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Assessment of materials from the former NER stables Monkwearmouth

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Abstract

The investigated materials comprised a total of 22 pieces weighing approximately 1510g. They represent a wide range of residues from metallurgical processes (probably from both foundry and forge work) as well as clinkers possibly from steam boilers. The material appears to have been dumped, or accumulated, in mixed contexts, including in one sample, waste of a presumably domestic origin.
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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.

This assessment was conducted in January 2023 and was commissioned by Jon Welsh. The materials derive from investigations on the site of the former NER Stables, Monkwearmouth.

Results

General

The submitted materials comprise a variety of industrial residues. Some of those items comprise fragments of discrete archaeometallurgical residues (slags, technical ceramics), others are slag-like materials (clinkers) formed from the inorganic residues of coal, and still others are concretionary materials containing small fragments of slag, fuel, clinker and brick, cemented together by redeposited iron oxides.

Clinker

Context (2) yielded an 18g fragment of low-density clinker, together with a few small pieces of similar debris. This clinker contained abundant white partially melted coal-shale remnants and carried coke fragments in deep dimples on its surface.
Clinker is represented by pieces weighing 42g and 104g from context (8) as well as by some very small fragments from context (2). The clinker pieces all appear to derive from quite small original masses.

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.

Slag

At least five kinds of slag appear to be present within the assemblage:

1. A black glass – an example of this weighing 72g occur in context (8). This piece shows a rather dimpled basal contact with abundant inclusions of pale sand. The piece contains some vesicles and also rounded inclusions with a ferruginous surface. The material appears highly siliceous. The piece produces a response in a metal detector, suggesting it has metallic iron inclusions. Glasses of an appearance similar to this piece are commonly formed in the melting of iron in cupola furnaces in foundries.

In context (2) there was a small fragment (6g) with dark glassy slag forming a cluster of amalgamated vertical prills (stalactite-like), a single sub-spheroidal bleb of glassy slag (0.9g) and a horizontal flow slag prill of similar dark glass.

2. A pale grey vesicular slag of rather siliceous appearance – context (8) yielded a piece of this material weighing 140g. The piece has much superficial adhering material similar to that described from the concretionary material from the same context.

3. A quenched dark slag with a conchoidal fracture – this occurs in context (2) in two pieces - one simply of slag (94g), the other has similar slag in a rather aggressive contact with firebrick. In both cases, abundant fine dendrites are visible in the slag despite its glassy appearance. The dendrites have a morphology suggestive of being a spinel mineral, possibly magnetite.

4. Vesicular grey fayalitic iron slags – these were represented by two fragments (34g and 14g) of dense slag from context (2), forming a flow sheet with large porosity in the centre of the flow lobes. The lower faces of the sheets show very slight dimpling, while the upper surfaces show various sub-spheroidal particles of up to approximately 4mm partially incorporated into the surface, with some of the smaller ones having short 'tails' suggesting of a low angle impact.
A further piece of dense slag (10g) from context (2) had a concavo-convex profile, with the concave surface having a texture indicative of having formed against a metal surface and with the convex surface locally rather irregular.

Another fragment (38g) from context (2) formed a fragment from the margin of a deeply dimpled thin slag sheet (34g), with coke fragments entrained within the dimples. This piece showed no clear evidence for flow.

5. Dense slag with copper weathering products – a single 146g fragment from context (8) was of a dense slag with a concave lower contact surface, suggestive of having formed against the surface of a piece of metal approximately 50mm wide, with a flat surface 35mm wide, bounded by rounded angles. It is unclear whether the copper has originated from within the piece, since the green secondary copper minerals occur on the surface of the piece, amongst adhering sandy concretion, across the fracture of the slag and inside the exposed vesicles. The outer surface appears to show fragments of coal shale and possibly firebrick bound inside the very irregular slag surface. Apart from the copper staining, this piece shows some similarity with the 10g concavo-convex fragment from context (2) which could have been fomed in contact with a similarly shaped metal object.

Technical ceramic

Context (8) produced a thin sheet of pale, coarse, firebrick-type ceramic forming the corner of a thin tile or eroded brick, with attached dense mid-grey slag (total weight 284g). The ceramic thins from 20mm thick on one edge to 10mm thick at 60-70mm from that edge. The rear face of the ceramic is an original planar surface, showing a slight brownish superficial colour and some dribbles apparently formed from a very fluid brown slag phase. Although signs of reaction between ceramic and slag are clear (with inclusions of ceramic extending into the slag on the front), in appears more likely that the piece had a tile-like original form, than to be a firebrick eroded down to such a thing remnant. The slag shows somewhat tabular vesicles aligned approximately parallel to the underlying ceramic, but slightly divergent and locally showing a curve to foliation produced by the vesicles. The apparently thin nature of the firebrick suggests that this might have been part of the lining of a ladle or some other similar component that held slag, most likely but not certainly during a steel-making process, rather than being from the lining of a furnace or hearth.

The firebrick margin attached to the dense quenched slag from context (2), shows pale grains of up to approximately 1.5mm set in a finer matrix.

Concretionary material

Context (8) yielded two fragments of concretion weighing 96g and 170g, containing small rounded slag fragments of up to 40mm in a finer fragmental matrix with a ferruginous cement. The weathering of the piece is yellowish, similar to that of the concretionary material attached to slag piece from this context described above.

The same context also produced a 130g fragment of concretion including a wide range of slag materials, fuel, sand and brick fragments, all encasing a large sherd from a plate, now highly discoloured and altered but probably a blue and white 'china'.

Interpretation

The material is suggestive of residues that have become variably cemented within a body of dumped fragmented waste.

The fragments are suggestive of material mixed from at least three sources.

The clinkers could be from a metallurgical source, but are just as, if not more, likely to be from steam boilers.

The dense slag in contact with the firebrick 'tile' resembles some steel production slags but given the evidence for incorporation of ceramic into the slag, its appearance so near the contact may not have been presentative of the main body of slag away from the ceramic. The process involved in the production of this piece is at best uncertain.

The other dense iron slags are probably indicative of derivation from a forge in the broad sense, although whether that involved manual work, power hammers or even rolling is not clear from the restricted amount of material. The glassy slags and possibly the quenched spinel-bearing slags would be compatible with an origin in an iron foundry (where iron is remelted for casting). The slags with the concave metal contact surface have a profile consistent with formation in contact with a rail. The width of the piece from context (8) (50mm) is however too narrow to be standard gauge railway but could be a narrow-gauge rail from inside the originating works.

The origin of a rather mixed assemblage such as this could be simply the aggregation of waste for employment as railway ballast or hard core from multiple sources. Many engineering works would however have undertaken both foundry and forge work (and have dealt in some copper alloy work as well as ferrous), so a single works could have produced the assemblage.

There is conclusive evidence that any of the slags was produced during primary metal smelting.

Further work

Detailed laboratory investigation and elemental analysis would be capable of providing further clarification on the processes that generated these residues. However, given the secondary nature of the originating contexts, such clarification would not necessarily be of great archaeological significance.

No further investigation of the materials is recommended, unless there are particular reasons for the utility of any additional information.

Table 1. Catalogue of materials from Monkwearmouth submitted for investigation, grouped by context. Fe? Indicates where metal detected by metal detector.

context		sample no	sample wt	item no	item wt		Fe?
2	ID8	12	330	1	94	smooth surface slag with metallic lustre, slightly etched surface shows fine dendrites (of wustite??).	y
				1	110	slag as 94 g piece attached to firebrick surface	y
				1	34	dense flow lobed slag, has hollow cores, external attached blebs	
				1	14	smaller piece as 34g dense slag	
				1	10	slag spall from metal object with rounded 120 degree angle,	
				1	38	prilly / dimpled slag with abundant coke clasts	
				1	6	dark glassy slag in amalgamated vertical prills	
				1	12	flow slag in prill, black glass	
				3	18	irregular brown spiky dense clinker with abundant white shale fragments	
				1	0.9	sub-spherical bleb of glassy slag/clinker	
6	ID7	1	133	1	130	concretion, includes badly stained fragment of rim of blue and white plate. The metallurgical component includes fuel debris, black glassy slag, dense grey iron slag and fine rusty materials.	
8	ID8	2	143	2	146	dense rough slag with fuel and ceramic clasts, shows Cu-staining on surface of slag and on adhering grey sand, one face is a concave surface, 35mm wide flat, curving up either side - so the slag may have solidified in contact with top of a rail.	
8	ID9	7	906	1	72	black glassy slag, moderate vesicular, some siliceous inclusions, locally lining slag-like base and dimples contain grey sand	y
				1	42	rough-surface, flange-like sheet of probable clinker, dense, rusty	
				1	104	irregular sheet of vesicular clinker, porous, large number of shale clasts	
				1	284	very dense grey slag, attached to fireclay sheet - probably eroded end of a firebrick, vesicular, very fine-grained	
				1	130	rather siliceous-appearing grey vesicular glassy slags, vesicular, in rusty matrix of concretion	y
				1	170	concretion with abundant small fragments of glassy slag, fuel and brick	
				1	96	concretion with abundant small fragments of glassy slag, fuel and brick	

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