Ancient Monuments Laboratory Report 48/95

THE ASSESSMENT OF SLAG AND OTHER METALWORKING DEBRIS FROM FRANCISCAN WAY, IPSWICH 1990

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Summary

Visual assessment of a 20% sample of metalworking debris, found in Late Saxon to Early Medieval contexts, provided evidence for both smithing and some smelting of iron on the outskirts of the town. Further examination and limited scientific study is recommended.

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ANCIENT MONUMENTS LABORATORY REPORTS SERIES

The assessment of slag and other metalworking debris from Franciscan Way, Ipswich 1990

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Introduction

The Franciscan Way / Wolsey Street site' (NGR TM 1644, IAS5003) was excavated in 1990 by Suffolk County Council in advance of re-development. Funding was provided by The Churchmanor Estates Company plc.

The site occupied an area of 1,500m2 on the south-western edge of the Saxon and Medieval town. During the latter period it formed part of the precinct of Greyfriars Friary. The low lying area, close to the River Gipping, appears to have been prone to flooding in the past and very little evidence of domestic occupation was found for either Saxon or Medieval periods. However, the site provided evidence of extensive ironworking activities between the late ninth and Early Medieval periods.

Site phasing

The earliest phase of activity, of Middle Saxon date, includes a number of wells and pits, a boundary ditch and slots for wooden fences. It is suggested that the area served as riverside pasture.
The first major phase of activity, occurred in the later ninth century when an extensive ironworking industry was established in the area. Metalworking debris was associated with a large area of cobbling, interpreted as either a yard or a remnant of a north-south road. In addition a pit of late ninth or tenth century date produced an antler brooch mould. Slag and general industrial waste was reported in the following quantities:

Middle Saxon	(c650-850)	0.005kg
Early Late Saxon	(c850-900)	141.608kg
Middle Late Saxon	(C 10th)	60.170kg
Early Medieval	(C11-12th)	123.845kg
Late Medieval	(C13-15th)	27.185kg
Late Medieval Transitional	(1.C15-16th)	2.750kg
Post Medieval		(1.715kg
Total (including undated contexts)		724.833kg

The industry appears to have declined in the twelfth century with very little slag recovered from later Medieval contexts. No coherent building plans, contemporary with the iron working, were identified, although a number of postholes around the cobbled area might have belonged to a post-built structure.

In the later Medieval period rectangular pits, possibly tanks for fish or textile/leather processing, and another "semi-industrial" feature of uncertain function, lay within the Greyfriars precinct. Finally, the site was used as a burial ground with most bodies appearing to date to the Early Post Medieval i.e. immediately post Dissolution.

Despite the widespread occurrence of iron slag no features, such as hearths or furnaces associated with specific metallurgical activities were identified.

Assessment of the metalworking debris

Because of the large size of the assemblage of debris from Franciscan Way only a proportion of this was examined. About 20% of the total of 725kg of slag was rapidly scanned visually and the categories of debris present identified (see Table 1). Material was randomly selected from the finds store and the contexts noted for reference to future context/phasing information. In addition a total of 49 soil samples were examined to determine the presence of hammerscale, which would help to more accurately locate the site of smithing hearths (Table 2).

Hammerscale determination methodology

Unless procedures are adopted on site for its identification', hammerscale is normally only recognised when soil samples, (or soil retained in unwashed slag samples), are examined. The presence of hammerscale can be determined by running a bar magnet over the sample. However, an alternative method, which allows rapid quantification, tests small samples of soil for magnetic susceptibility which gives very high values when magnetite-rich hammerscale is present (for the application of this technique see Mills and McDonnell 3) Soil samples from the site were examined to ensure no stones, iron fragments, slag lumps or other material were present. Magnetic susceptibility measurements were made using a Bartington Meter Model MS2 on samples of approximately 100cm3. In all cases the sample was accurately weighed so that the mass specific magnetic susceptibility could be calculated (Given as m2kg-1). A rapid check on the presence of hammerscale was carried out using a bar magnet which also enabled the presence of any spheroidal hammerscale to be determined.

Table 1 Page 1 Metalworking debris from Franciscan Way, Ipswich

observable phase	context No	date	context interpretation	weight (g)	slag types present
111	111	Early Medieval?	Pit	600	smithing hearth bottom(s).
115	115	Early Medieval	Pit	8000	vitrified hearth/furnace lining, dense ironworking slag, cinder, smithing hearth bottom(s), frag. tap slag.
116	115	Early Medieval	Pit (contaminated by 272)	10000	tap slag (lots), dense ironworking slag, undiagnostic ironworking slag.
145	114	Middle Late Saxon?	Part of 114 (south of 121	18000	smithing hearth bottom(s), vitrified hearth/furnace lining (heavily slagged), undiagnostic ironworking slag.
146	114	Middle Late Saxon	113 has collapsed into an earlier feature	1700	undiagnostic ironworking slag, cinder, block (lining attached).
157	157	Late Medieval Transitional?	Small pit, undefined, seen after 158 excavated	2000	undiagnostic ironworking slag, dense ironworking slag, vitrified hearth/furnace lining
158	158	Early Medieval?	Pit	7000	smithing hearth bottom(s), undiagnostic ironworking slag.
171	171	Early Medieval??	Shallow pit	3000	undiagnostic ironworking slag, smithing hearth bottom(s) (small), vitrified hearth/furnace lining.
172	114	Early Late Saxon	Part of 114, contaminated by 171	6000	undiagnostic ironworking slag, vitrified hearth/furnace lining, cinder.
174	114	Middle Late Saxon	Part of 114, around 171, uncontaminated	20000	dense ironworking slag (lots-some flowed), vitrified hearth/furnace lining, undiagnostic ironworking slag, smithing hearth bottom(s).
260	158	Early Medieval?	As 259, lower fill, (uncontaminated)	5000	ferruginous concretion, iron-rich cinder, undiagnostic ironworking slag
264	264	Early Late Saxon	Pit	400	tap slag.
265	264	Early Late Saxon	Part of 264, lower fill	2000	dense ironworking slag, tap slag (very little), charcoal/slag concretion, cinder

268	1	unstratified	Mixed group from 330 and 331	300	tap slag.

Table 1 Page 2Metalworking debris from Franciscan Way, Ipswich

observable phase	context No	date (g)	context interpretation	weight	slag types present
273	273	Early Medieval	Pit (contaminated?)	200	vitrified hearth/furnace lining (dark glaze).
274	274	Early Late Saxon??	Pit.	5000	large block (2750g), iron-rich cinder.
275	143	Early Medieval	Northern half of 143, upper fill	1600	vitrified hearth/furnace lining (very lightfabric),cinder, undiagnostic ironworking slag , tap slag.
280	115	Early Medieval	North-east quarter of 115, upper fill, uncontaminated	6000	smithing hearth bottom(s), undiagnostic ironworking slag.
297	264	Early Late Saxon	West half of 264, upper fill, (contaminated?)	4000	dense ironworking slag, tap slag, undiagnostic ironworldng slag, iron object
298	264	Early Late Saxon	West half of 264, lower fill	6000	tuyere frag, iron object, tap slag, undiagnostic ironworking slag
418	335	Middle Late Saxon?	North-western part of 335, upper fill	1100	undiagnostic ironworking slag, tap slag.
420	159	Middle Late Saxon?	Northern side of 159, upper fill, as 351	3200	undiagnostic ironworking slag, vitrified hearth/furnace lining, cinder.
431	405	Late Medieval	Part of 405, lower fill (Cont. a lot of mortar)	1500	vitrified hearth/furnace lining, undiagnostic ironworking slag.
432	428	Early Medieval	Northern part of 428 (contaminated?)	930	undiagnostic ironworking slag (dark red staining).
433	1	unstratified	Mixed group from 382 and 432	1600	iron object, dense ironworking slag, undiagnostic ironworking slag
434	434	Late Medieval(+)	Pit	280	vitrified hearth/furnace lining
450	382	Late Saxon??	Northern side of 382	4250	undiagnostic ironworking slag, tap slag.
511	503	Early Late Saxon	Eastern half of 503, upper fill	15000	smithing hearth bottom(s), vitrified hearth/furnace lining, iron-rich cinder & cinder (all cindery).

Table 2 Page 1 Magnetic susceptibility data from Franciscan way, Ipswich

observable phase	context No.	sample No.	date context	interpretation	mag. sus. (x10-8 m2 kg-1)	hammerscale flake	hammerscale spher.	comments
101	9	1	Early Late Saxon?	Charcoal tip	226	n	n	
101	9	2	Early Late Saxon?	Charcoal tip	238	y	n	
238	236	11		Charcoal tip within fill 236, basin shape	511	y	n	
238	236	12		Charcoal tip within fill 236, basin shape	500	y	n	
362	361	5	Early Medieval	Part of 361, lower fill (contaminated)	131	y	n	
362	361	6	Early Medieval	Part of 361, lower fill (contaminated)	170	y	n	
365	304	3		Within 304, layer rich in charcoal	329	n	n	
365	304	4		Within 304, layer rich in charcoal	174	n	n	
404	404	7		Shallow scoop cont. a lot of burnt material	5608	lots	occasional	
413	411	8		Carbonised plank fragment, within 412	795	y	n	
414	411	9		Carbonised timber, found within 412	513	y	n	
446	446	10		Shallow pit/scoop, in red sand, prehistoric?	407	n	n	brown/orange
506	482	17		Sample of waterlogged organic layer.	75	n	n	
506	482	18		Sample of waterlogged organic layer.	60	n	n	
530	493	15		Sample from layer of yellow clay in 493	13	n	n	"pit 493"
530	493	16		Sample from layer of yellow clay in 493	13	n	n	"pit 493"
663	552	25	Late Saxon??	As 662, lower fill	1074			
663	552	25	Late Saxon??	As 662, lower fill	513	y	n	"tray 2"
663	552	26	Late Saxon??	As 662, lower fill	386			
666	537	28	Middle Saxon??	Western half of 537, upper fill	262	n	n	
667	537	29	Middle Saxon??	As 666, lower fill	93	n	n	
712	711	32	Early Late Saxon?	Part of 711, upper fill	637	n	n	cindery
712	711	33	Early Late Saxon?	Part of 711, upper fill	663			
738	731	36	Early Medieval	Red burnt material with 703	145	n	n	
734	731	35	Early Medieval	Layer in 731, grey ash?	179	n	n	

Table 2 Page 2 Magnetic susceptibility data from Franciscan way, Ipswich

observable phase	context No.	sample No.	date	context interpretation	mag. sus. (x10-8 m2 kg-1)	hammerscale flake	hammerscale spher.	comments
739	731	37	Early Medieval	Layer in 731, dark organic material	184	y	n	
741	740	38	Middle Late Saxon	Part of 740, lower fill	674	y	n	
741	740	39	Middle Late Saxon	Part of 740, lower fill	591	y	n	
745	377	40	Early Medieval	Part of 377	2069	y	n	
753	731	41	Early Medieval	Layer in 731, clay, burnt in places	14	n	n	
754	731	42	Early Medieval	Hard baked clay, part of 753	30	n	n	
756	731	43	Early Medieval	Layer in 731, dark brown loamy material	185	n	n	
761	731	44	Early Medieval	Layer of burnt sand, brown loam, grey ash, charcoal	185	n	n	
784	731	46		Sample from layer 782 in 731	91	n	n	
786	731	47		Sand, clay, gravel and charcoal layer	125	n	n	
791	543	48	Middle Saxon??	Western half of 543, upper fill	533	y	n	cindery
792	543	49	Middle Saxon??	As 791, lower fill	63	n	n	
792	543	50	Middle Saxon??	As 791, lower fill	166	n	n	
795	731	51	Early Medieval	Natural sand and gravel layer of 731	53	n	n	
813	812	57	Early Late Saxon	Part of 812, lower fill	2285	y	n	
813	812	58	Early Late Saxon	Part of 812, lower fill	2307	y	n	
813	812	58	Early Late Saxon	Part of 812, lower fill	2654	y	n	
830	731	59		As 784 sample of 782 from eastern half of 731	33	n	n	
855	855	62	Late Medieval??	Large pit, lined with carbonised planks	108	n	n	
861	855	64	Late Medieval?	Carbonised plank lining in 855	86	n	n	
861	855	65	Late Medieval?	Carbonised plank lining in 855	91	n	n	
946	946	66	Late Saxon??	Pit	193	y	n	
952	952	67	Late Saxon??	Pit	414	y	n	
953	952	70	Late Saxon??	Part of 952, lower fill	35	n	n	

Summary of results

Visual examination of metalworking debris allowed the material to be categorised on criteria of morphology, density, colour and vesicularity. It should be stressed that many "classes" of iron working slags form part of a compositional and morphological continuum. Only certain classes of material are strictly diagnostic and can be unambiguously assigned to a single metalworking process. Others may derive from a restricted range of processes but, when found in association with the diagnostic types, may provide support for the identification of these activities. Some forms of debris may originate from a very wide range of high temperature processes and are of no help in identifying crafts or industries. Class names and the criteria on which they are based may vary between specialists. Those currently used by the Ancient Monuments Laboratory are defined below.

Explanation of classification

The early excavators' reports from the site stressed that the assemblage appeared to indicate the smithing i.e. hot working of iron, rather than smelting i.e. the primary extraction of the metal from the ore. However, the assessment identified evidence of both processes.

Smithing

Evidence for smithing is recognised by two main forms; bulk slags and micro slags. Of the bulk slags produced during smithing only the smithing hearth bottoms are unlikely to be confused with the waste products of smelting and are therefore considered to be diagnostic of smithing. These hearth bottoms are recognisable by their characteristic plano-convex form, having a rough convex base and a smoother, vitrified upper surface which is flat, or even slightly hollowed as a result of the downwards pressure of the air blast from the tuyère. Compositionally, smithing hearth bottoms are predominantly fayalitic (iron silicate) and form as a result of high temperature reactions between the iron, iron-scale and silica from either the clay furnace lining or sand used as a flux by the smith.

In addition to bulk slags, iron smithing also produces micro slags of two types. Flake hammerscale consists of fish-scale like fragments of the oxide/silicate skin of the iron dislodged during working. Spheroidal hammerscale results from the solidification of small droplets of liquid slag expelled during working, particularly when two components are being fire welded together or when a slag-rich bloom of iron is first worked into a billet or bar. Hammerscale is considered important in interpreting a site not only because it is highly diagnostic of smithing but, because it is often allowed to build up in the immediate vicinity of the smithing hearth and anvil, it may give a more precise location of the activity than the bulk slags which may be transported elsewhere for disposal.

Table 2 shows the considerable variation in mass specific magnetic susceptibility of the samples. The lowest recorded 13x10-8m2 kg-1' and the highest over 5000 x10-8m2 kg-1. The correlation between observed hammerscale presence and high magnetic susceptibility was good, although occasional samples containing cindery or oxidised material also gave moderately enhanced values. Using this method certain soil samples from Franciscan Way were shown to contain high proportions of hammerscale and this was found to be predominantly flake hammerscale.

Smelting

Earlier examination of the material from Franciscan Way had not identified the presence of ironsmelting debris. This assessment found debris from this process to be widely dispersed through the contexts, though not a large component of the assemblage. The most easily identified slag that is characteristic of smelting is tap slag. This is a dense fayalitic slag which shows a characteristic "ropey" flowed morphology on its upper surface. This material is the product of a furnace in which surplus slag is periodically "tapped" out through a hole in the lower wall of the furnace rather than being allowed to accumulate inside the structure. Material classified as dense slag may also be the product of smelting but could possibly be confused with unusually well-consolidated smithing slags. Similarly, two dense blocks of slag could be either large smithing hearth bottoms or solidified masses of smelting slag. Despite the presence of smelting slag, no possible ores were identified, suggesting that the smelting may have been carried out elsewhere and the smelting slag transported to the site (perhaps for use as hardcore).

Other debris

Four categories not considered diagnostic are vitrified hearth lining, cinder, iron rich cinder and undiagnostic ironworking slag. Material listed as vitrified hearth/furnace lining forms during either iron smelting, iron smithing or non-ferrous metal working as a result of a high temperature reaction between the clay lining of the hearth/furnace and the alkali fuel ashes or fayalitic slag. The material may show a compositional gradient from unmodified clay on one surface to an irregular cindery material on the other. An associated material, classed as cinder, comprises only the lighter portion of this, a porous, hard and brittle slag formed as a result of high temperature reactions between the alkali fuel ashes and either fragments of clay which had spelled away from the hearth/furnace lining or another source of silica, such as the sand used as a flux during smithing. Iron-rich cinder is a similar material but contains a significant iron content, visible as rusty-orange/red hydroxides. The debris classed as undiagnostic ironworking slag is more dense (having a composition which is predominantly fayalitic) but the morphology of the slag lumps is irregular and similar materials may be produced by either smelting or smithing operations.

Ferruginous concretion forms as a result of the redeposition of iron hydroxides, similar to the natural phenomenon of iron panning, although the process is likely to be enhanced by the nature of the surrounding archaeological deposits, particularly iron-rich waste. It is possible that the iron objects relate to iron production. No clear evidence of non-ferrous metal working was identified during the assessment, although occasional instances of lining that appeared more glazed than vitrified may derive from this.

Changes in slag type with date

Comparison of the frequency with which different categories of slag occur in different phases appears to show slightly greater proportions of tap slag in the Early Late Saxon and Middle Late Saxon periods (6 instances out of 35) than in the Early and Late Medieval periods (3 instances out of 30). By contrast, over the same time span the occurrence of smithing hearth bottoms increases (3 in Saxon contexts, 5 in Medieval). Although these figures can only be very approximate it does seem possible that later activity at the site saw a shift away from smelting to increasing smithing on the site.

Conclusions

The Franciscan Way site produced large quantities of metalworking debris within a relatively restricted area. The diagnostic components of the bulk slag and debris derived from both iron smelting, i.e. the primary production of iron from its ore and iron smithing. However, within the sample examined, the limited quantities of tap slag, compared to the large volume of slag that can be produced from tapped furnaces, may indicate that this activity was peripheral to the site or occurred on a relatively small scale. The slightly higher occurrence of tap slag in the earlier period might suggest that the importance of smelting lessened during the occupation of the site whilst smithing became more significant.

Further evidence of iron smithing was provided when soil samples were tested for magnetic susceptibility which showed several contexts, especially in the Early Late Saxon and Late Saxon periods to contain large quantities of hammerscale. No positive] evidence of non-ferrous metalworking was found within the assemblage to complement the reported finding of an antler brooch mould. However, if brooches were being produced in pewter, the working of this easily melted alloy would not produce debris which was easily recognisable on an archaeological site.

Potential for further work

The rapid examination of a small proportion of the Franciscan way assemblage resulted in an uneven coverage of the periods excavated and a lack of quantifiable data. Despite the absence of associated structures the site has considerable metallurgical interest and offers the opportunity to study shifts in local iron production and working on a well dated site adjacent to a major Saxon settlement.
As a first stage it would be necessary to visually examine the entire assemblage, classify and weigh it. The data thus derived could be used to study the chronological and spatial distribution of different types of metalworking debris on the site and to compare the results with those of other contemporary sites in Ipswich.

Scientific investigation of a limited range of the smelting slags (examination by optical microscopy and phase analysis by scanning electron microscope (SEM) based energy dispersive X-ray analysis (EDXA)) would allow the material to be chemically characterised and allow wider, objective comparison with material from other sites.

Magnetic susceptibility (or other means of identifying hammerscale) should be carried out on any further soil samples.

Time requirements

Examination and classification of c725kg debris, production of report 10 days

If required,

Preparation, optical microscopy, recording, microanalysis of 5 representative slag samples including production of report with black and white plates 10 days

Additionally,
Magnetic susceptibility @30 samples/day

Storage of slag

Iron working slag, being predominantly fayalitic, is not prone to deterioration and requires no special storage treatment.

References

1. Unpublished site summary provided by John Newman, Suffolk County Council Planning office.

2.Starley, D. (1995) Hammerscale Historical Metallurgy Datasheet No.10.

3. Mills, A. and McDonnell, J G (1992) The Identification and Analysis of the Han Hammerscale from Burton Dassett, Warwickshire. Ancient Monuments Laboratory Report 47/92.