

Ancient Monuments Laboratory  
Report 33/96

THE EXAMINATION OF INDUSTRIAL  
DEBRIS FROM GREAT HOLTS FARM,  
BOREHAM, ESSEX

T Finney

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Summary

A total of 54.5kg of industrial debris, recovered from a Roman farmstead site at Great Holts Farm, was examined to determine its technological origin. Most of the debris was produced by ironworking, of which around two thirds is diagnostic of iron smithing.

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## The examination of industrial debris from Great Holts Farm, Boreham, Essex.

Thomas Finney

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### Introduction

Excavation by the Essex County Council Field Archaeology Group of the Roman farmstead at Great Holts Farm was carried out, in two stages, between November 1992 and June 1993, prior the extension of a gravel extraction pit. The farmstead was constructed on undeveloped ground in the early second century A.D. It was extended in the fourth century and was in use until the early fifth century. In the later period it consisted of two to three enclosed timber buildings which included a large domestic farmhouse with its own baths, linked to a network of rectangular fields by a ditched driveway 250m long<sup>1</sup>.

A total of 54.5 kg of industrial debris was recovered from various areas of the site, mostly as the fill of pits and ditches, and non from identifiable working areas. No structural evidence for a metallurgical industry was recovered; although a number of 'ovens' were recovered their usage is unclear.

### Examination of industrial debris

The visual examination of metalworking debris allows it to be classified into various categories based on its morphology, density, colour and vesicularity. Of these categories only a small proportion are diagnostic of a particular metal working process. Others can only be assigned to the working of a particular metal, whilst many can be produced by a wide range of high temperature processes.

All the debris from Great Holts Farm was individually weighed, visually examined and classified to type (see table 1).

**Table 1: Interpretation of industrial debris from Great Holts Farm**

context	date	type	notes	wt.	interpretation	comments
5013	U	F	cremation 12	4	plaster	
5016	U	F	pit 14	5	clay	
5029	E	F	seg.4003. part of ditch 29	71	hearth/furnace lining	
5034	E	F	seg.4003. part of ditch 29	21	undiagnostic ironworking slag	
5069	E	F	ditch 52	<1	charcoal	
5069	E	F	ditch 52	36	cinder	
5069	E	F	ditch 52	22	fuel ash slag	
5069	E	F	ditch 52	11	hearth/furnace lining	
5069	E	F	ditch 52	20	iron object	
5069	E	F	ditch 52	60	smithing hearth bottom(s)	one double decker
5069	E	F	ditch 52	40	undiagnostic ironworking slag	
5069	E	F	ditch 52	2	unfired clay	orange
5708	E	T F	seg. 4087. part of ditch 52	52	cinder	
5118	R	T F	cut feature 77	14	burnt clay	
5139	E	T F	pit 89	26	smithing hearth bottom(s)	
5139	E	T F	pit 89	54	undiagnostic ironworking slag	cindery inclusions
5139	E	T F	pit 89	18	hearth/furnace lining	3 tuyere holes
5139	E	T F	pit 89	25	fired clay	
5139	E	T F	pit 89	10	cinder	
5139	E	T F	pit 89	15	stone	flint
5139	E	T F	pit 89		hammerscale	flake and spheroidal
5169	E	T F	ditch 91	20	cinder	
5189	L	Tr F	drain 93	7	cinder	
5198	L	Tr F	seg. 4016. part of drain 93	32	iron object	
6122	L	T F	seg. 4128. part of drain 93	18	undiagnostic ironworking slag	
6122	L	T F	seg. 4128. part of drain 93	18	undiagnostic ironworking slag	
5160	L	F	ditch 100	7	hearth/furnace lining	
5440	U	F	cut-feature 120	3	undiagnostic ironworking slag	
5316	L	T F	ditch 177	27	undiagnostic ironworking slag	cindery
5345	L	F	ditch 177	20	undiagnostic ironworking slag	cindery
5345	L	F	ditch 177	46	hearth/furnace lining	
5345	L	F	ditch 177	35	smithing hearth bottom(s)	
5764	L	P F	seg. 4096. part of ditch 198	17	undiagnostic ironworking slag	
5765	L	T F	seg. 4096. part of ditch 198	10	hearth/furnace lining	
5765	L	T F	seg. 4096. part of ditch 198	16	iron object	
5765	L	T F	seg. 4096. part of ditch 198	75	smithing hearth bottom(s)	
5765	L	T F	seg. 4096. part of ditch 198	52	undiagnostic ironworking slag	
5766	L	S F	seg. 4096. part of ditch 198	60	undiagnostic ironworking slag	
5365	L	F	enclosure ditch 204	14	iron object	
5484	U	T F	seg. 4048. part of gully 264	48	undiagnostic ironworking slag	
5485	U	T F	seg. 4050. part of ditch 267	26	undiagnostic ironworking slag	
5646	L	T F	seg. 4077. part of ditch 299	88	smithing hearth bottom(s)	
5646	L	T F	seg. 4077. part of ditch 299	71	undiagnostic ironworking slag	
5646	L	T F	seg. 4077. part of ditch 299	11	fired clay	
5647	L	Tr F	seg. 4077. part of ditch 299	29	iron object	
5647	L	Tr F	seg. 4077. part of ditch 299	44	undiagnostic ironworking slag	
5647	L	Tr F	seg. 4077. part of ditch 299	15	smithing hearth bottom(s)	
5662	L	Tr F	ditch 229	52	iron object	
5662	L	Tr F	ditch 229	76	hearth/furnace lining	
5595	E	T F	seg. 4063. part of ditch 303	12	undiagnostic ironworking slag	
5595	L	F	seg. 4063. part of ditch 303	54	iron object	
5589	L	S F	seg. 4061. part of ditch 307	20	smithing hearth bottom(s)	
5608	E	T F	seg. 4065. part of ditch 310	20	cinder	
5608	E	T F	seg. 4065. part of ditch 310	4	fuel ash slag	
5608	E	T F	seg. 4065. part of ditch 310	11	hearth/furnace lining	
5608	E	T F	seg. 4065. part of ditch 310	79	iron object	
5608	E	T F	seg. 4065. part of ditch 310	12	smithing hearth bottom(s)	
5608	E	T F	seg. 4065. part of ditch 310	21	undiagnostic ironworking slag	
5624	E	P F	ditch 310	12	iron object	

context	date	type	notes	wt.	interpretation	comments
5073	E	F	ditch 311	20	iron object	
5073	E	F	ditch 311	18	hearth/furnace lining	
5073	E	F	ditch 311	19	cinder	
5073	E	F	ditch 311	61	stone	flint
5073	E	F	ditch 311	14	smithing hearth bottom(s)	
5073	E	F	ditch 311	12	undiagnostic ironworking slag	cindery/rubble inclusions
5616	E	S F	seg. 4074. part of ditch 311	50	smithing hearth bottom(s)	
5616	E	S F	seg. 4074. part of ditch 311	10	undiagnostic ironworking slag	
5616	E	S F	seg. 4074. part of ditch 311	14	cinder	
5616	E	S F	seg. 4074. part of ditch 311	44	hearth/furnace lining	
5616	E	S F	seg. 4074. part of ditch 311	50	smithing hearth bottom(s)	
5624	E	P F	ditch 311	4	fired clay	
5638	E	T F	seg. 4076. part of ditch 311	34	undiagnostic ironworking slag	
5624	E	P F	ditch 312	59	hearth/furnace lining	
5653	L	T F	seg. 4078. part of ditch 312	18	smithing hearth bottom(s)	
5654	L	P F	seg. 4078. part of ditch 312	31	smithing hearth bottom(s)	
5654	L	P F	seg. 4078. part of ditch 312	35	undiagnostic ironworking slag	
5624	E	P F	ditch 313	15	smithing hearth bottom(s)	
5622	L	T F	ditch 314	76	hearth/furnace lining	
5656	L	S F	depression 318	26	iron object	
5656	L	S F	depression 318	39	undiagnostic ironworking slag	
5032	L	F	seg.4002. part of ditch 323	27	hearth/furnace lining	
5037	L	F	seg.31. part of ditch 323	12	undiagnostic ironworking slag	flowing structure
5037	L	F	seg.31. part of ditch 323	12	undiagnostic ironworking slag	
5762	U	F	ditch 330	11	undiagnostic ironworking slag	
5771	L	F	seg. 4099. part of ditch 337	33	iron object	
5771	L	F	seg. 4099. part of ditch 337	93	fired clay	
5771	L	F	seg. 4099. part of ditch 337	38	undiagnostic ironworking slag	
5771	L	F	seg. 4099. part of ditch 337	12	Fe concretion	
5744	U	F	gully 346	34	undiagnostic ironworking slag	
5750	U	T F	posthole 351	3	fired clay	
5750	U	T F	posthole 351	41	cinder	
5776	L	F	ditch 360, recut of ditch 361	50	undiagnostic ironworking slag	
5776	L	F	ditch 360, recut of ditch 361	11	hearth/furnace lining	
5776	L	F	ditch 360, recut of ditch 361	25	fuel ash slag	
5776	L	F	ditch 360, recut of ditch 361	98	iron object	
5776	L	F	ditch 360, recut of ditch 361	85	smithing hearth bottom(s)	
5778	L	P F	seg. 4102. part of ditch 361	12	cinder	
5778	L	P F	seg. 4102. part of ditch 361	86	iron object	
5148	L	T F	building 368	5	iron object	
5801	E	T F	ditch 371	43	undiagnostic ironworking slag	
5801	E	T F	ditch 371	11	fired clay	
5801	E	T F	ditch 371		hammerscale	flake
5801	E	T F	ditch 371	85	hearth/furnace lining	some tuyère holes
5801	E	T F	ditch 371	10	iron object	
5801	E	T F	ditch 371	17	smithing hearth bottom(s)	
5801	E	T F	ditch 371	1	stone	
5801	E	T F	ditch 371	90	undiagnostic ironworking slag	
5881	E	P F	ditch 371	84	undiagnostic ironworking slag	
5815	L	T F	ditch 385	12	undiagnostic ironworking slag	
5815	L	T F	ditch 385	39	hearth/furnace lining	
5815	L	T F	ditch 385	11	iron object	
6170	E	T F	seg. 4132. part of ditch 390	10	hearth/furnace lining	
5923	L	T F	cistern 415	12	smithing hearth bottom(s)	
5923	L	T F	cistern 415	20	undiagnostic ironworking slag	
5824	L	S F	box pit, part of building 416	69	iron object	
5976	L	F	seg. 4111. part of build. 416	92	stone	"pudding stone"
6024	L	F	postpipe 541. part build.416	35	stone	
6343	L	F	seg. 4167. part build. 416	62	hearth/furnace lining	
5891	L	T F	pond 421 in box section 450	24	undiagnostic ironworking slag	

context	date	type	notes	wt.	interpretation	comments
6148	L	F	pond 422	1	fuel ash slag	
6171	L	F	seg. 4169, part of pond 422	35	smithing hearth bottom(s)	in two parts
6171	L	F	seg. 4169, part of pond 422	1	fuel ash slag	
6171	L	F	seg. 4169, part of pond 422	16	undiagnostic ironworking slag	
6171	L	F	seg. 4169, part of pond 422	<1	iron object	
5904	L	Tr F	cut-feature 456	6	cinder	
6066	L	T F	well 567	28	iron object	
6459	L	F	fill from base of well 567	60	undiagnostic ironworking slag	
6462	L	F	fill from base of well 567	16	fuel ash slag	
6462	L	F	fill from base of well 567	9	fired clay	
6462	L	F	fill from base of well 567	9	hearth/furnace lining	
6462	L	F	fill from base of well 567	14	cinder	
6463	L	F	fill from base of well 567	12	hearth/furnace lining	
6463	L	F	fill from base of well 567	<1	charcoal	
6463	L	F	fill from base of well 567	31	fuel ash slag	
6082	L	F	praeurnium 575	91	fuel ash slag	
6082	L	F	praeurnium 575	90	undiagnostic ironworking slag	
6082	L	F	praeurnium 575	19	fired clay	
6104	L	F	posthole 581, building 368	66	hearth/furnace lining	
6104	L	F	posthole 581, building 368	20	iron object	
6104	L	F	posthole 581, building 368	79	undiagnostic ironworking slag	
6104	L	F	posthole 581, building 368	49	fired clay	
6104	L	F	posthole 581, building 368	8	fuel ash slag	
6107	L	F	posthole 583, building 368	5	cinder	
6115	L	F	posthole 586, building 368	30	hearth/furnace lining	
6115	L	F	posthole 586, building 368	22	undiagnostic ironworking slag	
6115	L	F	posthole 586, building 368	64	cinder	
6117	L	F	postpipe 588, building 368	7	hearth/furnace lining	
6117	L	F	postpipe 588, building 368	11	cinder	
6117	L	F	postpipe 588, building 368	3	fired clay	
6117	L	F	postpipe 588, building 368	13	undiagnostic ironworking slag	
6129	?L	F	of depression 597. ? building 417	5	hearth/furnace lining	
6129	?L	F	of depression 597. ? building 417	77	undiagnostic ironworking slag	
6102	L	F	posthole 605, part build. 368	24	hearth/furnace lining	
6163	L	F	seg. 4131, part of ditch 620	9	fuel ash slag	
6162	L	P F	pit 621. ?part of building 417	64	undiagnostic ironworking slag	
6162	L	P F	pit 621. ?part of building 417	16	fired clay	
6162	L	P F	pit 621. ?part of building 417		hammerscale	flake
6231	U	T F	posthole 666	14	undiagnostic ironworking slag	
6231	U	T F	posthole 666	12	fired clay	many inclusions
6272	L	F	flue 672, part of praeurnium	18	fired clay	ashy, non-industrial
5919	L	F	of 778, recut of pond 421	8	hearth/furnace lining	
6252	PR	F	seg. 4139 part of p. Roman robbing 798 of bath suite 414	18	iron object	
6253	?PR	F	robber cut 809 in bath suite 414	18	undiagnostic ironworking slag	
5515		S		10	iron object	
5515		S		12	hearth/furnace lining	
5515		S		60	undiagnostic ironworking slag	
5524		S		25	iron object	
5614		SF		4	undiagnostic ironworking slag	
5679		S		53	dense ironworking slag	
5736		Us		52	undiagnostic ironworking slag	
5736		Us		19	vesticular basalt	
5890		SF		50	smithing hearth bottom(s)	
6292	?	? ?		47	smithing hearth bottom(s)	responds strongly to magnet
6339		Us		11	undiagnostic ironworking slag	
6370		S		80	undiagnostic ironworking slag	

**Key** E= early Roman L=late Roman R= Roman PR= post Roman U= undated  
F= fill TF=top fill PF= primary fill SF= secondary fill TrF= tertiary fill S= surface cleaning Us= unstratified.

## Explanation of Classification

Evidence for iron smithing is present in the form of **smithing hearth bottoms**. These are largely fayalitic (iron silicates) in composition and are formed during the smithing (hot working) of iron due to a high temperature reaction between the iron, iron-scale, and silica from either the clay furnace lining or the sand used as a flux. Typically, they are plano-convex in form, characteristically having a rough convex base and a smoother vitrified upper surface, which can sometimes be slightly hollowed due to the downwards blast of air from the tuyère.

Hammerscale is also diagnostic of iron smithing and appears in two different forms. **Flake hammerscale** comprises of small 'fish scale' like fragments dislodged by mechanical or thermal shock when the iron is forged. **Spheroidal hammerscale** forms from small droplets of liquid slag expelled from the iron during hot working, particularly during the fire welding of iron, and also as a result of the primary smithing of an iron bloom. During the examination of the debris, hammerscale was detected in the soil contained in the sample bags using a bar magnet. It was not quantified, and therefore is only recorded as being present.

**Undiagnostic ironworking slag** is similar in density to smithing hearth bottoms, but has an irregular morphology and could have been produced by smithing or smelting. **Dense slags** are similarly non-diagnostic. In the absence of other evidence of smelting however, both categories are considered to be the product of smithing activities.

**Vitrified hearth/furnace lining** is produced by a high temperature reaction between the clay lining of a hearth or furnace, and the alkali fuel ashes or fayalitic slag. It can be formed by iron smelting, iron smithing, non-ferrous metal working or other pyrotechnical processes. This material usually shows a compositional gradient from un-modified clay on one side to a glazed surface or irregular cindery material on the other.

**Cinderis** also produced by fuel ash or slag attack of the clay lining of hearth or furnace. It resembles the more heavily reacted surface of a hearth/ furnace lining.

**Fired clay** can be produced by any high temperature process. This includes industrial processes, domestic processes, and accidental burning.

**Fuel ash slag** is the result of a high temperature reaction between alkaline fuel ashes and silicates from soil sand, or clay. This reaction is shared with many other pyrotechnical processes and the slag is not diagnostic of ironworking or other metalworking processes. The slag is low in density, high in vesicularity and light grey/brown in colour.

**Undiagnostic iron concretion** forms as the result of the redeposition of iron hydroxides, similar to the natural phenomenon of iron panning, although the process may be enhanced by the nature of the surrounding archaeological deposits, particularly iron-rich waste.

Table 2. Quantities of debris from Great Holts Farm.	
Slag type	Total Weight (g)
smithing hearth bottoms	19491
undiagnostic ironworking debris	21579
dense slag	536
fuel ash slag	494
cinder	1370
iron objects	2304
vitrified hearth/ furnace lining	5953
stone	223
iron concretion	128
unfired clay	7
fired clay	2453
plaster	4
Total	54542

## Discussion

The quantity of industrial debris recovered from Great Holts Farm is not large in comparison to other sites of the Roman period. The only process for which there is diagnostic evidence of is iron smithing, indicated by the large amount of smithing hearth bottoms recovered, and the small amount of hammerscale. There is no diagnostic evidence for iron smelting. Roman smelting sites are characterised by the occurrence of the distinctive tap slag, formed by the liquid slag running out of the furnace when tapped, and solidifying into lava-like flows.

Although undiagnostic ironworking slag can be produced by both smelting and smithing, in the absence of clear evidence for smelting, it is also assumed to be the result of smithing.

There is no evidence for the working of non-ferrous metal. Diagnostic evidence for this comes in the form of crucible and mould fragments, pieces of waste metal or non-ferrous corrosion products attached to debris.

The assemblage is distinctive in that such a large proportion of the material is diagnostic smithing hearth bottoms. The reason for this cannot be satisfactorily explained, perhaps the required conditions of formation for this particular slag were correct.

Table 3 shows the distribution of the 112 smithing hearth bottoms in terms of mass and dimensions. It is worth noting that compared to other Roman sites, the smithing hearth bottoms from Great Holts Farm have a rather low mean mass.



**Table 3: Statistics of the smithing hearth bottoms from Great Holts Farm (n=112)**

	range	mean	$\sigma$
weight (g)	39-508	180	111.5
length (mm)	40-120	74	16
width (mm)	30-90	58	14
depth (mm)	10-60	29	10

From the site plans two loose, but discrete, areas of concentration of industrial debris were identified (fig. 1), one a network of ditches (area A), and the other around the farmhouse building (area B). Debris from these areas were sorted into categories in tables 4 and 5 in order to try and identify differences in the nature or dating of the two groups.

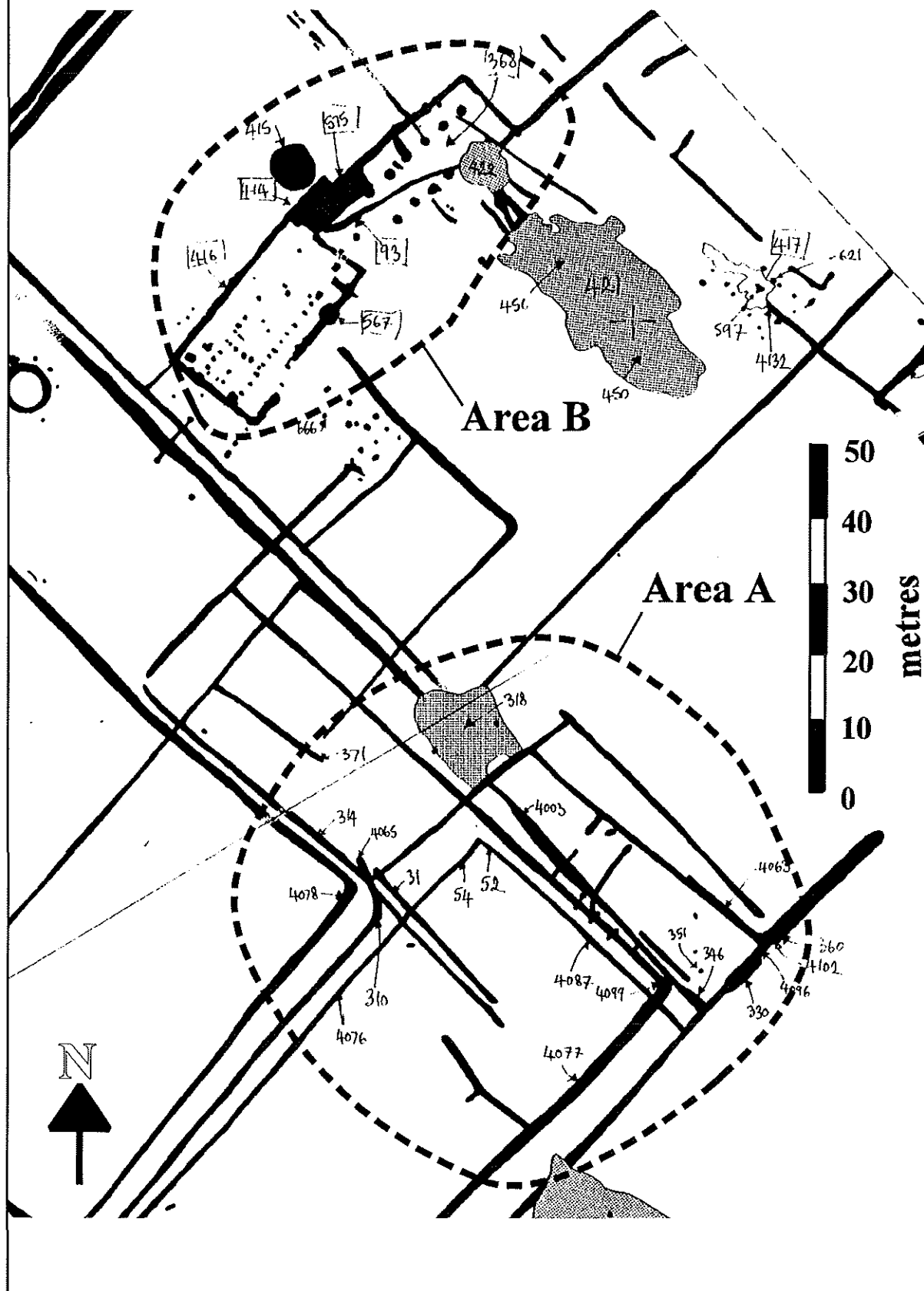
Table 4: Debris recovered from 'ditch area' (area A)			
Total	31080g	Smithing hearth bottoms	13617g
Breakdown of total:			
Fills of early Roman features			23482g
Fills of late Roman features			7402g
Unstratified			196g

Table 5: Debris recovered from 'house area' (area B)			
Total	16185g	Smithing hearth bottoms	3162g
Breakdown of total:			
Fills of early Roman features			10391g
Fills of late Roman features			5762g
Fills of Roman features			14g
Fills of possible post Roman features			18g

A total mass of 47265g was located in these two areas, amounting to 87% of total debris from the site. The diagnostic smithing hearth bottoms make up 44% of the total mass of debris recovered from area A, but only 20% of the total mass of debris from area B. These two groups may be a result of a difference between practice or practitioners, or different disposal patterns.

Grouping of industrial debris temporally is difficult. It is often redeposited and reused after it is produced, it can be found used as hardcore and as a building material, and is a useful source of rubble. Most of the debris from each area was found within the fills of early Roman features with a much smaller proportion filling late Roman features. It is possible then that most, if not all, the smithing activity took place in the earlier period, and the debris in the later fill is redeposited early material.

**Figure 1: Areas of debris concentration**



## Conclusions

Iron smithing is the only metallurgical process that can be identified as having taken place at Great Holts Farm. In comparison to the length of occupation of the site the amount of debris recovered is small and either represents a short lived period of smithing activity, or intermittent smithing over an extended period of time. The lack of any deposits of debris found at their source of production makes it difficult to conclude more about the nature of this smithing activity. It is possible that the smithing activity took place within the early Roman period, however the small amount of hammerscale recovered within the soil surrounding the debris may indicate repeated redeposition of the material.

## Potential for further work

Due to the limited size and significance of the industrial debris assemblage from Great Holts Farm, further examination and analysis of the debris is not justifiable.

## Storage of industrial debris

Ironworking slag, being predominantly fayalitic, is not prone to deterioration and requires no special storage conditions. Vitrified material also does not require special storage treatment. Iron objects must be stored in desiccating condition to inhibit corrosion, and should be recorded by x-radiography. It is recommended that the debris is retained.

## References

1. Germany, M. (1995) *Great Holts Farm, Boreham Essex, site summary*. Essex County Council Planning Department Field Archaeology Group.