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Evaluation of archaeometallurgical residues from Ballyellin 1, Co. Wexford (North Service Area Scheme, E4146)

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Abstract

The assemblage from Ballyellin 1, Co. Wexford comprises 41kg of archaeometallurgical residues from ironworking (smithing). These are primarily derived from smithing hearth cakes (SHCs; total 24.8kg) but also include fragments of tuyère (total 1kg) and indeterminate slag fragments (total 10kg). The residues are typical of those from iron-working. Of the SHC material, 34 examples were sufficiently complete to permit measurement or estimation of the original weight of the cake. Approximately 32% of the SHCs weighed less than 500g and 76% weighed less than 1000g, placing them within a relatively tight weight range which may suggest that a particular type of iron working activity was being repeated.

All the material was recovered in a foundation slot trench. There was no evidence for any iron working features, suggesting that the features from which the material is derived lay outside the excavation area or had been truncated. The trench is dated by a single ^{14}C date on alder charcoal to cal. AD 890-920 and 940-1030.

The weight-frequency distribution of the, admittedly small, SHC assemblage differs from that of other Irish sites in lacking examples of large SHCs, (commonly seen in early medieval assemblages) and also in lacking the small SHCs typically seen in medieval and later blacksmithing assemblages. The SHC assemblage with most similar published weight-frequency distribution is that from Burton Dassett, a 14th-15th century village smithy in the English midlands. The significance of that observation is uncertain, but tentatively suggests that work practices at the Ballyellin site were dissimilar to those on other studied Irish early medieval sites. Possible reasons for this are discussed.

Contents

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. It should be noted that after washing, the overall weights of materials were considerably lower than those originally recorded.

Results

Description of materials

Smithing Hearth Cakes (SHCs)

A variety of textures were represented ranging from well developed 'thin crust' cakes, with iron rich upper surfaces and charcoal residues and moulds, to less well formed, 'prilly' cakes, which were often highly vesicular and charcoal rich. Also present, though less frequent, were dense, 'thick crust' examples. Several cakes had the remains of slumped tuyère material incorporated in their upper surfaces.

The basic mode of formation of an SHC is probably broadly the same across all of these 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 additions of sand flux too, with the resulting iron silicate melt forming the slag. The common origin means that SHCs typically have a bowl like for. 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.

The SHCs from Ballyellin 1 have an unusually narrow range of weights. The mean weight of the 34 SHCs for which the original weight is able to be estimated is 682g (range 143g – 1525g). When compared with other Irish iron-working sites, the Ballyellin SHC assemblage has a very low proportion of SHCs with weights less than 500g (32%). This is a comparable proportion to that seen on sites (e.g. Clonfad; Table 2) where the largest SHCs range up to many kilograms in weight and the mean SHC weight is as high as 1300g. The proportion of SHCs of greater than 1000g is similar to that observed on a range of (predominantly large) sites. On the other hand, the complete lack of SHCs of over 1525g cannot be matched by any studied early medieval assemblage.

Indeterminate Slag
Approximately 10kg of material was classified as indeterminate. 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. It is very likely that much of this material is derived from smithing and may include less diagnostic fragments of SHC and slag which formed within the hearth but outside the main SHC. It may potentially include slag from within the fuel bed, slag from around the blowhole and also lining slags generated from melted ceramic. Indeed several fragments of indeterminate slag have residues of coarsely tempered fired clay which are likely to be tuyère debris.

Technical Ceramics
At least 8 fragments (approx. 1kg) of tuyère were identified. These were heavily vitrified on one surface and oxidised on the other. All the fragments contain coarse temper including particles of quartz and limestone.

Other fragments of fired clay may also be the remains of tuyère however these are too small or badly preserved to be certain.

Interpretation

The residues from Ballyellin 1 indicate that the metallurgical activity being undertaken was iron working (smithing) – there is no evidence for iron smelting. The SHC assemblage is suggestive of blacksmithing (the end use of iron for the manufacture or repair of artefacts) rather than bloomsmithing (the refining of raw blooms) as the primary activity. The assemblage is fairly small, but may not indicate the full extent of the activity, and it may be noteworthy that the adjacent Ballyellin Site 52 on the N11 scheme also produced some similar SHCs, apparently in derived contexts (Young 2008b).

All of the material was recovered from contexts associated with a sub-rectangular slot trench (bounding an area 7m by 6m, 0.5m wide and 0.4m deep) (C6 - cut of trench, C4 - upper fill, C26 – lower fill) which has given a single ^{14}C date on alder charcoal of cal. AD 890-920 and 940-1030 (SUERC-32355).

No metalworking features were uncovered suggesting that the slag assemblage was derived from hearth(s) which lay beyond the excavated area or which had been truncated.

The rather narrow weight distribution of the SHCs is an interesting feature of this site. It is possible that the lack of larger SHCs is simply a result of a small sample size, or of taphonomic processes. If, however, the recovered SHC assemblage is representative of the SHCs produced at the site, then it suggests a somewhat different pattern of work than at other studied sites.

The late 9th-early10th centuries are not a period with particularly well-known smithing residue assemblages, so there are few good comparative assemblages. The assemblage from Woodstown is probably 9th century (Young 2006b) and many other major assemblages including Clonfad (Young 2009, in prep.), Borris (Young 2009d), Blackchurch (Young & Kearns 2010), Parknahown (Young 2009a), Lisleagh (author's unpub. data) and Ballinglanna North (Young 2009f)) are mainly/entirely pre-9th century. The SHC assemblage from Coolamurry (Young 2006a) now appears to be mainly 12th-13th century in age, and other later medieval assemblages are known from Ballykilmore (Young 2009c)and Garryleagh (Young 2009g). Assemblages of similar age in Britain are also rare, but the 12th century assemblages from Mill Street (Young 2009e) and Willow Lane (Young 2007b), Worcester are dominated by small SHCs, with the later assemblages from Deansway (McDonnell & Swiss 2004), both in Phase 8 (11th-13th century) and Phase 9 (13th-15th century), as well as a 14th-15th century assemblage from Burton Dassett (McDonnell 1992), having larger SHCs, more similar to those from Ballyellin. In particular the assemblage from Burton Dassett shows a rather similar mean (550g) and range (130-1670g).

If Ballyellin 1 had returned a 12th-15th century date (as was the case with adjacent site Ballyellin 2), therefore, then an Anglo-Norman influence might have been suspected. The available ^{14}C date is a little early for this, although Viking influence might be proposed alternatively.

The differences between the Ballyellin assemblage and other described assemblages must, however, be due to real procedural or technological differences. Although such differences may often seen as a result of differing cultural practices, that is not necessarily the case. To interpret Ballyellin, it is important, therefore, to look at the underlying technical reasons for a narrow range of SHC size, but with the SHCs heavier than those typically assigned to blacksmithing in medieval Ireland. The differences in task or local procedure that might reduce the production of small (<500g) SHCs might include:

- the work period; if the SHCs of other early Irish (and indeed many British) sites represented hearth clearance each morning/afternoon, then the Ballyellin (and British later medieval examples), might represent clearance half as often i.e. daily (giving double the mean SHC weight).

- the task; the Ballyellin SHCs might represent work with a different balance of processes, perhaps in being forge welding-intensive, which would lead to a greater lose of iron from the workpieces to the hearth. For instance a blade-smith might be expected to generate more slag in a typical work period than a nail-maker.

The lack of large (>1.5kg) SHCs in the assemblage might be due to the arrival of iron on the site in a fully-refined state. This has been proposed for later medieval sites in Ireland, but not, so far, for sites this early. For later medieval sites, this has been interpreted as due the rise of a more commercial culture, with finished iron being traded widely. What has not yet been examined in Ireland is the nature of early medieval iron-working in areas that were not primary iron-producers. Most areas in Ireland have at least some resources of iron ore, mainly bog iron ore, but it may be noteworthy that the previous archaeological investigations on the course of the N11 in northern Co. Wexford did not produce any evidence for iron smelting (Young 2008b).It is possible that if the local inhabitants did not have access to iron within their own networks, then traded iron from further afield have arrived in a more finished form.

Alternatively, it might not be the state of the iron that was important, but the size of the pieces of iron supplied, with the processing of smaller billet fragments generating less slag than the processing of large billets.

The current individuality of the Ballyellin assemblage when compared with other sites is an interesting phenomenon, but one which cannot fully be explained at present, so the above interpretations are extremely speculative.

Evaluation of potential

The main potential for further analytical study of the Ballyellin assemblage lies in its homogeneity. Compared other assemblages of SHCs of medieval age, the assemblage has a very narrow weight range, suggesting a limited range of processes were being undertaken. Such assemblages offer much to the eventual interpretation of sites yielding a much more diverse range of SHCs, where identifying particular subgroups within the overall range of morphology may be difficult.

Analysis of selected examples of SHCs and associated tuyères from Ballyellin would therefore be useful within a general strategy for the analysis of SHCs from other apparently single-purpose sites (such arguments are being advanced for the analysis of sites from the M8, for instance, which have yielded SHCs of much larger sizes, but within narrow size ranges).

In particular, the analysis of the slags would reveal whether they contain a significant compositional influence derived ultimately from smelting (via smelting slags included in unrefined iron), or whether they are a simple mix of iron with tuyère ceramic (plus a little fuel ash), as is the case with blacksmithing residues.

Analysis of the Ballyellin residues would not necessarily produce extra interpretation for the site, but might well do so. It would provide significant evidence to assist with the interpretation of residues on a national basis. A limited suite of analyses is therefore recommended.

The assemblage is recommended for retention, being an unusual assemblage and having research potential.

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Table 1. Catalogue of residues from Ballyellin 1, Co. Wexford

context	sample	wt (g)	number	description	SHC details		
26	1	1231	1	thin crust SHC with dimpled base, iron rich upper surface with organic moulds	100	1231	170x165x60
		50	1	fired clay, mostly oxidised, one area more heavily fired than the rest with particles of quartz			
		481	7	fragments of indeterminate slag			
		558	1	SHC, rusty appearance in areas, occasional flow textures on upper surface as well as quartz rich areas and charcoal moulds	100	558	120x95x50
		559	1	SHC with frequent large charcoal moulds on base, rusty appearance on parts of upper surface	100	559	130x100x30
		478	5	possible fragment of small SHCs with small charcoal moulds and residues			
		320	1	probable fragment of SHC (difficult to estimate the size) frequent charcoal residues on base			
		33	1	high fired clay, oxidised on one surface and almost vitrified on the other			
		170	6	indeterminate slag			
		77	1	slag and fired clay, partially oxidised			
		941	1	fragment of SHC, occasional charcoal residues	90	1045	140x100x40
		22	1	high fired clay			
		280	4	indeterminate slag			
		188	1	poorly consolidated slag			
		209	1	fragment of highly vesicular, poorly consolidated SHC, charcoal rich	50	418	100x(45)x45
		244	1	fairly dense indeterminate slag			
		402	3	possible fragments of tuyère, oxidised on interior - relatively coarse temper (87x69x43mm) (54x64x38mm) (53x41x30mm)			
		513	1	possible fragment of SHC, two large moulds on lower surface			
		66	1	fired clay, oxidised in one small area (possible tuyère fragment)			
		328	1	indeterminate slag			
		135	1	possible fragment of small SHC			
		487	8	indeterminate slag			
		498	10	indeterminate slag			
		40	2	coarse tempered fired clay, oxidised on one surface (possible tuyère but too small to be certain)			
		510	1	SHC, dimpled base, thin basal crust, rough upper surface with rusty appearance and occasional charcoal moulds and residues	100	510	110x80x55
		304	1	star' shaped fragment of slag with four pointed protrusions - slightly curved inner surface			
26	22	293	1	natural stone (possibly sandstone)			
		434	1	small SHC, rusty appearance on upper surface	100	434	110x75x50

context	*sample*	*wt (g)*	*number*	*description*	*SHC details*		
					% orig.	*orig. wt.*	*dimensions*
		34	2	small fragments of fired clay, mostly oxidised			
		30	1	fragment of flowed slag			
		209	1	fragment of thin crust SHC			
		874	24	fragments of indeterminate slag			
4	3	532	1	fragment of SHC, occasional charcoal moulds on upper surface	90	591	120x100x40
		163	1	fragment of indeterminate slag and fired clay			
		402	1	fragment of dense SHC, occasional charcoal moulds on base	80	502	100x80x50
		231	1	fragment of slag with blebby base, partially fused quartz rich concretion on upper surface			
		283	1	possible fragment of SHC, quartz rich upper surface			
		144	1	indeterminate slag			
		840	29	indeterminate slag			
		26	1	fragment of slag and clay with frequent inclusions			
		16	1	nub of low density slag			
		317	1	small SHC, iron rich upper surface	80	396	90x80x40
		257	1	fragment of indeterminate slag, dimpled surface with occasional charcoal moulds			
		30	1	indeterminate slag			
		791	1	SHC, rusty areas on upper and lower surfaces, charcoal residues on upper surface	90	878	110x100x40
		387	1	fragment of SHC, raised pad on upper surface composed of quartz-rich lining slag, vitrified upper surface	100	387	115x80x30
		779	1	fragment of irregularly shaped SHC with frequent charcoal moulds			
		143	1	small bowl shaped, fairly low density SHC	100	143	75x65x30
		476	5	fragments of indeterminate slag, occasional charcoal moulds and residues with quartz rich areas			
		279	1	possible fragment of SHC, rusty in areas			
		218	1	fragment of SHC with occasional flake hammerscale residues, rusty in areas			
		1144	1	fragment of large thin crust SHC, basal crust thin, with charcoal, thick interior charcoal rich material, partially fused quartz rich slab on upper surface	75	1525	170x(80)x70
		254	1	small SHC, occasional charcoal moulds on base	100	254	105x70x40
		115	1	possible fragment of small SHC, rusty appearance			
		166	4	indeterminate slag			
		46	2	fired clay with coarse quartz inclusions			
		8	1	fired clay with coarse quartz inclusions on one surface, one relatively flat surface			
		366	3	possible fragments of tuyère, one has vitrified external surface, all three are oxidised on interior (79x52x46mm) (61x44x34mm) (60x51x57mm)			
		334	1	fragment of poorly consolidated slag - possibly fragment of SHC			

context	sample	wt (g)	number	description	SHC details		
					% orig.	orig. wt.	dimensions
		191	1	indeterminate slag with small quantity of oxidise clay attached			
		262	1	indeterminate slag with coarsely tempered oxidised clay attached			
		114	1	fragment of indeterminate slag with quartz rich concretion attached			
		1001	7	indeterminate slag			
		241	2	fragments of small SHC			
		43	1	indeterminate slag			
		22	1	fired clay, approx. 16mm thick, oxidised on one side			
		66	2	fragments of relatively low density slag, one appears to have a fuel ash component			
		12	1	fragment of slag lobe			
		71	2	fragment of coarsely tempered fired clay, oxidised on one surface			
		247	1	fragment of small SHC, small stone protruding from base	80	308	110x70x30
		615	1	roughly plano convex SHC	95	647	130x100x35
		629	1	irregular slightly prilly majority of SHC with deep bowl	90	698	110x105x75
		275	1	small SHC with rusty appearance	100	275	110x80x30
		206	1	small dense SHC with charcoal inclusions and lining slag on upper surface	70	294	95x(40)x30
		185	1	fragment of possible tuyère, coarsely tempered, oxidised on one surface			
		111	1	fragment of fairly flat dense slag			
		44	1	coarsely tempered fired clay, oxidise on one surface, vitrified on the other			
		137	1	indeterminate slag - sharp to touch			
		491	8	indeterminate slag			
		522	1	fragment of SHC, rough upper surface with rusty areas suggesting iron pieces, some tuyère debris on top	90	580	120x90x45
		599	1	SHC with flat broad, lobate bowl with deeply impressed charcoal, rusty appearance in areas, major lump of tuyère debris on top	100	599	120x95x50
		146	1	fragment of small SHC	80	182	75x65x40
		166	1	fragment of small SHC, quartz rich in one area			
		185	1	small, relatively flat SHC, occasional organic moulds on upper surface			
		293	1	fragment of SHC, dimpled upper surface			
		23	1	fragment of flowed slag			
		20	1	high fired quartz rich clay			
		867	25	indeterminate slag			
		7	1	fragment of slag lobe			
		58	1	high fired clay, vitrified in areas			
		1229	1	fragment of SHC with deep bowl (80mm), another possible interpretation is this is a thin crust deep below and upper slag - in which case the proportion may be much less	90	1365	150x100x80

context	*sample*	*wt (g)*	*number*	*description*	*SHC details*		
					% orig.	*orig. wt.*	*dimensions*
		214	1	possible fragment of SHC			
		1077	28	indeterminate slag			
		579	1	fragment of dense SHC, charcoal residues on upper surface	90	643	110x80x55
		680	1	SHC with small protrusion of prilly flowed material from base, upper surface with proximal lining slag pad	90	755	130x110x45
		811	1	SHC with ridge of partially fused quartz rich material on upper surface	95	853	100x110x50
		414	1	SHC with rough upper surface	90	460	110x80x60
		57	2	fragments of coarse tempered fired clay, oxidised on one surface			
		245	7	indeterminate slag			
		1029	1	dense, well consolidated plano convex SHC, possible tool marks on upper surface	100	1029	115x105x40
		796	1	possible fragment of SHC, very irregular shape so proportion uncertain, crust thin, possible flowed end, possible tool mark cutting through broken end	70	1137	170x111x60
		23	1	fired clay			
		49	1	indeterminate slag			
		356	1	fragment of dense slag with well developed flow textures on upper surface and one large mould of round stick. Flow lobes with maroon surface			
4	7	556	1	fragment of dense, thick crust SHC, rough slag protrusion from upper surface, counterpart to 4-18 419g piece, angular base with adhering sediment	57	975	130x110x75(30)
4	18	414	1	fragment of thick crust SHC, proportion unknown (?15%)			
		419	1	fragment of dense thick crust SHC, counterpart to 4-7 556g piece	43	see above	see above
		495	2	fragments of fairly coarse tempered fired clay, oxidised on one surface, highly fired on the other			
		34	2	small fragment of fired clay, partially oxidised			
		20	1	indeterminate slag			
4	23	2	1	thin fragment of fired clay			
6	4	266	1	indeterminate slag with dimpled texture			
		258	1	possible fragment of thin crust SHC			
6	5	38	3	indeterminate slag			
6	14	38	2	indeterminate slag			
		374	7	natural stones			

context	*sample*	*wt (g)*	*number*	*description*	*SHC details*		
					% orig.	*orig. wt.*	*dimensions*
		48	1	natural stones			
		57	1	coarse tempered fired clay			
6	17	1320	1	dense SHC, charcoal rich so lightly irregular, bowl 60, but thicker at proximal end	100	1320	150x115x80
		1007	1	double layer SHC with lower thin crust dimpled cake, central charcoal rich material and small upper slab SHC	100?	1007	170x80x85
		86	3	fired clay, oxidised in areas, one with vitrified surface			
		60	2	indeterminate slag			

Table 2: Comparison of the Ballyellin 1 assemblage with other Irish smithing assemblages

	Garryleagh	Coolamurry	Navan	Moneygall	Parknahown 5	Blackchurch (site 48)	Ballyellin 1	Trumra 4	Clonmacnoise (NG)	Ballykilmore	Woodstown 6	Clonfad
date	13th-14th	10th?-12th	E. Med.	E.Med/ Med	5th – 10th ?	5th -10th?	9th -11th	5th – 6th	7th - 10th	14th - ?	9th -10th	7th - 9th
SHC count	25	41	17	22	89	70	34	57	258	43	140	381
SHC min. wt	84		60	114	86	108	143	92	54	80	68	60
SHC max. wt	802	2588	2990	1800	2898	2450	1525	3163	7815	4033	6310	11000
SHC mean wt	331	386	507	527	567	629	682	727	762	898	1060	1302
% <500g	76%	83%	82%	55%	70%	53%	32%	47%	52%	51%	40%	30%
% <1000g	100%	95%	88%	95%	84%	81%	76%	75%	78%	74%	71%	61%
% >1000g	0%	5%	12%	5%	16%	19%	24%	25%	22%	26%	29%	39%
% >3000g	0%	0%	0%	0%	0%	0%	0%	2%	3%	7%	7%	9%
Modal 100g interval	100-200g	100-200g	100-200g	200-300g	400-500	200-300	500-600	100-300	200-300	400-500	200-300	300-400

Assemblages ordered by mean weight.

Garryleagh from Young 2009g; Coolamurry from Young 2006a; Navan Site 1 from Young 2007a; Moneygall from Young 2008c; Parknahown 5 from Young 2009a; Blackchurch from Young & Kearns 2010; Ballyellin 1, this study; Trumra 4 from Young 2008d; Clonmacnoise New Graveyard site from author's unpublished data; Ballykilmore from Young 2009c; Woodstown 6 from Young 2006b; Clonfad from Young 2009b.

	Ballyellin 1	Carmarthen	Marsh Leys Farm	Worcester 35 Mill St	Worcester Willow St	Prior Park Cricklade total	Worcester Deansway (period 8)	Worcester Deansway (period 9)	Burton Dassett
Date	9th – 11th	Roman	Roman	12th	12th	11th-15th	11th – 13th	13th-15th	14th- 15th
SHC count	34	136	30	23	28	17	61	32	60
SHC min. wt	143	100		74	86	156	168	144	130
SHC max. wt	1525	820	824	782	770	794	1490	1800	1670
SHC mean wt	682	227	333	233	327	329	492	499	550
% <500g	32%	94%	77%	91%	82%	82%			
% <1000g	76%	100%	100%	100%	100%	100%			
% >1000g	24%	0%	0%	0%	0%	0%			
% >3000g	0%	0%	0%	0%	0%	0%			
Modal 100g interval	500-600g			100-200g	100-300g				

Table 3: Comparison of the Ballyellin 1 assemblage with some British blacksmithing SHC assemblages.

Carmarthen from Crew 2003; Marsh Leys Farm from Young 2005; Worcester 35 Mill St from Young 2009e; Worcester Willow St from Young 2007b; Prior Park, Cricklade from Young 2008a; Worcester Deansway from McDonnell & Swiss 2004. Burton Dassett from McDonnell 1992;

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