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Evaluation of archaeometallurgical residues from Greencastle, Co. Down (AE/01/13)

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Abstract

The assemblage includes a total of 3.7kg of material from deposits ranging in age from 13th century to post-medieval. The majority of the material probably comprises residues from iron-working (smithing), although some of the coal residues are not certainly from smithing; there is a small amount of material from other processes, including fuel ash slags which may not be metallurgical, a single sherd of crucible and some highly fired ceramic of uncertain origin, but possibly clay coatings (shroud) applied to a metal artefact either during brazing or steeling.

The material occurs largely in dumped deposits, so is largely lacking any relationship with metallurgical structures or features. The one exception may be the problematic clay shroud fragments, which are spatially associated with possible hearth c159.

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Methods

All investigated materials were examined visually, using a low-powered binocular microscope where necessary. All items were logged to a database (Table 1). As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Results

Description of the residues

Iron slag
Slags from the working of iron occur both as well-formed smithing hearth cakes (SHCs) and as smaller indeterminate slag fragments, some of which may be parts of SHCs, but most are probably slag which did not become incorporated within the SHC, but formed elsewhere in the hearth.

The SHCs for which the original size is estimatable include the following examples:

C5: 100g piece (250g original weight), Ph. 5
C5: 656g piece (729g original weight); Ph. 5
C30: 600g piece (750g original weight); Ph. 1
C34: 234g complete; Ph. 4
C39: 308g complete; Ph. 3

Of these all are very dense, moderately vesicular examples of conventional form (as are the other SHC fragments), except for the example from c39. This cake is still attached to the hearth wall or tuyère front (discrimination between these is not possible) and has a deep, almost inverted-pyramidal form comprising a mass of amalgamated prills. The slag attached directly to the lining fragment shows a maroon surface tint.

In contrast, none of the conventional SHCs shows a surviving wall attachment. These SHCs are typically rather tabular, with flat tops, only moderate vesicularity

and a general lack of fuel inclusions. They probably range down from the larger examples listed above to small examples of less than 100g, but none of the small examples is sufficiently well preserved to be described with certainty.

Clinker and other coal residues

This group of materials includes pieces of fresh coal, pieces of coal shale with local vitrification and clinker. The clinkers (solidified molten or partially-molten coal residues) range from porous varieties with occasional inclusions of shale, through to dense well-flown materials with steely-grey interiors and dark glassy surfaces with a maroon sheen. The denser clinkers are probably also classifiable as iron slags.

Fired and vitrified stones

A variety of pieces of residue are identified as heat-altered stone. They vary from light, vesicular, pumice-like materials, often with a grey to slightly purple or lilac colour (which are interpreted as rocks with a high original carbonate content, which has dissociated to create the vesicles), through to dense siliciclastic rocks (such as sandstones), which may show some partial melting and are typically coated in fuel-ash glaze.

Such rock particles may be accidental incorporations in hearths through having been introduced within the fuel (particularly in coal), or may be fragments derived from the substrate of a hearth, or even may be discrete clasts that had been incorporated within a hearth wall.

Another possible interpretation of some of this burnt stone is that it might represent impure limestone that has not reacted fully during lime-burning.

Certain fragments of coal shale ("dirt") have been excluded from this category and counted with the coal residues.

Smithing "floor"

These materials are small concretions inn which corrosion of iron particles has provided an iron-rich cement which binds together particles of hammerscale. Such concretions may form within a build-up of hammerscale on the smithy floor (hence the name), but may equally form in an accumulation of smithy waste elsewhere. The occurrence of particles such as these may indicate reworking of a hammerscale-rich deposit elsewhere, but if the concretions formed *in-situ* then they indicate a hammerscale-rich deposit that was not recognised during excavation.

Oxidised fired clay "lining"

Several pieces of vitrified oxidised-fired "lining" were recovered in addition to the material adhering to the SHC from c39 described above. Several pieces are simple planar fragments (from c23, c58 and c69), but there are three examples (from c23, c30 and c69) which show pats of the margins of blowholes of about 25mm diameter.

It is not known whether these fragments derive from a simple walled hearth with a blowhole (as is most common in British medieval contexts) or whether they are from the tips of ceramic tuyères (the normal Irish medieval practice).

The apparently large proportion of blowhole margins (the small sample size notwithstanding) might be taken as indicating that repair of the hearth typically involved repair of the blowhole (for instance after removal of an adhering SHC like that from c39).

Low Density Fuel Ash Slag

The category of fuel ash slag (LD-FAS) is employed here for mostly pale, often internally grey but superficially khaki-coloured, highly vesicular, fragile residues, generally in isolated or aggregated rounded blebs. They are distinct from the harder, denser, grey, maroon-surfaced, clinkers described above, which are also technically fuel ash slags.

The residues are dominantly glassy, but locally bear fine sand-grade grains of pre-existing sediment.

Such slags are unlikely to be of metallurgical origin, but rather might be expected to derive from domestic hearths (particularly where the fire is kept alight for long periods) or from structures like corn-drying kilns (e.g. Young 2010a). They may be particularly prone to formation in hearths cut into a calcareous substrate.

Reduced fired clay shroud?

Dark, vesiculated, vitrified, externally glazed, reduced-fired clay fragments that are curved in section were recorded from c138 and c164. They superficially resemble tiny fragments of crucible, but are not formed of a typical crucible fragment and the internal voids appear to have been (on the basis of extremely incomplete examples) from 6-8 mm in diameter. One example appears to show a right angled, instead of curved central cavity, and one shows an apparently planar extension to the curved cavity. The largest piece is only about 10mm by 20mm.

Various fragments show the termination of material, which tapers down towards the margin of the cavity, forming an acute angle.

The exterior of the pieces shows a dark, almost black glaze, which is often irregular, with fissures and irregular penetration of the vitrification towards the central cavity, suggesting break-up of the material during vitrification.

In most cases the central void is much less strongly fired than the outside, but in one example there is a delicate raised glassy meshwork, with a flat, but curved surface, raised above the interior of the ceramic, indicating that the glass had flowed over the surface of a curved object originally contained within the void.

The fragments are too small for, and do not show the usual vitrification pattern of, crucibles. The firing is too intense and reduced for moulds. Although the nature of these tiny fragments remains unclear, there are two possible scenarios which might be considered. One would be the rather trivial possibility that these were soft, plastic, ceramic (perhaps clinker?) fragments that have adhered to the surface of the smith's tools – perhaps a round-sectioned poker. The second, more interesting possibility, is that they represent deliberate clay coatings applied to metalwork during processing.

There are two particular circumstances where this is undertaken. The first is during the brazing of ironwork

with a non-ferrous metal (usually copper alloy) coating, such as was undertaken to place the bronze coating on wrought iron bells (Young 2009b, 2009c and *in prep.*). In this case the coatings would be extremely thin, and the central cavity small – so they might perhaps be for brazing pins for instance. Another possibility is a use to partially coat an iron artefact during steeling. The idea of this is to prevent carbon reaching those parts of the artefact that were not required to be steeled – for instance the smith might prevent carbon from reaching the back of a knife, which would be preferred to remain soft, with just the cutting edge becoming hardened (and more brittle).

Crucible

A single probable sherd of crucible was recovered from c169. The piece is deformed, but appears to represent the angular rim of a crucible some 80mm in diameter, with an upright rim 8mm thick. The fabric is coarse and quartz-rich. The superficial glaze is variable from clear (over some of the protruding quartz grains) to blood red, suggesting the incorporation of some copper.

Other materials

Besides the materials described above the assemblage also includes pieces of iron, some certainly artefacts, particularly nails, which have generally produced concretions. At least one piece of this material has "exploded" though rusting after excavation.

The assemblage also includes several pieces (from c23, c39, c43) of fired clay that is even textured, silty and which contains moulds of substantial organic pieces (possibly twigs or straw?). This material is interpreted as burnt daub.

Distribution of the residues

The stratigraphic distribution of the different residue classes is illustrated in Tables 2 and 3.

In general there is a wide and sporadic distribution of material, in agreement with much of the residue being in dumped deposits.

None of the residues relates with certainty to any structure, although the occurrence of the possible clay shroud fragments do appear related to possible hearth c159.

Interpretation

The majority of the residues derive from iron-working. There is no clear indication that smithing was undertaken within the excavated area, although that remains a possibility, particularly within Phase 1.

The SHCs range up to 750g weight. The assemblage is very small, so comparison with the weights of SHCs on other sites cannot reasonably be attempted. This size range does however correspond to that observed on medieval sites involved in simple blacksmithing (i.e. not involved in the chain of iron production, but rather the end use of iron in the manufacture or repair of artefacts) in both Britain and Ireland during the medieval period.

The occurrence of both "conventional" SHCs and those comprising amalgamated prills has been noted on other sites, particularly those with a late medieval to post-medieval age where "light" smithing was being undertaken (e.g. Ballykillaboy, Co. Wexford, Young 2010b and Ballykilmore, Co Westmeath, Young 2009a and *in prep.*)

The only microresidue evidence for smithing comes from the small "smithing floor" concretions from c23. This context also yielded a range of other residues associated with iron working. The context is interpreted as one of the Phase 4 early post-medieval midden deposits, and it is unlikely that it indicates in-situ iron working.

Most, if not all, of the clinkers are likely to be residues from iron working too. The high levels of inorganic material in coal readily lend themselves to the generation of clinker, or slag, outside of the main SHC development in the hearth. Certain clinker occurs in Phase 4, but materials that are probably clinker occur in Phases 1 -3 as well. Identification of these earlier materials is not quite certain, as vitrification of stone clasts may mimic the vitrification of coal dirt. This is unfortunate, for it leaves slightly open the question of the occurrence and use of coal on the site in the medieval period. It is however likely that the possible clinkers are indeed such and that coal was being used from the 13th century onwards. Clear and unequivocal use is indicated in Phase 4, but it is known that the relatively local sources at Coalisland, Co. Tyrone, were being exploited by the mid 17th century (Bardon, 1991, p. 203). Supply of coal in the medieval period might have been from undocumented exploitation of the East Tyrone coalfield, or supply might have been by ship from England or Wales (although again, documentary evidence suggests that a significant level of coal export from south Wales to Ireland was a largely post-medieval development). It is clear, however, from the list of medieval pottery from the site, that trade with areas with suitable sources (e.g. Bristol) was routine, Early use of coal in Ireland is rare, and poor dating evidence precludes the close dating of the spread of its use.

It is unclear whether the smithing was undertaken with hearths blown through a ceramic tuyère or through a blowhole in a clay wall; the blowhole fragments are just too small to allow discrimination. The use of a ceramic tuyère is the tradition in Irish smithing, but on some post-medieval sites (e.g. Ballykilmore, Co. Westmeath, Young 2009a) the tuyères appear to have been developed to such a large size (>200mm diameter in some instances) that they become more difficult to recognise.

The curious possible vitrified clay shroud fragments are much smaller than previously-recorded examples of such materials from brazing (e.g. Young 2009c), so their identification is extremely tentative. Their occurrence only in deposits spatially associated with the possible hearth c159 suggests a link with that feature.

The only good evidence for non-ferrous metalworking is a single crucible sherd, that appears to have been used for handing copper alloy, from c169 (Phase 3).

The LD-FAS is an interesting material, which, although theoretically able to been derived from a number of processes, has been particularly associated with corn drying kilns in some recent work (e.g. Young 2010a). This material all derives from phases 2 and 3 and appears to be present within general refuse.

Evaluation of potential

This rather varied group of residues is mainly associated with dumped deposits many of which are of uncertain age. With the possible exception of the material tentatively identified as clay shroud, the residues are not associated with hearths or other potential metallurgical features. This reduces the value of further analytical investigation of any of the material.

There are two areas in which further investigations could usefully be employed:

Firstly, there is the question of the date of introduction of the use of coal. This is an interesting question, but the evidence from the thirteenth century deposits is equivocal. The clinker-like residues are probably clinker, and analysis could confirm this. However, it is quite possible that stratified finds of coal, or coal residue, may already be known from the castle itself, negating the need for analysis of this assemblage.

The second area of interest is the assemblage of possible clay shroud material. Analysis of some of these fragments would help determine their origin. SEM imaging and microanalysis of the specimen (from c138) with the internal glass should reveal if the piece was used in brazing; similar internal glazes on the shroud from Clonfad had raised copper contents. The general use of brass rather than bronze in the later medieval period would also be expected to result in an elevated zinc content if used for brazing with this alloy. Sectioning of a piece, although destructive, would also allow for examination for contamination by metal droplets, and would also confirm the identification of the material as fired clay rather than clinker.

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Table 1: summary catalogue by context. Weights in gram.

context	***weight***	***description***
unstratified. possibly 121 NW corner	36	3 small pieces of slag
	116	rounded mass of accreted ash and organics bound by iron corrosion - could be cored on slag but more likely iron metal - magnetic
Tr1 surface	13.8	irregular dimpled lump of iron slag with charcoal in dimples locally
topsoil	106	very dense iron slag - probably part of small SHC
1	108	small fragment of extremely dense SHC, irregular top, probably fuel impressions, finely dimpled base, fuel probably charcoal
5 (+50?)	100	40%? of small SHC
	2	iron fragment, curved, ?disintegrated nail
	8	3 small slag pieces
5	656	110x95x35 95% of dense compact slightly biconvex SHC
11	14.2	irregular dimpled low density slag, with silver/maroon surface - so probably clinker
23	10	grey green glassy slag lump with partially fused quartz grains -
23	5.5	coal - 3 pieces
	34.4	5 shale fragments with lightly vitrified surfaces
	9.8	vitrified lining
	11.2	vitrified margin of 25mm diameter blowhole, very clinkery slag attached
	3.4	fired clay with lots of organic temper- has hole right size to be blowhole but has reduced-fired margin, so probably daub
	104	14 small pieces of clinker - variable textures
	4	small short dome headed nail
	76	large part of small SHC ,attached sediment contains flake hammerscale
	48	dense slag disc, like a tiny SHC, c50mm diameter, accretionary layer with god organics and hammerscale, slag has probably coal residue inclusion
	24	fired clay with grit - similar to other pieces with coarse organics
	8	lining slag like bleb - possibly clinker
	12	3 small smithing floor concretions
	40	two pieces of slag with adhering concretion

context	*weight*	*description*
27	10.1	bone
30	600	80% or more of small extremely dense SHC. 110x(90)x50, originally c110 diameter, bowl has slightly dished top, base irregular
	16	indeterminate iron slag fragment
	4	glassy slag - 4 or 5 small fused, and now vesicular, pebbles
30	17.8	fired clay with vitrified surface showing margin of 25mm diameter blowhole
30	74	broken pebble with possible mortar on outside - inside vesicular with white glassy material in voids
34	234	small dense irregular SHC, 80x65x35, prilly base, top has fine adhering organics (chopped straw?)
36	36	9 low density clinkery blebs
	20	small angular fragment of very dense slag
36-39	150	c20 pieces of low density "clinker" and 3 denser more iron -rich pieces. Looks like coal residue - but accompanied by charcoal (small twigs) -lacks characteristic colour of coal clinker - but clear examples of shale inside melt. Also lots of dust/matrix
39	1	fired clay with ?straw impression. Oxidised orange
	6	pebble with vitrified surface
	4	2 pieces of vitrified vesicular friable droplets, one with shale clasts
39	308	small SHC with straight but overhanging wall/tuyère attachment on one side. Pendent prills of dark, dense, very shiny slag on base near the wall, further out slightly more friable. Top appears to show shale fragments, wall attachment not deep - so unclear if true wall or tuyère tip, 75x75x50mm. Internal texture very vesicular where seen. Wall slag shows maroon surface
41	48	many pieces of low-density friable frothy slag, in rounded blebs 20mm across mainly - fuel ash slag
42	2.5	irregular dark to maroon glassy bleb - probably several small fused pebbles
43-66	13.1	4 masses of low-density friable frothy slag, 2 big 2 small, fuel ash slag
43	2.8	small piece of low density frothy slag material - a dark friable vesicular glass bearing sediment grains, fuel ash slag
43	52	18 plus debris of frothy low density fuel ash slag
	12	iron-rich slag fragment with piece of probable coal shale - so may be clinker
	4	vitrified pebble - possibly clinker

context	*weight*	*description*
	24	lump of hard buff fired clay with organic temper and gently curved out surface - daub?
44	43.9	corroded iron lump, exploded, appears to have been nail
47	1	extremely friable - probably skeletal vitrified pebble / fuel ash slag
	7	iron corrosion binding gravel
	2	small pebble in ?mortar
48	62	c45 pieces plus debris of vesicular friable glassy fuel ash slag, some show fuel impressions
49	24	rounded grey/lilac vesicular crystalline lump - vitrified stone?
50	1	broken rounded bleb of pale frothy glass with pale crystals
58	4.1	oxidised clay with vitrified surface - almost planar - lining or tuyère?
59	24	iron slag lump
68	4.8	fused very shiny blebs of moderately dense slag
	13.3	corroded iron in concretion
	6.1	natural stone
69	20	3 pieces of lining slag - 2 conjoining to show part of edge of 20mm diameter blowhole
	58	dense iron slag lump
82	0.5	fragmented low-density friable frothy slag
95	5.7	9 pieces of small droplets of low-density friable frothy fuel ash slag
97	11.5	11 pieces of vesicular frothy glass plus debris, fuel ash slag
101	19	coal
110	1.3	dark vesicular frothy glass bearing a few white specks, probably fuel ash slag rather than clinker

context	*weight*	*description*
117	34	small piece of grey vesicular lining slag with smooth glassy dished top, with surface extending over "rim" at one end. Bulk is a pale fuel ash slag like material of fused sediment - but has one small adhering blob with the maroon colour and denser fabric of typical clinker
121	32.4	vesicular grey vitrified pebble
121	49.5	ball of corrosion around iron
121	32	pale grey vesicular glassy slag. Has lip at one end with possible sandy contact on basal surface (cf c117), dense fuel ash slag, ?upper part dark maroon/grey dense vesicular, lower part pale green sandy.
128	12	dimpled nub of grey vesicular moderately dense slag with vitrified glassy surface, with a maroon tinge. Probably clinker
135-136	15.9	small irregular finely dimpled lump of dense slag
	4.3	well flown bleb of dense slag - slightly maroon surface extremely shiny
	2.7	vitrified pebble
138	3.7	9 tiny fragments (plus a few bits) of dark grey, highly fired, vesicular, crucible-like material. 5mm wall typical thickness, very rich in organic temper - small leaves? where not so intensely fired. Internal diameter, where seen, appears to have been 6-8 mm for the simple parts. One pair of fragments seems to show a flange extending off the core (assuming the core was an object). One piece shows a raised internal glass trellis.
	0.6	fused bleb, green glass with local reddish tint, highly vesicular.
	28.1	small dense SHC fragment
139	7	Quarter-round section of extremely low density material, crystalline and vesicular in core but green glassy dimpled surfaces. One of the ?fracture surfaces also has some glass - suggests broken fired stone
162	6.1	6 lumps/blebs of low-density friable frothy fuel ash slag
164	2.7	7 tiny pieces of vitrified material - 2 appear to be fragments of a very thin-walled, crucible-like material as in c138, with dark external glaze with brown spots - others less clearly from hollow piece and maybe from blebs, two of which are very irregular and show pale inclusions so might possibly be coal residues.
169	6.5	probable rim of thick-walled coarse-grained crucible. Wall 8mm thick at rim. Reddish glaze suggests use of Cu-alloy. Fabric very quartz-rich. Curvature suggests vessel 80mm in diameter

Table 2: Residue classes tabulated by phase and context. Totals by phase in the toned rows. Weights in gram.

context	SHC	Indet. iron slag	smithing floor	lining	LD-FAS	burnt stone	vitrified pebbles / misc lining slag	clinker?	clinker	coal / coal shale	shroud?	crucible	iron	daub	stone
Phase 1															
30	600	16		18		74	4								
110					1										
117								34							
128								12							
138	28						1				4				
139						7									
164											3				
	628	***16***		***18***	***1***	***81***	***5***	***46***			***7***				
Phase 2															
11								14							
41					48										
44													44		
47						1							7		2
48					62										
49						24									
50					1										
58				4											
59		24													
68								5					13		6
69		58		20											
82					1										
121					32	32							50		
		82		***24***	***144***	***57***		***19***					***114***		***8***
Phase 3															
36		20							36						
36-39									150						
39	308					2			4					1	
42							3								
43-66					13										
43					55			4	12						
95					6										
97					12										
135-136		20					3								
162					6										
169												7			
	308	***40***			***92***	***2***	***6***	***4***	***202***			***7***		***25***	

context	SHC	Indet. iron slag	smithing floor	lining	LD-FAS	burnt stone	vitrified pebbles / misc lining slag	clinker?	clinker	coal / coal shale	shroud?	crucible	iron	daub	stone
Phase 4															
23	76	48	12	21			10	8	104	40			4	27	
34	234														
101										19					
	310	***48***	***12***	***21***			***10***	***8***	***104***	***59***			***4***	***27***	
Phase 5															
unstratified. possibly 121 nw corner		50											116		
topsoil	106														
1	108														
c5 (+c50?)	756	8											2		
	970	***58***											***118***		

Table 3: residue classes totalled by phase. Weights in gram.

	SHC	Indet. Iron slag	smithing floor	lining	LD-FAS	burnt stone	vitrified pebbles/ misc. lining slag	clinker?	clinker	coal / coal shale	shroud?	crucible	iron	daub?	stone
1. 13th century construction	***628***	***16***		***18***	***1***	***81***	***5***	***46***			***7***				
2. Subsequent infilling and levelling up of the site		***82***		***24***	***144***	***57***		***19***					***114***		***8***
3. 14th century building with stone foundations	***308***	***40***			***92***	***2***	***6***	***4***	***202***			***7***		***25***	
4. 17th century midden (rubbish) deposits	***310***	***48***	***12***	***21***			***10***	***8***	***104***	***59***			***4***	***27***	
5. Modern farm-related debris.	***970***	***58***											***118***		

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