

# GeoArch

Report 2007/09

Evaluation of metallurgical residues  
from the Navan Inner Relief Road  
project, Site 1 (06E274), Co. Meath

Dr Tim Young  
7<sup>th</sup> March 2007

# Evaluation of metallurgical residues from the Navan Inner Relief Road project, Site 1 (06E274), Co. Meath

Dr T.P. Young

## Abstract

*Material from this site comprises approximately 14.9kg of macroscopic archaeometallurgical residues. These are primarily derived from smithing hearth cakes (SHCs; total 11.9kg), but also include fragments of tuyères (total 122g) and lining slags (120g), alongside 2.2kg of indeterminate slag fragments. The residues are typical of those from iron-working. Of the SHC material, only 17 examples can be used to measure or estimate the original weight of the cake. 14 (82%) of these SHCs weighed less than 500g and 15 (88%) less than 1000g. All these small SHCs had very "conventional" forms and textures; they are interpreted as residues from iron-working, most probably from the production of artefacts (blacksmithing) rather than being part of iron production. Only 2 cakes had weights of over 550g, and these were very much larger at 2.6 and 3.0kg. These two large cakes had a very different, porous texture lacking a strongly developed basal crust. SHCs with this texture are poorly understood at present but have been interpreted as residues from bloomsmithing (the compaction and refining of raw blooms) when found on other early medieval sites.*

*The technology employed appears to have utilised a shallow hearth, cut into the ground. Air blast was fed to the hearth through a ceramic tuyère. Such technology seems to have been the standard in Ireland for smithing from early medieval times, surviving, at least locally, well into the post-medieval period.*

*Residue from the late ditch C274 is clinker, from a coal-fuelled process. Some of the clinker is very dense and is therefore likely, but not certainly, to be residue from coal-fuelled blacksmithing. The advent of coal as fuel in blacksmithing is not well documented, and certainly varies by area. There is some evidence for coal use as early as the medieval period, but widespread adoption appears to have been during the 19<sup>th</sup> century.*

*Over 97% of the recovered archaeometallurgical residues (14.5kg) derive from the area of the ditch junction, where there is good archaeological evidence for metallurgical activity in the upper fills of ditch C70. The amount of slag recovered is quite modest, and the smithing hearth(s) may have only been in use for short period of time. The use of ditches as locations for iron-working has parallels on other early medieval sites.*

## Contents

Abstract .....	1
Methods .....	1
Results .....	2
Interpretation .....	3
Evaluation of potential.....	3
References .....	4
Tables	
Table 1: Summary catalogue, by context .....	5
Table 2: Residue classes by context .....	8
Table 3: Comparison of SHC assemblage 1 .....	9
Table 3: Comparison of SHC assemblage 2 .....	10

## Methods

All the material from the collection was inspected visually (and with a low-powered stereo-microscope where necessary) and recorded to a spreadsheet. All complete, or substantial parts of, smithing hearth cakes were weighed individually and the proportion they represented of the original cake was estimated. This database is reproduced as the catalogue in this report.

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 residues*

**Smithing hearth cakes:** The smithing hearth cakes (SHCs) fall into two groups: smaller SHCs of conventional type, and large SHCs with a porous texture and little or no basal crust.

The conventional SHCs have a very narrow size distribution (range 60-550g, mean 202g), with 9 of the 15 conventional SHCs falling between 100 and 200g. The small examples are dominantly rather circular in plan, with the large ones slightly more elongate. The slag of the bowl is dense, has a small crystal size and bears sparse rounded vesicles. The basal crust ranges up to 20mm in thickness in the largest of these cakes. In general, where the crust has a concave upper surface, the bowl of the upper surface is empty (i.e. not filled with charcoal-rich slag as is often seen) and some examples have small areas of siliceous glaze on the upper surface.

The larger porous SHCs have reconstructed original weights of 2.6 and 3.0kg. The two cakes have rather different shapes, one is broad and shallow, the other small in plan, but much deeper. The heavier cake shows raised area of denser slag on the upper surface, presumably at the proximal end. Both examples have highly vesicular grey, friable slag with little or no differentiation of a basal crust.

If the SHC population is taken as a whole, then the range in weight is 60-2990g, with a mean of 507g.

In all cases where the SHCs gave evidence for the nature of fuel employed, that evidence indicated that charcoal was used.

**Pro-tuyère tongues:** material from C5 and C69 includes specimens which can be interpreted as pro-tuyère tongues. This working term is used provisionally to describe a particular type of slag cake which forms immediately in front of the tuyère, has a strongly lining influenced upper surface and has dense iron rich slag lobes below. The origin of these cakes is not well understood. The complete examples are included within the count of SHCs, with which they seem to be closely related.

**Indeterminate iron slag:** the collection contained 2.22kg of iron slag fragments which were not identifiable. This amounts to approximately 15% of the residue assemblage. This figure is slightly lower than on similar sites studied with a similar methodology (about 20% at Clonfad and Woodstown, rising to 34% at Coolamurray and 40% at Carrigoran).

**Lining slag:** C6 yielded 5 fragments of lining-influenced slag totalling 120g. These pieces appear to be isolated blebs or balls of slags, some with dimpled surfaces from contact with the charcoal. The term "lining slag" is used because of its widespread employment to indicate a slag with a composition dominated by input from ceramic materials. In this instance the likelihood is that the source of that ceramic input is melting of the tip of the tuyère, rather than of a hearth lining in the strict sense.

**Tuyères:** tuyère sherds were limited to some rather small fragments. They showed a slagged front, and greenish-grey unglazed sides, which were quite

strongly curved suggesting a fairly small diameter (probably in the order of 120mm).

**Lining:** this category has been used for the eight small fragments of fired, and in one case vitrified, clay totalling 48g recovered from C6. These small fragments cannot be assigned to any particular origin with certainty and the generic term "lining" is employed despite the likelihood that this material was derived from tuyères.

**Concretion:** this term indicates a, usually rounded, mass of secondary iron minerals, which apparently surrounds a piece of corroded iron. The iron may either be contained within slag or may be in the form of discrete particles or artefacts. In this assemblage a single example from C6 is apparently cored on a thin sheet of iron.

**Clinker:** clinker is a melted or partially melted residue derived from the burning of impure coal. It may include materials produced during metallurgical use of coal (e.g. in a blacksmith's forge), but also includes materials without external addition of metals, such as residues from hearths and boilers. The material here (from C275) includes some low density small fragments, which may be simply fused coal residue, but also a piece of denser clinker sheet, which is very likely to be residue from a coal-fuelled blacksmiths hearth.

### *Stratigraphic distribution*

The focus of deposition of residues was the partially-silted ditch C70. The residues were associated with features, including a possible hearth (C62) cut into the earlier silts. The features were overlain and filled by charcoal-rich layer (C41, C63) containing residues, which was in turn overlain by a sandy silt (C6) containing abundant slag (and which also filled the gully to the north where it was called C69). Presumably C6/C69 must either represent residues from a different iron-working area, or more likely the degradation of a slag dump associated with the sub-C41 features. Only 272g of slag were recovered from probable early medieval deposits outside this area.

The late ditch (C274) yielded a small assemblage of clinker.

## Interpretation

The assemblage from the Phase 1 levels at Navan Site 1 clearly indicates that the principal activity was iron-working. The localised nature of the deposits in the upper silts of ditch C70 are strongly suggestive of an association with the possible hearth feature C62.

Unfortunately the supplied documentation did not include detailed plans of the possible hearth and associated features, and reappraisal of the structures might be considered during the analysis phase of investigation of the residues. However, some comment can be made on the nature of the features. The pit with the burnt base (C62) could be considered as a possible hearth. Its dimensions are given as 0.78m diameter by 0.13m deep. Adjacent to the pit was prominent flat stone, 180x250mm and a stakehole.

Both the residue assemblage and the associated features are best paralleled (amongst sites examined by the author) at Carrigoran (Co. Clare; Young 2006e)

and Coolamurray (Co. Wexford; Young 2006a), both of which may be 10<sup>th</sup> century in date.

At Carrigoran, C887 was a furnace or hearth 0.77m in diameter and 0.20m provisionally (pending full analysis of the slags) interpreted as a smelting furnace, despite containing tuyère sherds.

The Coolamurray site had three probable hearths (C27: 1.0 x 0.9m by 0.2m deep, C59: 0.92 x 0.82m by 0.3m deep and C100: 1.2 x 0.8m). Two of these hearths had adjacent stakeholes (each 0.14m diameter and 0.35 and 0.50m from the edge of the hearths).

A site on High Island (Co. Galway; Young 2006b) produced a small smithing hearth, at least 0.9m long by 0.4m wide, which was probably of 10<sup>th</sup> century age.

Although the fill of C62 (C63) at Navan contained a sparse slag assemblage, this can be paralleled in the hearths at Coolamurray which, it would seem, were kept clear of macroscopic slags, but which did have accumulations of microresidues. It will be important to examine any environmental samples from C63 with this in mind.

If C62 is a hearth, then the adjacent stone could be interpreted in several ways. One obvious interpretation is the possibility that it formed an anvil. However, stone anvils are not well-documented from this period. Another possibility is that the stone was positioned to support either the tuyère or bellows. Substantial pieces of sandstone have been found associated with burrs (the zone of interaction of the slag in an SHC with the adjacent hearth wall/tuyère tip, sometimes seen as a bulbous protrusion on the proximal end of the SHC) on other sites, suggesting they either supported the tuyère, or had been pushed in to slow down damage to the hearth below the tuyère.

Although the slag assemblage from the site is quite small, and therefore it would be inappropriate to place too much reliance on the SHC size distribution, the assemblage bears particular comparison with two other recently described assemblages: those from Carrigoran Site 6 (Co. Clare; Young 2006e) and Coolamurray Site 7 (near Moneytucker, Co. Wexford; Young 2006a). A comparison with the weight distribution of SHCs on these sites is presented in Table 3.

All three sites share an SHC weight distribution in which the vast majority of cakes fall into the smaller size divisions (especially 100-200g), but with some outlying large cakes. Carrigoran differs from Coolamurray and Navan in having evidence for iron smelting on site. It is possible, however, that all three sites were involved with occasional bloomsmithing. The size distribution of the smaller, conventional, SHCs alone is close to that seen on early blacksmithing sites in Britain too (e.g. the Roman assemblage from Marsh Leys Farm, Young 2005a, a Roman assemblage from Carmarthen, Crew 2003, and medieval assemblages from Burton Dassett, McDonnell 1992 and Worcester Deansway, McDonnell & Swiss 2004; all shown in Table 4).

Navan, Coolamurray and Carrigoran have assemblages which, however, contrast markedly with early medieval assemblages from Clonmacnoise (Young 2005b), Clonfad (Young 2006c) and Woodstown (Young 2006f), which are probably associated with centres of iron production, in which bloomsmithing was a major activity. These sites show SHC assemblages where the modal interval is much heavier (usually 300-400g), the mean SHC weight

typically over 1kg, at least 20% of SHCs weigh over 1kg and at least 5% weigh more than 3kg.

The total amount of slag recovered at Navan is relatively modest, and the material recovered from a very limited range of contexts, so there is little to suggest that iron-working was a significant or long-lived activity on the site.

The small assemblage of clinker from the late ditch (C274) is in strong contrast with the older material from the site. Although the onset of coal use varies regionally, in most areas away from the coast and the coalfields there seems to be little coal use before the advent of mass transportation (canals and railways) from the late 18<sup>th</sup> century onwards.

## Evaluation of potential

The relatively restricted nature both of the main Phase 1 assemblage and its stratigraphic distribution means that the assemblage is likely to form a homogeneous group, with an origin within a restricted set of activities.

The relationship between the various forms of smithing hearth cakes remains rather controversial, and analysis of examples from this assemblage would add significantly to that debate. Additional compositional data for these slags would also assist in evaluating any differences between the activities taking place on a large scale in iron-working centres and those being undertaken on a small-scale on rural sites.

It is recommended that some textural and chemical analysis is undertaken on examples of smithing slags from the assemblage across the range of textures and sizes represented, together with analysis of the tuyère ceramic, which is likely to have been a major contributor of silicate material to the slag.

In addition, the significance of the features present on the surface below the main slag accumulation should be clarified, with detailed descriptions of the features being integrated with investigation of the micro-residues present in environmental samples, wherever these have been collected from relevant contexts.

## References

- CREW, P. 2003. Slags and other iron-working residues. pp. 333-340 *in*: H. James, *Roman Carmarthen: Excavations 1978-1993*. Britannia Monograph Series 20, Society for the Promotion of Roman Studies 2003.
- McDONNELL, J.G. 1992. The identification and analysis of the slags from Burton Dasset, Warwickshire, Ancient Monuments Laboratory Report, 46/92.
- McDONNELL, J.G. & SWISS, A. 2004. Ironworking residues. pp. 368-378, *in*: H. Dalwood & R. Edwards Excavations at Deansway, Worcester, 1988-89: Romano-British small town to late medieval city. CBA Research Report 139.
- YOUNG, T.P. 2005a. Evaluation of metallurgical residues from Marsh Leys Farm. *GeoArch Report 2005/07*. 10pp.
- YOUNG, T.P. 2005b. Metallurgical Residues from Clonmacnoise, Part 1: Evaluation of material from the waste water treatment works (02E1407). *GeoArch Report 2005/08*. 29pp.
- YOUNG, T.P. 2006a. Evaluation of archaeometallurgical residues from N30 Moneytucker – Jamestown, sites 1, 4, 5 and 7 (04E0329, 04E0326, 04E0325, 04E0323). *GeoArch Report 2005/13*. 20pp.
- YOUNG, T.P. 2006b. Archaeometallurgical residues from High Island, Co. Galway (95E0124). *GeoArch Report 2006/04*. 10pp.
- YOUNG, T.P. 2006c. Evaluation of archaeometallurgical residues from Clonfad 3, Co. Westmeath (A001:036). *GeoArch Report 2005/14*. 7pp.
- YOUNG, T.P. 2006d. Evaluation of archaeometallurgical residues from Ballykilmore 6, Co. Westmeath (A001:032). *GeoArch Report 2005/15*. 17pp.
- YOUNG, T.P. 2006e. Evaluation of archaeometallurgical residues from Carrigoran, Co. Clare (98E0338). *GeoArch Report 2005/18*. 12pp.
- YOUNG, T.P. 2006f. Evaluation of archaeometallurgical residues from sites on the N25, Co. Waterford (Woodstown 6, Adamstown 1,2,3). *GeoArch Report 2006/15*. 38pp.

Context	Notes	Weight (g)	Description
3		270	4 pieces of charcoal-rich slag, all probably SHC fragments
5		790	(150)x(80)x80mm 5 pieces of the side of a large thin crust cake. Possibly deformed slightly on extraction. Shows a small area of smooth lip - presumably the blowing side.
		76	small fragment of crust similar to above large mass
		102	small plano-convex SHC 65x50x35mm of which bowl 20mm deep
		90	small pro-tuyère tongue - siliceous glaze on top, dense lobes below, 75x45x25mm
		148	rounded low density slag mass - possibly a biconvex SHC
		210	5 indeterminate slag pieces
		26	strange friable slag with smooth surface - possibly part of 148g mass above
		56	rounded dimpled slag lump - very broken, brownish
6	1 of 5	424	"burger-like" SHC with slightly detached lower thin crust. 105x90x35mm, flat top, crudely dimpled base
		190	broken conventional SHC - possibly part of 268g piece below
		130	natural stone
		168	possibly most of friable small SHC
		62	2 dimpled rounded masses of lining slag
		414	7 miscellaneous SHC fragments
		252	15 smaller iron slag fragments - probably from SHCs
		48	8 small fired (and vitrified in one case) ceramic fragments
		6	natural stone
6	2 of 5	376	64 tiny indeterminate slag fragments
		136	small highly weathered SHC, 70x60x25mm, slightly dished top
		24	small concretionary mass, possibly cored on piece of sheet iron c30x25mm
		304	irregular biconvex discoidal mass of slag - probably an unusual SHC, 100x90x45mm
		126	part of small irregular SHC, deeply dimpled top, charcoal rich base. (90)x(75)x40mm (mainly only 20mm)
		158	small SHC, possibly complete, 85x60x25mm
		30	small disk of lining slag
		228	6 larger lumps of indeterminate iron slag
	probably fallen out of above	34	3 small slag pieces
		92	c70% of small SHC, (70)x(50)x25mm

Context	Notes	Weight (g)	Description
6	3 of 5	38	iron disc c47mm in diameter and 10mm thick - probably <4mm actual iron
		566	38 pieces of indeterminate slag
		10	2 small sherds of probable tuyère with oxidised fabric
		20	large sherd from tuyère lip, strongly curved side
		372	large part of a medium sized conventional SHC, dense crust to 15mm, apparently empty bowl
		268	large part of a medium sized conventional SHC, dense crust to 15mm, broken in 3 pieces
		28	2 pieces of lining slag
		480	4 big pieces of porous thin crust type SHC fragments
6		2600	broad shallow SHC with vesicular grey slag with no real differentiation of hard crust - probably would qualify as a thin crust SHC. Very weathered and porous - not clear how original the top is - some friable material may have been lost. Base is a double bowl shape - but appears a single entity, 260x220x55
6		2990	205x170x95 large thin crust style SHC. Typical rather friable slag, has raised possibly denser area at proximal end, bowl 60mm deep, flat topped
6		12	2 scraps of charcoal rich slag
36		60	possible tiny SHC, circular in plan, flat top pendent lobes, 55x55x25mm
41		50	folded dense iron rich slag, apparently curved rounded a metal object, (60)x(50)x30 has right angle folded side and wide flat area with bowl below
		170	probably most or all of small SHC, but folded - similar very dense shiny slag to folded slag item above. (75)x(60)x35mm
		294	26 pieces of indeterminate iron slag
		38	8 small tuyère sherds
		56	dense lobate slag 70x45x20mm maybe flow from under tuyère - but not typical - dimpled base very dense
63		12	2 pieces of probable corroded iron - one probably a nail
		90	dense slag, probably the lip of a thin crust SHC
		122	4 pieces of indeterminate vesicular and charcoal-rich slag
69	1 of 2	494	part of broad shallow SHC, (130)x100x50mm, bowl 40mm, crust 20mm thick, bowl mainly empty, glazed in centre of hollow, proximal end missing, estimated as 90% of cake
69	2 of 2	154	2 pieces making up most of a small SHC, conventional, 80x(50)x25mm
		112	2 pieces making up half of small SHC, dense, 75(45)x25mm
		196	80x70x40mm small SHC, weathered
		212	18 small pieces of indeterminate iron slag
		54	7 small tuyère sherds
		48	2 pieces of rusty lining slag - small tongue pieces?
		150	rusty moderately dense tongue, usual vitrified top, has flow lobes on base which must have been in contact with a hard surface, 80x60x30mm

---

Context	Notes	Weight (g)	Description
77		570	rottenstone - natural
192		2	scrap of charcoal-rich slag
275		108	pieces of dense clinker - possibly coal-fuelled smithing slag, 85x45x40mm
		24	2 small pieces of clinker

*Table 1: Summary catalogue, by context and bag*

<i>Context</i>	<i>SHC</i>	<i>tongue</i>	<i>Indet. slag</i>	<i>lining slag</i>	<i>tuyère</i>	<i>lining</i>	<i>concretion</i>	<i>clinker</i>	<i>iron</i>	<i>total residue</i>	<i>location</i>	<i>area</i>
3	270									<b>270</b>	upper fill of C2	boundary ditch
5	1412	90	266							<b>1768</b>	main & lower fill of ditch C4	ditch junction
6	8974		1216	120	30	48	24		38	<b>10412</b>	upper fill of C70 over C41	ditch junction
36	60									<b>60</b>	fill of pit C35	ditch junction
41	170		400		38					<b>608</b>	spread in ditch C70	ditch junction
63	90		122						12	<b>212</b>	fill of pit C62 in ditch C70	ditch junction
69	956	198	212		54					<b>1420</b>	fill of gully C68	ditch junction
192			2							<b>2</b>	lower fill ditch C18	curving ditch
275									132	<b>132</b>	late ditch C274	upper
<i>total</i>	<b>11932</b>	<b>288</b>	<b>2218</b>	<b>120</b>	<b>122</b>	<b>48</b>	<b>24</b>	<b>132</b>	<b>50</b>	<b>14884</b>		

Table 2: Nature of archaeometallurgical residues by context

	Navan Site 1	Carrigoran	Coolamurray	Clonfad	Clonmacnoise (Waste water scheme)	Woodstown 6	Clonmacnoise (New Graveyard site)	Burton Dassett	Marsh Leys Farm	Carmarthen
count	17	18	41	513	38	140	117	60	30	136
min	60					68	100	130		100
max	2990	3866	2588	11000	5540	6310	7815	1670	824	820
average	507	553	386	1153	1087	1060	843	550	333	227
<500	82%	72%	83%	29%	39%	40%	50%		77%	94%
<1000	88%	89%	95%	64%	68%	71%	78%		100%	100%
>1000	12%	11%	5%	36%	32%	29%	22%		0%	0%
>3000	0%	6%	0%	7%	8%	7%	3%		0%	0%
modal class	100-200	100-200	100-200	300-400	300-400	200-300	400-500		100-200	100-200

Table 3: Comparison of the Navan SHC assemblage with other Irish early medieval assemblages. Carrigoran from Young, 2006e; Coolamurray from Young, 2006a; Clonfad from Young, 2006e; Clonmacnoise Waste Water Scheme from Young 2005b; Woodstown from Young, 2006f; Clonmacnoise New Graveyard site from the author's work in progress.

The early medieval assemblages from Carrigoran and Coolamurray are interpreted as being dominantly blacksmithing residues. The early medieval assemblages from Clonfad, Clonmacnoise and Woodstown are interpreted as including bloomsmithing residues.

	Marsh Leys Farm	Carmarthen	Worcester Deansway (period 8) 11 <sup>th</sup> – 13 <sup>th</sup>	Worcester Deansway (period 9) 13 <sup>th</sup> -15 <sup>th</sup>	Burton Dassett 14 <sup>th</sup> - 15 <sup>th</sup>
	Roman	Roman			
count	30	136	61	32	60
min		100	168	144	130
max	824	820	1490	1800	1670
average	333	227	492	499	550
<500	77%	94%			
<1000	100%	100%			
>1000	0%	0%			
>3000	0%	0%			
modal class	100-200	100-200			

Table 4: Comparison of the Navan SHC assemblage with British blacksmithing assemblages. Burton Dassett from McDonnell 1992; Marsh Leys Farm from Young 2005a; Carmarthen from Crew 2003; Worcester Deansway from McDonnell and Swiss 2004.

# GeoArch



*geoarchaeological, archaeometallurgical & geophysical investigations*

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