

# Evaluation of pyrotechnological residues from Ballyarnet, County Londonderry

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## Abstract

*Excavations at Ballyarnet produced a significant quantity of slag-like materials, which were provisionally interpreted as archaeo-metallurgical residues. Examination of the specimens shows them to be clinker; partially slagged residues from the burning of coal. The residues include pieces of shale impurity from the coal, ranging from intact pieces with visible fossil plant remains, through fully vitrified debris. At least one fragment had small coal fragments remaining in the associated adhering soil.*

*Coal use in this area in antiquity is unlikely, and a relatively recent origin for the material is suggested. Only one of the fifty six samples was attributed to a context certainly believed to be prehistoric. Several pieces show lobate glassy slags resting on a planar, rough surface, suggestive of the wall of the enclosing hearth. The highly vitrified slag part of the clinker suggests a higher temperature and/or a more prolonged period of elevated temperature than is typical in a domestic hearth. None of the material showed any associated hammerscale, so an origin in a smithy is unlikely, although not discounted. Possible interpretations might include other types of industrial hearth, including boilers for steam engines.*

*In addition to the clinkers, there are a few isolated fragments of coke; probably coal residues rather than deliberately coked material.*

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## Methods

The archaeometallurgical residues have been evaluated by brief visual inspection and the use of a lower-powered binocular microscope. Descriptions and interpretations of material are necessarily limited by this approach.

## Description

The assemblage from Ballyarnet comprises 56 registered small finds, of which several comprise more than one piece of material. 48 of those finds are attributed to the superficial disturbed layer and a further 5 to the layer of small stones and gravel directly beneath. Only a single find was recorded as from a context interpreted as ancient (604).

The material forms a relatively homogeneous assemblage. There are three principal phases present in the material:

1. *Dark glass.* Where fresh this glass is typically black and is generally vesicular. The surface is coloured in most instances, with red, brown, grey and rarely blue colours recorded; a brownish maroon is most common. In some examples the surficial layer of the glassy slag is composed of crystallites of an unidentified mineral.

2. *Shale.* Many, indeed most, specimens have included shale fragments. Some of these are extremely fresh, and in at least one case (sf4099) there are remains of plant fossils present. The shale fragments show varying degrees of alteration by heat, and at the most extreme are probably responsible for (3) below.

3. *Vitrified sedimentary material.* The dark glass may bear patches and swirls of pale glassy material, sometimes with visible quartz grains. Such patches are probably the result of incorporation, albeit with incomplete mixing, of melted shale fragments.

The material has two main morphologies. The first is simply as shale fragments with a slagged coating. The second is a sheet-morphology with a planar, rough face, opposite a strongly lobate surface of smooth, flowed, glassy slag. The dimples between the lobes sometimes contain small fragments of coke.

In addition to the coke associated with the clinker there are several isolated pieces, including one particularly large lump (sf 4079). These are likely to be coal residues, rather than material that has been coked deliberately.

The material attributed to context 604 (sf 4395) comprises six pieces of clinker and some fine debris. This material is entirely similar to the bulk of the collection attributed to higher stratigraphic levels.

Although many of the pieces have matrix still adhering, no examples of hammerscale were observed. The matrix typically contains small bladed crystals of gypsum (commonly found to have formed around sulphur-rich slags and clinkers).

## Interpretation

The entire collection can be attributed to residues from the burning of coal. The absence of hammerscale and of any dense slags suggests that the material does not derive from ironworking, although the presence of significant volumes of glassy slag does indicate that the residues were generated in conditions of prolonged or elevated heating. Clinker assemblages of this kind may be associated with boiler hearths – particularly including those of steam engines, but also of coal-fired domestic heating systems.

Although none of the material is indicative of the generating process, it is extremely unlikely that this assemblage relates to a prehistoric use of coal, and the nature of the assemblage combined with its stratigraphic location suggests a relatively modern origin.

## Evaluation of potential

Although the process which produced this residue has not been determined, the fact that it is a clinker from coal makes it extremely unlikely to be prehistoric, particularly since coal does not occur naturally in the area. The material could be investigated further to attempt to determine whether there was evidence for derivation of the residues from a metallurgical process, but the relatively superficial context of the find and its likely modern age may render such investigation as non-essential. The residue assemblage appears to have low potential for the furtherance of understanding of the prehistoric site.

No further analytical work is recommended.

<b>context</b>	<b>S#</b>	<b>weight</b>	<b>comments</b>	
		<b>(g)</b>		
BA02	101	4010	8.7	Probable shale fragment (but not shale itself not visible) one side of slab pale cream to brown dimply/bubbly material, other side more lobate slags with maroon surface
BA02	101	4012	128	48g piece mainly dark shale piece with a slagged surface. Shale has shiny fossils. Surface brown bubbly. Larger (80g) piece has a flat surface with shaley debris, rest is lobate, slag mainly dark vesicular glass with red-brown surface but very variable
T4	401	4045	4	Irregular prill of grey slag, quite dark internally.
T4	401	4049	18.8	Irregular piece of dark crystalline slag with large vesicles, surface variable from crystalline grey to red smooth, a few patches of possible melted shale.
T4	401	4053	158	4 pieces of highly corroded slag material, lots of secondary rust materials accreting in other particles (including 1 piece coal), lots of gypsum crystals in adhering soil
T4	401	4055	130	Greyish vesicular dense slag block, bearing a wide variety of shale chips and pieces in various states, surface of slag mainly grey crystalline.
T4	401	4061	44	Rough slightly lobate sheet of slag with abundant shale - some exploding and delaminating
T4	401	4065	30	Rounded piece of reddish stone set in a moderately flowed slag with fuel dimples on one side, slag grey to reddish brown smooth surface, except in dimples where becomes microlobate and black
T4	401	4074	3	Small fragment of black glassy slag with brown/white variegated surface and shale chips
T4	401	4075	4	2 small blebs of slag. 1 broken shows internal structure. Surface brown smooth, internally cream, vesicular, tending grey in centre. Smaller bleb seems richer in sedimentary grains
Tr1	101	4079	68	Large block of coke with one black melted surface
T5	501	4080	13.4	Rather dense slag with one rough surface (presumed base) rest lobate and brown surfaced
T5	501	4080	11.4	Lobate small piece of dense slag, mainly crystalline but some is glassy.
TR1	101	4087	12	Irregular lobate piece with variegated brown smooth surface, black internally at least in part, some included shale and grains
TR1	101	4089	6	Black glassy vesicular slag with shale chips. Surface mainly brown and smooth
T4	401	4093	29	Descending prills of slag with rough rear face. Parallel to rear face is lump of shale with possible contorted shale (or bone?) adjacent
T4	401	4095	30	Weathered looking slag, probably well flow onto a flat surface. Bears many shale chips. Some quite coarse material - both melt and rock
T4	401	4096	16.6	Greyish slag binding masses of variable fired-melted shale pieces. Surface brown bubbly on shale where melted in void space
T4	401	4097	2	Coke with some small shale chips
T4	401	4098	34	Dense brownish lump, probably with organic inclusions and possible quartz. Has well slagged surface and black glass intruding in. Just possibly a piece of fired bog ore.
T4	401	4099	3.7	Partially melted shale fragment with organic fossil remains and coked ?stem, adhering pale slag with brown smooth surface
T4	401	4101	7.7	Lobate slag piece with smooth surface brown, grey even small blue area, internally vesicular grey-pale
T4	401	4102	2.8	Dark glass with large vesicles and reddish surface attached to dark shale chip
T4	401	4103	1.3	Friable coke
T4	401	4104	18.1	Large piece of fired "shale". Brown melted surface, locally grey and crystalline, internally some crystalline areas, but others show swirls of ?organics
T4	401	4105	3.7	1.5 small piece of slagged shale, 2.2 black shiny brittle vesicular slag - possible burnt peat residue?
T4	401	4108	66	Complex lobes on rough rear face, abundant shale chips
T4	401	4122	14	Triangular piece, probably a shale lump, with melted surface (brown) and adhering slag
T4	401	4126	4.4	Pale vesicular material with brown bubbly surface, rounded ball

T4	401	4128	18.2	Highly vitrified dark shiny glass with grains bearing lots of partially melted shale fragments
T4	401	4130	4.4	Complex lobed bleb of grey crystalline slag cored on shale chip
T1	101	4138	12.6	Probable shale, but not slagged, instead neatly and smoothly glazed with black-greenish glaze
TR1	101	4139	3.9	Extremely shiny glassy slag. Surface varies from black to brick red, lots of melted grains on surface, sometimes leading to white swirls. Internally a mush of grains, white-clear, with some large vesicles
T1	101	4140	9.8	Brown very shiny slags coating pale vesicular slag -presumably melted shale
T1	101	4143	16	Well slagged shale piece, pale shale one side, reddish dimply the other, grey crystalline slag attached to one end
TR1	101	4147	7	Irregular prill of dark glassy slag with smooth brown surface, lots of small included shale fragments
TR1	101	4149	14.7	11.6-3.1, small piece pale vesicular glassy clinker with brown surface, larger irregular lump of brownish surface, grey internally slag resting on pale vitrified shale
Tr1	101	4150	13.6	Messy clinkery material with abundant shale fused by dominantly reddish slag
T4	401	4154	28.3	Reddish or black with grains surface over angular clast, which is itself not visible
TR4	401	4158	8.9	Shale/micaceous siltstone, with brown smooth slagged surface
T4	401	4159	9.2	Shale chips, melting to white vesicular slag, surrounded by black glassy vesicular slag, surface dark grey crystalline verging to maroon. Smooth
T4	401	4160	11.8	Glassy slag binding a mass of shale chips, very irregular, but with one smooth surface
TR1	101	4170	24.8	1 rough surface, rest lobate, mainly born. Internally variable from dark dense well flowed slag, through to pale vesicular and some almost unaltered shale
TR1	101	4173	8.5	Pale shale, vitrified to white vesicular slag, in contact with black vesicular slag with smooth brown surface
T1	101	4175	74	Dense block, inside not seen, probably a shale block with heavily slagged surface, surface variable from maroon or almost black glassy, through thin bubbly reddy brown coat to patches of vesicular pale material indicating greater melting
TR1	101	4177	4.9	Irregular pale to black glassy slag, binding large shale pieces. Dominantly brown surface
TR1	101	4179	2.8	Small piece of dark slag with shale chips. Surface varies from red smooth to black with grains
T4	401	4189	3	Contorted fired shale. One surface brown smooth, the other mainly dark glass with clear grains
T4	401	4201	1.3	Partially meted sandy sediment, reddish brown smoothish surface on part
T4	401	4206	13.7	Contorted highly glassy piece with lots of included crystals and vitrified vesicular pale patches. Dominantly black glass, but swirls of brown and white on surface too giving highly variegated patterns
T4	402	4225	5	Black to reddish brown slag binding numerous shale chips, some highly vitrified
T1	102	4236	9.3	Glassy vesicular black slag with browner crystalline surface, attached to fired shale piece
TR1	102	4322	7.7	Pale buff "nodule" with remnants of pale to clear glaze. Nodule shows heat crazing on one end.
T3	302	4347	19	Contorted piece of "lining slag" with variegated green red cream white surface, with grains. Dimpled hold laminated coke-like material
T3	302	4348	98	Large block of stone/shale with brown slagged surface. Surface locally very pale green yellow with slightly crystalline glassy slagged surface.
T6	604	4395	50	6 pieces - all burnt shale to clinkery slags. 1 piece shows crystalline surface.