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Evaluation of archaeometallurgical residues from New Weir Forge, Herefordshire

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Abstract

Material from New Weir forge, Herefordshire, comprises micro-residues and some macro-residues from bulk sampling, together with limited collections of hand-picked macroscopic slag from stratified contexts.

The assemblage provides a good cross-section of the macro- and micro- archaeometallurgical residues produced by a 17th-18th century finery forge. Such residues are currently poorly known and this assemblage has enormous potential to address these shortcomings.

The overall collection has three main components:
- a sparse assemblage interpreted as being mainly from smithing from Trench 1,
- a rich assemblage from Trench 3 including material believed to have been produced both during the fining process and during the subsequent compaction of the loup (bloom)
- an assemblage of coarse hammerscale, from Trench 4, believed to be associated with the heating of billets for rolling.

In addition to the material from the forge itself, early deposits in trenches 3 and 6, together with sporadic material from Trench 1, contain examples of blast furnace slags, which probably provide the first physical evidence for the operation of a blast furnace on this site between c. 1575 and1616-1623.

Contents

Methods

The submitted materials included a variety of material besides archaeometallurgical residues. The assessment has not examined samples wholly of other materials.

All investigated macroscopic materials were examined visually, using a low-powered binocular microscope where necessary and recorded to a database (Table 1).

The bulk samples were weighed, wet sieved at 212µm, dried, then separated into magnetic and non-magnetic fractions using a magnet and reweighed. Each subsample was then given a summary description (Table 2). The residues have not been picked.

As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

This project was undertaken for Herefordshire Archaeology.

Results

Description of the residues

Iron-rich slag

The iron-rich slags from New Weir Forge are superficially divisible into five morphological classes plus a 'bucket' category for other materials:

a. dense flowed slags

b. slag runners/rods/spikes

c. dense slag sheets

d. dense slags rich in moderately coarse charcoal

e. dense slags with bowl-like morphology

f. others

Some of these classes are closely-related and some slag pieces may show regions of more than one morphological class.

a) dense flowed slags

These materials include dense, dark, iron-rich slags with the morphology of a prill or bleb (or an amalgamation of such slags) indicating flow of fluid slag.

The major pieces in this group are suggestive of slag accumulation in masses of blebs or prills, but mostly in a form rather different from typical bloomery tapped slags and suggestive of slags that may have dripped, rather than flowed, into the accumulation. This leads to individual components being small, typically equant rather than strongly elongate and often with signs of fragmentation. In addition, the prill masses often show a suggestion of variable prill orientation, indicating that the slag masses may have been deformed when hot – perhaps by raking away from the tapping area.

No complete tapped masses were present in the collection, with the largest fragment (from T3, 010) weighing almost 2kg, but still only a part of a much larger accumulation.

Two examples of dense flowed slags from Trench 2 showed constraint by hard edges: one suggesting slag flow in a curved channel, possibly with a metal margin and the other showed accumulation of flowed slags against a sub-vertical margin.

b. slag runners/rods/spikes

Broadly rod-like slag pieces were a very common feature of the slag assemblage from New Weir Forge.

They are rather variable in detail, with varieties with a sub-circular cross section (*rods*), which often taper markedly (*spikes*), but also with varieties with a flat top, suggesting the flow channel was not filled (*runners*). The terms *rods*, *runners* and *spikes* are used here for practical differentiation within the assemblage, but are not established or acknowledged terms in general use in archaeometallurgy, at least in these narrow definitions.

Several examples show multiple, sub-parallel, rods or runners. This is a very important observation for the interpretation of the precise origin of these slag pieces – and may suggest that the entire length of a 'rod' was not formed within a tap-hole blocking, but that they may have formed through rodding through a bed of charcoal, ash, or even of hearth slag.

One specimen (from Trench 3, 008) weighed 3.1kg and had a somewhat conical mass of slightly blebby, granular-appearing slag, out of which arises a stout (40mm diameter) rod, with the fractured base of a probable second rod adjacent. Such pear-shaped slag blocks may be behind the use of the term 'hambone' for some forge slags, although that term has not been satisfactorily defined.

c. dense slag sheets

The items assigned to this category show a rather granular slag, often with abundant fine charcoal debris, passing outwards into a much denser, sometimes crudely layered, slag with a planar to slightly curved outer face.

In most cases, although the outer surface is planar, it is rough.

d. dense slags rich in moderately coarse charcoal

This group of specimens includes material with an iron-rich slag binding together pieces of charcoal, in some cases with the dense slags showing a lobate or prilly texture, indicative of downward flow of the slag through the fuel bed.

None of these specimens showed a clear original margin, although one specimen did appear to have a plano-convex 'bowl' form.

e. dense slags with bowl-like morphology

One substantial specimen of nearly 2kg (from Trench 3, 008), together with some less-certain fragments indicate slag development with a dense bowl-like form, overlain (with an intervening void) by less dense, charcoal-rich slags. The deep bowl was at least 60mm deep and contained tubular vesicles.

The overall morphology of this piece resembles large examples of smithing hearth cakes (SHCs), although the precise mechanism of origin of some of the comparative material (e.g. the large SHCs described by Young 2009) remains uncertain.

f. others

Much of the slag present on the site occurs in a fragmented state. The macroscopic slag collection descried here consists of almost entirely of hand-picked 'representative' pieces. None the less, some of the hand-picked material is in pieces which are not readily identifiable, as is the slag present in the bulk samples. Such material includes fragments of flowed material, massive dense slags, highly vesicular paler slags and charcoal-rich textures, alongside small slag pieces in the form of prills, sheets and blebs.

One interesting type of slag that doesn't fall within the categories above is a thin sheet form, that occurs when fluid slag coats the surface of a tool or workpiece. These materials are commonly met with in

micro-residues and classed as slag flats. Here, a good example of such material occurs in Trench 3, 008, occur as a sheet extending on two approximately perpendicular sheets, just a few millimetres thick, from an angle of just a little over a right angle. The object coated by the slag measured at least 40 x 20mm in cross section, but may, of course, have been much larger. It is not known in this instance whether this was a tool (it seems rather large) or the workpiece (perhaps the edge of a billet).

Iron-poor slag

There are three types of relatively iron-poor slags present in the assemblage.

The first is clinker, the partially melted residue from the burning of coal. This is mainly present as small droplets with a typical maroon surface, seen in some of the sieved samples. There were no macroscopic clinkers identified in the assemblage.

A second iron-poor slag is represented by a single specimen of a charcoal-rich slag from Trench 3, 008. The glassy slag in this specimen is variable in colour from dark to a duck egg green. Such material emphasises the problems associated with the interpretation of charcoal-rich materials, and although such a piece might most likely be a low-iron slag from, for instance, a chafery, it could also be a charcoal-rich slag from a blast furnace.

The third low-iron slag type can be attributed to an origin in a blast furnace with a much higher degree of certainty. The slags are pale green, dark green or lilac-grey coloured glasses. The larger pieces show a flow thickness of about 60mm, with a slightly charcoal-dimpled base. Many of the pieces show some degree of devitrification.

Micro-residues

Wet sieving of the supplied soil samples has generated some interesting collections of micro-residues.

The micro-residues here are mostly materials from the hot working of iron, that are referred to in the archaeological literature as hammerscale and in the modern literature as millscale, reflecting the dominance of the hot working of ferrous materials by rolling in modern industry. Essentially the material has a common origin – the oxidation of hot iron in air. The oxidation will generate superficial layers of various iron oxides, which may then split from the workpiece (through differential thermal contraction or deformation) as flake hammerscale. If iron is to be welded, then the iron needs to be either hot enough that the surface oxides melt, or sufficiently hot that they can be melted with the addition of a flux (typically quartz sand). In either case, forming the weld squeezes the two layers of iron together and the molten oxides will be forced out by the impact of the hammer, with the jet of molten material typically chilling in flight to form spheroidal hammerscale. Spheroidal hammerscale may also be generated during compaction of a bloom containing residual slag. The compaction of the bloom is effectively a welding operation and the molten entrained slag is expelled forcibly.

The material will be described as hammerscale here, although, as discussed later, some might derive from the rolling and slitting processes.

One group of microresidue samples comprises those from Trench 1, contexts 010,027, 029 and 031. These samples are characterised by a rather moderate amount of fine flake hammerscale, but relatively abundant, but very small, spheroidal hammerscale.

Deposits from the upper levels of Trench 1 (context 009) locally contain hammerscale, but in a more conventional assemblage, rich in flake hammerscale.

Good hammerscale assemblages were also recorded from Trench 3 contexts 006 and 008, and, to a lesser extent, context 011. These assemblages produced a large quantity of both flake and spheroidal hammerscale. Some assemblages (particularly from 008) produced a good number of very large spheroids, and at present it is unclear if these are all very large spheroidal hammerscale or whether some may be slag droplets from within a hearth.

The final hammerscale assemblage is that from context 003 or Trench 4. Here the flake hammerscale is extremely thick (up to 2m), with the tripartite layering (haematite-magnetite-wustite layers) even visible with a lens. This assemblage effectively lacked spheroidal hammerscale.

Iron

The submitted materials were rich in iron, much of it in very small fragments and highly corroded. These small fragments are likely to represent losses of iron during the various industrial processes. Corrosion of small iron pieces produced abundant small concretions in some of the bulk samples.

Larger pieces of iron include some that are clearly artefacts (dominantly nails). One large piece of iron has a shape not unlike a cold chisel, but widens towards the possible blade. In general, however, the artefactual ironwork has not been examined.

Trench 6 context 013 produced almost 70 pieces of iron, many elongate and some strongly curved; it is possible that some of this material might be waste from the slitting mill. Some of the corroded iron fragments showed a lack of corrosion on some of the planar faces, but instead a pale surface layer. It is possible that some of these pieces may have has a non-ferrous metal coating.

Other materials

The samples contained very little other material directly associated with the metallurgical processes. There were a few brick fragments, but none clearly of metallurgical purpose.

Distribution of the residues

It seems likely that none of the hand-picked macroscopic residues was recovered from any context directly related to its origin. In contrast the micro-

residues in Trenches 1 and 4 may be indicative of *in-situ* activity.

In Trench 1 the bulk samples provided evidence of hammerscale assemblages in association with small fragments of dark slag. This appears to be directly associated with the location. Trench 1 samples are also noteworthy for the persistent occurrence of small quantities of blast furnace slag.

Trench 2 yielded a small quantity of picked residue material. The majority of these materials were of flowed dense slags.

Trench 3 included several layers of slag deposition (008 & 010) which yielded larger, fresher, pieces of slag than other contexts examined on the sites. These slags included flowed material, 'rods', and bowl-like dense slags. The deposits on the associated floors (006, 011), together with slag layer 008, yielded rich hammerscale assemblages. The original sub-floor below the lowest floor in this trench produced an assemblage of seven pieces of blast furnace slag.

Trench 4 produced a distinctive assemblage with exceptionally thick hammerscale and broken slag debris.

Trench 6 produced a large collection of iron fragments, as well as a piece of blast furnace slag from an alluvial deposit below 004.

Interpretation

It has been argued that the 'Part of a perambulation of the Forest of Dean, May 1634' (Hart 1995) describing 'a certain old weare now utterly ruinated built to drive a Furnace of Lord Gray of Ruthen' indicates that the furnace built at Whitchurch by The Earl of Shrewsbury by 1575 was situated at New Weir. The use of 'Lord Gray' (rather the 'the Earl of Kent'), suggests that the furnace had been abandoned before 1623. There has been no reported physical evidence for a blast furnace at this site.

The suggested identification of the New Weir site as that of a blast furnace in the late 16th/early 17th century is now supported by the occurrence of blast furnace slag (in significantly-sized pieces) in early deposits in Trenches 3 and 6, and (as small fragments) through much of the succession in Trench 1. These deposits are not necessarily (indeed almost certainly not) of the period of the blast furnace, but presumably the ground on which he forge was constructed included quantities of waste from the earlier works.

The forge at New Weir was first clearly attested (Cranstone 2009) in 1684, and in 1695 it is described as being lately rebuilt on an old foundation. There is some disagreement over whether that 'old foundation' was the 1575 blast furnace, or whether there had been an earlier forge on the site. On balance, the lack of clear reference to the site in the mid-17th century and its apparent complete abandonment at the time of the 1634 survey, suggest there earlier references to a forge refer to the 'Old Forge' and that the 1684 reference is to essentially a new build, but utilising aspects of the site and perhaps water management of the 1575 furnace.

The essential core of the forge operation, the fineries and chafery, are represented particularly by the deposits in Trench 3. In the various slag make-up deposits the residues are well preserved, with large fragments of macro-residues and abundant micro-residue assemblages. Most of the macroscopic residues examined are suggestive of finery waste, with dense slags rich in fine-grained charcoal, associated with slag rods of various types and with accumulations of flow-lobed slags probably tapped from the hearth. The separate finds of planar-based dense slags are probably to be interpreted as the basal residues of the finery – and formed in contact with the iron plates forming the hearth base; it is just conceivable, however, that similar slags might arise in the chafery.

The microscopic residues, dominated by flake and spheroidal hammerscale, do not, in contrast, represent waste from the fining process as such, but from the subsequent compaction of the loop (bloom) and its hot-working down to anchony or bar. Some of the large spheroids may possibly not be hammerscale, but be slag drips formed inside the fuel bed of a hearth.

Identifying possible macroscopic waste from the chafery is more problematic, but it is possible that the large SHC-like slag cakes may be from a chafery. As mentioned above, the planar-based slag sheets might also be from a chafery, but their texture appears to more closely resemble those of slags attached to the slag rods – and hence be indicative of an origin in a finery.

The micro-residues from Trench 4 differed from those of Trench 3, in being dominated by abnormally thick flake hammerscale (up to 2mm). Even with low magnification the layering within the flake is clearly visible. The oxide layer on iron grows through diffusion of oxygen and iron. This process is slow, so a 2mm scale probably requires a heating period measurable in hours – though precisely how long depends on the temperature. Such long heating periods do not tally with the rapid heating and working of iron either in the chafery or indeed the blacksmith's forge. A more likely explanation is that such scale derives from the heating of finished billets from cold, for working under a hammer (to start the plate production process for instance), or for working in a rolling or slitting mill. Given the high level and superficial stratigraphic location of these materials, an origin seems possible in the heating of billets for processing in the rolling mill which is supposed to have existed at New Weir Forge in the later years of its use.

The deposits from Trench 1 contain various disparate items of residue and many of these are likely to be residual, or at least, not associated directly with this area of the site. Some of the pieces may be residues from smithing, but there are no totally convincing examples of smithing slags. The microresidues present a rather more coherent picture for smithing – although residue assemblages are rather sparse in most cases. The characteristic property of the samples from this trench is the occurrence of unusually fine-grained spheroidal hammerscale. The distribution of such material may sometimes be modified (because of preferential movement of spheroidal hammerscale by earthworms to act as lining to aestivation burrows). The pattern is so consistent in this case it is probably a real feature of the original assemblage. No research has been undertaken on the size of spheroidal hammerscale particles in relation to task, but would seem likely that assemblages of small particles would relate to light forge welding activities, rather than the processes undertaken within the manufacture of iron. The apparent presence of large amounts of fine-grained iron debris (now largely corroded) might also relate to smithing activities.

Evaluation of potential

Present understanding of 17th-18th century finery forge residues is very poor. Uncertain discrimination of late bloomery and finery slags bedevils some early accounts. On other sites, the overlaying of 'new' late 18th-19th century technologies upon earlier works again makes certain assignation of residues to particular technologies difficult. Compositions and mineralogies of some finery slags were provided by Gordon (1997), but these are for late, North American, examples and may not be representative of earlier European techniques.

The assemblage from New Weir Forge includes both macro-and micro- residues employed as floor make-up deposits within the forge building. This material appears fresh and relatively unaltered and so is likely to have been deposited (either directly or secondarily) soon after its production. This material is currently interpreted as containing both finery and chafery residues. The documentary evidence seems to suggest (Cranstone 2009) that New Weir Forge was operated in a rather conservative manner and therefore the fining wastes are likely to pertain to a straight-forward Walloon-style finery. The collected samples from Trench 3 provide a small, but varied group of materials, from securely stratified contexts. The major slag types: granular sheets, charcoal-rich hearth slags, rods/runners/ tapped slags and plano-convex cakes are all present within the collection.

The macro-slags from Trench 3 are also accompanied by micro-residue assemblages, including hammerscale. It is assumed that these microresidues, like the associated macroresidues, derive from the fining and related bloom-compaction processes. Contrasting morphologies of micro-residues were recovered from Trench 1 (interpreted as deriving from smithing) and Trench 4 (interpreted as deriving from billet heating for rolling/slitting).

The assemblage is limited in size and does not derive from contexts directly related to the metallurgical hearth or furnaces. None-the-less, the stratigraphic control and the association (particularly for the microresidues) with particular parts of the structure, means that the assemblage has a very high potential to contribute to understanding of the finery forge. Cranstone (2009) has already indicated the significance of improved understanding of the finery forge to the national research strategy (Bayley *et al.* 2008). Improved understanding of the residues will also feed back into improved understanding of the excavated structures.

The potential of the assemblage from the forge could be realised through sampling and analysis (both bulk chemical and microtextural) of representative material of the major macroscopic and microscopic residue classes. In addition, some analysis of the pre-forge blast furnace slag would also have potential for interpretation of the resources employed in this earlier phase of activity on the site.

References

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Table 1: Summary catalogue of macro-residues and associated materials from New Weir Forge

Trench	C	Wt	No	Notes
TR1				
T1	001	600	1	slab of layered slag, very dense but vesicular, one face appears to have been in contact with planar object, but curves and sheet bends towards one side. Whether this is the side or base of a hearth is not clear, full of finely divided charcoal
		342	1	dense angular slag lump with adhering mass - probably containing iron since starting to crack away from the main slag.
		222	10	pieces of dense slag with either clear evidence for flow or smooth surfaces. None has a classic tapped slag morphology
		152	3	pieces of corroded iron.
		62	1	curved slag piece, vesicular low density - rather like the up-curved upper margin of a dished SHC, but not really identifiable
T1	005	618	8	iron pieces - included substantial pointed spike
T1	005	642	6	(plus bits) fragments of corroded iron. All very irregular and probably debris rather than artefacts
		256	1	fragment of sheet of slightly blebby charcoal-rich slag with rough crudely planar base
T1	007	34	2	pieces of corroded iron
T1	009	128	1	angular piece from body of probable slag runner - very dense with large internal cavities with very smooth surfaces
		258	2	pieces of iron, one half crescentic, the other massive irregular
		12	1	small sandy concretion (on iron?) containing piece of coal and piece of green glassy slag (blast furnace?)
		14	1	bone
		68	1	concretion around corroding iron
		204	1	fragment from margin of a low density, bulbous slag cake. The lower face is moderately planar with deep charcoal dimples, grey, the upper face is more maroon, with a bulbous form, internally the slag is steel grey and highly vesicular
T1	012	86	1	concretion formed of sand and charcoal, probably with some slag, but cementation may be due to enclosed iron
		16	2	small fragments of flowed dense slag, one with chill against planar surface, the other as raised coalesced droplets?
T1	012	178	1	corroded iron rod ?20x25x80mm
		458	1	possibly rolled-up piece of very dense lobate slag
		646	1	fragment from bowl-shaped accumulation of lobate slag, up to 80mm thick

Trench	C	Wt	No	Notes
		318	1	second prilly bowl-like fragment - appears not to join the above piece
		262	1	slab of slag with contact or compression surfaces top and bottom. Internally vesicular and locally blebby
		84	2	pieces of dense slag similar to that in 646 g bowl fragment above
		296	5	pieces of rather prilly irregular slag, not dissimilar to upper part of bowls above
		258	1	sandy concretion on ?iron with abundant fired clay clasts
		140	1	fragment from margin of a slag bowl, possibly SHC, basal crust to c15mm, upper richer in fine charcoal, base finely dimpled
TR2				
T2	001	38	4	small slag fragments (1 prill, 1 sheet, 1 low-density lobe, 1 indet)
T2	002	228	11	pieces of concretion - iron in ashy slag rich material - at least are small square cross sectioned material so potentially nails
		536	11	pieces of dense slag in tap-slag like morphologies
		48	1	possible small 'spike' fragment c 30mm across
		134	1	rounded slag lump with dimpled base - just possibly an SHC fragment
		354	24	fragments of slag with an amorphous form - generally charcoal bearing and vesicular
T2	006	28	3	fragments of moderately dense flowed slag
		562	7	concretions on corroded iron
		112	1	dense flow slag, cooled in curved channel -possibly metal to judge by extreme chilling,
		136	1	messy pile of blebby lobes with included or adjoining corroded iron
		144	1	curious flowed slag resting against sub-vertical edge. Top with large lobes, base lobes and charcoal imprints all in non-wetted shiny surface
		42	1	small fragment from bleb accumulation
TR 3				
T3	008	3100	1	large hambone-type slag, rather granular mass associated with c40mm 'rod', all with a rather blebby texture
		1270	1	double, laterally persistent 'spike' - lower component subcircular in section, but the upper appears flat-topped, all in a granular, friable, charcoal-rich slag.
		310	1	sub-circular cross-sectioned 'spike'. 230mm long, c. 25mm diameter
		362	1	section of semi-circular sectioned spike, 45mm wide, 30mm deep and 140mm in length, top has rather wispy blebs or lobes attached
		1965	1	section of large slag bowl with deep dense bowl, 60mm deep, tubular vesicles, a gap, then charcoal-rich friable material on top
T3	8	132	1	slag flowed between moderately coarse charcoal - varies from normal dark colour to a duck-egg green, low iron, variety

Trench	C	Wt	No	Notes
		23	1	slag sheet from coating on sub-right angled object >40x20mm
		6	1	curved slag sheet with attached blebs - probably a fragmented flow lobe top
T3	010	594	1	block of low density slag dominated by fairly coarse charcoal. Composed of rather wispy prills. Very lime coated
		1995	1	dense broadly plano-convex mass of rather crude flow blebs. Each bleb very large - looks as if may have dropped from above into the pile - rather than being a neatly flowed mass. Moderately lime coated.
		1145	1	somewhat wedge-shaped slab of rather granular-appearing slag with very fine charcoal, resting on sub-planar, slightly curving, face
		196	1	fragment of charcoal-rich slag showing good flow lobes penetrating between charcoal
		1135	1	granular dense charcoal-rich slag probably lining a slightly curved bowl margin
		498	1	substantial 'spike', 140mm in length, c40mm diameter, narrowing, overlain by possible second flow fragment at thick end
		1490	1	80x60x240mm curious double runner - hole must have been rerodded adjacent to earlier opening - both phases are partially open-topped
		160	1	100x25mm small length of tapering spike of smaller diameter than most examples
T3	012	536	7	pieces of glassy blast furnace slag - mostly in a slightly lilac grey glass - very unusual colour, all rather even and dense
TR6				
T6	013	734	26	pieces of corroded iron - mainly elongate - could they be slitting mill waste?
		10	1	prill of dense slag
		20	2	two brick fragments, one with a concave curved margin
T6	013	956	42	fragments of iron - varying from thin sheet to bar, 1 substantial pointed bar (17x17x90mm) and few nails. Really unclear if this is structural ironwork or not
T6	alluvial below 004	142	1	dense partially devitrified dark green slag with charcoal dimpled base - blast furnace slag

Table 2: Summary catalogue of materials from processed soil samples from New Weir Forge

context	#	raw wt	magnetic fraction			non-magnetic fraction		
			wt	%	notes	wt	%	notes
TRENCH 1								
NW09 T1 009	1	174.0	5.7	3%	dark slag , rust with small iron fragments and some flake & spheroidal hammer scale	34.5	20%	sand with pebbles, charcoal and coal, mortar or lime.
NW09 T1 009	2	187.8	7.4	4%	rust and rusted iron fragments, dark slag and moderate hammerscale flakes	52.9	28%	sand with coal, pebbles and few fragments of green (blast furance?) slag, bone, grey vitrified lining and one piece of iron ore
NW09 T1 009	3	132.8	13.2	10%	rusty concretions and some dark slag fragments with rare flake hammerscale	22.0	17%	sand, charcoal, coal and few pebbles; one very small fragment of green slag
NW09 T1 009	4	278.3	62.7	23%	small sandy concretions with rusted iron fragments, small amount of dark slag and very little flake hammerscale	22.7	8%	sand, pebbles, with coal and charcoal; a few fragments of green and black slag
NW09 T1 009	5	228.1	19.7	9%	very small fragments of rusty iron, dark slag with very little spheroidal & flake hammerscale	65.3	29%	sand with coal, pebbles, few ore fragments, mortar or lime and few fragments of green slag
NW09 T1 009	6	242.1	9.6	4%	rust and rusted iron fragments, some coated in mortar or lime, moderate flake hammerscale and dark slag , fairly abundant spheroidal hammerscale & clinker droplets	104.7	43%	sand with pebbles, black dense slag, mortar or lime, pieces of bricks, charcoal and coal
NW09 T1 009	7	208.1	42.1	20%	rusted iron fragments with small amount of dark slag	41.0	20%	sand with coal, charcoal, pebbles and few small fragments of bone
NW09 T1 009	8	230.0	13.8	6%	rust with moderate amount of flake and spheroidal hammer scale and two large fragments of iron	45.5	20%	sand, mica and pebbles with small amount of fine charcoal and coal pieces; and few small green slag fragments
NW09 T1 009	9	219.0	11.3	5%	rust with rich flake hammerscale & spheroidal hammerscale, dark slags, corroded iron coated in mortar or lime	98.7	45%	mortar with sand and black slag fragments (very fine grained or glassy, highly vesicular, possible sand inclusions), pieces of bricks and pebbles, charcoal and coal
NW09 T1 010	1	497.5	15.3	3%	rust with iron fragments and small dark slag fragments. Rich in very small spheroidal hammerscale	76.7	15%	sand with stones, pebbles, ore and fired clay (probably bricks), small amounts of charcoal, mortar

context	#	raw wt	magnetic fraction			non-magnetic fraction		
			wt	%	notes	wt	%	notes
NW10 T1 027	1	2194.4	225.3	10%	rust with abundant small iron fragments, rich in tiny spheroidal hammerscale, some flake hammerscale and few fragments of dark slag	584.8	27%	sand with pebbles, coal, charcoal, a little mortar, iron ore, a very few grey/blue slag fragments and some fragments of dark slag. One fragment of clay pipe, 10mm long, 3/32" int. diameter. One small fragment of probably glazed tile.
NW10 T1 029	1	1755.2	380.4	22%	rust with some large iron fragments, dark slag , some flake hammerscale and fine spheroidal hammerscale	382.8	22%	sand with charcoal and pebbles, small amount of coal, mortar and few green/blue/grey fragments of slag
NW10 T1 031	1	2400.3	436.4	18%	rusty with iron fragments in various sizes, a small amount of dark slag and rich in fine spheroidal hammer scale and some flake hammerscale	497.3	21%	sand with pebbles, coal, charcoal and green blast furnace slag
NW10 T1 035	1	2080.4	862.4	41%	rust, concretions and iron fragments in various size, and small amount of black slag	363.3	17%	sand with pebbles, coal, small amount of charcoal, moderate amount of green slag and red fired clay (probably bricks) and grey fired clay
TRENCH3								
NW09 T3 006	1	1054.4	70.7	7%	rich hammerscale assemblage with a few iron fragments and pieces of dark slag	419.8	40%	fragments of black/grey slag with sand, coal, charcoal and small amount of mortar or lime
NW09 T3 008	1	3176.2	264.7	8%	rich hammerscale assemblage with abundant spheroidal hammerscale and fragments of dark slag	2030.2	64%	fragments of black slag with charcoal, very small amount of mortar, a few burned stones and a little sand. Four types of slag can be distinguished: a) many fragments of low density black and grey slag with chaotic texture with charcoal prints and attached small fragments of charcoal. The largest fragment maybe part of the hearth bottom close to the channel through which slag was tapped out; b) a large amount of medium density slag with upper surface with lobes, bottom surface with prills and charcoal moulds, dark grey colour with occasionally a glossy surface; c)a small amount of thin black slag sheets with flat surfaces; d) a large amount of black/grey slag prills
NW 09 T3 011	1	77.2	5.8	7%	steely grey slag pieces and some hammerscale (both flake and spheroidal)	17.1	22%	sand with mortar or lime, charcoal and black/grey slag

context	#	raw wt	magnetic fraction			non-magnetic fraction		
			wt	%	notes	wt	%	notes
TRENCH 4								
NW09 T4 003	1	2951.4	340.7	12%	thick flake hammer scale, some iron fragments	1573.8	53%	black and grey slag (occasionally with glossy parts, medium and high density, with vesicles, some fragments with lobes, other with prills) with coal, small amount of charcoal, pebbles, fired clay (probably bricks) and little of mortar or lime and sand

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