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Assessment of archaeometallurgical residues from 27-31 Church Street, Dublin (03E1307)

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Abstract

This collection included a sparse assemblage of ironworking (blacksmithing) residues of medieval and early post-medieval age, accompanied by traces of evidence for copper alloy working. These materials all occurred in waste pits and dumped deposits. There was no evidence for in-situ metalworking.

The medieval ironworking residues were consistent with an Irish tradition of smithing extending back into the early medieval period, which whilst the dominant form of ironworking across the country has only had limited published evidence from medieval Dublin itself.

The site was used as a foundry during the later post-medieval/modern period, but the collections contained very little archaeometallurgical residue from this phase of the site.

Contents

Abstract 1

Methods 1

Results
- Description of Residues 1
  - Smithing residues 1
  - Indeterminate residues 2
  - Medieval copper-alloy working residues ... 2
  - Foundry residues 2
  - Other 2
- Distribution of residues 2

Interpretation 2

Discussion 3

Further work 3

References 4

Table 1: 5
Table 2: 9
Table 3: 11

Methods

All materials were examined visually with a low-powered binocular microscope where required. As an evaluation, the materials were not subjected to any high-magnification optical inspection, not to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

The examined materials are listed in Table 1.

This project was commissioned by Maeve Tobin, of IAC.

Results

Description of residues

The submitted materials amounted to an overall total of approximately 11kg. Approximately one half (5.5kg) of this comprised whole or fragmentary smithing hearth cakes. The nature of collection is described by Tables 1 and 2.

Smithing residues

SHCs are the typical form of slag mass formed in a smithing hearth. They form from the reaction of melted furnace ceramic, fuel ash and debris (iron, iron oxide) lost from the workpiece. Their size indicates, amongst other things, the amount of iron lost to the hearth during a work-period.

There were only nine slag pieces that were sufficiently complete as to enable estimation of their weight. Several of these were highly weathered and some also bore accretion, so these weights are only estimates of the original weight of the SHCs. These pieces ranged in weight (or estimated weight, where incomplete) from 151g to 788g (for a complex piece, see below), with an average of 391g.

There was a wide range of type of SHC observed, with medium-sized (200-400g) examples dominant amongst the complete examples. These varied from examples with a slightly dished top, to examples in which charcoal-rich slag lay on top of the bowl, giving an overall biconvex shape. One particularly complex example (from (671)) showed the remains of the front

face of the tuyère (or overhanging blowing wall), with a sheet of slag descending from its front, and with a medium sized SHC extending away from the wall, and with the SHC itself contain a fragment of an earlier-formed SHC protruding downwards at an angle from its base. Such a compound mass would be formed when the hearth has not been cleaned between work periods, perhaps to enable the use of the hearth to continue with a single task, whilst, at least partially, removing the previous SHC away from impeding the blast.

Some of the fragmentary SHCs show the brittle fracture of some particularly dense, deep SHCs. These have a thick slag bowl, with coarse olivine crystals suggesting that the bowl has solidified from a fully liquid puddle of slag. Such textures and morphologies are much more common in Irish ironworking that British, and have been termed 'thick crust' SHCs (Young 2012, A3.25).

There were no certain finds of the ceramic tuyères themselves, but several slag fragments provided circumstantial evidence. The large slag block from (671) shows a thin skin of oxidised-fired ceramic attached to the rear of the slag mass. The outline of this suggests that it represents the tip of a tuyère, and at very least a substantial overhang is indicated. A piece from (1128) shows the development of a slag 'beard' on which is probably a tuyère tip. The lower margin of the ceramic is not sufficiently well seen to determine whether it had a straight or curved lower margin, but again must have been overhanging. An interesting slag piece from (1168) apparently also shows an overhang, although this piece is difficult to orientate.

There was very little associated vitrified lining or lining slag compared with many assemblages (perhaps because the slag blocks had been transported for their disposal in the pits.

The evidence for the use of charcoal fuel was almost universal, but the previously mentioned slag block from (1168) showed abundant clasts of coal rather than charcoal.

A clinker block from (11) had a size and shape strongly suggestive of it being a poorly consolidated smithing hearth cake. It contained abundant coal shale and had a weight of 138g. This piece was entirely different in form from the medieval examples. Clinkery cakes such as this are produced when smithing is undertaken using coal (or coke) fuel in a hearth with an iron tuyère. This means that there is no source of silicate and alumino-silicate material other than the fuel ash.

Indeterminate residues

There was a variety of materials formed of dense slag, but which were not identifiable as being from SHCs. This material may include both slag that formed outside the SHC (either as a separate 'beard' for instance, or as a flow into the hearth) and material that was actually from an SHC, but is now too degraded for that to be determined.

Medieval copper-alloy working residues

The collection included a few pieces of slag showing the characteristic weathering products of copper alloy. The slags were mostly examples of low density lining slag, or vitrified lining, but there one piece (from 2061) of more dense slag. These materials are likely to be indicative of the casting of copper alloy artefacts, but it is just possible that some of these materials might be intrusive from the later non-ferrous foundry.

Foundry residues

There was a remarkably small collection of residues from the post-medieval/modern foundry. The residues present were solely from contexts (106)/(109)/(115), the fill of [94]. These residues include fragments of shale-rich clinker (both with and without staining by copper weathering products) and flows of both lead (or lead alloy), apparently over a plank, the impression of which was retained by the lower face of the metal, and by a small flow-lobed mass of copper (or copper alloy). There were no metallurgical slags, in the strict sense, from the foundry phase (Phase 10).

Other

The slag collection included much material that was artefactual – including approximately one quarter of the assemblage by weight that comprised concretions on iron artefacts, rather than archaeometallurgical residues. Where identifiable, these artefacts were mostly nails. Some of those nails were large, and one, from (951), appears to have a rove *in situ*.

As well as the ferrous artefacts, the collections included two fragments of a sheet copper-alloy object (from (1042) and a fragment of a cast iron object from contexts (106)/(109)/(115).

Distribution of residues

The stratigraphic distribution of the residues is illustrated in Table 2.

Evidence for metalworking in Phase 5 was restricted to a single fragment of lining slag (from context (230). The medieval deposits of Phases 6 and 7 yielded most of the evidence for iron working, including all the traditional, dense, SHCs. The SHC-like clinker mass was from Phase 9, and a 17th century date would be entirely compatible with the use of coal fuel and an iron tuyère.

The evidence for the working of copper alloys prior to the foundry ranges across Phases 6, 7 and 9, but is represented by a very small amount of material.

Further evidence of copper alloy working, as well possibly as lead working (although flowed lead may occur during building destruction too), occurs in the deposits associated with the late foundry, but the residues of this period are surprisingly few.

Interpretation

Although the SHC assemblage is very small, it is significant for it is one of the first medieval assemblages from Dublin to have received systematic investigation. Some caution must be taken in interpreting the weight-frequency statistics of such a small collection, but the figures presented above (range 151g to 788g, average 391g) are remarkably similar to those of several other medieval assemblages from Ireland (Table 3a left). It has been argued (Young 2009c) that the development of SHC assemblages with average weights in the 300-400g range is associated with the distribution of iron in fully processed form, as opposed to the early medieval period when most smithing sites show a large proportion of cakes above

1.5kg in weight, probably indicating the refining of raw bloom or partially refined billet.
Assemblages of this type from the Irish medieval converge with those of the medieval period in Britain (which did not, apparently, have an earlier tradition of distribution of iron in a less than fully processed state; Table 3b).

Although it might be tempting to interpret such changes as associated with increasing Anglo-Norman and subsequent British influence, there is good evidence that this was not the case, at least in a direct sense. In this context, the evidence from centres of Anglo-Norman influence, like Dublin, are important. At Church Street, the tentative evidence for the use of ceramic tuyères and the development of the 'thick crust' SHCs with their slag puddles, indicates that smithing was undertaken within a distinctly Irish (not Anglo-Norse or Scandinavian) tradition. Evidence for the use of ceramic tuyères in Dublin is not new (see Rondelez 2013, 165, for a summary), but the new evidence amplifies it.

The light weight of the Phase 9 iron slag/clinker is compatible with the weights of slags observed on other post-medieval sites (Table 3a right). This may suggest the use of an iron tuyère (see Moxon 1703 for contemporary usage).

The scant evidence of copper alloy working in the medieval deposits is insufficient to provide much evidence for its nature, beyond the statement of its occurrence.

The foundry (Phase 10) produced little evidence for activities by way of archaeometallurgical residues.

Discussion

The site provides an indirect source of evidence for industrial activity being undertaken in adjacent areas during the medieval period. That activity included blacksmithing and the evidence is that it was conducted within a tradition of Irish ironworking extending back to the start of the early medieval period. These is some evidence for some casting of copper alloys also being undertaken in the area.

It remains unclear whether the evidence supports continued metallurgical activity through the late medieval period into the early post-medieval, or whether some/all of the residues of this period are simply reworked. The occurrence of most of the copper residues in Phases 7 and 9, suggests that the working of copper alloys at least may have done so, and the ironworking clinker in Phase 9 suggests that iron working either continued to, or resumed in, the 17th century Phase 9.

There are of features from the foundry phase (Phase 10) that have thus far not been interpreted in detail. The following comments are based on observations of contemporary foundries elsewhere and may assist with any interpretation. The provisional text of the stratigraphic report suggests that the fill of at least one of the industrial pits is waste moulding sand. This may suggest that the pits lie within the area in which casting was undertaken. The description of loosely walled pits (such as furnace (94)) resembles that of casting pits. When casting larger objects, it was necessary to place the moulds at a low level, typically within a pit, to enable the molten metal to be poured into the top of the mould. Such pits may be dug into the floor of the moulding shop (or an adjacent external area). They are commonly ephemeral, with loose walling to maintain the edges of the pits whilst they are open. Sometimes foundries maintained more substantial, often brick-built, pits if they were habitually undertaking the same type of casting.

One problem affecting casting floors and their pits would be the presence of groundwater. Careful attempts at drainage are a common feature of moulding floors.

A further feature to be expected associated with moulding floors for works that made large castings would be the foundations for a crane for moving the large moulds (and sometimes the hot metal too).

Three forms of furnace are commonly found in foundries of this period:

- **Crucible furnaces** for melting no-ferrous metals. These typically comprise a narrow shaft opening into an ash pit in a cellar, with the air being drawn by the attached chimney through the cellar, up the shaft and its contained fire-grate, and then laterally through flues to the chimney. The crucible would be introduced into the shaft above the fire grate through a door in the floor of the workshop. Although of slightly unusual plan, it is possible that the brickwork of context (19) might be the base of a truncated crucible furnace of this type.

- **Reverberatory furnaces** were the principle means of melting iron in foundries until the early 19th century, and for large quantities of iron well after that. Although they may involve the use of underground flues to connect the furnace to the chimney, it is possible for these to be entirely above ground, and this leave little trace on truncated sites. They may be indicated by rectangular plinths, with evidence for a firebox at one end, and connected to a chimney at the other.

- **Cupola furnaces** were the principle means of melting iron after the early 19th century. They are usually iron or iron-bound shaft furnaces, often constructed on metal legs, blown by forced draft. They may be represented by square or circular foundations.

As the works on this site is documented as a brass works, it is possible that only crucible furnaces would have been present. Since crucible furnaces typically employ the draft induced by a chimney, there is no need for a blowing engine. Steam power may be employed, however, for other aspects of such works – for blowing any smithy hearths and for turning any equipment used to machine the castings.

Another aspect of a foundry that may lead to burnt deposits is the need for a drying house to dry (and perhaps warm) moulds.

Further work

The context and nature of the archaeometallurgical residues means that there is little extra to be gained from their further scientific analysis. Accordingly, no follow-up analysis is recommended.

However, there are few metalworking assemblages from Dublin, so the material should be deposited in its

entirety with the site archive, in an appropriate institution.

References

Dabal, D.D. & Young, T.P., 2011. Archaeometallurgical residues from Gorteens, 93E0013. GeoArch Report 2011/06. 8pp.

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.

Moxon, J. 1703. *Mechanik exercise or the doctrine of handy works*. 412pp.

Rondelez, P. 2013. Ironworking in late medieval Ireland, c. AD. 1200 to 1600. Unpublished PhD Thesis, University College Cork.

Young, T.P. 2007. Evaluation of archaeometallurgical residues from Willow Street and Mill Street, Worcester. GeoArch Report 2007/12. 10pp.

Young, T.P. 2008a. Archaeometallurgical residues from Coolamurry 7, 04E0323. GeoArch Report 2006/10. 46pp.

Young, T.P. 2008b. Evaluation of archaeometallurgical residues from Prior Park, Cricklade. GeoArch Report 2007/23. 5pp.

Young, T.P. 2009a. Evaluation of archaeometallurgical residues from 35 Mill Street, Worcester*, GeoArch Report 2009/33, 9 pp.*

Young, T.P. 2009b. Evaluation of archaeometallurgical residues from the N18 Oranmore-Gort, Moyveela 3, Co. Galway (E3907). GeoArch Report 2009/39. 6pp.

Young, T.P. 2009c. Evaluation of archaeometallurgical residues from the N8 Fermoy-Mitchelstown, Garryleagh, Co. Cork (E2433). GeoArch Report 2009/47. 12pp.

Young, T.P. 2010. Evaluation of archaeometallurgical residues from the N9/N10 Waterford-Kilcullen, Site AR015, Ballykillaboy, Co. Kilkenny (E2502). GeoArch Report 20010/10.

Young, T.P. 2012. Appendix 3 -. Exploiting the bog -: iron production and metalworking, pp. A3.1 – A3.60 *In:* P. Stevens & J. Channing, *Settlement and Community in the Fir Tulach Kingdom*. National Roads Authority and Westmeath County Council.

Young, T.P. 2015. Assessment of archaeometallurgical residues from Hen Gastell. *GeoArch Report 2015-23*. 12pp.

Young, T.P. 2016. Assessment of archaeometallurgical residues from Tidworth, Wiltshire (ACW338). *GeoArch Report 2016//20*. 11pp.

Table 1: summary catalogue. Assm = assemblage, SHC = smithing hearth cake. Weights in gram. S = sample, I = item.

context	s wt	I wt	I no	notes
Phase 5				
199	14	14	1	concretion on iron
200	25	25	1	concretion on iron
230	14	14	1	twisted piece of lining slag,
400	414	385	1	iron object in concretion with cobbles, needs X-Ray
887	38	38	1	decomposed concretion containing a probable medium-sized nail
951	92	92		large nail with possible washer, possible second flat piece of iron as well (explosion makes it difficult to determine)
Phase 6				
209	109	109	1	fragment of dense SHC with deep smooth bowl-shaped top; base irregular with crudely dimpled lobes.
289	34	23	3	three corroded and accreted nails
		11	1	flat piece of iron in concretion
379		99	1	soft ochrey lump of weathered material - possibly slag but may be purely concretion
392	60	60	3	concretions with nails
413	214	20	1	nail with very large c30mm square head
		157	1	fragment of thick crust SHC with 25mm thick crust
508	95	8	1	stone
		86	1	concretion on probable large nail (needs X-Ray)
671	950	788	1	complex smithing slag mass: 100x120x45mm main SHC, which has fragment of earlier SHC sticking downwards from base, also overlain by large mass of quartz-rich lining slag, rear face of which shows imprint of tuyère tip; base/front of tuyère has slab of slag oriented vertically with the main SHC arising out of its front; some charcoal particles

context	s wt	l wt	l no	notes
		154	1	probable slag piece encased in charcoal and plant-rich concretion - shape suggests that core is a fragment of small SHC, but slag not actually visible
708	258	227	1	badly decomposed small concavo-convex SHC, 80x60x35mm
845	399	386	1	95x80x35mm, plano-convex dense SHC; top of SHC is smooth, planar; internally shows horizontal lines of vesicles; base of SHC is formed of slightly lobes with large planar bases, highly polished in appearance; no fuel clasts, except tiny charcoal clasts in top locally
906	98	96	1	part of small SHC, highly weathered, charcoal rich on base, dimpled top with central hollow
913	151	151	1	60x80x35mm, dense small SHC, slightly dished top, slightly prilly base probably, but partly obscured
1030	363	363	1	SHC, folded hot at one end, 70x130x30mm, plano-convex originally, microprilly base, dimpled/fuel-impressed top
1042	220	5	1	copper alloy sheet object (needs cleaning by conservation lab)
		139	22	heavily accreted corroded iron nails and probable nail fragments (X-Ray?)
		16	12	concretionary debris
		<1	1	copper alloy sheet fragment (possibly part of item above)
		16	4	stones
1128	2345	605	1	large block with concretion lying over probable SHC with large downward protrusion
		466	1	concretionary mass with lots of organics as per upper layer of slag above; in this case it is unclear if there is slag and staining might suggest an iron core
		420	3	substantial fragments of SHC bowls with very thick crusts
		437	1	block of prilly slag with lots of charcoal - could be prilly SHC or FB
		295	2	fragments of dense but porous very iron-rich slag, but without good surfaces for giving morphological identification
		68	1	slag beard attached to base of overhang or tuyère; ceramic apparently has planar base, but curved frontal erosion, although curved base just possible
1168	165	10	3	slag debris
		155	1	complex zone of interaction possibly overhanging between wall or tuyère and slag, with slag penetrating in reddened lobes into ceramic; overhanging prilly slag abuts reduced-fired ceramic and includes abundant coal clasts

context	s wt	l wt	l no	notes
1314	369	369	1	95x80x50(30) mm, neat well-formed biconvex SHC, lobate and dimpled surfaces, probable charcoal clast on top, but might be in concretion
1344	12	<1	1	bloated ceramic with Cu-weathering products
		4	1	fired clay
		8	1	concretion on probable large nail
1506	40	40	3	concretions on iron
1519	53	53	1	iron object exploded into 8 fragments
1552	148	148	1	ball of charcoal-rich slag with dimpled surface extending of much of outside - possibly indicating that this is a more-or-less complete small SHC, but this is not certain
1721	544	522	1	(60)x90x60mm (40mm bowl), dense small SHC, lower low dimpled bowl, then lower density central section and denser upper pad with slightly lobate margin; overall slightly biconvex, probably 60-70% preserved; some stone and concretion included in weight, so originally c.750g; bowl has tubular vesicles
		19		corroded and accreted nail, with a few concretionary debris fragments
1889	33	33	1	lobate mass of crystal-rich lining slag - flat top with lobate/dimpled base - could be considered a fragment of tongue
1952	326	326	2	badly weathered fragments of smithing hearth cakes, details not determinable, both contain some iron
1972	282	272	1	neat SHC; plano-convex but with charcoal-rich material stacked on planar top either side of axis; 90x75x50(25) mm; very weathered
2061	106	106	1	block of copper slag, contains metal, dense (not washed to conserve)
Phase 7				
69	216	213	1	65x70x30mm small, very dense SHC with irregular lateral protrusion
203	972	626	1	large concretion on iron - object inside unknown, not exploded, needs X-Ray (excess cobble concretion trimmed off - but item still not visible)

context	s wt	l wt	l no	notes
270	508	508	1	large piece of unusual very thick crust SHC, possibly due to deformation and possibly due to planar slab of ?stone in base of hearth; proportion unclear but cannot be more than half
1165	30	30	1	broken lump of rather frothy FAS with abundant Cu-weathering products
1171	63	72	5	brown glassy slag with Cu-weathering products; one fragment denser - so might have metal; all pieces just possibly fragments of a single piece
Phase 8				
86	12	12		fragmented iron-rich concretion, probably on iron
Phase 9				
11	148	138	1	70x90x40mm, clinker mass, shale-rich, size and shape suggestive of SHC
11	38	38	1	concretion on iron
11	251	55	3	concretions on iron - 2 appear to be nails
		151	1	concretion just starting explode - host sediment fine, core not seen
		8	1	dimpled vitrified and glazed foliated lining with Cu-alloy staining
		18	1	concretion in sediment with shell and bone - not certainly an iron concretion
11	32	9	1	nail
		23	1	gravelly concretion broken to reveal probable nail
11	53	53	assm	highly fragmented and decomposed Cu slag
Phase 10				
106/109/115	1380	127	assm	debris - much rust, slag, clinker, etc.
		308	2	lead spill - bears imprint of wood (plank?) on one side, irregular the other
		156	1	fragment of cast iron
		121	1	lobed copper alloy spill
		286	4	slabs of shale-rich clinker with Cu staining
		362	4	pieces of clinker without Cu staining

Table 2: summary of residues, by type and context. SHC = smithing hearth cake. Weights in grams.

context	conc.	I slag	SHC	other smithing	slag indet	fired clay	Cu alloy artefact	Cu slag	clinker with Cu	clinker	Cu spill	lead spill	cast iron
Phase 5													
199	14												
200	25												
230		14											
400	385												
887	38												
951	92												
Phase 6													
209			109										
289	34												
379	99												
392	60												
413	20		157										
508	86												
671			788		154								
708			258										
845			386										
906			96										
913			151										
1030			363										
1042	155						5						
1128	466		1025	68	732								
1168				155	10								
1314			369										
1344	8					4		<1					
1506	40												
1519	53												
1552				148									
1721	19		522										
1889				33									

1952		326							
1972		272							
2061			106						
Phase 7									
69		213							
203	626								
270		508							
1165			30						
1171			63						
Phase 8									
86	12								
Phase 9									
11	276		61		138				
Phase 10									
106/109/115				286	362	121	308	156	

Table 3. Comparison of the weight frequency statistics of the SHCs from Church Street, Dublin, with those of other blacksmithing assemblages. All weights in gram.

a. medieval sites in Ireland

Site:	Garryleagh	Clonmacnoise	Coolamurry	Moyveela	Ballykillaboy	Gorteens
County:	Cork	Offaly	Wexford	Galway	Kilkenny	Kilkenny
Reference:	Young 2009c	Author's unpub. data	Young 2008a	Young 2009b	Young 2010	Dabal & Young 2011
Age:	13th-14th	medieval	12th-13th	17th-18th	16th-17th	17th-18th
SHC count	25	33	41	15	106	27
SHC min. wt	84	68	62	44	50	52
SHC max. wt	802	1457	2588	388	478	748
SHC mean wt	316	341	386	134	134	206
% <500g	76%	79%	80%	100%	100%	93%
% >1000g	0%	6%	5%	0	0%	0%

b. medieval sites in Britain

Site:	Tidworth	Hen Gastell	Worcester 35 Mill St	Worcester Willow St	Prior Park Cricklade total	Worcester Deansway (period 8)	Worcester Deansway (period 9)	Burton Dassett
Reference:	Young 2016	Young 2015	Young 2009a	Young 2007	Young 2008b	McDonnell & Swiss 2004	McDonnell & Swiss 2004	McDonnell 1992
Age:	10-11th	11th-12th	12th	12th	11th-15th	11th – 13th	13th-15th	14th- 15th
fuel	charcoal		charcoal	charcoal	charcoal			
SHC count	12	7	23	28	17	61	32	60
SHC min. wt	80	72	74	86	156	168	144	130
SHC max. wt	680	1000	782	770	794	1490	1800	1670
SHC mean wt	265	260	233	327	329	492	499	550
% <500g	75%	86%	91%	82%	82%			

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