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Evaluation of metallurgical residues from Dunnyneill Islands (AE/03/71)

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Abstract

Excavations on Dunnyneill Islands yielded a total of 1.75kg of residues from pyrotechnological processes (of which 1.19kg was contributed by just two pieces of smithing hearth slag). Despite the small size of the assemblage, over half of which came from topsoil or disturbed contexts, there was a strong relationship between residue type and both site phase and geographical location.

Phase 2 contexts yielded four examples of glazed stones (Trenches 1 and 4). These glazed stones indicate a very high temperature process, but one in which a worked metal was not contributing to slag formation. These materials were likely, therefore, to have been generated in a glass-working hearth, in a metal working hearth in which the metal was enclosed in a crucible or possibly even in some non-industrial process in which high temperatures were generated. Phase 2 also yielded a fragment of a straight walled crucible, but the evaluation was not able to determine the use of this crucible.

Phase 3 contexts only yielded a single small piece of iron-working slag (Trench 1).

Phase 4 contexts produced 4 fragments of crucible and two slag fragments associated with the probable working of Cu-alloy (Trenches 1, 2, and 4). One of these sherds is from a crucible identical to that seen from Phase 2. There was also a single fragment of a smithing hearth cake with an unusual texture indicative of very high temperature conditions (Trench 4).

In the lower section of the site, the low earthwork yielded a significant assemblage of iron-working (smithing) slags from the ditch fill and a small amount from the bank construction. The same area yielded a large collection of iron-working slag from disturbed contexts.

Contents

Description

The material falls into several distinct categories, and will described by those divisions:

1. glazed pebbles

The collections include five small specimens in which stone chips have become glazed. Four of these were stratified in Phase 2 deposits (three from 421, one from 110) and the fifth was from topsoil (301). The pieces contained different geological substrates: two were sandstone, one was probably calcareous mudstone, one was a fossiliferous shale and one was probably a tuff.

The glaze in most cases was thin, even and fairly clear, sometimes with a pale greenish colour. One piece (sf #485) was rather more complicated, and showed a colour change from clear or slightly green where attached to the stone, but becoming darker towards the ?top of the piece and almost black where it is contact with some ashy material.

2. crucibles

There were four certain pieces of crucible, plus two other probable pieces. Only three (sf #18, #206 and #700) provided any indication of form. Sf #18 appears to form part of a gently concavo-convex disk, 4.5mm thick at the thickest point seen, about 50mm in diameter, with widely splayed short rim. The piece is slag on the concave side. The most likely interpretation of this piece seems to be a crucible lid, although the form is not unlike some “heating trays” (e.g. cf. Zienkiewicz 1993, fig 46 nos 7 and 9), . Sf #700 is the largest fragment, has a pale fabric and shows a flat, or gently incline base, an outer face almost vertical, or even slightly inturned, 20mm high, culminating in a slightly outurned rim with an apparent diameter of 60mm. The upper surface is very gently inclined inwards, giving a thickness of 11mm at 15mm inside the rim. Both inner and outer faces are vitrified, with the outside showing deep fissures and the vitrification on the inside including a few small yellowish patches. Sf #206 is a small sherd, almost triangular in cross section. The piece gives the impression of having a steep side, turned out into a rounded rim, but with only a gently concave upper surface, which is slagged; it is clearly a small fragment of a similar crucible to #700.

These two sherds show some similarity in general form to the dog-bowl crucibles recorded in many sites in the Early Medieval of the Atlantic seaboard. They are similar in general form to type B1 at Dunadd (Lane & Campbell 2001), although the side of the crucible sherds from Dunnyneill is only vertical externally. This type of crucible at Dunadd and elsewhere is typically not reduce-fired, has been heated from above and in at least some occurrences has been linked to glass working rather than metalworking, and in others to the parting of silver from gold (Bayley 1995). The present examples do appear to have been reduced, and the example with the base preserved shows the base to have been heavily vitrified and fissured suggesting that heating from below had occurred; the Dunnyneill crucibles seem therefore to have been used differently to other examples of a similar shape elsewhere.

Other, less well-preserved, pieces, appear to have been rather thin-walled. Further investigation of the pieces might yield more information on form, but it seems possible that the thin splayed material is from a crucible lid. All specimens were in a pale grey, sandy fabric.

All the crucible fragments were coated in glassy slag, which in some examples showed patches with a red or chestnut colouration suggestive of the presence of copper oxides, but the two sherds of shallow, thick crucible had variegated dark (black) to yellow internal deposits.

All of the crucible material came from stratified contexts assigned to Phase 4 (one piece from each of 107 and 203, three pieces from 404), apart from the large sherd of "dog-bowl" crucible, which drives from Phase 2 (context 424).

3. glassy slags with evidence for Cu

Phase 4 also yielded a single piece of glassy slag with a colouration that would appear to indicate the presence of Cu-oxides.

4. glassy slags without evidence for Cu

These materials derive entirely from Trench 7 and are all certainly or probably associated with vitrified hearth lining. They included the group of sf #590 – 605 (context 712) which may comprise just one or two original, now fragmented pieces (possibly one with and one without attached lining material). Part of this group shows the slag forming a thin sheet with large crystals of ?olivine showing on one side. Similar material was recovered from context 706 (Sf #547, 548), also showing large crystals on one side of a dimpled sheet. Sf #548 also showed some accreted flake hammerscale.

Context 713 yielded a specimen that appears to show several small sandstone pebbles, or pieces of sandy lining, fused together by a glassy slag.

5. plano-convex smithing hearth slag cakes

The upper part of the site yielded a substantial piece (105g) of a plano-convex slag cake from Phase 4 (context 407, sf #303). This piece appears on general morphological grounds to be a smithing hearth cake, but the broken face shows bladed olivine crystals up to 17mm long. Such a large crystal size indicates a substantial pool of molten slag, which was allowed to cool slowly.

A small piece (29.8g, broken in two) of vesicular grey iron slag was recovered from Phase 3 (context 106), and this is very likely to be a smithing hearth slag.

From the lower part of the site, Trench 7 produced a much larger assemblage of iron-working slags, although much of the material came from disturbed contexts within the tree throw. Substantial fragments of plano-convex smithing hearth cakes came from context 704 (sf #514, 125g), context 712 (#487, 500g) and context 714 (#582 690g). These pieces indicate total cake weights in the range of 500-1000g, consistent with an origin in blacksmithing. Various smaller pieces of iron slag from the same trench can be identified as small pieces of smithing hearth cakes.

6. iron slag films

Two small pieces from trench 7 (sf# 509 and 524, both from context 705) were from thin films of crystalline iron slag. Such films may be the result of slag solidifying against an object (such as a stone) within the hearth, but are sometimes indicative of processes outside the hearth. They may arise from slag on the workpiece being detached during hammering, or they may arise from slag sticking to a tool, such as a poker.

7. other materials

The collection contains a small amount of materials that are not metallurgical residues, of which only sf #706 is worthy of any comment here. This piece has not been examined in detail, but appears to be a piece of organic-rich sediment, containing snail shells and chips of bone, which has undergone partial burning.

Discussion

Although the total amount of metallurgical residues collected is quite small (1.6kg), the collection resolves into evidence for a series of geographically and temporally distinct activities.

The material from Phase 2 comprises small glazed stones. The glazing on the stones is pale, in contrast to that seen when stones become glazed in iron-working hearths, and the glazes show little signs of interaction with adjacent objects. This suggests that the stones have been subjected to very high temperatures in a hearth or furnace where the stones were not in contact with iron. Two possibilities are an origin within a hearth used for heating crucibles or within a furnace used for glass working; other possibilities, including non-industrial origins, also exist.

The flat-bottomed, vertical walled crucibles from Phases 2 and 4 are interesting, and not necessarily from copper alloy working. As noted above, a variety of processes have been associated with similar crucibles elsewhere, including use as heating trays, for glass working and as parting vessels.

The evidence for copper alloy working provided by the crucible and slag remains from Phase 4 is limited in scope, but very coherent. The evidence points to the use of small crucibles, so the production of small castings would be indicated. The form of the crucibles cannot firmly be established on the present material, but a lidded form seems to be suggested. There have been suggestions that lidded crucibles may be associated with brass working (e.g. Rehren 1999). However, it is possible that crucibles themselves are wide, shallow forms. These wide crucibles ("heating trays") are, at least in some instances, interpreted as

cupels associated with precious metal refining or assaying (e.g. Zienkiewicz 1993, Bayley 1995)

Iron-working is indicated primarily by the material from trench 7, where a good range of residues is present, from well-developed smithing hearth cakes, through more amorphous hearth slags, to pieces of vitrified hearth lining. Two pieces of probable iron slag were also recovered from the upper part of the site (phases 3 and 4).

Significance and potential

The significance of the assemblage is the evidence it gives for the range of craft activity undertaken on the site. The small size of the assemblage imposes a limit to the potential for understanding the variability, frequency and intensity of that activity.

The phase 2 glazed stones have been interpreted above as possibly being associated with glass working. Microanalysis of the glazes would be useful in determining whether this is the case, by examining the evidence for external chemical contribution to the glaze. The phase 2 crucible is significant, particularly given the debate over the use of the bowl-like crucibles (Lane & Campbell 2001).

Analysis of the copper alloy-working residues from Phase 4 would aid in identifying the metal alloys being worked. Detailed investigation of the crucible sherds should be undertaken to determine whether they are indeed from lids, or whether perhaps some might be from cupels.

The large piece of probable iron-slag from Phase 4 (sf #303) is unusual in its exceptionally coarse grain size. For this reason it would be worthy of further detailed study, including both textural and chemical analysis. The possibility that this piece was derived from a copper-working process certainly needs to be examined.

The iron-working slags from Trench 7 are indicative of blacksmithing in a nearby area, but further detailed investigation of these materials would be unlikely to produce significantly more information on general process. Technological details, including an evaluation of any possible flux used in the process, might be gained from detailed textural studies. The well-formed slag cakes provide good comparative material against which the unusual cake from Phase 4 can be assessed.

References

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Appendix 1: Note on two possible stone beads

Description

SF#1, context 101
A subcircular annular object 10mm x 12mm, with 3mm diameter subcircular hole in centre, formed of white, finely crystalline calcite. 2.2 to 2.5mm in maximum thickness. The inward sloping part of both faces is 8-9mm in diameter. A discontinuous zone approx 1mm wide around the central hole has radial fluting, which appears to be associated with an internal microstructure. The main part of the annular structure shows fine concentric markings, with approximately 100μm between rings and slightly more developed rings approximately 800μm apart. This appears to be an internal microstructure to the rock. This microstructure is cut by the outer edge of the object. In some areas a finer radial crystal structure appears to be present between the rings

SF#239, context 405.
An irregularly and roundedly parallelogram shaped annular object, 6mm x 8mm, with a central hole approximately 2mm x 1mm, and less than 2mm thick. The main part of the annulus is formed of white, opaque calcite, but the zone around the central hole is formed of grey limestone, with a gently inwardly sloping surface. The margins of the hole are abruptly broken off at a right angle to the plane of the annulus. The two faces of the annulus appear different; on one side the hole is near the margin of the zone of grey limestone of which the margin is roughly parallel to the circumference of the object, on the other the inward-sloping part of the surface is lenticular, with its grey limestone fill pierced rather more centrally.

Discussion

It seems likely that both objects are modified fossils. #1 has an internal microstructure indicative of a biological origin. The peripheral concentric and central radial structure might be suggestive that fossil might be coral. Coral fossils are not naturally annular, so the fossil must have been abraded naturally and/or artificially into its present form.

#239 does not have a visible internal microstructure. It is clearly (unlike #1) an originally annular bioclast, with a central cavity filled with grey limestone. The most likely interpretation is that the original bioclast was a pelmatozoan ossicle (probably from a crinoid).

In both cases the original fossils have been eroded; in #1 with a smoothly eroded surface gently dipping inwards to the perforation from both sides and in #239 with an early (natural) inwards dipping smooth surface worn into the limestone in the centre of the annular fossil, which has subsequently been mechanically broken through to produce the hole.

Differentiating natural from anthropogenic reworking and alteration of these fossils is difficult. The smooth general profile of each object might be natural; the central abrupt perforation of #239 is more suggestive of artificial shaping, although such breakage could have occurred naturally once the disc had worn thin in its centre.

Context	*Phase*	*SF#*	*weight*				*description*
			Fe	*Cu*	*?*	*natural/other*	
Upper part of site							
110	2 loam	83			0.69		glazed chip of fossiliferous shale
416	2 bank	495				11.3	bone
421	2 fill of curvilinear	482			8.12		glazed piece of sandstone
421	2 fill of curvilinear	485			2.13		complex piece centred on part melted stone chip - gives clear/slightly green glass. Darkens near ?top where become black near ash
421	2 fill of curvilinear	491			0.39		small glazed sandstone pebble
424	2 Fill of curvilinear	700		7.88			Piece of straight-walled crucible
			0	***7.88***	***11.33***		
106	3 loam	20	29.8				piece of vesicular iron-rich slag broken in two - probably from a smithing cake
			29.8	***0***	***0***		
104	4 levelling	26		1.57			dark glassy lining slag - red colouration looks like Cu oxides
107	4 slumped/slighted bank	18		1.68			small piece of sandy rim of crucible or lid, very widely splayed, coated in Cu-rich glass or enamel
203	4 ditch fill	40		2.46			highly vitrified and vesicular piece of sandy material, probably crucible, with Cu red glass
404	4 levelling	197		0.45			small fragment of flow-banded chestnut glass with small amount of attached lining/crucible slag
404	4 levelling	206		0.85			fragment of wide-splayed crucible rim with orange glassy residue
404	4 levelling	224		0.58			vitrified sandy material, blending into glassy cu-slag, probably crucible
407	4 loam	303	150				unusual p-c cake fragment. Upper vesicular, glassy, greenish, with patches of ?quartz in clear glass (flux?), interior dense - locally bladed olivine to 17mm forming smooth brown surface
			150	***7.59***	***0***		
301	topsoil	111			2.91		glazed piece of ?tuff
605	topsoil	457			30.65		clinker
			0	***0***	***33.56***		

Context	Phase	SF#	weight Fe	Cu	?	natural	description
Lower part of site							
707	bank	550			8.01		irregular bleb of lining slag - internal variable grey - blue, externally variable cream - chocolate, vesicular
707	bank	565			5.63		irregular lining slag, mainly dark but some blue streaks
			0	***0***	***13.64***		
702 fill	upper fill	487	500				p-c cake
712 fill	primary fill	586	26.36				dense rusty p-c cake fragment. Lower face dimpled, upper in rounded lumps with lining melted in
712 fill	primary fill	589			2.4		small piece of vitrified hearth/furnace lining
712 fill	primary fill	590	9.04				dimpled lining slag sheet, glassy with v large ?olivines on one side, dark surface, patches of green glass & lining, rusty charcoal in some dimples
712 fill	primary fill	591	5.94				as 590
712 fill	primary fill	592			0.6		vitrified lining
712 fill	primary fill	593			0.01		vitrified lining (2 pieces)
712 fill	primary fill	594				1.03	natural crinoidal limestone
712 fill	primary fill	595	3.37				dark lining slag with charcoal incl. V heterogeneous
712 fill	primary fill	596	0.14				glassy
712 fill	primary fill	597			0.19		vitrified lining
712 fill	primary fill	598			0.09		vitrified lining
712 fill	primary fill	599			0.19		vitrified lining
712 fill	primary fill	600	0.36				dark glass with lining and rusty surface
712 fill	primary fill	601				0.14	rotten igneous rock?
712 fill	primary fill	602	0.24				glassy slag
712 fill	primary fill	603	10.2				irregular ?contorted glassy iron slag with lining etc.
712 fill	primary fill	604	5.41				as 603
712 fill	primary fill	605	1.38				glassy with lining
712 fill	primary fill	609			0.19		small chip of bluish-grey vesicular glassy lining slag
			562.44	***0***	***3.67***		
701	topsoil	483			13.12		broken nub of dark glassy lining slag rich in sediment and small sandstone clasts
704	topsoil	514	125				fragment of probable smithing slag, contains piece of fired white rock
704	topsoil	553			3.93		small lobe of dark glassy lining slag
705	hillwash	509	1.74				thin film of well flowed iron slag, max 4mm thick
705	hillwash	515			9.5		irregular piece of lining slag with fused and slagged lining or pebble blebs in dark glassy slag
705	hillwash	524	1.58				thin double layer cf. 509. Good crystalline slag - could be from anvil or other hard face
706	fill of tree throw	546			20.39		part fired piece of organic material with charcoal, bone chips and snails
706	fill of tree throw	547	20.6				small piece of rusty iron slag, slab, lower face dimpled, rusty charcoal, v coarse olivine, upper face very vesicular
706	fill of tree throw	548	40.41				cf. 547 - but larger slab, lower face coarse olivine, but mainly green/cream vesicular glass, smooth upper surface. ? accreted flake scale.
713	fill of tree throw	576			0.61		3 small ?sandstone grains fused together with vitrified glaze
714	fill of tree throw	582	690				p-c cake (part)
714	fill of tree throw	585	5.19				dense dark crystalline iron slag with pendent blebs. Slightly vesicular
714	fill of tree throw	608	6.27				small fragment of dense dark slag with dimpled surface and accreted rusty material with charcoal
714	fill of tree throw	610	0.5				irregular piece of vesicular iron slag - possibly from margin of thin sheet
			891.29	***0***	***47.55***		
	overall total		***1633.53***	***7.59***	***109.75***		

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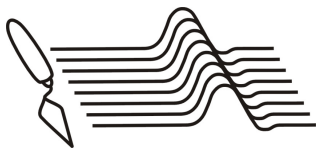

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