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Assessment of archaeometallurgical residues from Sheepfold NER Stables (SNS23)

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Abstract

The investigated materials comprised two bulk samples and some examples of 'scoria bricks' from the site.

The two samples were derived from near the base (Sample <1>) and near the top (Sample <2>) of a section of made ground. The samples were formed of a mixture of the same materials, but in different proportion.

The lower sample was dominated by residues from the process of converting pig iron to wrought iron, with slags from the puddling process and scale from hammering or rolling.

Large quantities of fuel waste (raw coal, coke and clinker) were present in both samples. This is probably mostly associated with the metallurgical waste, but other sources are possible.

The upper sample shows a higher proportion of building rubble, including brick and tile fragments, mortar and slate.

Both samples contained a small quantity of domestic waste (pottery, glass).

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Methods

All materials were examined visually, using a low-powered binocular microscope where required.

The bulk samples were wet-sieved at 10mm and 1mm. The <1mm fraction was discarded. The results of this sorting (Table 2) should not be considered a definitive granulometric description.

The >10mm fractions of the two samples were sorted into their different classes of material.

The 1-10mm fraction was inspected as a bulk material and a small extract of magnetic particles was made to determine the presence of hammerscale.

This assessment was conducted in April 2024 and was commissioned by Jon Welsh of AAG Archaeology.

Results

Description of the bulk samples

Sample <1>, (31)

Sample <1> comprised 53% of its weight in particles >1mm, with 19% 1-10mm and 27% <1mm. This sample was dominated by dense iron-rich slags. Pieces of such slag and rusted slag accretions of over 10mm in size constituted just over 50% of the bulk sample. The sample was thus markedly bimodal, with a coarse-grained component of large dense slag fragments, a middle size range with small slag fragments, hammerscale, slag spheroids and fuel debris (in a particularly large proportion) and a large, unexamined sub-1mm fraction.

The slag component included large blocks of dense slag with an angular fracture. These the form of a sheet 40-50mm thick and show a marginal planar contact with non-wetted flow lobes. There are tubular vesicles at a high angle to a margin in other pieces. The opposing face of the dense slag sheets is highly irregular and possibly altered by hot air.

The assemblage also includes thinner sheets, some showing cracking, that may be slag dislodged from the work-piece during hammering.

The thinnest sheet-like pieces in the >10mm fraction resemble very coarse hammerscale. It is not known if there is a continuum with more typical scale present in the 1-10mm fraction.

Dense slag also occurs, albeit in much lesser quantities, in morphologies indicative of flow. These pieces include tapslag like fragments together with individual isolated flow prills.

A very small amount of slaggy material that can be identified as clinker (the melted or partially-melted inorganic residue from burning coal). These pieces include slag-coated shale, as well as more blebby material indicative of a degree of flow.

Much of the iron-rich material (equivalent to 20% of the whole sample by weight) is in the form of accretion containing multiple particles bound by secondary iron oxides ('rust'). These pieces may be indicative of the local presence (or former presence) of metallic iron, that has corroded liberating iron that has then contributed to cementing phases.

Ceramic building materials included oxidised fired curved sheet fragments (pantiles?) and brick fragments.

Other artefacts from the sample included 2 sherds of domestic pottery and part of a copper-alloy bolt.

Sample <2>, (02)

Sample <2> comprised 29% of its weight in particles >1mm, with 24% 1-10mm and 47% <1mm. This sample contained a much lower proportion of the dense slags in >10mm particles compared with sample <1>; they constituted just 9% by weight of the sample <2>. The sample contained a much higher proportion of mortar (mortar particles of >10mm comprised 13% of sample <2>). The contribution of building materials is also reflected by the presence of fragments of slate in Sample <2>. This sample also contained higher levels of siliceous gravel than did sample <1>.

The sandy lime mortar present in the sample included fragments with layers of whitewash on the surface, suggesting they had come from a wall coating. The largest mortar fragments, however, were of a darker colour, and formed fragments of a sheet 40mm thick, with coal fragments and dust firmly adhering to one face.

As with sample <1>, this sample contained a high level of fuel debris, flake hammerscale and slog droplets in the 1-10mm fraction, but this fraction showed a very high proportion of fine mortar debris.

Ceramic building materials included oxidised fired curved sheet fragments (pantiles?) and brick fragments, together with some smaller pieces from hard reduced fired bricks (possibly blue engineering bricks).

The dense iron-rich slags present resembled those of Sample <1>, but were in smaller pieces, as were the fragments of accretion.

Other artefacts from the sample included 2 sherds of domestic pottery and one shard of vessel glass.

Scoria bricks

The supplied material comprised two fragments of 'scoria' brick (of 1835g and 1005g).

These bricks are formed of a hard grey crystalline slag with occasional zones of large, rounded vesicles of up to 45mm. The surfaces are chilled, forming a surficial layer that is white on the margins and mostly blue on the upper surface (presumably the base of the mould). The blue surfaces show what resembles a coarse fracture, but which appears to be the expression of very large flow lobes across the floor of the mould.

Such bricks were made by the Tees Scoriae Brick Company, using a process invented by Joseph Woodward, who founded the company in 1872 (Morris 1981). The bricks were made initially at the Clay Lane Blast Furnace, in Eston, but later at numerous ironworks (Cargo Fleet Iron Works, Middlesbrough; Skinninggrove...) as a means of obtaining extra revenue from the slag-rich production of iron from the Cleveland Ironstone. The company was still producing bricks at Skinninggrove into the 1960s, but failed in 1966 and was formally wound up in 1972.

Interpretation

The two bulk samples comprised the same groups of materials, broadly speaking, but in different proportions. Samples <2> contained more building materials, whereas sample <1> contained more material of metallurgical origin.

The metallurgical materials were dominantly from the processes involved in the conversion of pig iron (cast iron from a blast furnace) into wrought iron, including the use of the process of puddling.

The dense slags are characteristic of those produced during puddling, with the dense slags that have chilled against the wall of a tram or wagon used to transport the slag to a waste dump being almost identical in appearance to those described from the Ynysfach Ironworks (Young 2014, 16-17; Young & Hart 2018b, 45-46).

The puddling process transformed cast iron (often a white cast iron produced from the grey cast iron from the blast furnace by the refinery process) into a crude bloom of iron that requires working (by hammering or rolling or both) to become finished wrought iron. The puddling process was developed by Henry Cort and patented in 1784, but it was only after the introduction of pre-treatment by refining c.1791 (Young & Hart 2018a) that the processes became widespread. During the early 19th century the process was ubiquitous for the production of wrought iron, with other techniques only surviving in specialised industries, such as the production of black plate for tinning. Puddling was even used to produce low carbon steel in the mid-19th century, but after a peak importance in the 1870s it became rapidly displaced by bulk steelmaking (King 2018).

The thinner sheets of dense slag may be associated with slag detached from the iron billets under the hammer, with the thinnest sheets (the thick hammerscale) in the >10mm fractions being scale that formed on the billets during their intermittent reheating prior to, or during, hammering and/or rolling. The term 'millscale' is commonly applied to scale formed during rolling, but the material forms in an identical manner to that called hammerscale. In a typical forge the puddled blooms will be compressed to a billet either under a power hammer or a 'squeezer', before rolling down to final form. Whilst the thick scale in the 1-10mm fraction may be produced on large billets that have undergone prolonged reheating, the finer scale in the 1-10mm fraction could be produced either during the hammering process or during subsequent rolling.

Hammering of the raw blooms (and probably also squeezing) produces a large quantity of slag spheroids of form similar to (but often larger than) the spheroidal hammerscale formed during manual forming. The spheroidal particles in the 1-10mm fractions may have been generated in this manner.

Whilst the origin of the present material cannot be determined with certainty, it should be noted that the Monkwearmouth Ironworks (Tyzack & Co.) is recorded as operating 7 puddling furnaces in 1863 (Armstrong *et al.* 1864).

Whilst the metallurgical input was dominant in the lower sample (Sample <1>), there was still significant input to the lower sample and a dominant input to the upper sample (Sample <2>) from other materials, most notably building materials (mortar, brick, tile, slate...).

Natural siliceous gravel was present in both samples, as were a number of clasts of non-rounded geological materials, and also a small number of artefacts (pottery, glass...).

Both samples appear more homogeneous in their metallurgical component than the hand-picked assemblage previously assessed from the same site (Young 2023), which contained waste from multiple metallurgical activities. However, the presence of highly cemented aggregated material in both samples meant that a significant proportion of the slag was not available for individual detailed examination. Nonetheless, an attribution of the accreted material to a similar origin to the pieces clean enough to examine individually seems likely.

Further work

No further work is suggested for the material. The ex-situ context of the samples means that further archaeologically-useful information would be unlikely to be generated from further detailed analysis.

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Table 1: summary of investigation of the bulk samples, weights in gram.

Fraction	Context (02), Sample <2>			Context (31), Sample <1>		
	Wt.	No.	Notes	Wt.	No.	Notes
total	10580			14820		
>10mm	3044	533	(29% of sample)	8019	840	(54% of sample)
	39	18	grey and purple slates			
	76	14	ceramic building materials	92	6	ceramic building materials
	1	1	vessel glass			
	4	2	domestic pottery	2	2	domestic pottery
	236	35	rounded siliceous gravel, including flint	56	10	rounded siliceous gravel, including flint
	62	26	other pebbles/stone fragments	54	3	miscellaneous sandstones/siltstones
				16	1	spall of pinkish granite with lime externally
	23	13	coal	6	7	coal
	35	55	coke	54	76	coke
	348	72	lime mortar; contains coarse sand, rare small coal grains	202	46	sandy lime mortar
	354	42	lime mortar, includes clasts with columnar secondary minerals in grey stone, some very sandy			
	126	38	lime containing highly vesicular slaggy material	26	7	coke coated in lime
	560	2	grey-weathering lime mortar apparently forming floor, with coal particles bound tightly to one surface. 40mm thick layer			
	456	97	rusty concretionary material, clasts variable, coal, coke, mortar, stone, slag droplets, thick hammerscale,	2977	201	accreted material
	212	14	extremely dense slag in sheet like form, contact surface appears to show chilled non-wetted lobes, but the other surface is extremely irregular and probably blown	288	48	slag in sheets, 5mm down to what appears to be thick scale
	42	3	fragments of extremely dense iron slag with large, rounded vesicles			
	8	3	fragments of dense slag with flow lobed surface (one shows coke clasts in interstices), some dense slag shows adhering lime	1165	71	dense slag with other indicators of flow - flow lobes, prills etc
				1520	6	dense slag fragments showing a flow lobed non-wetted surface. Largest piece shows tubular vesicles within c50mm thick slag layer
				396	8	angular fragments of massive dense slag
	10	2	pale spheroidal material - dolomitic limestone?			
	240	41	indeterminate dark iron slag fragments	1125	337	indeterminate slag fragments, mostly vesicular
	18	2	vitrified/slugged cermaic			
	4	1	clinker	28	5	clinker
				12	6	very shiny dark glassy prills - possibly clinker
	18	7	miscellaneous stony material			
	162	44	brown material - clay lumps? And brown stones			
	10	1	shaft of copper alloy bolt			
1-10mm	2525		scale and spheroids abundant (24% of sample)	2830		scale and spheroids abundant (19% of sample)
remainder	5011	47%	finest and moisture (47% of sample)	3971	27%	finest and moisture (27% of sample)

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