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Evaluation of archaeometallurgical residues from the N8 Fermoy-Mitchelstown, Garryleagh, Co. Cork (E2433)

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Evaluation of archaeometallurgical residues from the N8 Fermoy-Mitchelstown, Garryleagh, Co. Cork (E2433)

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Abstract

Excavations at Garryleagh produced 18.2kg of metallurgical residues derived from iron-working (smithing). These derived from two features, a pit ([c13]: interpreted here as a smithing hearth) and an adjacent ditch [c9]. The smithing hearth yielded only a small proportion of the residues (1.3kg), but these included a small amount of hammerscale. Residues from the ditch were dominated by smithing hearth cakes (SHCs). Twenty five examples of SHCs were either complete, or sufficiently so that the original size could be estimated; these had a weight range of up to about 800g, with a mean weight of 331g.The assemblage also include 1.4kg of sherds from ceramic tuyères. The tuyère morphology was not well demonstrated by the specimens, but the tuyères appear to have been moderately large (the radii of curvature of three fragments were 80, 120, and 150mm) and either to have had a large bore (specimens are present with bores of 24 and 40mm) or were allowed to burn back to a point where the bore began widening.

The fill of smithing hearth [c13] gave a ^{14}C date of cal AD 1283-1318 and 1352-1390 (2σ). Apparently isolated floor-level hearths of medieval to post-medieval age have been a surprisingly regular feature of recent road schemes.

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Methods

All materials were examined visually with a low powered binocular microscope. Macroscopic slag pieces were individually weighed, described and recorded to a database. The summary catalogue is given in Table 1.

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

The dominant class of residue were the smithing hearth cakes (SHCs). These are typically rather small (weight range 84-802g, mean weight 331g), with 76% of the measurable SHCs weighing less than 500g.

The SHCs were in general dense, compact cakes. Several showed attachment to the lower face of tuyères. At their simplest the attached SHCs formed a semicircular “flange” in front of the tuyère (e.g. #3), but more developed cakes developed outwards and downwards. One shows rather planar basal surfaces which hint at its possible development above a stone placed below the tuyère (#4).

The overall morphology of the SHCs is rather variable, with most of the small ones rather slab-like, but larger ones are essentially plano-convex. A variety of more complex morphologies occur, including forms with a distinct double layer structure, sometimes with a wedge-shaped upper layer (e.g. #28) indicating an “avalanche” of material from the tuyère face, and possibly even as the result of merging of separate “bowl” and “tongue” components during their development, although this appears to be a more common feature in much larger SHCs.

(*The “pro-tuyère tongue”, Young 2006, 2009, is a feature observed in assemblages from Ireland in which a tuyère has been employed, particularly where large SHCs are generated. Detailed understanding of tongues is the subject of on-going research, but they are currently interpreted as being distinct from SHCs and are excluded from the analysis of SHC weight. Melting of the tuyère face produces a silicate-rich slab extending in front of, and usually downwards from, the tuyère face, within the cool area just below the blast. Reaction of iron oxides derived from the workpiece with the silicates in the tongue generates a low-melting point fayalitic melt, which apparently drips down from the tongue to accumulate as a separate slag cake, usually of bowl-like morphology, lower in the hearth. In other words, the tongue forms in the equivalent location to a*

normal SHC but the iron-rich component is not retained at that level, but is lost to a location lower in the hearth. In some SHCs there is an upper silicate rich zone equivalent to the tongue and a lower iron-rich zone, all within a single cake. In the development of large SHCs it seems the tongue and bowl components may remain separated, but may unite as both components grow within the hearth.)

One interesting feature of the SHCs is the relatively common occurrence of quite strongly reddened tops to the SHCs. This is indicative of the presence of oxidising conditions produced by the air blast from the tuyère, and demonstrates that these SHCs were formed quite high in the hearth.

Small pieces of iron-poor glassy slags (e.g. #7, #19, #34, #39-41, #86, and within #112) may simply be lumps melted from the tuyère, or may be fragments of tongues. Better examples of true tongues occur more rarely (#127 and #129).

Tuyère sherds comprised 1.4kg of the assemblage and were formed of a soft fabric (frequently oxidised fired to an orange colour in the observed fragments) which contained scattered large angular quartz grains. Derived tuyère material appears as a scatter of gravelly material, usually in a glassy matrix, across the upper proximal surface of many of the SHCs. The tuyère morphology was not well demonstrated by the specimens, but the tuyères appear to have been moderately large (the radii of curvature of three fragments were 80, 120, and 150mm) and either to have had a large bore (specimens are present with bores of 24 and 40mm) or were allowed to burn back to a point where the bore began widening (the bore of a tuyère typically widens towards its rear face to allow insertion of the tip of the bellows or a pipe associated with the bellows).

A few pieces show the development of dense, fluid slags in the area immediately in front of the tuyère (e.g. #122), which may accumulate as flow lobed blocks (e.g. #33, #72, #126 and #96) below the tuyère.

Smaller slag fragments are mainly debris from fractured SHCs, but a few pieces appear to be primary nubs (e.g. #28 and #117) and may be examples of slags accumulating in the base of the hearth outside of the SHC.

A few of the specimens of both tongues and true SHCs show evidence for deformation, mainly twisting, which was probably incurred during the extraction of the slag from the hearth by the smith.
The assemblage contained a few pieces of concretion, probably formed around corroded iron, most of which occurred in the deposits within the hearth. The concretions from the hearth [c13] contain abundant hammerscale (both spheroidal and flake).

Distribution of the residues

The majority of the residues (16.9kg) were recovered from the fills of ditch [c9] (mainly [c10], but a small quantity from [c12]).

A small quantity of residues (1.3kg) was recovered from the fill of pit [c13] which is interpreted (see below) as a smithing hearth. Residues from the hearth include 838g of slags, which are mainly dense slags in various prills and blebs indicative of a degree of flowage. Such slags in isolation might be suggestive of iron smelting rather than smithing, but the description above has shown how there are flowed slags associated with the SHCs and tuyère sherds, and therefore these are probably slags that have flowed on the blowing wall of a smithing hearth. The remaining materials from the hearth include 26 sherds of tuyère (278g), 13 pieces of lining slag (110g) as well as the hammerscale-bearing concretions described above.

Description of the metallurgical features

Pit [c13] was a shallow, sub-circular cut (0.9m x 0.87m x 0.15m deep). Despite the flowed nature of some of the slag materials within it (see above), the other residues (both macro- and micro-residues) clearly indicate an origin in iron-working smithing. The size of the feature is comparable with that of other floor level smithing hearths, and indeed with a typical modern smiths forge hearth.

The feature shows a lack of firing of the clay into which it is dug, which is typical with smithing hearths, where the hot-zone occurs within the fuel pile, largely above the level of the tuyère (itself probably resting on the original ground surface). Unless there is substantial slag generation, there is little heat transfer to the base of the cut.

Thus, in contrast to the initial field description of the features, [c13] is to be interpreted as a smithing hearth, not a smelting furnace. The associated fragments of vitrified ceramic are not fragments of furnace lining, but sherds of tuyères.

Interpretation

As recognised during excavation, it is likely that the operation of the hearth [c13] is likely to have produced the slag dumped into ditch [c9] and that therefore the two features are likely to have been contemporary.

The SHC assemblage is quite small, so the inferences drawn from the distribution must be considered to be somewhat tentative. The restricted weight range of the SHCs (maximum weight of 802g), however, indicates that the smithing undertaken in the hearth was mainly or entirely associated with the end-use of iron (blacksmithing) rather than with the refining of raw iron blooms.

The dating of the smithing hearth as 13th-14th century (a single 14C date on mixed charcoal gives a date of cal AD 1283-1318 and 1352-1390) is important. Most recorded early medieval to medieval smithing assemblages contain a small proportion of SHCs above 2kg in weight that are probably associated with a degree of bloom refining (e.g. Table 2, Coolamurry, Navan and Moneygall) . This feature differentiates Irish assemblages from contemporary SHC assemblages in Britain (e.g. Table 2: Marsh Leys, Carmarthen, Worcester, Cricklade and Burton Dassett). It has been argued (Young in prep.) that this low level of bloom refining on sites which are otherwise apparently not directly associated with the production of iron may be associated with the distribution of iron from producers to end-user smiths in the form of only partly-consolidated blooms (billets) rather than as fully-refined bar iron. Such a distribution pattern has been described for medieval and early post-medieval Denmark by Pleiner (2000; p241-2).

In Ireland, the evidence currently suggests a progressive replacement of the distribution of iron to smiths as billet, by the distribution of finished iron (presumably as bar iron). This change is reflected in the disappearance of large SHCs from smithies not directly involved in iron production, possibly particularly when industrially produced bar iron became more of a commodity in the 17th-18th centuries. Thus later medieval and post-medieval Irish assemblages more closely resemble the British examples quoted above.

The apparently large size of the tuyères at Garryleagh is another feature associated with smithing of a medieval to post-medieval age. Early medieval tuyères tend to be rather

smaller than the size tentatively suggested by the limited evidence at the present site.

Ballykilmore 6, Co. Westmeath, includes a phase of iron production in the later medieval period. A feature associated with iron smelting (possibly a furnace) gave a ^{14}C date of cal. AD1298-1371 and 1378–1407. Associated smithing slags were probably largely associated with bloomsmithing, but were also associated with the use of large tuyères, somewhat similar to the examples from Garryleagh.

Apparently isolated medieval to post-medieval floor-level smithing hearths have been recorded widely in recent years, but the social context of such structures is essentially unknown. Recently described occurrences include:

Coolamurry, Co. Wexford (Young 2008a), included three smithing hearths with their associated waste dumps, but apparently isolated from other features. The site produced ^{14}C dates ranging from the 9th to 12th centuries AD.

Moycarky (AR15), Co. Tipperary (Young 2009c), contained a probable smithing hearth within a cluster of features, two of which gave 14th-15th century dates (cal AD 1302 – 1418 and cal AD 1312 – 1433). The excavators interpreted the site as a possible ephemeral campsite.

At **Clonfad**, Co. Westmeath (Young 2009a, in prep.), there were many scattered hearths, some yielding hammerscale, which postdated the monastic activity and some of which were dated to the 17th or 18th centuries by artefacts.

Mucklagh (Co. Offaly, Young 2007) produced slags which resemble those from Garryleagh This site produced smithing resides from a length of ditch, but no smithing hearth was discovered. The weight-frequency distribution of the SHCs from Mucklagh is very similar to that from Garryleagh (Table 2), as it is to several British blacksmithing assemblages (for which a stock bar iron is inferred, rather than billets, as the “raw” material). The Mucklagh assemblage also shows distinct similarities with Garryleagh in details of the material – including large tuyères, SHCs with well-flowed proximal ends with non-wetted contacts with the sub-tuyère wall, reddened tops and veneers of gravelly tuyère-derived melts. The Mucklagh assemblage is, however, tentatively dated to the 18th-19th centuries, right at the end of the period of use of this traditional technology.

Evaluation of potential

The Garryleagh assemblage provides a very useful additional datapoint in the development of smithing during the medieval to post-medieval period. The apparently rather tight relationship between the collection of residues in the ditch and the surviving hearth is a particularly welcome aspect. The dating of the site to the 13th-14th centuries is important, for it places the site firmly within a period when the nature of iron supply in Ireland seems to be changing. A full scientific analysis of the Garryleagh residues would provide a good comparison with smithing practices of the earlier tradition (e.g. Coolamurry), in which iron appears to have supplied to the smith in an unfinished form.

A minor issue with the research potential of the residues is the present lack of microresidues from the hearth apart from the examples sealed into concretions by the corrosion of iron particles. If any unprocessed environmental samples from the hearth contexts remain, it is recommended that these are sieved with retention at 100 or 200μm to provide a microresidue (hammerscale...) sample.

In summary, analysis of a suite of SHC and tuyère samples is strongly recommended. If this analysis is pursued, then examination of microresidues would also be recommended, if any can be retrieved.

The collection is significant, so retention of the entire collection is advised.

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context	*find*	*wt*	*no*	*notes*	*propn*	*original*
10	1	140	1	fragment of dense iron-rich sheet with gravelly lining material attached to one side. SHC fragment		
10	2	24	1	sherd of deeply vitrified tuyère front		
10	3	652	1	SHC attached to fragment of tuyère tip. Extends 60mm down from tuyère, then 90mm out at about 110 degrees. Both surfaces rather planar - so may be contacts with stone. Body of SHC is 25-40mm thick, wedge shaped, with 40mm radius halo of tuyère material in lumps on proximal upper surface, overall 120x110x75mm	100	652
10	4	198	1	60x95x55mm flange of dense slag in semicircle in front of tuyère, dense slag covered top and bottom with fragments of degraded vitrified tuyère.	100	198
10	5	90	1	dense SHC fragment with large well-etched olivine dendrites, white tuyère-derived material on top		
		158	1	thin sheet like SHC crust - no clear margins so proportion not determinable		
10	7	34	1	dimpled dense slag - probably a tongue fragment		
10	8	424	1	irregular SHC-like mass hanging from tuyère tip - possibly vertically below it, lots of tuyère material near tip, 100x100x45mm	100	424
10	10	66	1	small SHC like piece of dense slag - but probably just a part of a larger body		
10	11	102	1	piece of sheet formed of highly dimpled slag rich in charcoal inclusions		
10	12	226	1	unusual gravelly lining slag burr - not clear if attached to tuyère or below since no material attached.		
10	13	34	1	fragment of dense slag sheet with gravelly tuyère material on top		
10	14	24	1	small concretion on iron fragment		
10	15	66	1	smooth-topped SHC fragment		
10	16	32	1	fragment of tuyère - fabric bright orange soft clay - has scattered large angular quartz grains and possibly lining slag, face covered in quartz grains		
10	17	506	1	dense SHC, 90x90x45mm, base dimpled, plano-convex, top obscured by accreted material	100	506
10	18	42	1	charcoal-rich slag lump		
10	19	56	1	irregular, possibly contorted piece of lining slag		

context	*find*	*wt*	*no*	*notes*	*propn*	*original*
10	20	92	1	square lump of slag, probably a SHC fragment, but just possibly a whole tiny SHC		
10	21	802	1	well- formed dense concavo-convex SHC with vitrified tuyère material at proximal side, 140x140x55mm (of which bowl 40mm) charcoal-rich top, rough base, SHC top seems level with tuyère base	100	802
10	22	426	1	irregular incomplete SHC, reddish, smooth, slightly dimpled on top, 95x100x40mm (of which bowl 30mm), dense, maybe mostly complete	100	426
10	23	176	1	irregular SHC fragment		
10	24	486	1	rather chaotic Fe-rich slag sheet with some maroon flow lobes on lip, overlain by gravelly lining slag type material, probably the proximal part, or all, of an SHC that was twisted strongly on extraction		
10	25	190	1	distal part of dense SHC, possibly broken off tuyère near margin (70) x 90 x25mm	100	190
10	26	78	1	part of small SHC with thickish crust with tubular vesicles		
10	27	280	1	large piece from dense slag puddle-type SHC, perfectly flat maroon top to puddle, which has a few bits of gravel "floating" in it. (70)x(70)x30mm. Proportion not known, base slightly lobate		
10	28	568	1	neat oval SHC with low bowl, overlain by flowed slag and tuyère-derived material - suggesting bowl was inclined. 140x100x75mm (of which bowl 25mm)	100	568
10	29-30	162	2	pieces of very weathered dense slag bearing large lumps of charcoal, shape unclear, probably SHC fragments		
10	31	20	1	sherd of slagged tuyère front		
10	32	68	1	SHC fragment, has thinnish crust with quite dense filling above		
10	33	98	1	complex flowed slag in lobes at different levels, a bit like a smelting flow slag- but very irregular		
10	34	92	1	probably a piece of tongue folded in half - but very irregular so precise nature of break and fold are unclear		
10	35-41	276	3	dense slag pieces, probably from SHCs		
		146	3	low-density glassy tongue-like fragments		

context	*find*	*wt*	*no*	*notes*	*propn*	*original*
10	42-53	128	1	large sherd probably from oxidised-fired tuyère, with curvature suggesting 300mm diameter, but this is not certain		
		326	9	gravelly lining slag - ranges from tongue-like material to more amorphous blebs		
		196	1	small dense SHC, surfaces possibly worn, 80x60x20mm		
		112	2	sheet-like dense slag - both probably SHC fragments		
10	54-56	130	1	triangular lump of very weathered slag, probably a small SHC or part of		
		28	2	round slag lumps		
10	57-60	70	3	glassy lining slags, one with ceramic back, probably remains of slagged tuyère front		
		146	1	small triangular SHC, completeness not quite certain, 70x70x25mm	100	146
		304	5	dense slag lumps, probably all fragments from smallish SHCs		
10	62	72	1	strange flow-lobed material - possibly folded		
10	63	30	1	folded slag sheet fragment		
10	64-66	134	3	sherds from face, 2 conjoining, of large tuyère. Margin of blowhole seen, face approximately 80mm radius, face maroon and curves into side which is vitrified and rough - probably the top of tuyère?		
10	67-73	352	1	slightly triangular SHC with rough surfaces, but probably complete, 80x90x40mm (of which bowl 35mm)	100	352
		268	1	most of SHC, flat wide, large round hollows in top, 90x90x35mm (of which bowl 20mm)	100	268
		308	3	3 pieces of smaller SHCs		
		94	2	indeterminate slags, possibly SHC debris		
10	74	30	1	small SHC crust fragment with tubular vesicles		
10	75-76	32	1	deeply vitrified tuyère front with possible blowhole margin		
		12	1	fragment of thin slag sheet		
10	77	110	1	curved (twisted?) sheet of slag - probably part of a small SHC		
10	78	52	1	sherd of tuyère face, rich dark glaze with quartz, fabric orange with gravel		
10	79	396	1	dense SHC, 105x95x30mm, dimpled top, finely dimpled base	100	396

context	*find*	*wt*	*no*	*notes*	*propn*	*original*
10	80-82	528	1	neat dense double layer SHC, with upper layer the larger 100x85x55mm	100	528
		170	1	dense but thin (8mm) crust dipping away from lower margin of tuyère. Margin strongly vitrified, but appears straight		
		48	1	fragment from slagged tuyère face		
10	83	82	1	large slab of face of vitrified tuyère, 24mm diameter blowhole, tuyère >120mm diameter, one half dull, purple, the other green glassy		
10	84	60	1	irregular slag sheet fragment with bend - possibly folded on extraction		
10	85-87	106	1	thin slag piece, possibly a small SHC, 60x65x20mm	100	106
		212	1	(60)x85x30mm broken small SHC, probably 80%, top smoothish, base irregular and dimpled	80	265
		8	1	slag fragment		
10	88-89	202	1	face of tuyère with gravelly build-up below(?) blowhole (just possibly a hood but probably not). Blowhole shows diameter of approximately 40mm, good orange fine fabric to tuyère		
		36	1	vitrified tuyère sherd - probably associated with above but no surviving join		
10	90	240	1	distal part of wide shallow dense plano-convex SHC	100	240
10	91-92	156	1	dense strongly flow-lobed slag mixed with failed tuyère debris - quite possibly a complete small SHC, but too irregular to be certain		
		86	1	irregularly-shaped dense slag piece - possibly distal part of SHC, or even all of small one		
		28	1	sherd of slagged tuyère front		
10	93	88	1	twisted SHC fragment?		
10	94-95	96	1	pyramidal mass of gravelly lining slag - from tuyère front		
		86	1	tongue of gravelly lining slag		
10	111	190	1	90x65x30mm small plano-convex SHC, rather rough appearance because of prilly internal texture, glassy top	100	190
10	114	86	1	slagged vitrified layer - probably from tuyère front		
10	115	42	1	small SHC fragment		
10		34	1	slag with abundant charcoal pieces bound in vesicular slag		

context	*find*	*wt*	*no*	*notes*	*propn*	*original*
10	117-118	92	1	irregular slag lump		
		24	1	lump, probably from tuyère debris		
10	119	212	1	slightly incomplete thin SHC, large charcoal pieces in base, a few dollops of lining slag on top, 80x65x30mm	90	236
10	120	468	1	neat dense SHC, plano-convex form with attached lump on one side. Tuyère front seen across one edge, scatter of lining debris across dimpled top, base with charcoal impressions, 95x110x50mm	100	468
10	121	122	1	small SHC/tongue, pyramidal with flat attachment, gravelly top, dense base, possibly best called a tongue	100	122
10	122	76	1	prilly dense slag and occasional tuyère debris hanging from lower tuyère margin		
10	123	126	1	60x60x30mm very irregular dense slag with scattered gravelly tuyère material, probably a small SHC	100	126
10	123	26	1	strongly slagged and flowed tuyère front		
10	124	100	1	very irregular slag - dense on one side, prilly with large charcoal pieces on the other		
10	125	84	1	probably entire tiny dense SHC with lining slag edges, 60x60x15mm	100	84
10	126-128	180	1	chaotic tongue-like material, rubbly tuyère debris above, large flow lobes below!		
		66	1	slab of rotten pale glassy lining slag - possibly a pro-tuyère sheet of debris		
		188	1	plano-convex mass of tongue-like composition and SHC shape. Top gravelly glass. Base bowl-shaped pale glassy, with Fe-rich concretion suggesting some iron has been leached from bowl	100	188
10	129	104	1	classic small tongue, semicircular, glassy above, rusty below, attached to tuyère front with purplish firing colour		
10	130-131	106	2	sherds from vitrified face of large tuyère/wall, purplish firing to surficial clay, grey and gravelly behind		
10	131	136	1	50x95x25mm very irregular piece, presumably whole SHC, dense slag peppered with tuyère debris	100	136
12	102-106	586	1	probably 90% of cake, quite strongly layered, with dense bowl and top - blown maroon, with bowl overlain with white lining slag - collapsed tuyère front presumably, (90)x(110)x55mm (of which bowl 50mm) lining slag infill to 15mm in centre of bowl	90	651
		216	4	4 pieces of SHC material with admixed white tuyère debris		

context	*find*	*wt*	*no*	*notes*	*propn*	*original*
12	112	126	1	complex folded/broken SHC fragment		
12	112	414	1	part of largish SHC, dimpled top, charcoal inclusions, rough base, proportion not known		
		122	1	chert: natural		
		148	1	block from SHC, dimpled base, rough top, proportion not determinable		
		284	1	fragment from dense SHC with 17mm crust, attached to tuyère front and overlain by tuyère debris, probably a small part of quite a large cake		
		102	1	irregular tongue, pale glass above, rotted iron slag below, form uncertain - so proportion uncertain		
12	115	14	1	weathered tongue fragment		
14	96-97	52	1	dense slag with flow lobes		
14	107	74	15	indeterminate slag pieces - look derived		
		10	1	tuyère sherd		
		16	2	lining slag fragments		
		40	2	stones: natural		
15	108	30	3	dimpled dense slags flown between small charcoal		
		4	1	lining slag influenced fragment		
		8	2	indeterminate slag fragments		
21	109	6	1	accretion around iron, very rich in flake and spheroidal hammerscale		
		26	2	lining/tuyère sherds - one with probable blowhole margin		
		44	4	gravelly lining slags with white clasts and purplish surface		
		6	2	stones: natural		
		58	9	blebby iron slags		
22	110	242	23	sherds of vitrified tuyère - ceramic all oxidised fired		
		266	18	crude flow slags		
		46	6	blebby dark glassy lining slags		
		38	1	charcoal and hammerscale-rich concretion		
		350	21	amorphous to blebby slag fragments - origin not clear		

Table 1: summary catalogue by context and find number

	Garryleagh	Mucklagh	Coolamurry	Navan	Moneygall	Marsh Leys Farm	Carmarthen	Worcester Deansway (period 8)	Prior Park Cricklade total	Worcester Deansway (period 9)	Burton Dassett	Ballykilmore
	13th-14th	18th–19th	10th-12th	E. Med.	E.Med-Med.	Roman	Roman	11th – 13th	11th-15th	13th-15th	14th- 15th	14th - ?
count	25	66	41	17	22	30	136	61	17	32	60	43
min	84	98		60	114		100	168	156	144	130	80
max	802	1206	2588	2990	1800	824	820	1490	794	1800	1670	4033
average	331	373	386	507	527	333	227	492	329	499	550	898
<500	76%	77%	83%	82%	55%	77%	94%		82%			51%
<1000	100%	95%	95%	88%	95%	100%	100%		100%			74%
>1000	0%	5%	5%	12%	5%	0%	0%		0%			26%
>3000	0%	0%	0%	0%	0%	0%	0%		0%			7%
Modal class	100-200	100-200	100-200	100-200	200-300							400-500

Table 2: Comparison of the Garryleagh SHC assemblage with other British and Irish blacksmithing SHC assemblages.

Irish post-medieval blacksmithing: Mucklagh from Young 2008c
Irish early medieval blacksmithing: Coolamurry from Young, 2008a; Navan Site 1 from Young 2007; Moneygall from Young 2008d
Irish late medieval/early post-medieval blacksmithing and bloomsmithing: Ballykilmore from Young 2009b;

British blacksmithing: Marsh Leys Farm from Young 2005; Carmarthen from Crew 2003; Burton Dassett from McDonnell 1992; Prior Park, Cricklade from Young 2008b; Worcester Deansway from McDonnell & Swiss 2004.

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