ADS SUPPLEMENTARY MATERIAL

Medieval and later Wealden Iron Workings: Ifield Forge and Mill.

Andrew Margetts

c/o Louise Rayner, Archaeology South-East, Units 1 & 2, 2 Chapel Place, Portslade

louise.rayner@ucl.ac.uk

Figures

Tables

ADS SUPPLEMENTARY MATERIAL

THE METALLURGICAL REMAINS by Luke Barber

Introduction

The excavations recovered 292,878g of material classified as slag from 35 individually numbered contexts. This total consists of 157,957g (105 individual pieces) of hand-collected material with the remainder being derived from one of 13 environmental residues. The size of individual pieces varies greatly, from tiny chips from within the residues to massive hand-collected pieces of up to 40kg. Not all the material is actual slag, but it is certain that all is the result of iron working activity. The combined assemblage is summarised in Table 1 by type.

The assemblage has been fully listed by context and type on metallurgical pro forma sheets, which are housed with the archive. The information from these has been used to create an Excel database for the digital archive. Although the hand-collected slag was counted as well as weighed, the material from the residues was simply weighed. This approach had to be taken as the residues included very large quantities of tiny pieces of slag that were too numerous to count and indeed divide by type. This mixed material was weighed and scanned to note the main types represented in each sample.

Slag Type	Weight
1a Concreted silt/clay with iron oxides & ore pellets	36,198g
1b As 1a but with common/abundant fe oxides/ore pellets, some iron-rich seams & a little charcoal	55,548g
1c Concreted silt/clay containing slag droplets	4578g
1d Lumps of burnt clay and chalk (flux?) with negligible slag	3856g
1e Broken up iron pan/concretion	Only noted in 'mixed' residues
2a Undiagnostic iron slag: grey and dense	9412g
2b Smelting tap slag	Only noted in 'mixed' residues
3a Undiagnostic iron slag: orange-brown & aerated	18,398g
3b Undiagnostic iron slag: slightly glassy aerated cinder	8696g
4a Blast furnace slag	16,201g
5a Waste iron within adhering burnt clay	2418g
5b High iron content dense waste	12000
5c Iron bar fragments	7264
6a Hearth lining	Only noted in 'mixed' residues
7a Hammerscale (spheres)	25g+
Mixed types in residues	118,284g

Table 1. Summary of slag assemblage by type

Period 1

The earliest iron working at the site, scientifically dated to the medieval period, was all clustered together below the later hammer pond. Pit [258] produced a significant quantity of waste (48,072g) from all of its fills combined. Fill [272] contained a single

33kg roughly cylindrical block (c. 340mm diameter by 350mm tall) of hard concreted clay with iron oxide pellets that had cemented the clay together (Type 1a). The secondary fill, context [259], produced a further 468g of the same material as well as 1600g of the denser iron concretion (Type 1b). However, this fill also produced a single piece of definite slag – a 396g fragment of Type 2a dense waste, most probably from smelting. The upper fill of the pit produced 12,608g of waste material including more Type 1a (1244g), Type 1d with weathered chalk (78g) and 11,280g of 'mixed' granules from the sample residues. The latter include a significant amount of the concreted clay types (1a to 1c) but also a notable quantity of tap slag dribbles (Type 2b) and dense slag, likely to be from smelting (Type 2a). This upper fill also contained 6g of intrusive blast furnace slag (Type 4a). Overall the feature is a difficult one to interpret from the slag waste alone as, although it clearly contains small quantities of bloomery smelting waste, the majority of material consists of iron-concreted silts and clays with numerous iron oxide pellets, some of which could easily be ore fines.

The adjacent furnace [145] is less ambiguous as to function, but once again the slag assemblage from it suggests a little contamination, though on a negligible scale. Context [144] produced 4334g of waste, most of which was of mixed granules from the sample residues. As well as concreted clays and chalky lumps (esp Types 1c and 1d) there were small pieces of tap slag and Type 3b cinder. Fill [143] contained a further 3965g of similar material, though with more concreted clays (Types 1a and 1b) and a few spherical pieces of Type 7a hammerscale. The latter are likely to be intrusive though they could represent spits during tapping. Tiny amounts of intrusive material are confirmed by small chips of blast furnace slag in fill [141], although the remainder of the waste (17,005g) is fairly similar to that in the other fills (including tap slag). The 17,536g of waste from fill [142] was once again of similar composition but contained 10g of blast furnace slag granules and a few Type 7a spheres. The adjacent pit [147] produced a very similar range of waste material (5043g), including iron-concreted clay, smelting waste and cinder.

All of the Type 2b tap slag from this cluster of features is badly fragmented but has only minor signs of wear. Larger pieces are notable by their absence and waste from this early activity does not appear to have been significantly redeposited in later features elsewhere around the site suggesting this early smelting was small-scale and short-lived.

Period 2

The period of the water-powered forge produced 160,794g of slag and related waste, including 50 hand-collected pieces. Although the site was that of a finery forge just under 10kg of blast furnace slag was recovered from its associated deposits – presumably brought in from the nearby Bewbush/Ifield furnace for construction purposes. The presence of five pieces (344g) in tree-throw [107] and timber sluice [128] construction deposits would certainly suggest material had been imported during the initial preparation and construction phase.

The working area of the forge itself produced a mix of slag types, most of which are, strictly speaking, undiagnostic of process. Certainly the 3610g of dense Type 2a slag must be treated so. However, the large quantities of fresh sizable pieces of Type 3a and 3b slags in this period (14,718g and 8592g respectively) suggest these are probably waste from the forge itself. Most of this material was recovered from demolition deposits such as those filling the wheel-pit [207]. Hammerscale is relatively rare, with only 24g being noted and most of that consisting of Type 7a spheres. A search of the residues revealed very few classic hammerscale flakes. Much of the waste was derived from mixed dumps over the working areas but some more sealed groups were present.

Interestingly the levelling deposit [214], for the floor of the forge, contained no slag, but the floor above (context [201]) consisted of a heavily trampled Type 1b clay (a 1752g sample being collected). Within this was a solid irregular block of type 1b trampled concretion weighing a massive 40kg and measuring c. 660 x 380 x 170mm. The piece had a plano-convex section and must represent an accumulation of trampled waste within which there is notable charcoal to 15mm across (context [219]). Despite careful examination these deposits did not contain any significant quantities of hammerscale accumulation suggesting the upper levels may have been truncated. The silt over the floor (context [172]) produced a 11,555g mixture of types, including 819g of blast furnace slag, 2g of 7a hammerscale and a 7,000g fragment from a wrought iron bar measuring 820mm+ long, with a cross-section measuring between 35 x 35mm and 40 x 35mm. This is thought to be part of a bar produced by the forge ready for the blacksmith. These were usually 2.75-4m long (Cleere and Crossley 1985, 266) so the current piece is clearly but a small section. The possible remains from another bar iron fragment were recovered from demolition material in wheel-pit [207] (fill [209]).

Hearth [184] produced waste material from both its associated 'fills'. Context [186] contained 4073g, including 1700g of Type 5a waste iron embedded in clay, possibly from the base of the hearth, a scattering of concreted clay fragments (Types 1a, 1c and 1d), 2g of intrusive blast furnace slag chips and a reasonable quantity of 7a hammerscale (estimated at over 300+ spheres). The upper fill contained just over 17kg of waste (context [185]). This produced a similar mix of types but with more intrusive blast furnace slag chips (10g) and proportionately more 7a spherical hammerscale (100+ examples in just a 5% sub-sample of the <2mm fraction of sample <12>.

Hearth [236] produced 16,498g of slag and associated waste. With the exception of a 3936g piece of Type 1b concreted clay from context [238], the material was recovered from context [237]. This included a 718g roughly square fragment of Type 5a waste that, as with [186], was possibly from the base of the hearth. Other material is very similar to that noted for hearth [184]: type 1b concreted clay (3238g), intrusive type 4a blast furnace slag granules (5g), over 100 spherical type 7a hammerscale pieces (5g) and 8596g of mixed granules from the residues that includes a range of type 1 waste as well as a little type 3a.

Periods 3/4

Little metallurgical waste was recovered from the periods associated with the mill. That which was, consists of a few pieces of residual concreted clays (types 1b and 1c) and type 3a and 4935g of blast furnace slag, the latter almost certainly imported for construction works on the dam.

IRONWORK by Elke Raemen

Only a single fragment of ironwork relates to Period 2. Layer [172] contained a single iron wedge (RF <7>). Examples of wedges have been found at other forges including Ardingly (Goodall 1976, 60) and Blackwater Green (Major 1992, 157). The wedge from Ifield, with burred head as a result of heavy hammering, is broad but thin, similar to several from Chingley Forge (e.g. no 30, p 64). It may have been used in stone quarrying or it may have been used structurally, perhaps similarly to wedges used in the construction of two hammers at Wortley Forge in South Yorkshire (Goodall 1975, 63; Goodall 2011, 27, 48).

1. RF<7> Wedge (Fig. 23)

   [172]; Period 2

   Incomplete. Large wedge with burred head. L145mm, W80mm, Th up to c. 15mm. Wt 590g. Some of blade missing.

NAILS by Elke Raemen

Five hand-wrought nails, all with rectangular sectioned shank and rectangular pyramidal head, were recovered from three different timbers ([136], [408] and [414]), all of which have been dated to Period 2. Only one nail is complete, measuring 171mm long (drain/trough [136]). Head dimensions range between 19x17mm and 25x23mm). Nails with pyramidal head were also found at Chingley Forge (Goodall 1975, fig 45, no 8) and Blackwater Green (Major 1992, fig 13, 15).

CHARCOAL ANALYSIS by Mariangela Vitolo

Introduction

A post-excavation assessment carried out on fifteen bulk soil samples (Margetts 2015) found that charred and waterlogged plant remains were scarce in all periods with limited significance and potential for further work. However the wood charcoal from four contexts was recommended for full analysis (Table 2), as it was deemed to have the potential to address research questions regarding fuel selection strategies for industrial purposes, as well as the local vegetation environment and possibly woodland management techniques in use at the site. The selected samples originated from period 1 disuse of a furnace and period 2 levelling deposit, pit and chafery hearth.

Methodology

At least one hundred charcoal fragments per sample underwent analysis. Fragments larger than 4mm were considered suitable as, in general, fragments of this size provide sufficient surface area once fractured for identification. However, from each sample at least 10 fragments within the 2-4mm size range were also analysed. The selected fragments were fractured along three planes (transverse, tangential longitudinal and radial longitudinal sections) following standardised procedures (Gale and Cutler 2000; Leney and Casteel 1975) and viewed under a stereozoom microscope for initial sorting and an incident light microscope (at 50, 100, 200 and

400x) to facilitate identification. Anatomical features visible in the archaeological specimens were compared with those documented in reference atlases (Hather 2000; Schoch et al. 2004; Schweingruber 1990) in order to provide taxonomic identifications. Where possible identifications have been made to species level, however genera, family or sub-family names are given where anatomical differences between taxa are insufficient to enable satisfactory identification. For several taxa such as oak, where there are only two native deciduous trees, identifications can be refined due to the limited range of native species within Britain. Cf., denoting 'compares with' is used as a prefix to the species or generic name where identifications are uncertain as a result of poor preservation or limited size of charcoal specimens. Nomenclature used as well as most habitat information follow Stace (1997).

Results

Period 1: Furnace [258]

The charcoal assemblage from pit [258] was dominated by beech (*Fagus sylvatica*) with a smaller amount of oak (*Quercus* sp.). Round wood was common, although fragments were not complete and therefore measurements and tree ring counts could not be carried out. The assemblage also contained many fairly large fragments. Post depositional sediment encrustations occurred frequently, as did distortions of the anatomical characters and vitrification, which hindered the identification of a number of fragments. Vitrification occurs when the wood anatomy fuses, showing a glassy appearance.

Period 2: Levelling deposit [172], pit [180] and chafery hearth [236]

Period 2 contexts yielded a wider variety of woody taxa. Levelling deposit [172] contained a large amount of iron working slag and pieces of sandstone, as well as charcoal. Sediment encrustations and vitrification also occurred often on the charcoal from this context and although round wood fragments were common, they were incomplete. There was not a particularly dominant taxon in this context; the ones that occurred in larger numbers were beech, oak and hornbeam (*Carpinus betulus*) with very small amounts of other taxa, such as alder (*Alnus glutinosa*), hazel (*Corylus avellana*), cherry/blackthorn (*Prunus* sp.) and the Maloideae subfamily. The latter includes taxa that are indistinguishable on grounds of wood anatomy, such as apple, pear, rowan, service and whitebeam. Most oak fragments displayed a very short latewood, sign of a slow growth rate.

Pit [180] yielded poorly preserved charcoal, with signs of sediment encrustations and vitrification. The assemblage was again dominated by beech and oak, with smaller amounts of alder, field maple (*Acer campestre*), possible hornbeam and Maloideae.

Chafery hearth [236] yielded the best preserved charcoal assemblage. Sediment encrustations were far less common and only one fragment was unidentifiable.

Beech and oak dominated the whole assemblage, with one fragment each of alder and hazel.

Discussion

Preservation

Preservation of the charcoal was variable across the features, although it generally ranged from poor to moderate, except for chafery hearth [236], where it was good. Post-depositional sediment encrustations occurred very commonly and are likely to be due to fluctuating water levels or possibly to episodes of flooding. Vitrification, which also occurred commonly, is generally linked to the use of high temperatures and could potentially be connected to the industrial nature of the features as high temperatures are required in metalworking. However, experimental evidence has shown that high temperatures alone are not sufficient to cause vitrification and that a secure cause is not yet known (McParland *et al* 2010). It is possible that other factors, such as prolonged burning, presence of resin or other material falling or leaking into the wood might concur with high temperatures to make charcoal vitrified.

Vegetation environment and fuel selection

A high degree of fuel selection seems to have been in use at Ifield Pond and a small array of woody taxa were represented in this assemblage. Deciduous woodland, hedgerows and scrub were mainly tapped into for fuel and, probably to a lesser extent, wet environments, which were represented by a small amount of alder.

Beech and oak were likely to have been widely available in the local landscape, as well as being selected for their excellent burning properties.

Although most of the deposits have a synthetic nature and the assemblage is likely to result from an amalgam of waste originating from mixed sources, there was not a large array of the woody taxa represented across both phases and feature types. Given the vast amount of metalworking activity carried out at the site and the presence of slag and industrial debris in the samples, it is very likely that the assemblage derives from fuel for industrial activities. This is confirmed by some characters of this assemblage. The woody taxa that feature more prominently, such as oak, beech and hornbeam, are all excellent fuels (Taylor 1981) and would have been very well suited for this type of activity. Other taxa that do not burn very well, for example alder, are present in low amounts and might have originated from other sources. In addition, the high temperatures required for ironworking might have concurred to cause the vitrification on the charcoal fragments. Moreover, the presence of >8mm fragments in some of the contexts (particularly in [258]) suggests that some or all of the assemblage might derive from charcoal that was burnt for fuel, rather than fresh wood. The absence of radial cracks also suggests the use of charcoal, as they have been linked to the presence of moisture in the wood (Fiorentino and D'Oronzo 2010). Charcoal makes a better fuel than fresh wood and it was needed in that form to fuel the furnaces (Tittensor 1978).

Woodland management

The dense woodland of the Weald, composed of oak and beech, produced valuable wood that, during the medieval period, was not only destined to local use but was also supplied to large cities like London and to the continent (Gale 2008; Tittensor 1978; Galloway *et al* 1996). In order to provide a rich supply both for the thriving local industry and for exports, this woodland was extensively managed. Evidence of coppiced hazel stems is for example available in the waterlogged wood assemblage from the nearby Asda site in Crawley (Gale 2008). Analysis of the charcoal assemblage from Ifield Pond has provided no direct evidence of fragments deriving from managed woodland, but many of the taxa represented are known to make good coppices. For example, oak and maple have been a large part of coppiced woodlands in southern England since the Middle Ages (Rackham 1971). Further, in the past hornbeam was extensively coppiced in the North Downs to supply both wood and charcoal (Taylor 1981). Beech coppice is less valuable, but in times of scarcity of construction timber it could have become more prominent (Roden 1968). Given the species composition in this assemblage and the large amount of wood needed to support the iron industry, it is very likely that the local woodland was managed in order to maintain an abundant supply.

Large tables

	Period	1	2	2	2
	Sample Number	17	7	8	16
	Context	260	172	181	237
	Parent Context	258	172	180	236
	Subgroup	121	55	62	108
	Context / deposit type	disuse of furnace	levelling deposit	pit	chafery hearth
Taxonomic Identifications	English Name				
Quercus sp.	oak	13	22	33	44
cf *Quercus* sp.			3	10	4
Fagus sylvatica	beech	70	32	31	51
cf Fagus sylvatica				3	1
Acer campestre				2	
Maloideae group	hawthorn, whitebeam, rowan, apple, pear		1	1	
Prunoideae *Prunus* sp.	Cherry/blackthorn		1		
Corylus avellana/Alnus	hazel		1	2	
Corylus avellana					1
Alnus sp.	alder		1	7	1
Carpinus betulus			27		
cf Carpinus betulus				1	
Indeterminate		17	12	10	1

Table 2. Charcoal Identifications

BIBLIOGRAPHY

Cleere, H. and Crossley, D. 1985. *The iron industry of the Weald*. Leicester: Leicester University Press

Gale, R. 2008. 'The Charcoal and Wood', in S. Stevens, 'Archaeological investigations at the Asda site, Crawley, West Sussex', *Sussex Archaeological Collections,* **148**, 107-47

Gale, R. and Cutler, D. 2000. *Plants in Archaeology*. Otley/London: Westbury/Royal Botanic Gardens, Kew.

Galloway, J. Keene, D. and Murphys, M. 1996. 'Fuelling the City: production and distribution of firewood and fuel in London's region, 1200-1400', *Economic History Review*, **69** (3), 447-72

Goodall I.H. 1975. 'Chingley Forge Metalwork', in D. Crossley, *The Bewl Valley Ironworks, Kent, c. 1300-1730*. London: The Royal Archaeological Institute, 59-84

Goodall I. H. 1976. 'The Metalwork', in O. Bedwin, 'The Excavation of Ardingly Fulling Mill and Forge, 1975-76', *Post-Medieval Archaeology,* **10**, 60-4

Goodall I.H. 2011. *Ironwork in Medieval Britain: An Archaeological Study*. London: Maney Publishing, The Society for Medieval Archaeology Monograph **31**

Hather, J.G. 2000. *The Identification of the Northern European Woods: A Guide for archaeologists and conservators*. London: Archetype Publications Ltd

Leney, L. and Casteel, R.W. 1975. 'Simplified procedure for examining charcoal specimens for identification', *Journal of Archaeological Science*, **2**, 153-159

Major, H. 1992. 'The Ironwork', in C. Place and O. Bedwin, 'The Sixteenth Century Forge at Blackwater Green, Worth, West Sussex: Excavations 1988', *Sussex Archaeological Collections,* **130**, 157-8

McParland, L.C. Collinson, M.E. Scott, A.C. Campbell, G. and Veal R. 2010. 'Is vitrification in charcoal a result of high temperature burning of wood?', *Journal of Archaeological Science*, **37** (10), 2679–2687

Margetts, A. 2015. *Post Excavation and updated project design report. The Mill Pond, Hyde Drive, Ifield, Crawley, West Sussex*. ASE unpublished report no. 2015343

Rackham, O. 1971. 'Historical Studies and Woodland Conservation', in E. Duffey and A.S. Watt, (eds.), *The Scientific Management of Animal and Plant Communities for Conservation*. Oxford: Blackwell Scientific Publications, 563-80

Roden, D. 1968. 'Woodland and its management in the medieval Chilterns', *Forestry,* **41**, 59-71

Stace, C. 1997. *New Flora of the British Isles.* Cambridge: University Press

Schoch, W. Heller, I. Schweingruber, F.H. and Kienast, F. 2004. *Wood anatomy of central European Species*. Online version: www.woodanatomy.ch

Schweingruber, F.H. 1990. *Microscopic Wood Anatomy* (3rd edition). Birmensdorf: Swiss Federal Institute for Forest, Snow and Landscape Research

Taylor, M. 1981. *Wood in Archaeology*. Aylesbury: Shire Publications

Tittensor, R. 1978. 'A history for the Mens: A Sussex Woodland Common', *Sussex Archaeological Collections,* **116**, 347-74