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Assessment of materials from Trelai Park, Cardiff

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Abstract

A collection of 244 pieces with a total weight of 2843g was submitted for assessment. Of this, some 1390g derived from pyrotechnological processes.

The interpretation of the dominant type of residue was problematic. Where it occurred in large pieces it most closely resembled a later 19th or 20th century blast furnace slag (being pale, vesicular, and finely crystalline in general), although it formed rather small flow units. This material apparently graded into a siliceous material in rounded lumps suggestive of a partially melted sandstone gravel. Pieces dominated by these two materials comprised 58% and 17% of the overall pyrotechnological material respectively. The apparently intergradational relationship between the crystalline slag and the siliceous partially melted material means an interpretation as a blast furnace slag is unlikely and in the absence of detailed analysis an origin in lime burning is tentatively suggested as an alternative origin.

A further 21% of the pyrotechnological assemblage is material associated with the combustion of coal, including not only coal and coal shale, but the organic residue from combustion, coke, and the inorganic residue, clinker. These materials might also have an origin in a process such as lime burning but might alternatively have been produced in the hearths of steam boilers – including those of agricultural machinery, or even domestic hearths.

The coal residues were common in the topsoil and subsoil of all three trenches, but were also recovered from the enclosure bank and from 5 of the 12 postholes in Trench 1. The possible lime burning slags (or just possibly blast furnace slags) were also present in the topsoils and subsoils, but also in the levelling deposits and in 6 of the 12 postholes in Trench 1. In total 8 of the 12 postholes produced pyrotechnological residues likely to be of Roman or later age. In addition, one posthole also yielded two fragments of lime mortar.

House floor (2003) in Trench 2 produced a single fragment of fuel ash slag compatible with an origin in a domestic hearth, oven or kiln as well as in a metallurgical hearth.

Early metallurgical activity was indicated by just 4 small pieces, with a combined weight of 51g. One fragment of a probable early iron smelting slag, probably of a non-slag tapping technology was recovered from Trench 1 but was unstratified. Three tiny fragments of iron slag probably produced during coal-fuelled iron working (and thus of Roman or later age) were found: one from the subsoil (1002) in Trench 1, one apparently from a posthole of RH 1 in Trench 2 (though assigned to a cut number) and one from the fill of posthole [1044] in Trench 1.

Thus, the site produced no stratified residues suggestive of metallurgical activity that were certainly non-intrusive. The persistence of material unlikely to be pre-Roman in age in the Trench 1 postholes may be sufficient to suggest these are younger than currently interpreted and potentially post-medieval. Further investigation of the pale slags might be required to determine their origin, and hence their age, more precisely.

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Methods

All materials were examined visually, using a low-powered binocular microscope where required. The catalogue of submitted material is presented in Table 1.

No further instrumental analysis has been undertaken, and thus the identification of mineral phases must be regarded as purely provisional.

This assessment was conducted in February 2023 and was commissioned by Dr Olly Davis. The materials derive from excavations in Trelai Park in summer 2022.

Results

General

A collection of 244 pieces with a total weight of 2843g was submitted for assessment. Of this, some 1390g were derived from pyrotechnological processes. The submitted materials comprise a variety of materials. A very small proportion of those materials (4% by weight) comprise fragments of certain archaeometallurgical residues (slags). Some are slag-like materials (clinkers) formed from the inorganic residues of coal, the organic residues from the incomplete combustion of coal (coke) and also fragments of coal and coal shale, with a total of 21% of the pyrotechnological materials. The remainder of the residues (75%) comprised a suite of problematic pale materials ranging from fully slag-like, probably calcium-rich, materials to partially melted silicic materials.

Pale slag-like materials

The pale slag-like materials have been divided in Table 2 into three groups:

Group 1. slags with a pale surface and grey core – these slags are mainly finely crystalline, with buff-coloured elongate crystals (possibly melilite) in a finer groundmass. The cores of some of the pieces are mid-grey in colour. In some cases, but not all, this is associated with a change to a more glassy microstructure. Some pieces show a flow-banded glassy superficial layer – and these quenched layers may contain pale (white to buff) euhedral crystals.

Some of the larger pieces show good evidence for flow. A 214g piece from context (1031) in particular, is a flow-lobed slag, probably from margin of a larger flow.

The material is commonly finely vesicular but is always compact and dense.

Group 2. Probable partially-melted sandstones – the main component of this material is a white, mostly fine grained, apparently quartzose material with a very dark associated interstitial phase. The interstitial material is typically almost black. Where it is abundant it is a glass, but it is unclear if all the finer occurrences re also glass. In a very limited number of instances the glass is blue. In most cases the quartz grains form a coherent hard material.

In several cases the material with this microstructure forms a rounded component within a larger piece of slag. This suggests the protolith for the siliceous material was in the form of rounded grains, in other words, a gravel.

The dense white siliceous zones show only a very low degree of vesicularity.

This microstructure may grade outwards into a grey/green glass with large vesicles and abundant large crystals of a tabular morphology. This material is often badly weathered.

These materials may in turn pass into a finer crystalline slag that resembles (1) above. In some pieces the type (1) slag simply bears small patches or inclusions of the white siliceous material

Group 3. Glassy slags with quartz grains – this material is very similar to normal metallurgical lining slags, with a dark glassy matrix within which lie partially melted relict coarse quartz grains. The limited amount of this material present lacked any attachment to ceramic wall material as s commonly seen in lining slags, so it is provisionally interpreted as simply being a variant of the partially melted material of the previous category, but with an abundance of the glass phase compared with the relict grains.

Clinker, coke, coal and shale

Many of the contexts yielded clinker. Clinker is the partially melted inorganic residue left from burning coal, typically forming a translucent grey slag with a maroon surface associated with the variably bloated remnants of lithic impurities in the coal. These may include pale bloated tabular bodies after coal shale and a distinctive khaki to brick red highly vesicular slag probably after a less fissile precursor.

The origin of clinker is not easily determinable. Clinker can be formed, to give a few examples common on metallurgical sites, in the small-scale forging of iron, in

the fireboxes of reverberatory furnaces and in the fireboxes of steam engines, essentially anywhere that coal is burnt in a situation where it is not in direct contact with a reactive component.

In this instance, the fragments of clinker are all very small, so do not represent deliberate disposal of industrial waste, but rather casual loss, such as from steam-powered equipment or even from farmyard manuring containing domestic waste.

The organic residues from partially burnt coal are termed coke. Coke may be produced deliberately as, principally, a metallurgical fuel, but most of the coke found archaeologically will be a simple residue

The raw material coal was present across the site in small quantities. These tiny fragments may have become distributed either through incorporation with other materials being disposed of or as accidental spills from steam powered equipment.

Fuel ash slag

A single fragment from context (2003) weighing 3.07g was a fuel ash slag (FAS) of a type quite distinct from the clinkers described above. It was a very highly vesicular pale grey glassy material passing into a grey, less bloated, ceramic.

This type of FAS is generated by reaction between the fuel ash (in this case wood ash) and the ceramic surface of the hearth. The calcium- and potassium-rich fuel ash fluxes the ceramic so that starts to melt at a relatively low temperature. The viscous partial melt produced inhibits the escape of volatile released from the reaction of any water, organics or carbonates present in the clay. The trapped gas forms vesicles that cause the partial melt to expand – producing a bloated texture.

Fuel ash slags of this sort may be produced in many types of hearths, but particularly those in which the heating is long-lived. The largest accumulations typically found on prehistoric sites are associated with either corn-drying kilns or with large domestic hearths.

Fayalitic iron slags

Early metallurgical activity was indicated by just 4 small pieces, with a combined weight of 51g,

One fragment of a probable early iron smelting slag was recovered from Trench 1, but was unstratified. This piece has a curved, slightly concave, non-wetted contact surface, presenting the smooth faces of several stacked flow lobes. Such textures are probably commonest on the contact surfaces between wood packing in the basal pits of non-slag tapping smelting furnaces (slagpit furnaces).

A small (15.3g) nub of dense, slightly vesicular dark slag, bearing pale bloated lithic inclusions and a piece of entrained coke, and with a slightly maroon crudely lobate surface, from the subsoil in Trench 1 (1002) can be interpreted as piece of coal-fuelled smithing slag.

Two further tiny fragments of iron slag probably also produced during coal-fuelled iron working (and thus of Roman or later age) were found: one apparently from a posthole of RH 1 in Trench 2 (though assigned to a cut number) and one from the fill of posthole [1044] in Trench 1.

Other materials

Context (1043) produced two fragments of sandstone gravel bound by a white material bearing abundant high sphericity coarse quartz sand grains. This material can be interpreted as a lime mortar. The mortar was not observed to carry any coal debris, which is a common feature of later post-medieval mortars, so the material is probably Roman, medieval or earlier post-medieval.

Context (2003) yield a large block (1065g) of iron ore. The piece has a smoothed convex surface and a fresh fracture. It can thus be interpreted as a fractured cobble. The ore comprises haematite and/or goethite with abundant quartz, surrounding a central void with vuggy quartz.

Quartz-rich iron ores are characteristic of the iron oxide ore bodies of the border Vale, from near Castell Goch in the east to Llanharry in the West (Sibley 1919; Thomas 2000; Vivian 1872, 1876, 1877, 1885,; Watson 1859). The Taff cuts the ore-bearing rocks in the gorge at Tongwynlais and the Ely crosses the same horizon near Pontyclun, with a major location for the extraction of such ores at Mwyndy. The most likely origin for present material is as a boulder carried by glacial or early post-glacial drainage The Devensian ‘glaciofluvial sheet deposits’ are mapped by the BGS as outcropping over a significant area around Victoria Park and Canton, but material derived from that body may also be present in the later channel of the Ely nearer to the site.

The very high quartz content of this particular specimen would have made this an unsuitable material for smelting and probably too hard for grinding for the production of red pigment. Nonetheless, such a large block, with its ‘recent’ fracture is likely to have reached the site through human agency.

The collection also included various pieces of natural rock.

Interpretation

The interpretation of the assemblage is not straightforward. The fayalitic iron slags provide tantalising hints of both iron smelting and iron smithing. The iron smelting slag is suggestive (but does not indicate with certainty) that smelting was undertaken in a non-slag tapping furnace. Such furnaces are not currently known in the area, but in theory might be expected to have been employed locally in both the Iron Age and, perhaps, in the early medieval period.

The iron working slags are indicative of the use of coal as fuel. This is not known to have been employed prior to the Roman period and after the Roman period was not used again in the Cardiff area until approximately the 13th century, after which coal became the dominant fuel for smithing until the present. The two pieces in useful stratified contexts (one of the postholes in Trench 1 and one of the postholes of RH1 in Trench 2) are both currently interpreted as pre-Roman, and thus if that interpretation is maintained, the pieces must be intrusive into those features.

The single piece of fuel ash slag present in the roundhouse floors in Trench 2 is not particularly indicative of process, but is most likely to be non-metallurgical.

The various coal-related residues are likely to derive from a variety of processes, but the concentration of these materials in the topsoil and subsoil is very likely to indicate most derive from agricultural activity. Small quantities from lower contexts may be intrusive.

The interpretation of the pale slags is the particularly problematic. The two extreme materials – the pale, mostly crystalline (melilite?) slag and the more siliceous component, probable partially-melted sandstone are both apparently present within single small fragments. Table 2 appears to show, however, a slight stratigraphic separation of the two components as dominant elements in the fragments. It is unclear if this is a real phenomenon, coincidence, or the result of a slight bias in size. The pale crystalline slag is presented by seven pieces larger than 20g (36g and 60g from (1002); 214g from (1031); 2 pieces totalling 43g from (1033); 37g from (1045); 202g from (2002)). These show features indicative of flow in multiple flow lobes. Where the larger pieces show such evidence for flow and show a lack of the siliceous inclusions, then they could potentially be blast furnace slags of the 19th or 20th centuries, but if all such material shares a single origin, then an alternative origin must be sought. An origin with lime production is possible, but remains unproven.

If the pale slags are from lime production, then their presence on the site could be due either to dispersal of residues from a kiln site (serving either agricultural or building purposes), or due to the agricultural use of lime (containing slag residues) in land improvement. Large scale use of burnt lime for land improvement is a post-medieval phenomenon (although small scale use of burnt lime and of unburnt marl occurred much earlier). By the late 18th and particularly from the mid-19th century, then direct application of crushed limestone and the use of crushed slag became dominant). Thus the spreading of burnt lime, potentially containing slag, is most likely to be of 16th to 18th century date. Slag formed as a result of lime burning for mortar could be from a much wider range of dates.

Further work

Detailed laboratory investigation and elemental analysis would be capable of providing further clarification on the nature of the 'pale slags'. These would appear very unlikely to be contemporary with the features that form the focus of this project, so whether that work would be justifiable needs to be a judgement made on project priorities. They may shed additional light on the subsequent history of the site.

The residues should be retained and deposited with the site archive in a suitable repository in due course.

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Table 1. Catalogue of materials from Trelai Park submitted for investigation, grouped by context and bag. Eights in gram.

Trench	Context	Item wt.	Item no.	Notes
tr1	1001	44.66	6	clinker
		7.45	2	coal shale
		4.06	1	glazed white fine sandstone
		4.35	1	lobed cream-coloured BF-type slag
tr1	1002	11.89	1	nub of dense, slightly vesicular dark slag, pale bloated lithic inclusions and a piece of entrained coke, slightly maroon crudely lobate surface
tr1	1002	8.16	1	appears to be pebble with a maroon altered surface with abundant sandy material attached to outside, partially with green glaze
		3.93	5	coke
		16.35	5	clinker
		4.27	1	sandy material bound by dark glass, passes laterally into BF-type material with tabular grains
tr1	1002	41.9	1	pale surfaced, grey cored vesicular slag, locally with green glass extending into vesicles, perhaps contains more siliceous zones?
		3.77	1	exploding fragment if iron
		1.05	1	burnt? coal
		11.78	5	clinker
		3.45	1	fragment of dark vesicular slag - smithing slag?
tr1	1002	44.21	7	porous white-surfaced gey material, varies from glassy to crystalline, spherical vesicles, BF-type slag
tr1	1002	35.86	1	pale slag in lobed flow, part appears like a partially-melted sandstone, clear hard crystals with a dark phase, but this lump is surrounded by material of a cream colour, finely crystalline and locally at least rather vesicular
		60	1	highly weathered cream-coloured with pale plates, hints of grey interior, some locally very siliceous glassy inclusions
		11.15	1	slag with a variety of lithic material, strongly altered, in glass; one clast is a dark shale, but unclear if a coal shale
		19.4	3	cream-coloured slag formed of network of pale tabular crystals
		6.97	2	small fragments of BF-like material
		3.59	3	dark glassy vesicular blebs, clinker
		13.14	5	partially melted gravelly and sandy materials with glazed surface
tr1	1006	2.71	1	fragment appears like BF slag on outside, on inside show large tabular crystals and vesicles, in green/grey glass
tr1	1008	2.33	3	broken fragment of small dimpled bleb of BF-type slag

tr1	1011	26.51	1	rounded lump of bloated stone, interior not seen, surface appears to be partially melted sandstone, locally with superficial glaze
tr1	1027	2.29	1	twisted bleb of sandy 'lining slag' with a variety of lithic clasts as well as single grains, dark glass
tr1	1029	6.25	1	slagged coal shale
		5.83	1	partially melted and bloated white rock, possibly impure limestone
tr1	1031	214	1	flow lobed slag probably from margin of a larger flow, deeply weathered, surface shows remnants of dark flow-banded glass bearing white phenocrysts. Internally finely crystalline and with some very fine vesicles, but largely dense
tr1	1031	6.98	1	glazed pebble - probably sandstone as small area shows white grains and dark interstitial phase, glaze clear to slightly green
tr1	1033	3.98	1	lobe of flowed dark slag with possible cream crystalline patches occasionally on surface
		0.52	1	clinker
tr1	1033	43.28	2	white surface grey interior, vesicular, BF-type slag
		1.6	1	glassy grey slag
		1.28	1	partially melted sandstone with clear superficial glaze
tr1	1041	43.88	1	sandstone
		20.54	2	porous white rock with spheroidal vesicles and apparently glassy surface, heat-altered fine sandstone
tr1	1011	3.07	4	tiny fragments of BF-like material - one with an external green glaze
tr1	1011	1.58	2	pale cream vesicular FAS-like material
		1.33	3	variable grey/white crystalline material with some glassy phase, heat altered sandstones?
tr1	1033	2.65	1	granule grading from material resembling lining slag into pale crystalline material resembling BF slag
		2.91	1	conventional khaki clinker with shale fragments
		1.57	1	glassy slag coated particle with adhering lithic grains, probably clinker
		0.13	1	coarsely vesicular (frothy) grey glassy slag
tr1	1037	3.19	1	dense hard material, pale grains bound by dark melt, with rich maroon superficial glaze
		5.34	1	probably a fragment of shale coated in multicolour clinker (grey, maroon (over salmon-coloured bloated material), green and pale), with bound-in clast of sandstone showing dark interstitial material
		0.61	1	porous salmon-coloured material, probably bloated shale

tr1	1043	1.38	1	coal
		0.19	1	coke
tr1	1043	1.89	1	coke
		1.03	1	vesicular mid-grey slag/clinker
		2.91	1	gravel and large quartz grains bound by white\calcareous material - lime mortar
tr1	1043	21.53	1	gravel held together by quartz grain-rich white material - this sand includes very coarse spherical grains, This appears to be lime mortar
tr1	1045	36.97	1	flow lobed slag, surface dark with large cream crystals. Base seems to include a grain of glazed sandstone
tr1	1045	4.12	1	dimpled grey fragment of fayalitic slag
		0.85	1	glassy grey vesicular slag with coarse tabular pale crystals
		0.44	1	fragment of slag with dark glassy core and pale crystalline surface
		0.7	1	probable grey vesicular glassy slag, but highly weathered
		0.39	1	pale siliceous slightly vesicular saccharoidal slag, grading into dark glass
		0.23	1	pale crystalline slag with vesicles
tr1	1053	1.82	1	porous slag, pale surface grey interior, where slag is coarse it shows pale plates, elsewhere vesicular, fine locally with grey material forming blebs on vesicle surfaces
tr1	1060	1.22	1	small fragment of partially-melted sandstone, pale grains in slightly blue glass matrix
tr1	1060	5.83	3	white surface, grey interior, vesicular, BF-type slag
tr1	1060	1	1	coal
tr1	1060	9.44	1	coke
tr1	1060	0.22	1	coal
		0.44	1	coke
		0.16	1	coal shale
tr1	1060	1.75	1	slightly bloated grey laminated sandy sediment, voids coated in yellow material, trace of external reddish glaze

tr1	1081	306	1	grey lithic-rich sandstone
tr1	1086	2.66	1	broken fragment of iron oxides with pseudomorphs after pyrite or marcasite.
tr1	unstrat	27.97	1	dark iron slag in amalgamated lobes with a common smooth surface - possibly a non-tapping iron smelting slag
tr1	unstrat	0.52	2	slightly glazed coal shale
		0.92	1	coke
		0.11	1	possible clinker - dark granular material
tr2	2002	202	1	pale surface, grey cored crystalline slag in a series of amalgamated small flows
		22.22	3	smaller fragment of BF-type slag
		17.23	6	fragment of sandy/gravelly material bound by glass, with glazed surface. Some more like partially-melted sandstone others more like typical lining slag
		3.96	2	mineralised crusts from rusted iron objects
		5.31	3	coke
		6.48	7	coal shale - one with superb plant fossils
		1.19	1	coal
		40.24	12	fragments and blebs of clinker
tr 2	2002	2.83	4	coal
		3.73	3	burnt coal shale
		0.36	1	dark shale
tr2	2002	13.5	6	coke
		2.65	1	coal
		7.34	3	small clinker fragment
		43.3	2	glazed material, one is glazed sandstone pebble, the other one or more pebbles, locally with blue glass between grains, bound by material more like BF-type slag
		6.19	4	smaller pieces of glazed lithology, sandstone? With grains bound by glass passing laterally into BF-type slag
tr2	2002	8.5	2	black vesicular glass with rich chocolate brown surface - clinker
tr2	2003	3.07	1	highly vesicular grey fuel ash slag, grading into less bloated grey ceramic
tr2	2003	1065	1	fragment from boulder of quartz-bearing haematite ore, quartz vug in centre, but coarse throughout, probably a brecciated texture, outer surface shows local contact with a fine orangey dolomite or sandstone

tr2	2011	3.68	1	vesicular grey slag, dimpled with coke preserved in a dimple, there are numerous tiny shale inclusions and one of charcaoal - so it may possibly have been a mixed fuel. Weathered.
tr2	2014	2.04	1	iron rich concretionary material - could be formed on burrow or artefact
tr2	2041	3.59	1	weathered or slightly burnt coal
tr2	unstrat	16.29	1	Heat-altered sandstone; some pale grains with dark interstitial phase, some more vesicular crystalline slag, parts of stone show clear surface glaze
tr2	unstrat	1.97	1	clinker
tr3	3001	4.27	1	clinker
		1.64	1	white/grey porous stone fragment - probably BF-type slag
		0.39	1	partially melted white rock
		5.9	2	highly porous tan coloured material with dark surface - FAS related
tr3	3002	18.89	1	bloated material, pale green internally, locally dark surface, surface shows foliation ,so this is very highly bloated former shale
		70	1	worn block of white surfaced slag, pale grey interior with white laths or more likely tabular crystals, vesicular with local small spherical vesicles
		5.37	1	green/grey creamy vesicular glass with local dark surface; clinker
		5.75	1	vitrified and slagged coal shale fragment
		0.23	1	salmon-coloured highly vesicular; clinker
		7.16	1	bloated probable sandstone with dark vitrified surface
		5.78	1	pale weathered slag with flow lobe and dark inclusions, some vesicles; BF-type slag
tr3	3002	1.02	4	coal shale
		1.3	1	sandstone fragment
		1.75	1	pale surface grey interior vesicular BF-type material
		21.78	17	clinker
		8	17	coke and burnt shale
ustr		0.23	1	white vesicular slag
		2.25	2	greenish/white vesicular fuel ash in blebs, locally dark surface

Table 2. Summary of materials from Trelai Park, totalled by class and context. FAS = fuel ash slag. All weights in gram. Topsoil, subsoil and levelling contexts shaded pale grey.

		Lime-making residues?			Coal residues		FAS	Fayalitic iron slag	Mortar	Natural stone	Iron ore	Rust
		Group 1	Group 2	Group 3	clinker	coal/coke/shale						
tr1	1001	*4.35*	*4.06*		*44.66*	*7.45*						
tr1	1002	172.48	72.58		31.72	4.98		15.34				3.77
tr1	1006	2.71										
tr1	1008	2.33										
tr1	1011	3.07	27.84				1.58					
tr1	1027			2.29								
tr1	1029		5.83			6.25						
tr1	1031	214	6.98									
tr1	1033	51.64	1.28		5							
tr1	1037		3.19		5.95							
tr1	1041		20.54							43.88		
tr1	1043				1.03	3.46			24.44			
tr1	1045	39.19	0.39					4.12				
tr1	1053	1.82										
tr1	1060	5.83	2.97			11.26						
tr1	1081									306		
tr1	1086										2.66	
tr1	unstrat				0.11	1.44		27.97				
tr2	2002	224.22	66.72		56.08	36.05						3.96
tr2	2003						3.07				1065	
tr2	2011							3.68				
tr2	2014									2.04		
tr2	2041					3.59						
tr2	unstrat		16.29		1.97							
tr3	3001	1.64	0.39		10.17							
tr3	3002	77.53	7.16		46.27	14.77				1.3	0	
n/a	unstrat	2.48										

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