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Ancient Monuments Laboratory
Report 39/96

THE EXAMINATION OF METALWORKING DEBRIS FROM HOUSESTEADS ROMAN FORT, NORTHUMBERLAND 1974-1981

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Summary

A small quantity of debris recovered from excavations in the north-east corner of the fort derived from both iron smithing and a wider range of non-ferrous alloy working. Some slag provided rare unambiguous evidence for the use of coal in Romano-British ironworking.

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The examination of metalworking debris from Housesteads Roman Fort, Northumberland 1974-1981

David Starley

Introduction

Excavations at Housesteads fort (NY 790688) between 1974 & 1981 investigated the north-east corner of the fort, focusing principally on barrack block XIII, the adjacent rampart back and the intervallum roadway areas from the north gate to the north-east angle tower and thence to the east gate[1]. The project served as a training dig for second year students at the Department of Archaeology in the University of Newcastle upon Tyne. Outside these intensive 3 week spells, excavation was continued by smaller numbers of volunteers. Between 1974 and 1977, the excavations were directed by C.M. Daniels and J.P. Gillam with J.G. Crow joining the team as assistant director from 1978. An industrial area was identified behind the ramparts, this included a number of large hearths of uncertain purpose.

Only small areas of the site were opened at any time, with excavation proceeding sequentially each season. The site/building codes derive from the numbering sequence of R.C. Bosanquet following trial trenching in 1898. The sequence of excavation was as follows:

1974-77	Complete exploration of building XIII (H13)
1977	Exploratory trench opened in the north rampart area. Building XIII excavation extended across the north end of the *via principalis*, revealing the east end of building VII (H13:11).
1977-78	Clearance down to the upper most road surface of the street between buildings XIII and XIV.
1978-79	North rampart back and roadway area- north gate to north-east angle tower (H20).
1979	Examination of the western-most contubernium/chalet of building XIV (H14:9).
1980-81	East rampart back and roadway area - north-east angle tower to east gate (H21).

1981 • Re-examination of the east end of building XV where a bath-house was inserted during the fourth century (first investigated by Wilkes in 1961) (H15:1).
- The east end of the road between XIII and XIV excavated down to a suitable level for display (HSE)
- Re-examination of the remains of building XIV, first excavated by Wilkes in 1961 (H14:1,3-6).

Site Phasing

A short pre-fort phase was identified in site H20. The fort itself can be divided into four phases:

I	The primary fort	Hadrianic
II	Modifications to the primary fort	Mid/late C2-C3
III	The chalet phase	Tetrarchic
IV	Modifications to the chalet phase	C4-early C5 (?)

To some extent phasing within the separate areas of excavation "float" with respect to other areas. Phasing codes used in the context lists follow the scheme of Mike Bishop (1989):

Table1 Housesteads 1974-81 Excavations- Provisional Phase Correspondence

Overall	H13:0/1	H13:2-11	H14	H15	H20	H21	HSE
Modern	M	M	M	M	M	M	M
Post Roman?	3+						
IV	3	3			4e		6
4th-early 5th			4	5	4d	4	5
century	2	2			4c		4
modifications					4b		3
III Chalets (c.AD 300)	1	1	3	4	4a	3	2
	v+	-					
II	v				3d		1
2nd-3rd	iv			3	3c		
century	iii	BA	2		3b	2	
modifications	ii			2	3a		
	I				2b		
I Primary Construction	CON	CON	1	1	2a	1	-
Pre-fort		HW			PR/1		
(inclu. H Wall	PR	PR	-	-		-	

Table 2 Metalworking debris from Housesteads

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
13	0	0	Topsoil	M	TS/N	iron-rich cinder	50	
13	0	2	Rubble and earth layer	M	2256	vitrified hearth lining	140	
13	1	48	Mixed loam	2	2713	iron object	5	
13	1	253	Stony and clay filled brown loam	CON	990	undiagnostic ironworking slag	50	
13	1	253	Stony and clay filled brown loam	CON		iron object	60	
13	1	253	Stony and clay filled brown loam	CON		ceramic	8	non-metallurgical
13	2	2	Rubble and waste material	3		crucible frags	10	red vitrification on outside
13	6	11	Rubble below topsoil	3	1259	blast furnace slag	5	pale blue
13	7	1	Rubble rather than topsoil	3	1301	undiagnostic ironworking slag	140	
13	7	1	Rubble rather than topsoil	3	1260-5	burnt stone	5	
13	7	1	Rubble rather than topsoil	3	1260-5	undiagnostic ironworking slag	20	
13	7	1	Rubble rather than topsoil	3	1260-5	flake hammerscale		
13	7	1	Rubble rather than topsoil	3	1285-93	undiagnostic ironworking slag	220	
13	7	1	Rubble rather than topsoil	3	1285-93	smithing hearth bottom	110	(50g60x50x20mm, 60g50x40x25mm)
13	7	1	Rubble rather than topsoil	3	1285-93	flake hammerscale		
13	8	0	Topsoil	M	215	undiagnostic ironworking slag	100	
13	8	0	Topsoil	M	215	coal	10	
13	8	0	Topsoil	M	215	burnt coal/shale	110	
13	8	0	Topsoil	M	1321-5	undiagnostic ironworking slag	30	
13	8	0	Topsoil	M	1321-5	cinder	20	
13	8	0	Topsoil	M	1321-5	iron object	10	
13	8	1	Lower topsoil	3	1253-4	undiagnostic ironworking slag	40	
13	8	1	Lower topsoil	3	1395-9	undiagnostic ironworking slag	70	
13	8	1	Lower topsoil	3	1395-9	iron object	5	
13	8	5	Lightish clay	1	1340-53	iron object	10	
13	8	5	Lightish clay	1	1340-53	undiagnostic ironworking slag	160	
13	8	5	Lightish clay	1	1340-53	flake hammerscale		
13	8	7	Early west wall	CON	1241	undiagnostic ironworking slag	30	

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
13	8	7	Early west wall	CON	1241	cinder	20	
13	8	7	Early west wall	CON	1241	iron object	10	nails
13	9	0	Topsoil	M	215	smithing hearth bottom	110	(110g70x60x20mm)
13	9	0	Topsoil	M	1242	undiagnostic ironworking slag	170	
13	9	3	Thin cover	M	420	undiagnostic ironworking slag	40	
13	10	1	Rubble	M	1935	lead spill	500	white corrosion products
14	3	1	Backfill?	M	9342	undiagnostic ironworking slag	20	very dense, high Fe?
14	3	1	Backfill?	M	9350	iron object	20	
14	3	1	Backfill?	M	9350	cinder	10	
14	3	1	Backfill?	M	9355	undiagnostic ironworking slag	20	
14	3	1	Backfill?	M	9355	ferruginous concretion	5	
14	3	1	Backfill?	M	9402	undiagnostic ironworking slag	20	
14	3	4	Construction trench	M?		iron object	10	
14	3	20	Hearth	?	9350	iron object	70	
14	9	5	Road surface	3		undiagnostic ironworking slag	1300	
14	9	5	Road surface	3		smithing hearth bottom	400	(160g80x70x35mm, 110g70x50x20mm, 90g60x40x30mm, 40g50x40x25mm)
14	9	5	Road surface	3		iron object	10	
14	9	5	Road surface	3		ceramic	5	
14	9	5	Road surface	3		flake hammerscale		
14	9	20	Cobbles	2		fuel ash slag	3	brittle, black = coal
14	9	21	Earlier road surface	2	8234-5	undiagnostic ironworking slag	50	
14	9	21	Earlier road surface	2		undiagnostic ironworking slag	80	
15	1	1	Excavation trench	M	9075	coal	40	
15	1	1	Excavation trench	M	9076	undiagnostic ironworking slag	30	
15	1	1	Excavation trench	M	9215	undiagnostic ironworking slag	35	
15	1	2	Topsoil	M	9093	undiagnostic ironworking slag	50	
15	1	2	Topsoil	M	9093	fired clay	5	
15	1	2	Topsoil	M	9120	coal	20	

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
15	1	2	Topsoil	M	9205	smithing hearth bottom	560	half (560g 120x60x50mm)
15	1	2	Topsoil	M	9205	flake hammerscale		few
15	1	2	Topsoil	M	9206	undiagnostic ironworking slag	220	
15	1	2	Topsoil	M	9214	undiagnostic ironworking slag	20	
15	1	2	Topsoil	M	9214	vitrified hearth lining	40	
15	1	2	Topsoil	M	9214	flake hammerscale		few
15	1	2	Topsoil	M	9217	coal	60	
15	1	2	Topsoil	M	9391	undiagnostic ironworking slag	10	
15	1	2	Topsoil	M	9392	coal	1	
15	1	4	Makeup for flags	4	9513	copper alloy spill	13	
15	1	4	Makeup for flags	4		fired clay	5	
15	1	5	Topsoil	M	9211	undiagnostic ironworking slag	70	
15	1	5	Topsoil	M	9211	iron object	60	
15	1	9	Topsoil	M	9202	undiagnostic ironworking slag	20	
15	1	10	Modern trench	M	9475	vitrified hearth lining	10	black glaze
15	1	11	Modern backfill	M	9428	smithing hearth bottom	100	(100g 80x55x 20mm)
15	1	11	Modern backfill	M	9428	flake hammerscale		few
15	1	25	Excavation trench	M	9469	undiagnostic ironworking slag	10	
15	1	33	Charcoal	5		charcoal/coal dust		
15	1	64	Soil and mortar - construction/?demolition level	5		iron object	5	nail
15	1	104	Construction material	5		fired clay	140	
20	1	0	Topsoil	M	4104-5	slag with copper corrosion	30	
20	1	0	Topsoil	M		crucible frags(3)	60	hand moulded, external vitrification
20	2	0	Topsoil	M	4217-8	smithing hearth bottom	200	(200g80x70x30mm)
20	2	0	Topsoil	M	4217-8	undiagnostic ironworking slag	20	
20	2	4	Fill of Clayton trench	M	5323	iron object	140	poss bar end 40x25x8mm
20	3	0	Topsoil	M	4711	undiagnostic ironworking slag	10	
20	3	0	Topsoil	M	5365	undiagnostic ironworking slag	340	

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
20	3	0	Topsoil	M	5365	flake hammerscale		
20	3	19	Charcoal layer	3b	7745	undiagnostic ironworking slag	5	
20	3	62	Charcoal layer - charcoal & red clay	3a		stone	136	weathered limestone?
20	3	75			5383	iron object	70	
20	3	75			5383	soil (no hammerscale)		
20	4	0	Topsoil	M	5296	undiagnostic ironworking slag	480	
20	4	0	Topsoil	M	5296	cinder	20	
20	4	0	Topsoil	M	5296	smithing hearth bottom	310	(150g80x70x30mm, 90g55x50x30mm, 70g70x40x25mm)
20	4	0	Topsoil	M	5296	lead/pewter	30	
20	4	0	Topsoil	M	5296	undiagnostic ironworking slag	10	
20	4	1	More compact than topsoil	4a		vitrified hearth lining	10	
20	4	1	More compact than topsoil	4a		cinder	30	
20	4	10	Rubble spread	4c		vitrified hearth lining	10	
20	4	10	Rubble spread	4c		cinder	10	
20	4	16	Soft soil depression	4a	6569	undiagnostic ironworking slag	10	
20	4	22	Charcoal spread	3b	7026	vitrified hearth lining	10	
20	4	35	Orange brown soil	3b	6777	vitrified hearth lining	3	Cu corrosion products
20	4	35	Orange brown soil	3b	6778	undiagnostic ironworking slag	80	
20	4	65	Construction cut	3a		stone		
20	4	75	Orange soil	2b		stone		weathered limestone (or mortar?)
20	5	0	Topsoil	M	4496	smithing hearth bottom	620	(620g120x100x70mm)
20	5	0	Topsoil	M	4498	iron object	470	prob. bar end (70x50x20mm)
20	5	0	Topsoil	M	4860-61	cinder	5	
20	5	1	More compact than topsoil	4a	5263	undiagnostic ironworking slag	60	
20	5	32	Charcoal layer	3b	6857	slag with copper corrosion	20	
20	5	56	Fill of expansion wall robber trench	3a	8148	coal? with slagged surface		
20	5	63	Hearth	3b		hearth lining		red, oxidised fired
20	6	0	Topsoil	M	5032-3	undiagnostic ironworking slag	110	

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
20	6	33	Rubble pack interval tower	4e	6593	iron object	15	
20	7	0	Topsoil	M	5454	iron object	60	
20	7	0	Topsoil	M	5454	undiagnostic ironworking slag	100	
20	7	0	Topsoil	M	7701	undiagnostic ironworking slag	90	
20	7	0	Topsoil	M		undiagnostic ironworking slag	100	
20	7	33	Brown sandy soil & rubble wall stones	4e		cinder	280	
20	7	33	Brown sandy soil & rubble wall stones	4e		smithing hearth bottom	380	(270g100x70x50mm, 110g70x50x30mm)
20	7	33	Brown sandy soil & rubble wall stones	4e		undiagnostic ironworking slag	40	
20	7	41	Soil with interval tower	4e	7806	cinder	10	
20	7	41	Soil with interval tower	4e		mortar	530	
20	7	56	Light brown soil	4a	8079	undiagnostic ironworking slag	30	
20	7	64	Grey brown loose layer with charcoal & bone	4a	8308	blast furnace slag	60	black. Analysed by XRF
20	7	75	Hearth material of 74	3a	8527	crucible frag	7	green & red flecks externally
20	7	75	Hearth material of 74	3a	8527	copper alloy spills + frags	170	
20	7	75	Pit sample	3a	8527	iron object	80	mineral preserved organics
20	7	75	Pit sample	3a	8527	ferruginous concretion	300	with hammerscale
20	7	75	Pit sample	3a	8527	ashy deposit	370	with hammerscale
20	8	1	Topsoil	M	7009	undiagnostic ironworking slag	10	
20	8	1	Topsoil	M	7108-17	undiagnostic ironworking slag	80	
20	8	8	Soil layer	4a	7149-53	undiagnostic ironworking slag	40	
20	8	21	Slag	3a		cinder	120	with coal frags
20	8	21	Slag	3a		flake hammerscale		
20	8	22	Grey brown soil	3d		iron object	20	
20	8	22	Grey brown soil	3d		coal	30	
20	8	22	Grey brown soil	3d		undiagnostic ironworking slag	20	
20	8	40	Soil	4a	8063	undiagnostic ironworking slag	10	

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
20	8	42	Fill of drain M	4a	8264	cinder	20	
20	8	46	Hearth in drain 41	4a	8087	undiagnostic ironworking slag	150	
20	8	58	Road surface	3a		stone		
20	8	75	Bedding for 19	4a	8516	soil cont. copper corrosion products & coal		weathered limestone/mortar?
20	9	5	Soil	4c	7265	undiagnostic ironworking slag	30	
20	9	10	Soil level	3b	8419	smithing hearth bottom	540	(540g130x120x70mm)
21	1	0				coal	10	
21	1	1	Turf & topsoil	M	8551	crucible frag.	5	wheel thrown black glaze
21	1	1	Turf & topsoil	M	8551	cinder	5	
21	1	8	Sand clay & loam some rubble abutting 6	4?	8795-6	coal	5	
21	1	9	Stone & loam	4	8720	cinder	10	
21	1	20	Material from weeding & cleaning	-	8701	undiagnostic ironworking slag	10	
21	1	20	Material from weeding & cleaning	-	8702	cinder	10	
21	1	22	N wall primary angle tower	1		iron object	260	
21	1	22	N wall primary angle tower	1		lead	15	
21	1	33	Fill of 34	4	880	undiagnostic ironworking slag	2	
21	1	33	Fill of 34	4	8846	crucible frag.	10	wheel thrown black & red glaze
21	1	33	Fill of 34	4	8847-8	iron object	20	
21	1	33	Fill of 34	4	8847-8	undiagnostic ironworking slag	15	
21	1	35	Rubble pack	4	9066	crucible frag.	5	
21	1	35	Rubble pack	4	9067	cinder	20	
21	1	35	Rubble pack	4	9218	crucible frag.	10	wheel thrown
21	1	35	Rubble pack	4	9321	crucible frag.	5	blob
21	1	35	Rubble pack	4	9323	coal	15	
21	1	35	Rubble pack	4	9326	iron object	5	
21	1	35	Rubble pack	4	9326	cinder	5	
21	1	37	Simpson trench	M	8932	iron object	100	

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
21	1	37	Simpson trench	M	9095	vitrified hearth lining	5	
21	1	37	Simpson trench	M	9141	coal	5	
21	1	37	Simpson trench	M	8933-4	crucible frag.	15	wheel thrown black glaze
21	1	37	Simpson trench	M	9139-40	crucible frag.	10	wheel thrown black glaze
21	1	43	Road surface	3	9434	iron-rich cinder	50	
21	1	44	Rubble	3?		crucible frag.	5	blob
21	1	44	Rubble	3?		crucible frag.	2	sheet offcuts
21	1	49	Yellow sand bronze charcoal frag	2	9427	coal	2	
21	1	51	Sandy layer	1		stone	100	
21	1	54	Sand/peat	1	9301	cinder	10	
21	1	54	Sand/peat	1	9365	cinder	10	
21	1	54	Sand/peat	1	9374	slag with copper corrosion	5	
21	1	54	Sand/peat	1	9375	ferruginous concretion	10	
21	1	54	Sand/peat	1		crucible frag.	10	
21	1	54	Sand/peat	1		crucible frag.	1	sheet
21	1	71	Cleaning rd surface & side of trench	-	9361-2	cinder	10	
21	1	71	Cleaning rd surface & side of trench	-	9361-2	iron object	10	
21	1	73	No record in context sheets		9410	crucible frag.	10	blob
21	1	81	Poss. hearth; burnt area; beside drain	?		undiagnostic ironworking slag	10	
21	1	81	Poss. hearth; burnt area; beside drain	?		crucible frag.	5	copper corrosion products inside
21	1	81	Poss. hearth; burnt area; beside drain	?		iron object	1	
21	1	81	Poss. hearth; burnt area; beside drain	?		crucible frag.	1	sheet
21	1	96	Organic layer	1	8570	cinder	2	
21	1	96	Organic layer	1	9447	crucible frag.	10	blob
21	2	2	Bosanquet trench	M	9094	vitrified hearth lining	10	
21	2	2	Bosanquet trench	M	9094	undiagnostic ironworking slag	10	
21	2	2	Bosanquet trench	M	9094	cinder	5	
21	2	2	Bosanquet trench	M		fired clay	20	
21	2	5	Orange soil layer - rampart?	3		copper alloy	40	spill

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
21	2	5	Orange soil layer - rampart?	3		iron object	40	
21	2	6	Charcoal layer	2	9209	ferruginous concretion	230	
21	2	6	Charcoal layer	2	9209	flake hammerscale		
21	2	6	Charcoal layer	2	9461	slag with copper corrosion	130	
21	2	6	Charcoal layer	2	9461	copper alloy	50	drips and offcuts
21	2	6	Charcoal layer	2	9465	iron object	300	
21	2	6	Charcoal layer	2	9465	vitrified hearth lining	100	
21	2	6	Charcoal layer	2	9465	undiagnostic ironworking slag	100	
21	2	6	Charcoal layer	2	9465	cinder	100	
21	2	6	Charcoal layer	2	9465	crucible frag	10	red glaze
21	2	6	Charcoal layer	2	9465	spheroidal & flake hammerscale		
21	2	6	Charcoal layer	2	9478	copper alloy		drips and blobs
21	2	6	Charcoal layer	2		iron object	30	
21	2	6	Charcoal layer	2		copper spills	40	
21	2	6	Charcoal layer	2		slag with copper corrosion	60	cindery
21	2	6	Charcoal layer	2		crucible frags	30	thin walled, spouted? rim, well vitrified on rim
21	2	6	Charcoal layer	2		coal	10	
21	2	6	Charcoal layer	2		copper alloy	15	many very small frags, trimmed sheet and bar with tapered ends
21	2	6			9478	copper alloy		drips and blobs
21	2	18	'V'-shaped stone spread	4	9087	iron object	20	
21	2	18	'V'-shaped stone spread	4	9087	undiagnostic ironworking slag	270	cindery
21	2	18	'V'-shaped stone spread	4	9087	smithing hearth bottom	220	(130g80x60x30mm, 90g60x50x25mm)
21	2	18	'V'-shaped stone spread	4		smithing hearth bottom	1190	(1190g180x100x80mm) with coal inclusions
21	2	20	Stone spread	3	8930	undiagnostic ironworking slag	15	
21	2	20	Stone spread	3	8931	crucible frag	18	vitrified externally
21	2	29	Stone spread in 18	?	9085	crucible frag.	20	black & red vitrification externally, triangular rim

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
21	2	29	Stone spread in 18	?	9088	vitrified hearth lining	240	
21	2	29	Stone spread in 18	?	9089	iron object	20	
21	2	29	Stone spread in 18	?	9089	cinder	20	
21	2	29	Stone spread in 18	?	9090	stone	300	
21	2	29	Stone spread in 18	?	9091	stone	110	
21	2	29	Stone spread in 18	?	9126	coal	10	
21	2	29	Stone spread in 18	?	9170	ceramic	20	not metallurgical
21	2	29	Stone spread in 18	?	9208	cinder	20	
21	2	39	Mixed pottery	-	9376	crucible frag.	5	slight vitrification
21	2	43	Road surface	?		iron object	10	
21	2	43	Road surface	?		cinder	5	
21	2	44	Burnt material from 60	2	9366	slag with copper corrosion	20	
21	2	48	Road surface (blue road)	2	9497	ferruginous concretion	20	
21	2	48	Road surface (blue road)	2		slag with copper corrosion	700	
21	2	48	Road surface (blue road)	2		stone	200	
21	2	48	Road surface (blue road)	2		coal	30	
21	2	48	Road surface (blue road)	2		bone	10	
21	2	48	Road surface (blue road)	2		vitrified hearth lining	30	
21	2	48	Road surface (blue road)	2		iron object	70	
21	2	48	Road surface (blue road)	2		undiagnostic ironworking slag	50	
21	2	48	Road surface (blue road)	2		mould frag	38	
21	2	48	Road surface (blue road)	2		crucible frag.	500	Wheel thrown, circular rim with spout, grey glaze
21	2	48	Road surface (blue road)	2		crucible frag.	100	spills
21	2	48	Road surface (blue road)	2		crucible frag.	5	offcuts
21	2	48	Road surface (blue road)	2		flake & spheroidal hammerscale		
21	2	56	Orange sand	2	9482	crucible frags.	10	black glaze
21	2	56	Orange sand	2	9483	slag with copper corrosion	30	
21	2	56	Orange sand	2	9484	cinder	20	

Site	Area	Context No	Context description	Phase	Find No.	Slag interpretation	mass (g)	Comments
21	2	56	Orange sand	2		slag with copper corrosion	20	
21	2	70	Pit/hearth	2		mould frag.	10	
21	2	70	Pit/hearth	2		slag with copper corrosion	60	
21	2	1?	Topsoil	M		undiagnostic ironworking slag	500	more cindery
21	2	1?	Topsoil	M		vitrified hearth lining	30	
21	2	1?	Topsoil	M		cinder	750	
21	2	1?	Topsoil	M		flake hammerscale		
21	3	63				charcoal	1	
21	4	1	Topsoil	M		iron object	3500	
21	4	7	Dark brown rampart material	3	8643	charcoal	2	
21	4	23	Rampart foundation	1		iron object	120	
21	4	30	Drain	1		coal & ash	20	
SE	1	1	Topsoil	M	8775	cinder	10	
SE	1	1	Topsoil	M	9039	coal	2	
SE	1	2	Loam - dark red-brown sandy	4	8713	coal	3	
SE	1	2	Loam - dark red-brown sandy	4	9016	crucible frag.	15	base of conical crucible (unused ?)
SE	1	12	Road surface	4	9389	vitrified hearth lining	5	
SE	1	13	Flagstones	4		iron object	5	
SE	1	13	Flagstones	4		coal	5	
SE	1	13	Flagstones	4		fired clay	15	
SE	1	17	Dark grey soil	4	8964	undiagnostic ironworking slag	10	
SE	1	21	Material	4		copper alloy	19	artefacts/offcuts
SE	1	29	Deep layer of dark red-brown soil	4	9312	iron object/crucible frag.	5	
SE	1	29	Deep layer of dark red-brown soil	4	9312	iron object/crucible frag.	5	
SE	1	29	Deep layer of dark red-brown soil	4	9313	copper alloy	2	heavily corroded
SE	1	31			9384	iron object	40	
unknown						crucible frag.	70	

Assessment of the metalworking debris

This involved the visual examination of all slags and metalworking debris retrieved from the site . The bulk slag totalled 24kg and this has been classified and quantified in Table 2 and summarised in Table 3.

Table 3 Housesteads, debris summary

slag type	weight (g)
smithing hearth bottom	4630
blast furnace slag	65
iron object	5686
ferruginous concretion	565
copper alloy waste	349
mould fragments	48
crucible fragments	964
slag with copper corrosion products	1075
lead/pewter	545
undiagnostic ironworking slag	5842
vitrified hearth lining	643
cinder	1557
iron-rich cinder	100
coal	278
charcoal	3
fuel ash slag	3
part burnt coal/shale	110
ashy deposit	370
fired clay	185
burnt stone	5
mortar	530
ceramic	33
stone	846
bone	10
total	24442

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 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

Evidence for the smithing (*i.e.* hot working) of iron comes in 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; typically 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.

Table 4	Smithing hearth bottom dimensions (n=20)		
	range	**mean**	**σ**
weight (g)	40-1190	237	285
length (mm)	50-180	83	32
width (mm)	40-100	62	22
depth (mm)	20-80	36	18

Twenty examples of smithing hearth bottoms were identified in the material from Housesteads. The statistics of this group, given in Table 3, show a very wide range of sizes. However, many examples were very small and the mean weight figures are unusually low for this (or any other) period. The Housesteads smithing hearth bottoms are also notable because they comprise a large proportion of the total weight of slag examined. By comparison with Roman debris from other sites they were also dense and well-consolidated, rather than the typically more cindery residues.

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[2]. During the visual examination of bulk slags, small quantities of hammerscale, almost exclusively of the flake variety, were identified in bags from nine different contexts. This information has been noted in Table 2, but without quantification.

Evidence for the smelting of iron *i.e.* the primary extraction of the metal from an ore was restricted to two fragments of very glassy material. One of these was analysed by X-ray fluorescence to confirm its identification. Such slags are not totally unknown from Roman iron smelting assemblages but, because they form only a very small component of the assemblage, they are explained as an unintentional product caused by excessive air supply in the presence of calcium-rich material. No raw materials or waste products typical of Roman iron smelting technology was identified. The latter would include the dense, fayalitic slags known as tap slags which show a ropy flowed structure on their upper surface and little porosity. It must be assumed that iron smelting was not carried out on the site and the material present is intrusive **blast furnace slag**, possibly deriving from recent, local use of the material as hardcore.

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. The largest piece of this material examined, from H20, Area 7, Context 75 contained flakes of hammerscale and provides further evidence of iron smithing.

Amongst the large quantity of **iron objects** found within the debris several may provide direct evidence of ironworking on site. Two pieces of what appeared to be the cut off ends of bar stock were recovered. The first fragment from H20, Area2, Context 4 measured 40x8mm in section and had been cut down to a length of 25mm. A second piece from the topsoil of H20, Area 5 of 50x20mm section was 70mm long.

Evidence for further metalworking activities, the casting and working of copper alloys was recognised in a number of forms. The largest category by weight was **slag with copper corrosion products**. Apart from the bright green copper oxides on the surface, this material does not differ greatly from that produced during iron smithing, often having a dense fayalitic structure. This would not be the waste product expected from purely melting and casting activities and may be indicative of hot working of copper alloys and iron in the same hearth. Unambiguous evidence of copper alloy melting and casting was provided by **crucible** and **mould fragments**. The former were present in a wide range of forms; both wheel thrown and hand moulded, coarse and fine fabrics and with and without the top crimped to a triangular opening. Many examples showed black or red glazes externally, the latter being a clear indicator of the presence of copper, whilst fewer had copper corrosion products attached. The two mould fragments were too small to identify the artefacts which were being cast from them.

Large quantities of copper alloy waste were included within the assemblage. These included amorphously shaped pieces described as drips, blobs and spills. In the context of the materials described above these are most likely to be waste products of casting although it is possible that copper artefacts, accidentally caught in a conflagration, could take a similar form. Offcuts took a limited range of forms most common were small trimmed fragments of very thin sheet, but small bars with tapered down ends were also present showing that copper artefacts were wrought as well as cast.

Lead, or as suggested by the very advanced corrosion, **pewter** was also identified. It is possible that this may have resulted from some manufacturing process. Unfortunately, the low temperatures required for the melting of lead alloys do not normally result in the formation of robust slags. With only three examples of the metal, it is thought that lead working, if it occurred at all, was not carried out on a significant scale on the site.

Four categories not considered diagnostic are **undiagnostic ironworking slag, vitrified hearth lining, cinder** and **iron-rich cinder**. However, in the absence of clear evidence for iron smelting on the site it is probable that most of the denser material within these three categories derives from iron smithing, although some of the lighter cindery material and the hearth lining material may be associated with non-ferrous alloy working and this is attested by occasional bright red glazes on hearth lining. Slags classed as **undiagnostic ironworking slags** are predominantly fayalitic, but their morphology is irregular and similar materials may be produced by smelting and smithing operations. **Vitrified hearth/furnace lining** can form 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 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 porous material but contains a significant iron content. A large bag (not weighed) of oxidised fired (red) lining from a hearth (Context 63, Area 5, H20) was of a crumbly nature. It provided no clues for the purpose of the hearth.

Fuels and their residues form a separate group of material. As well as a few examples of **charcoal**, fragments of **coal** were found from numerous contexts. Whilst a number of Romano British sites have provided evidence to link the use of coal to metallurgical processes, the extent and exact purposes to which the fuel was used remain unclear[3].

Many early reports are based on unsound assumptions as to the nature of the metalworking activity. Unambiguous evidence linking the fuel to diagnostic debris is rare and the smithing hearth bottom containing coal fragments from Phase4 of Site21, Area2, Context 18 provides an unusually powerful link. The **fuel ash slag, ashy deposit**, **fired clay** and **burnt stone** may result from a number of high temperature processes and cannot be assumed to originate from metallurgical processes.

Conclusions

Although the quantities of debris recovered from the excavations of Housesteads Fort were modest, they represented a broad range of metallurgical activities. Iron smithing was represented by smithing hearth bottoms, hammerscale and bar ends, whilst non-ferrous alloy working had left crucibles and mould fragments from casting as well as offcuts indicating the working of sheet and bar. There is no evidence of iron smelting on site and insufficient material to more than suggest the possibility of the working of lead or other lead-based alloys.

At the time of examination phasing for the site was provisional, with some uncertainty over continuity between the separate sites. A brief examination of the data did not point to any particularly intense period of metalworking activity. Non-ferrous debris is associated with all phases from the primary construction of the fort onwards. Iron smithing, surprisingly, appears more restricted with no firm evidence during the construction phase and only limited material in Phase II, restricted to H20. Iron working debris becomes more common in the later phases and a large proportion of the smithing hearth bottoms were from topsoil contexts, perhaps because they are easily recognised even during rapid removal of overlying deposits.

The excavation of the north and east rampart provided 75% of the weighed slag in the assemblage, and a further large bag of furnace lining from the north rampart, H20, was unweighed. This material, together with most other reported to be from hearths in this area, provided no firm evidence with which to link the structures to metalworking activity. However, hearth 75 (H20, Area7) did contain both hammerscale and non-ferrous debris suggesting iron smithing at least in the immediate vicinity. It should be noted that elsewhere the comparative rarity of archaeologically surviving smithing hearths has led to the assumption (supported by graphic evidence) that most smithing hearths were built into raised platforms for ease of working.

Assessing the importance of metalworking at Housesteads is problematic. On the one hand such limited quantities of debris may bear witness only to small scale or short term working of iron. However, the relatively dispersed nature of the evidence, by area and period, suggests much larger scale of activity but with the majority of bulk debris not being deposited in the immediate area of activity.

Potential for further work

Despite the relatively small size of the debris assemblage, its greatest potential lies in the wide range of material available for study. Recognition of iron bar stock on a smithing site and unambiguous linking of smithing with the use of coal are rare occurrences. Unfortunately, such limited quantities of material would restrict any conclusions that might be drawn. Thus the material might be more appropriate for a wider study, such as one that compared it with similar assemblages from other sites, perhaps as a student project.

The non-ferrous assemblage certainly deserves more detailed study than the time available within this assessment. Again, the importance of the assemblage lies in its wide range of materials. Such a study would include detailed examination of the crucible fragments by a specialist in that subject, together with non-quantitative analysis of metallurgical residues attached to the crucibles. This material should then be compared with analyses of copper alloy waste and artefacts from the site, to provide a basis on which to understand the range and significance of the copper alloy working within the fort at Housesteads.

Storage of slag

Slag, being predominantly fayalitic, is not prone to deterioration and requires no special storage treatment. Crucible fragments are relatively stable and may be stored as ceramics, unless they also contain significant metallic residues. Mould fragments are normally unfired, are relatively fragile and require protection from physical attrition. All iron, copper alloy and lead alloy objects should be removed and stored under more appropriate conditions. It is recommended that all debris should be saved.

References

1. Information on site background, contexts and phasing provided by Alan Rushworth: Housesteads Project Slag Analysis: Background Information and Context Lists, February 1996.

2.Mills, A. and McDonnell, JG. The Identification and Analysis of the Hammerscale from Burton Dasset, Warwickshire, Ancient Monuments Laboratory Report 47/92.

3. Dearne, Martin J. and Branigan, Keith. The Use of Coal in Roman Britain, Antiquaries Journal, 75, 1995, pp71-105.