired furnace wall
154		26	150	150	c100	assemblage with coffee bean spheroids and sinter but dominated by small resinous multiple contorted prills
154		28	2465	2465	c100	flow slags, but 75% of this material is "furnace bottom"-related
155		40	384	384	c300	large collection of basal slag fines - coffee bean spheroids, prills, slag fragments, sinter
155		46	2875	1495	106	flow slags amalgamated into "furnace bottom"?
155		46	2875	1380	58	good free flow slags
156		25	2645	2645	c160	flow slags, with associated lining fragments
156		45	90	90	c100	slag fines including coffee bean spheroids, prills, films and a little sinter
169		36	2625	584	21	good flow slag
169		36	2625	2045	85	amalgamated prills and more massive material - presumably from "furnace bottom"
170		37	24	24	c50	slag fines including coffee bean spheroids, prills, films and a little sinter
179		42	1652	422	1	burr with well marked rim of grey wall against fine charcoal rich slag
179		42	1652	1230	1	possibly also a burr- rather messy piece involving dense slag and wall, with a ceramic/slag breccia - could equally well be wall foot?
180		43	2515	2515		oxidised fired clay, not vitrified
181		41	158	158	1	flow slag penetrating pit wall
183		69	272	272	38	rather scrappy assemblage of blebs and flow slags
185		60	758	758	58	ashy and concreted rounded slags - probably all flow slags
185		61	4	4	6	3 fragments of prill/bleb, 3 possible sinter fragments
187		50	11770	3495	1	block of indurated "furnace base" with down-wall slag flows and horizontally-layered charcoal-rich pit infill
187		50	11770	1315	1	charcoal-rich slag with a large mould, includes 120g bits
187		50	11770	4135	1	block of slag and wall with scooped margin suggesting this is blowhole side
187		50	11770	2825	1	large block of "furnace bottom" with only a small wall attachment
190		48	156	156	39	prilly and blebby slags concreted in ash
197		53	3375	3375	c300	flow slags
197		55	66	66		assemblage of slag fines, coffee bean spheroids, sinter and small prills
198	bag1	54	4932	802	26	flow slag
198	bag2	54	4932	1435	1	(now broken but probably 1 originally) wall foot? Accumulation of flow slags with large wood moulds (photo)
198	bag3	54	4932	2695	118	broken up "furnace bottom" and other flow slags

200	52	2421	1225	4	4 blocks with a basal crust with tubular vesicles, all possibly fragments from medium sized SHCs
200	52	2421	476	6	reduced fired furnace lining
200	52	2421	428	1	wall contact of charcoal-rich slag with a large wood mould
200	52	2421	292	2	slightly lobate-structured charcoal-rich blocks
201	63	34	34	39	small assemblage of flow slag fragments plus small amount of possible sinter
203	58	32	32	33	scrappy assemblage of small slag blebs, fragments and films
203	59	264	154	24	scrappy slag pieces, many lining-related, many in rather flat pieces
203	59	264	110	4	rounded concretionary lumps - not clear if slag or iron is inside
210	64	48	48	13	small assemblage of flow slag fragments, blebs and charcoal-rich slag fragments
211	65	154	154	16	small scraps of mainly grey vesicular slag, not diagnostic
211	66	50	26	29	sintery or charcoal rich slags
211	66	50	24	20	bog ore particles - very important for any future analysis
212	73	772	772	50	flow slag in rather stout prills mainly
218	75	4	4	26	mainly sinter fragments, some prill material and one charcoal-rich slag fragment
218	77	1725	420	36	flow slag
218	77	1725	1305	c200	dull slags grading into sinter
236	81	2168	378	30	vitrified lining, largest piece shows change of direction, possibly top of scoop above b/h - but other geometries are possible
236	81	2168	1790		oxidised ceramic - lots as ground powder
237	82	3365	3365	c300	flow slag, mainly in rather thick stubby flows, grading into sintery/blebby floor material

Table 1. Summary catalogue by context and sample

		furnace bottom	*flow slag*	*fines*	*ceramic*	*burr*	*crust (shc?)*	*indet. slag*	*concretion*	*ore*	total
	Furnace C85 ("figure of eight")										
143	Upper fill of furnace	**0**	**2510**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	2510
	Furnace C64 (part of C64/C169 pair)										
154	Upper fill	**2465**	**0**	**150**	**216**	**0**	**0**	**0**	**0**	0	2831
	Furnace C169 (part of C64/C169 pair)										
169	Cut of furnace	*2045*	*584*								
170	Fill of furnace 169			*24*							
		2045	**584**	**24**	**0**	**0**	**0**	**0**	**0**	**0**	2653
	Furnace C65 (part of C65/C/216 pair)										
218	Upper fill	**0**	**420**	**1309**	**0**	**0**	**0**	**0**	**0**	**0**	1729
	Furnace C216 (part of C65/C/216 pair)										
236	Upper fill				*2168*						
237	Lower fill, 0.40m diameter		*3365*								
		0	**3785**	**0**	**2168**	**0**	**0**	**0**	**0**	**0**	5953
	Furnace C92										
156	Upper deposit of furnace,		*2645*	*90*							
187	In-situ slag attached to reduced fired lining	*11770*									
181	Reduced fired clay		*158*								
179	=C180					*1652*					
180	Oxidised-fired clay				*2515*						
155	Lower fill of furnace	*1495*	*1380*	*384*							
200	Fill of C92 (not listed in stratigraphic report text)	*720*			*476*		*1225*				
		13985	**4183**	**474**	**2991**	**1652**	**1225**	**0**	**0**	**0**	24510
	Furnace C157										
197	Upper fill		*3375*	*66*							
198	Middle fill	*2695*	*2237*								
	Pit cluster C56, C57, C58,C59										
201	fill of figure of 8 waste pit c056		*34*								
185	fill of figure of 8 waste pit c056		*758*	*4*							
212	fill of pit 057		*772*								
183	fill of pit 058		*272*								
190	fill of pit 059		*156*								
		0	**1992**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	1996

	Other features										
15	cut of shallow pit , fill is 132		*12*								
76	stake hole filled with 123				*112*						
76	stake hole filled with 123							*8*			
203	fill of pit 091, 0.60x.60x.1			*32*				*154*	*110*		
94	cut of small burnt pit, .17x.06x.05, filled with 153							*54*			
121	fill of pit c016, along with nuts, .88x.4.,14	*1740*									
131	fill of pit c070, .55x.34x.11							*24*			
141	fill of pit 061, ,85x.80x.15		*350*								
150	fill of posthole c009			*28*							
211	deposit in pit 084 - stone dump/sump							*180*		*24*	
210	non archaeological		*48*								
		1740	**410**	**92**	**112**	**0**	**0**	**574**	**220**	**24**	3172
	total	20235	13464	2053	5487	1652	1225	574	220	24	44934

Table 2. Summary of residue types by feature and context.

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