

Ancient Monuments Laboratory  
Report 91/93

ASSESSMENT OF SLAG AND OTHER  
METALWORKING DEBRIS FROM ROMAN  
CONTEXTS AT WINCHESTER PALACE,  
SOUTHWARK, 1983-84

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Summary

A total of 150kg of industrial debris recovered from the Stave East area of the excavation was found to derive predominantly from ironsmithing, with lesser quantities being associated with non-ferrous metalworking. However, most of the material was found within levelling dumps and there is no clear indication that any metal production or working occurred on the site.

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# ASSESSMENT OF SLAG AND OTHER METALWORKING DEBRIS FROM ROMAN CONTEXTS AT WINCHESTER PALACE, SOUTHWARK, 1983-84

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## Introduction

In 1983-84 archaeological excavations were carried out on the site of Winchester Palace<sup>1</sup>, by the Museum of London's Department of Greater London Archaeology in advance of redevelopment on the Southwark river-front. Roman occupation of the site was divided into four phases, the first three appear to have been of short duration, totalling approximately 60 years. Following the demolition of the third phase, large quantities of material were imported onto the site to level the ground (provisionally dated AD 70-120<sup>2</sup>). This was followed by the construction of substantial masonry buildings which survived in use for at least 150 years, until the fourth century.

Although no metallurgical structures, such as hearths or furnaces, were found on the site, relatively large quantities of metallurgical debris were recovered, particularly from the levelling-up deposit. Examination of this debris was carried out to identify the industrial processes which produced them and to assess the potential of the assemblage for further analysis.

The standard examination strategy was revised after 30 boxes of debris were presented instead of the 3-4 expected! As far as possible material from all contexts was visually examined, total weights of slag were recorded and the types of slag present qualitatively assessed<sup>3</sup>. However, shortage of time allowed only a very rapid scan through the later contexts (< 600). No detailed recording of these contexts was made except for the large quantities of very distinctive material in contexts (27) and (287) and some copper alloy waste from context (302). The extent of this later, unrecorded material was about 10kg, from a total of 150kg.

Originally, soil samples had been saved for hammerscale determination, however, the location of these was not known at the time of assessment. Where hammerscale is recorded below it was identified from small quantities within the soil adhering to unwashed samples. It is probable that hammerscale escaped detection in other contexts.

The findings of the visual examination are tabulated below:

Metalworking debris from Winchester Palace, Southwark				
context	group	weight (g)	slag interpretation	trench/context information
27	47.07	8950	cinder (very hard and brittle - high temp. coke burning?), flake hammerscale	Stave East post-Med.
287	65.19	4700	cinder (very hard and brittle - high temp. coke burning?)	Stave East late backfilling
302	41.03	5	Cu alloy waste	Stave East
700	26.16	550	iron-rich cinder, cinder	Stave East levelling dump over buildings 6-9
702	26.16	250	iron-rich cinder	Stave East levelling dump over buildings 6-9
706	43.2	5	cinder	Stave East
707	26.17	15	iron object	Stave East
709	39.01	100	undiagnostic ironworking slag	Stave East
712	39.01	250	undiagnostic ironworking slag	Stave East
714	36.08	50	iron-rich cinder	Stave East
717	26.15	550	vitified hearth/furnace lining, undiagnostic ironworking slag, smithing hearth bottom (250g 100x70x40mm)	Stave East levelling dump over buildings 6-9
718	28.27	80	vitified hearth/furnace lining (glazed), iron-rich cinder	Stave East levelling dump over buildings 6-9
721	26.11	10	cinder	Stave East
724	43.22	100	vitified hearth/furnace lining	Stave East
725	26.17	450	undiagnostic ironworking slag, vitified hearth/furnace lining	Stave East
730	26.15	470	cinder, undiagnostic ironworking slag, vitified hearth/furnace lining	Stave East levelling dump over buildings 6-9
733	39.02	30	iron-rich cinder	Stave East
736	28.27	100	undiagnostic ironworking slag	Stave East levelling dump over buildings 6-9
739	38.01	20	iron-rich cinder	Stave East
742	38.03	150	cinder	Stave East
743	43.22	10	cinder	Stave East
748	28.27	1500	vitified hearth/furnace lining (some black glaze), undiagnostic ironworking slag, cinder, flake hammerscale	Stave East levelling dump over buildings 6-9
749	28.27	5300	frag. smithing hearth bottom, undiagnostic ironworking slag, cinder, iron-rich cinder, iron object, flake hammerscale	Stave East levelling dump over buildings 6-9
750	39.01	5	cinder	Stave East
751	26.14	2300	vitified hearth/furnace lining, cinder, undiagnostic ironworking slag, flake hammerscale	Stave East
752	28.27	350	vitified hearth/furnace lining, iron-rich cinder	Stave East levelling dump over buildings 6-9
753	38.03	150	cinder	Stave East
755	26.09	120	vitified hearth/furnace lining (blue glaze), poss. tuyere	Stave East
756	26.08	50	vitified hearth/furnace lining (black glaze)	Stave East

Metalworking debris from Winchester Palace, Southwark				
context	group	weight (g)	slag interpretation	trench/context information
757	28.08	1450	vitrified hearth/furnace lining (some blue glaze), iron object, cinder, ferruginous concretion, fuel ash slag, flake hammerscale	Stave East levelling dump over buildings 6-9
760	43.21	30	iron object	Stave East
762	36.08	1600	cinder, iron-rich cinder, undiagnostic ironworking slag, iron object, flake hammerscale	Stave East
764	33.04	10	vitrified hearth/furnace lining	Stave East
773	42.03	40	vitrified hearth/furnace lining (black glaze), undiagnostic ironworking slag (Cu corrosion specks)	Stave East
775	28.27	5000	vitrified hearth/furnace lining, undiagnostic ironworking slag, flake and spheroidal hammerscale	Stave East levelling dump over buildings 6-9
776	28.08	5500	vitrified hearth/furnace lining, cinder, undiagnostic ironworking slag, iron-rich cinder, flake hammerscale	Stave East levelling dump over buildings 6-9
779	28.26	5400	undiagnostic ironworking slag, cinder, ferruginous concretion, vitrified hearth/furnace lining	Stave East levelling dump over buildings 6-9
780	28.26	250	cinder, vitrified hearth/furnace lining	Stave East levelling dump over buildings 6-9
790	42.03	100	fired clay, iron object	Stave East
795	28.23	750	vitrified hearth/furnace lining, undiagnostic ironworking slag, cinder	Stave East levelling dump over buildings 6-9
797	35.01	200	iron-rich cinder	Stave East
798	34.01	40	fired clay	Stave East
799	32.02	525	smithing hearth bottom (525g 130x110x50mm)	Stave East
802	u/s	125	vitrified hearth/furnace lining, cinder	Stave East
808	24.06	150	vitrified hearth/furnace lining	Stave East
810	36.04	900	vitrified hearth/furnace lining, cinder	Stave East
811	28.34	3300	vitrified hearth/furnace lining, undiagnostic ironworking slag, cinder	Stave East levelling dump over buildings 6-9
818	25.64	250	vitrified hearth/furnace lining	Stave East
819	28.34	1200	vitrified hearth/furnace lining, cinder	Stave East levelling dump over buildings 6-9
820	28.25	800	vitrified hearth/furnace lining, cinder, flake hammerscale, smithing hearth bottom (300g 80x80x40mm)	Stave East levelling dump over buildings 6-9
821	28.25	300	undiagnostic ironworking slag	Stave East levelling dump over buildings 6-9
822	28.23	16200	vitrified hearth/furnace lining, undiagnostic ironworking slag, cinder, flake hammerscale	Stave East levelling dump over buildings 6-9
833	28.25	900	vitrified hearth/furnace lining, undiagnostic ironworking slag, flake hammerscale	Stave East levelling dump over buildings 6-9
835	28.06	10200	undiagnostic ironworking slag (some very cindery), cinder, vitrified hearth/furnace lining (some black glaze some Cu corrosion specks), flake and spheroidal hammerscale, smithing hearth bottoms (150g 90x70x35mm, 125g 90x60x30mm)	Stave East levelling dump over buildings 6-9

Metalworking debris from Winchester Palace, Southwark				
context	group	weight (g)	slag interpretation	trench/context information
838	28.25	400	vitrified hearth/furnace lining (red glaze & Cu corrosion specks), iron-rich cinder, flake hammerscale, charcoal	Stave East levelling dump over buildings 6-9
839	28.23	50	cinder, flake hammerscale	Stave East levelling dump over buildings 6-9
841	28.34	200	undiagnostic ironworking slag, vitrified hearth/furnace lining, fuel ash slag, cinder flake hammerscale, burnt bone	Stave East levelling dump over buildings 6-9
849	39.1	700	iron-rich cinder, flake hammerscale	Stave East
853	28.06	100	vitrified hearth/furnace lining, cinder, flake hammerscale, burnt stone	Stave East levelling dump over buildings 6-9
857	28.25	200	cinder, charcoal	Stave East levelling dump over buildings 6-9
878	28.02	250	vitrified hearth/furnace lining, cinder, flake hammerscale	Stave East levelling dump over buildings 6-9
884	34.01	30	vitrified hearth/furnace lining (translucent grey glaze)	Stave East
895	28.34	1900	undiagnostic ironworking slag (cindery & dense), cinder, vitrified hearth/furnace lining, iron object, flake hammerscale, smithing hearth bottom (125g 70x60x40mm)	Stave East levelling dump over buildings 6-9
901	28.01	6700	undiagnostic ironworking slag, cinder, vitrified hearth/furnace lining, flake hammerscale, burnt flint, smithing hearth bottom (350g 100x90x45mm, 350g 100x90x40mm, 200g 90x70x35mm)	Stave East levelling dump over buildings 6-9
918	28.01	15	undiagnostic ironworking slag	Stave East levelling dump over buildings 6-9
919	22.01	80	burnt stone, fired clay	Stave East
923	43.02	600	vitrified hearth/furnace lining	Stave East
931	37.01	100	undiagnostic ironworking slag, vitrified hearth/furnace lining	Stave East
932	28.34	5	vitrified hearth/furnace lining	Stave East levelling dump over buildings 6-9
933	28.34	5	vitrified hearth/furnace lining	Stave East levelling dump over buildings 6-9
936	28.23	700	cinder, vitrified hearth/furnace lining, iron-rich cinder	Stave East levelling dump over buildings 6-9
937	33.03	750	iron-rich cinder, cinder	Stave East
957	28.31	3250	iron-rich cinder, vitrified hearth/furnace lining, cinder	Stave East levelling dump over buildings 6-9
963	28.31	6200	vitrified hearth/furnace lining, cinder, iron-rich cinder, flake hammerscale, smithing hearth bottom (150g 90x70x35mm)	Stave East levelling dump over buildings 6-9
966	32.01	5	vitrified hearth/furnace lining (blue glaze)	Stave East
967	28.07	4450	vitrified hearth/furnace lining, undiagnostic ironworking slag, iron-rich cinder, flake hammerscale	Stave East levelling dump over buildings 6-9
968	3.01	5	vitrified hearth/furnace lining (blue glaze)	Stave East
973	26.02	15	fired clay	Stave East
979		10	fired clay	Stave East

Metalworking debris from Winchester Palace, Southwark				
context	group	weight (g)	slag interpretation	trench/context information
999	28.05	400	iron-rich cinder, cinder, flake hammerscale	Stave East levelling dump over buildings 6-9
1000	20.01	750	vitified hearth/furnace lining	Stave East
1002	28.23	450	vitified hearth/furnace lining, cinder	Stave East levelling dump over buildings 6-9
1004	39.01	1200	undiagnostic ironworking slag, iron-rich cinder, flake hammerscale	Stave East
1005	39.01	2500	vitified hearth/furnace lining, undiagnostic ironworking slag, flake hammerscale, smithing hearth bottom (500g 120x100x45mm)	Stave East
1009	28.31	1200	undiagnostic ironworking slag, cinder, vitified hearth/furnace lining	Stave East levelling dump over buildings 6-9
1022	27.05	100	vitified hearth/furnace lining, undiagnostic ironworking slag	Stave East levelling dump over buildings 6-9
1034	27.03	200	iron-rich cinder	Stave East levelling dump over buildings 6-9
1037	27.03	50	iron-rich cinder	Stave East levelling dump over buildings 6-9
1089	28.23	16500	ferruginous concretion, cinder, flake and spheroidal hammerscale, undiagnostic ironworking slag, vitified hearth/furnace lining (some black glazed)	Stave East levelling dump over buildings 6-9
1096	26.19	40	iron-rich cinder	Stave East
1099	26.19	50	iron object	Stave East
1110	28.18	3600	vitified hearth/furnace lining, undiagnostic ironworking slag, iron-rich cinder	Stave East levelling dump over buildings 6-9
1123	29.02	50	cinder	Stave East
3000	not listed	30	uncertain poss. cinder from coke burning	? unstrat
3030	not listed	200	undiagnostic ironworking slag	? reclamation dump
3046	not listed	200	ferruginous concretion	? reclamation dump
3081	not listed	125	? mortar	? reclamation dump
3107	not listed	50	? mortar	? reclamation dump
3111	not listed	10	? mortar	? reclamation dump
3230	not listed	100	iron object, ceramic	? reclamation dump
3234	not listed	125	stone +?	? reclamation dump
3520	not listed	3	fuel ash slag	? reclamation dump
3823	not listed	15	cinder	? reclamation dump
5470	55.07	125	cinder, ferruginous concretion	Area B (Stave West)

A large proportion of the material in the Winchester Palace assemblage was identified as **vitified hearth/furnace lining**. This may derive from either iron smelting or smithing structures where the material forms as a result of high temperature reactions, between the clay lining of the hearth/furnace and the alkali fuel ash or fayalitic slag. A compositional gradient from unmodified clay on one surface to an irregular cindery material on the other can generally be seen in this material. However, a small proportion of the material from Winchester Palace was characterised by a thin, uniform, black, red or blue glaze on a well fired, but not overheated, clay fabric. This is more suggestive of the working of non-ferrous alloys rather than iron. This evidence was supported by the existence of a small number of crucible fragments

which have been examined in a previous study<sup>4</sup>. However, other examples of highly slagged lining, and "ironworking slags" showed small specks of bright green copper corrosion, these may well have derived from occasional working of copper alloys in the blacksmiths hearth, such as the brazing, riveting or inlaying of iron artefacts. Context (755) also produced the remains of a *tuyère* (air inlet nozzle) from a hearth or furnace.

**Cinder**, comprises only the lighter portion of the vitrified hearth lining, 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 spalled 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, making it denser.

Material clearly diagnostic of ironsmithing was found as **smithing hearth bottoms**. These are recognisable by their characteristic plano-convex form, having a rough underside and a smoother, vitrified upper surface often hollowed as a result of downwards pressure from the air blast of the *tuyère*. Compositionally, hearth bottoms are of largely fayalitic (iron silicate) composition and result from high temperature reactions between the iron, iron scale and silica from either the sand used as flux or from the hearth lining. Dimensions for the smithing hearth bottoms, given below, are small compared examples from other Roman assemblages.

Winchester Palace smithing hearth bottom dimensions (n=11)			
	range	mean	std dev
weight (g)	125-500	275	140
length (mm)	80-120	100	15
width (mm)	60-110	80	15
depth (mm)	30-50	40	5

Further evidence for the smithing of iron was found in the form of **hammerscale**. These micro-slags may conform to two types. The first, **flake hammerscale**, consists of "fish-scale" like fragments of the oxide/silicate skin of the iron which become dislodged due to mechanical and thermal shock during hot working. **Spheroidal hammerscale** results from the solidification of small droplets of liquid slag expelled during higher temperature hammering of the iron, particularly when two components are fire-welded together, but also during the primary smithing of the iron bloom into a billet. As mentioned above, the assessment of hammerscale was undertaken under far from ideal conditions. However, of the hammer-scale that was identified, flake hammerscale appeared to be the predominant, if not sole, constituent. This suggested that the ironsmithing activities from which they derive involved the shaping of metals (as might predominate in trades such as nail smithing) rather than complex forging and welding of composite items. On most archaeological sites hammerscale distributions are generally regarded as important indicators of the location of ironsmithing activities because deposits are more likely to remain in the vicinity of the smithy than the bulk slags, which may be removed elsewhere. However, there



seems little doubt that on the Winchester Palace site the hammerscale had also been imported, along with the bulk of the soil, macro slags and quantities of charcoal.

It should be noted that both iron smithing and iron smelting slags form part of an iron oxide-iron silicate-glassy continuum with various degrees of vesicularity and contamination from the fabric of the furnace lining. Some categories in the table are based on morphological criteria rather than directly on technological origins. **Undiagnostic ironworking slag**, for instance, is of fayalitic composition but has an amorphous, blocky, form. Similar material can originate from either iron smithing or iron smelting (extraction of metal from ore) and it cannot help to distinguish the nature of the ironworking activity on site.

**Ferruginous concretions** forms as a result of the redeposition of iron hydroxides. This "iron panning" is a common natural phenomenon, although the process may be enhanced by the surrounding archaeological deposits, particularly where iron artefacts or iron working debris are present. **Fuel ash slag** is a very lightweight and normally light-coloured (grey-brown), highly porous material that results from the reaction between alkaline fuel ash and silicates from soil, sand or clay at elevated temperatures. The reaction is shared by many pyrotechnological processes and the slag is not diagnostic. Finally, three contexts (27), (287) and (3000) produced a very lightweight, hard and brittle cindery material, probably deriving from some later, high temperature coal/coke burning process.

## Conclusions

The slag examined had been recovered almost exclusively from the Stave East area of the Winchester Palace site. Only 125g of material was labelled as originating from Stave West; a remarkably low quantity for an urban site. A very high proportion (by weight) of the Stave East debris belonged to contexts associated with the late first/early second century levelling deposits which sealed buildings 6-9. The nature of the deposits, and absence of excavated metalworking structures, suggests that the processes which produced the debris were not actually carried out on the area excavated. The metalworking debris, at best, provides some evidence of the nature of industries/crafts operating in the vicinity of the site.

The diagnostic ironworking slags, were exclusively associated with smithing, *i.e.* hot working of iron. No slags characteristic of smelting, *i.e.* the primary production of iron from its ore, were identified. In the absence of clear evidence of smelting, it is therefore likely that the "undiagnostic slags" also derive from smithing.

In addition to the ironworking debris, small quantities of material deriving from non-ferrous metalworking were identified. Visual examination was unable to determine either the specific processes or metals involved, although the bright green corrosion products on some fragments suggested that the latter included copper alloys.

## Potential for further work

Although the purpose of the Roman structures at Winchester Palace has not yet been fully interpreted, there is no evidence that metalworking, or any other industrial process, played any significant role on the site. This therefore limits the significance of the metalwork debris assemblage and it is not felt that further, more in-depth, investigation of the material would be justifiable.

## Storage of slag

Ironworking slag, being predominantly fayalitic, is not prone to deterioration and requires no special storage treatment. It is recommended that all the slag should be saved.

## References

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