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Report 2010/35

Evaluation of archaeometallurgical
residues from Carrickmines Castle,
Carrickmines Great, Co. Dublin
(02E1532).

Evaluation of metallurgical residues from Carrickmines Castle, Carrickmines Great, Co. Dublin (02E1532).

Dr T.P. Young & T. Kearns

Abstract

The assemblage comprised approximately 16kg of residues. Those residues which were identifiable with confidence were slags, particularly smithing hearth cakes (SHCs), produced during iron-working (blacksmithing). There was evidence in both medieval and post-medieval levels for the use of coal as a fuel in the blacksmithing, sometimes used in addition to, rather than just instead of, charcoal. Unfortunately, the stratigraphic control did not permit more precise dating of the onset of the use of coal at Carrickmines Castle.

The presence of well-formed SHCs and of a few fragments of tuyère, indicated the use of ceramic tuyères for blowing the hearth.

There was a very high proportion (over 70% of the assemblage) of indeterminate slags. Although some of this material will have been fragmented SHCs, the use of coal in a forge increases the proportion of slag that will form outside the SHC and which will form as somewhat amorphous hearth slags.

This assemblage contained none of the possible iron smelting residues recovered from earlier investigations at the same site.

The majority of the residues derive from medieval contexts, and it is uncertain whether the smithing slags from post-medieval contexts indicate a continuation of the activity or residual material.

One post-medieval context (c767) yielded a number of pieces of glassy slag likely to have been produced in blast furnace (iron smelting) or cupola furnace (iron founding) and which would therefore be likely to be of later post-medieval age.

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Methods

All investigated materials were examined visually using a low-powered binocular microscope where necessary. All 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

Description of materials

Smithing Hearth Cakes (SHCs)

Approximately eight either complete or almost complete smithing hearth cakes were identified in the assemblage. They are all fairly small with a mean weight of 362g (range 106g – 655g). Morphologies and textures varied from small dense cakes to less well consolidated cakes. Occasionally tuyère debris was seen on their upper surfaces. Some showed corrosion suggestive of the inclusion of metallic iron particles.

The majority contain frequent coal residues and one example (106g) has fairly large charcoal moulds on its upper surface.

Much of the material is fragmentary and is clearly derived from similar cakes, however these were not large enough for original weights to be estimated.

The basic mode of formation of an SHC is broadly the same across all morphologies – when the work-piece is placed in the hearth it will undergo some superficial oxidation, and occasionally more serious breakage, which results in iron metal and iron oxides being lost to the hearth. Here the iron oxides will be fluxed by molten ceramic material from the hot tip of the tuyère and possibly by deliberate addition of sand flux too, with the resulting iron silicate melt forming the slag. The common origin means that SHCs typically have a bowl like form. They generally form within a small area of contact between the slag bowl and the ceramic tip of the tuyère or the hearth wall. This zone of contact may have enhanced reaction, leading to a particularly dense slag (the burr).

The size and density of the SHC will be controlled by the amount of iron lost, the temperature the hearth is being run at, the rate of loss of the tuyère, the period of working and the way in which the smith manipulates the hearth.

These processes are modified when the fuel employed is coal. Coal contains a higher proportion of inorganic material than charcoal and bulk coal typically contains fragments of shale; both of these materials may form slags (clinkers) which may be dispersed in the hearth and may not become incorporated into a clear SHC.

Indeterminate Slag

This category includes the pieces of slag that were too fragmented to identify as well as pieces that are of non-diagnostic shapes and textures. Much of the indeterminate slag from this site contained frequent coal residues. It is very likely that all the indeterminate slags in the assemblage are smithing slags and may include less diagnostic fragments of SHC and slag which formed within the hearth but outside the main SHC (forming a continuum between smithing slag lumps and clinker). It may potentially include slag from within the fuel bed, slag from around the blowhole and also lining slags generated from melted ceramic.

Fuel Ash Slag (FAS)

Small fragments of fuel ash slag were also identified and again these are very likely to be derived from smithing.

Technical ceramic

One fragment of tuyère (99g) was identified. It was manufactured using a limestone and quartz rich temper. The fragment was too small for its morphology or dimensions to be calculated. Other fragments of ceramic (the material listed as "lining" in Table 2) may also be fragments of tuyère, but are too small for certain identification.

Blast furnace slag

224g of deep olive green, glassy slag with sandstone inclusions was identified as blast furnace slag. Very similar glassy slags may be produced in cupola furnaces in iron foundries. These iron-poor slags, whether from primary smelting in a blast furnace or

remelting in a cupola, would be most typical of 19th century processes, although similar slags were occasionally generated in earlier post-medieval processes.

Coke

The site yielded 3 small fragments of coke, two of which were recovered from the same context as the probable blast furnace slag (C767). Coke may either be produced deliberately as a fuel, or may be found as a waste product from partially-burnt coal. Coke was the dominant fuel in both 19th century blast furnaces and cupola furnaces.

Corroded iron

The assemblage consisted of approximately 100g of small fragments of corroded iron, all of which were too small for further identification.

Clinker

The assemblage contained one small (19g) fragment of clinker (the partially-melted inorganic residue from the burning of coal).

Concretions

There were several concretionary masses formed by the binding of a deposit by the secondary iron minerals formed after the weathering of slag or iron metal.

Interpretation

The archaeometallurgical residues from Carrickmines Great are almost entirely derived from iron working (smithing). The majority of residues contain firm evidence for the use of coal and a small number provide evidence for the use of charcoal as fuel. This use of coal, together with the small size of the SHCs, indicates that the smithing was the end use of iron (blacksmithing), rather than as a part of iron-production.

The assemblage has close comparisons with a slightly smaller assemblage of material from Carrickmines Castle (Young 2006) which consisted of small SHCs (range 45g-695g) with evidence for the use of both coal and charcoal as fuel. This earlier study of material from the same site also produced evidence for some possible bloomery iron smelting slags, but no further material of this type was contained in the present assemblage.

The use of coal in blacksmithing is known in Britain from the Roman period with a resurgence in the Middle Ages. At Carrickmines, the coal would need to be imported either from one of the Irish coalfields (which did not have a wide distribution before the 17th century) or more likely from one of the British coalfields, especially South Wales (although the limited documentary evidence for coal exports to Ireland from South Wales are mainly post-16th century, the trade in pottery from the same Bristol Channel area was well established by the 13th century). The location of Carrickmines places it in a likely situation to be receiving coal imports from a relatively early period.

The small size of the assemblage suggests a relatively low level of blacksmithing which is not indicative of any 'industrial' scale activity.

A single context (C767) yielded residues presumed to be derived from smelting iron in a blast furnace. It is not known if there is a blast furnace in the near vicinity, however these slags almost certainly had an origin outside the excavated area.

Evaluation of potential

The chief interest in this assemblage lies in its evidence for the early use of coal. Further analysis of the present material is unlikely to shed additional light on this. It is recommended however that the dating of coal use at Carrickmines Castle should be reviewed, should any further stratigraphic clarification become available in the future.

References

YOUNG, T.P. 2006. Evaluation of archaeometallurgical residues from Carrickmines Castle. *GeoArch Report 2006/3*. 13pp.

Table 1. Summary catalogue of material

sample	context	plot	feature	wt (g)	quantity	description	% orig.	orig. wt.
3		1	53	233	79	indeterminate slag with few coal residues		
57		1	53	409	1	small dense SHC (103x8935mm)	100	409
32		3	107	51	2	fragments of indeterminate slag, one quite dense		
12		2	108	10	5	indeterminate slag		
36		12	108	16	2	fragments of iron rich indeterminate slag		
52		12	108	40	6	fragments of indeterminate slag		
7		12	108 baulk	12	2	indeterminate slag		
16		12	108 baulk	38	2	fragments of dense iron rich slag		
18		12	108 baulk	106	8	indeterminate slag		
37		12	108 baulk	5	1	iron rich indeterminate slag		
85		12	108 baulk	4	1	tiny fragment of rusty indeterminate slag		
40		4	109	57	4	indeterminate slag, one with coal residue		
46		4	109	1	2	tiny fragments of indeterminate slag		
4		8	128	17	1	small fragment of blebby slag with few coal residues		
5		15	128 baulk	2	1	lining slag		
11		18	128	28	2	small fragments of dense blebby slag		
22		25	128	559	25	fragments of relatively dense indeterminate slag, larger fragments contain frequent coal residues		
35		22	128	48	4	vesicular indeterminate slag		
38		22	128	2	1	tiny fragment of indeterminate slag		
38		22	128	<1	1	coal		
38		22	128	<1	1	fired clay		
42		22	128	9	3	indeterminate slag, one fragment is iron rich		
47		15	128	11	2	indeterminate slag		
50		15	128 baulk	22	1	fragment of slightly curved heavily fired quartz rich clay with glassy external texture (47x34x15mm)		
58		14	128	1842	295	mostly very small fragments of indeterminate slag, largest fragment may be fragment of small SHC (105g)		
59		14	128	298	40	fragment of indeterminate slag		
60		14	128	8	1	lining slag		
60		14	128	177	36	indeterminate slag, several fragments have rusty appearance		
71		16	128	45	2	indeterminate slag		
72		16	128	22	4	corroded iron		

<i>sample</i>	<i>context</i>	<i>plot</i>	<i>feature</i>	<i>wt (g)</i>	<i>quantity</i>	<i>description</i>	<i>% orig.</i>	<i>orig. wt.</i>
72		16	128	23	1	fragment of dense indeterminate slag		
73		16	128	3	1	oxidised fired clay		
73		16	128	98	3	indeterminate slag		
74		16	128	10	1	lining slag		
74		16	128	15	4	small fragments of indeterminate slag		
75		16	128	147	25	small fragments of indeterminate slag		
75		16	128	6	1	fuel ash slag		
75		16	128	19	1	fragment of clinker		
76		16	128	19	1	long, narrow fragment of indeterminate slag with occasional coal residues		
80		16	128	44	30	very small fragments of indeterminate slag		
81		16	128	17	4	corroded iron		
81		16	128	13	1	concretion formed around corroded iron		
81		16	128	29	1	fragment of dense indeterminate slag		
82		14	128	3	1	corroded iron		
82		14	128	29	1	fragment of indeterminate slag		
84		17	128	13	2	indeterminate slag, rusty appearance in places		
89	202		128	99	1	fragment of tuyère, coarsely tempered with limestone and quartz (72x52x24mm)		
90		25	128	43	11	fragments of fired clay, 5 fragments are vitrified on one surface		
93	202		128	65	6	lining slag, largest piece has purple tinge in places		
96	202		128	14	2	fragments of low density slag		
97	203		128	25	1	quartz rich lining, vitrified on one surface		
97	203		128	7	1	indeterminate slag		
102	202		128	23	1	fragment of iron rich, rusty slag with occasional charcoal moulds		
103	202		128	8	1	indeterminate slag		
2		11	129	15	1	fuel ash slag		
2		11	129	71	6	fragments of indeterminate slag, one with few coal residues		
6		10	129	21	4	pebbly concretions		
9		11	129	57	2	fragments of low density, vesicular slag with frequent charcoal moulds		
13		10	129	12	2	clay and pebble concretions		
13		10	129	175	39	small fragments of indeterminate slag, a few fragments contain small coal residues		
14		10	129	247	36	small fragments of indeterminate slag, many with frequent coal residues		
14		10	129	146	1	small SHC with one clay rich area (oxidised) and occasional coal residues on upper surface	100	146
15		11	129	31	9	indeterminate slag		
21		11	129	934	74	fragments of indeterminate slag		
24		11	129	86	4	indeterminate slag, the largest fragment has occasional coal residues		
25		11	129	67	8	fragment of indeterminate slag with occasional maroon tinge		

<i>sample</i>	<i>context</i>	<i>plot</i>	<i>feature</i>	<i>wt (g)</i>	<i>quantity</i>	<i>description</i>	<i>% orig.</i>	<i>orig. wt.</i>
28		10	129	236	31	small fragments of fairly dense slag, occasionally dense		
29		11	129	105	3	indeterminate slag, largest fragment has blebby texture and few coal residues		
29		11	129	8	4	very small fragments of fired clay		
30		24	129	64	3	indeterminate slag, one quite dense with occasional coal residues		
41		4	129	12	1	fragment of blebby indeterminate slag		
55		10	129	855	65	indeterminate slag, mostly very small fragments		
55		10	129	2	1	fragment of shale with small quantity of slag attached		
55		10	129	2	1	coke		
55		10	129	68	2	slag and clay concretions		
55		10	129	17	2	slag and clay concretions		
56		10	129	56	2	lining slag		
56		10	129	126	1	fragment of relatively dense slag, possible fragment of SHC		
56		10	129	366	91	small fragments of indeterminate slag		
61		10	129	15	3	small iron rich concretions		
61		10	129	445	78	small fragments of indeterminate slag		
62		10	129	490	80	indeterminate slag with few coal residues		
62		10	129	17	2	corroded iron		
63		10	129	189	1	small roughly plano convex SHC, quartz rich upper surface	100	189
63		10	129	6	3	corroded iron		
63		10	129	11	1	low density vesicular fuel ash slag		
63		10	129	276	43	small fragments of indeterminate slag with occasional blebby textures		
64		10	129	327	29	small dense fragments of indeterminate slag		
65		10	129	70	25	very small fragments of indeterminate slag		
66		10	129	293	52	fragments of indeterminate slag		
66		10	129	9	1	corroded iron		
66		10	129	29	1	clay and slag with coal residues		
67		10	129	50	1	slag with clay rich concretion		
67		10	129	37	2	indeterminate slag		
67		10	129	28	11	small fragments of fired clay with some slag attached		
86		7	129	2	3	very small fragments of indeterminate slag		
92	206		129	33	1	fragment of blebby slag with occasional coal residues and quartz rich clay		
99	207		129	9	1	lining slag		
99	207		129	56	2	fragments of dense slag, smaller fragment is iron rich		
53		6	161	599	1	dense SHC, blebby base, iron rich concretion on upper surface (104x86x54mm)	100	599
53		6	161	60	10	fragments of indeterminate slag		
53		6	161	9	1	lining slag		

<i>sample</i>	<i>context</i>	<i>plot</i>	<i>feature</i>	<i>wt (g)</i>	<i>quantity</i>	<i>description</i>	<i>% orig.</i>	<i>orig. wt.</i>
17		13	174	107	31	very small fragments of indeterminate slag		
26		13	174	263	40	small fragments of indeterminate slag		
44		13	174	6	4	very small fragments of iron rich concretions		
44		13	174	6	1	low density slag		
45		13	174	83	4	fragments of indeterminate slag, iron rich in areas		
88		13	174	28	5	indeterminate slag		
98	379		174	590	1	SHC with occasional coal residues	90	655
94	299	T11	181	83	1	fragment of slag, possible fragment of small SHC		
11	325	T11	192	56	3	low density indeterminate slag, one is iron rich		
101	325	T11	192	525	1	SHC, with poorly consolidated interior, rusty base (118x153x51mm)	95	552
101	325	T11	192	230	1	small SHC, rusty upper surface with few charcoal moulds	95	242
106	325		192	257	30	fragments of rusty indeterminate slag, several pieces are iron rich with few charcoal residues		
20		5	221	178	30	fragments of indeterminate slag		
20		5	221	6	1	corroded iron		
20		5	221	6	11	very small fragments of indeterminate slag		
20		5	221	6	8	very small fragments of indeterminate slag, occasionally iron rich		
20		5	221	449	156	fragments of indeterminate slag with occasional limestone residues		
20		5	221	10	3	corroded iron		
20		5	221	5	1	fragment of shale		
27		31	221	78	3	fragments of indeterminate slag		
31		33	221	19	1	fragment of blebby, flowed slag		
31		33	221	13	1	fragment of clay rich slag		
39		23	221	7	1	indeterminate slag		
49		23	221	4	1	low density fuel ash slag		
70		23	221	8	1	small nub of indeterminate slag		
83		23	221	4	3	fragments of fired clay, heavily fired on one surface		
83		23	221	6	2	low density indeterminate slag		
87		31	221	15	1	lining slag, glassy on one surface		
87		31	221	1	1	very small fragment of fuel ash slag		
87		31	221	5	2	slaggy concretions		
33		19	257	7	1	small fragment of flowed slag		
69		28	270	<1	1	tiny fragment of indeterminate slag		

<i>sample</i>	<i>context</i>	<i>plot</i>	<i>feature</i>	<i>wt (g)</i>	<i>quantity</i>	<i>description</i>	<i>% orig.</i>	<i>orig. wt.</i>
77		32	309	<1	1	indeterminate slag		
68	692	Jungle	336	82	1	indeterminate slag		
34		30	353	9	2	2 very small fragments of indeterminate slag		
48		30	353	27	2	fragment of indeterminate slag, one with occasional coal residues		
51		30	353	12	2	corroded iron		
51		30	353	83	2	fragments of indeterminate slag, one very dense, the other very vesicular		
8		27/28	370	325	45	small fragments of indeterminate slag, with occasional blebby textures		
8		27/28	370	20	1	low density fuel ash slag		
19	558	tennis court	370	509	46	fragments of indeterminate slag with occasional coal residues		
43			370	38	1	fragment of indeterminate slag with few coal residues		
43			370	106	1	SHC (64x54x26mm), frequent large charcoal moulds	100	106
78		27	370	14	1	fragment of blebby indeterminate slag		
10		20	740	31	1	fragment of iron rich indeterminate slag		
107	770			63	1	possible fragment of SHC, blebby base, rusty upper surface with few coal residues and thin organic moulds		
107	770			34	1	fragment of indeterminate slag with rusty appearance		
1	767			380	16	fragments of indeterminate slag		
1	767			24	2	coke		
79	767	26		6	1	low density vesicular slag		
91	767			224	22	fragments of very glassy slag with sandstone inclusions, deep olive green in colour, one fragment is iron rich		
23		9 baulk		208	1	fragment of thin crust SHC (97x(67)x29mm) (proportion uncertain)		
23		9 baulk		75	18	very small fragments of indeterminate slag		
23		9 baulk		13	1	lining slag		
95	178			49	1	iron rich indeterminate slag		
104	379			4	1	indeterminate vesicular slag		
105	11			31	1	indeterminate slag		
105	11			4	1	oxidised fired clay		

Table 2: Summary of residue classes by context or feature

origin	feature description	date	SHC	indet. slag	lining slag	lining	flowed slag	coal	fuel ash slag	clinker	concretion	blast furnace slag?	iron	evidence for coal?	total
F53	linear ditch	medieval	409	233										y	642
F107	linear ditch			51											51
F108	linear ditch	medieval		287											287
F128	secondary fosse	medieval	105	3278	78	171		1	6	19			35	y	3658
F129	tertiary fosse	medieval	461	4847	65	19		2	26	2	212		17	y	5634
F161	bank		599	60	9										668
F174	mill pond	medieval	590	491							6			y	1087
F181	linear ditch		83												83
F192	large linear ditch	medieval	755	313											1068
F221	primary, revetted fosse	medieval		740	28	4	19		5	5	5		16		806
F257	former test pit 2						1								1
F270	stone rich feature cut into F221			1											1
F309	large linear ditch			1											1
F336, C692	linear ditch	medieval		82											82
F353	large fosse	post-medieval		119									12	y	119
F370	main room of building F368	post-medieval	106	606					20					y	732
C740	rear wall of building F368	post-medieval		31											31
C770	tennis court	?	63	34										y	97
C767	spread of silt	post-medieval		386				24				224		y	634
?	sample 23 from plot 9 baulk		208	75	13										296
C178	soil layer beneath topsoil			49											49
C11	topsoil			31		4									35
totals			3379	11715	193	198	20	27	57	26	223	224	80		16062

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54 Heol y Cadno,
Thornhill,
Cardiff,
CF14 9DY.

Mobile:
Fax:
E-Mail:
Web:

07802 413704
08700 547366
Tim.Young@GeoArch.co.uk
www.GeoArch.co.uk