Ancient Monuments Laboratory Report 113/97

METALLURGICAL STUDIES OF MISCELLANEOUS ARTEFACTS AND DEBRIS 1996

D Starley

Summary

Small quantities of waste products and materials from five sites were identified by visual examination, metallography and physico-chemical analytical techniques. The sites included a historical blast furnace at Foxbrooke, Derbyshire, an Iron Age settlement at Salford, Bedfordshire, medieval phases from the Buttermarket site in Leominster, Herefordshire and a site at Redesdale, Northumberland, for which no details were provided. Further debris, from the Bunyan centre, Bedford, was found to be non-metallurgical.

Author's address :-

Dr D Starley
ENGLISH HERITAGE
23 Savile Row
London
W1X 1AB

METALLURGICAL STUDIES OF MISCELLANEOUS ARTEFACTS AND DEBRIS 1996

David Starley
Ancient Monuments Laboratory

Introduction

This report provides details of a number of studies of metal artefacts and debris from high temperature processes examined at The Ancient Monuments Laboratory during 1996.

The visual examination and X-ray fluorescence analysis of industrial debris from Redesdale, Northumberland

Background

A single piece of slag weighing 904g was submitted by David Cranstone of Lancaster University Field Archaeological Unit on behalf of a local amateur field worker. No information was supplied with the slag apart from its provenance: near Blackwood Lane, Redesdale, NGR NY 805 980.

Visual examination

This did not provide a clear indication of the origin of this rather unusual slag. It conformed approximately to the dimensions and morphology expected of a smithing hearth bottom, but had an unusually dense, non-porous nature. It gave a dark grey (fayalitic) streak on an unglazed porcelain tile and was surprisingly strongly attracted to a magnet (*ie*, contains magnetite or iron).

X-ray fluorescence (XRF) analysis

No traces of non-ferrous metals were identified. As well as a strong peak for iron small peaks for manganese, calcium and potassium were present (a high kV excitation energy prevented the detection of silicon).

Interpretation

The slag would appear to be of predominantly fayalitic ($2FeO.SiO_2$) composition with a significant magnetite or metallic iron content. This composition can be found in both iron smithing and iron smelting slags. The small concentration of manganese may be relevant; a primitive bloomery smelting furnace is run at a relatively low temperature such that most manganese in the ore passes into the slag rather than into the metal and from there to the smithing slag. Unfortunately this evidence is weakened by not knowing the quantity of manganese in other components, particularly the ore, against which to compare the slag.

On balance, despite having the appearance of a smithing hearth bottom, the nature of the slag, together with the presence of manganese suggest the sample **probably** originates from iron smelting rather than smithing. It should be pointed out to the excavator that a more extensive sample might have provided a better base from which to determine its source.

The visual examination of industrial debris from Salford, Bedfordshire

Background

A small quantity of slag, not exceeding 2kg was submitted to the Ancient Monuments Laboratory by Bedfordshire County Council Archaeology Service.

Excavations undertaken by the Unit at Salford between 1989 and 1990 revealed a multi phase site including an Iron Age settlement with 16 round houses. The distribution of ironworking debris was restricted almost entirely to the drip gullies of two structures; 4 (362g) and 11 (639g).

Visual examination

This identified a well-formed smithing hearth bottom from context 2510 and some very small "probable" heath bottoms from contexts 1474, 1800 and 2500. However, a small sample of magnetic material retrieved from context 1800 did not appear to be hammerscale and the single fragment of material from context 3689 was a natural limonite nodule. The small quantity of other material was often of a cindery, iron-rich nature with charcoal impressions

Interpretation

The examination confirmed the interpretation of the Bedfordshire finds specialist, that the assemblage derived from iron smithing.

The visual examination of possible industrial debris from the Bunyan Centre, Bedford

Background

A single bag of material weighing less than 1kg was submitted to the Ancient Monuments Laboratory by the Bedfordshire County Council Archaeological Service. The material came from a pit-fill, dated by ceramics to the early to middle Iron Age.

Examination and interpretation

Examination revealed the material to be a naturally occurring iron-rich conglomerate. There is no reason to believe the material derived from any industrial or craft process.

Visual examination of industrial debris from the Buttercross site, Leominster, Herefordshire

Examined and interpreted by Tom Finney

Background

The Buttermarket site (HWCM 7044) was exacavated by Hereford and Worcester County Archaeological Service between July and August 1991. Apart from two specific features, the residues (including slag and hammerscale) occurred in low level concentrations across the whole site, in particular during the earliest phase (12th to 15th century). The total quantity of metalworking debris recovered (6.3 kg) was very small compared to most iron working sites and was not found *in situ (i.e.* associated with a working floor or structural evidence for metalworking).

Visual examination

Small, rounded magnetic clay 'balls' of unknown origin had in many cases been misidentified by the excavator as spheroidal hammerscale. Spheroidal hammerscale was present, but not as frequently as recorded on the finds sheets supplied. Spheroidal hammerscale is produced during high temperature smithing (either hot working of an iron bloom or forge welding of two pieces of iron).

A small quantity (1.4 kg) of smithing hearth bottoms were identified by their plano-convex shape. Along with the hammerscale recovered, smithing hearth bottoms are diagnostic of iron smithing.

A small amount of slag has coal/coke inclusions. It is possible these fuels were being used in place of charcoal for ironsmithing.

Interpretation

The assemblage results from iron smithing. Its small size represents only a short period of smithing activity, perhaps during the construction of a building. There is no evidence for iron smelting, or the working of non-ferrous metals.

Metallographic examination of ferrous alloy from Foxbrooke Furnace, Renishaw, Derbyshire

Background

A sample cut from an iron pig was provided by David Cranstone. The site (SK 42837725) is a 17-18th century charcoal blast furnace, later used as a sickle mill.

Metallographic examination

Under the optical microscope, in the as polished state, localised clusters of graphite flakes were visible as well as polygonal inclusions (Plate 1). Etching in 4% Nital showed the microstructure to also comprise pearlite, cementite (Fe_3C) with microhardness of Hv_{300} 1043, 1070,1119 and a eutectic phase (Plate 2).

SEM-based micro analysis

Although the energy dispersive detector on the SEM is not sufficiently sensitive to give quantitative results for any but the highest levels of impurity elements present, the results in Table 1 allow phases to be identified with greater certainty; the small polygonal inclusions are manganese sulphide and the eutectic phase is rich in phosphorus.

Table 1 Sem-based microanalysis or Foxbrooke furnace cast iron

analysis No.	phase analysed	weight % element						
		C	Si	P	S	Ti	Mn	Fe
FF01	bulk iron	nd	nd	2.09	nd	nd	0.32	97.59
FF02	polygonal inclusion	nd	nd	nd	32.66	nd	64.27	3.08
FF03	eutectic phase	nd	0.6	1.63	nd	nd	nd	97.77
FF04	eutectic phase	nd	nd	2.32	nd	nd	0.32	97.36
FF05	pearlite	nd	0.31	nd	nd	nd	0.28	99.42
FF06	pearlite	0	0.39	0	0	0	0	99.61
FF07	graphite	90.52	nd	nd	nd	nd	nd	9.48
FF08	iron matrix	nd	0.21	0.85	0.08	nd	0.39	98.47

Interpretation

The sample shares features of white and grey cast iron and is best categorised as a mottled cast iron with a significant phosphorus content, probably originating from the ore, and manganese sulphide inclusions which suggest the use of coke as the fuel in the blast furnace. The mottled structure, with carbon present as graphite flakes and cementite, indicates a relatively rapid cooling rate.

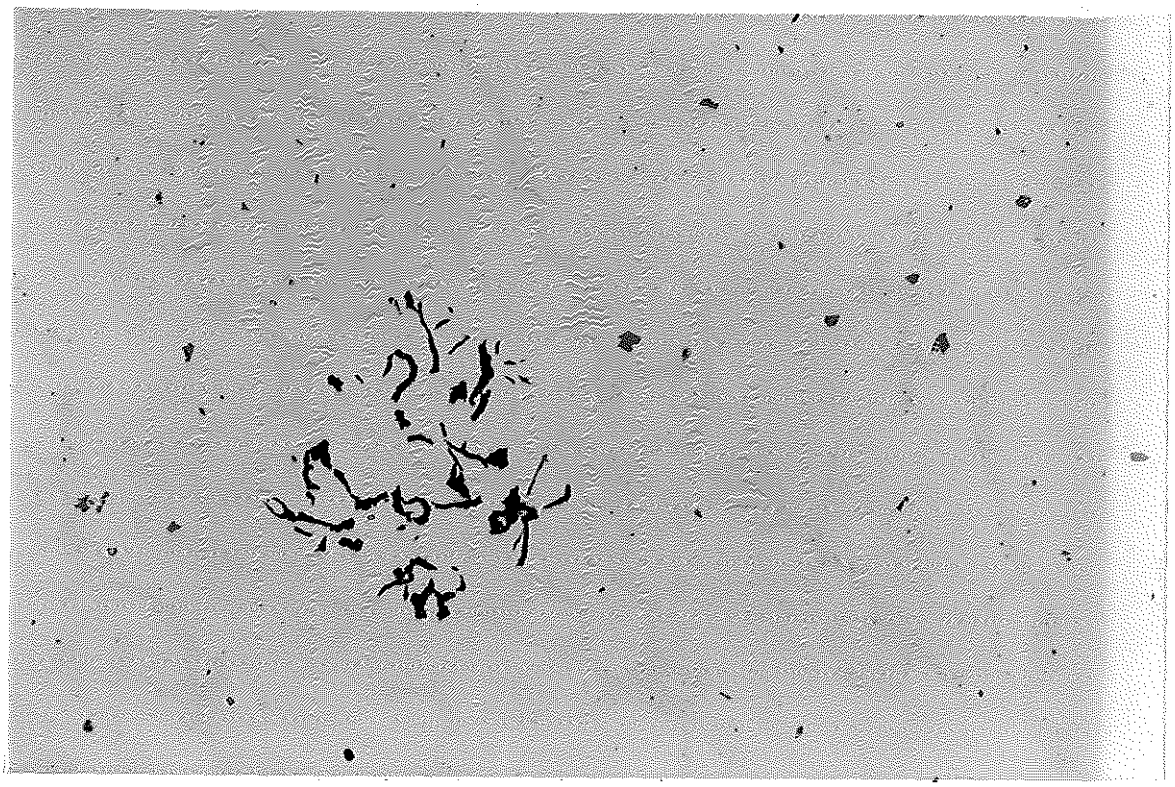

Plate 1 Micrograph of unetched Foxbrooke Furnace Cast Iron x100. Localised region of flake graphite (black) and polygonal manganese sulphide particles (grey).

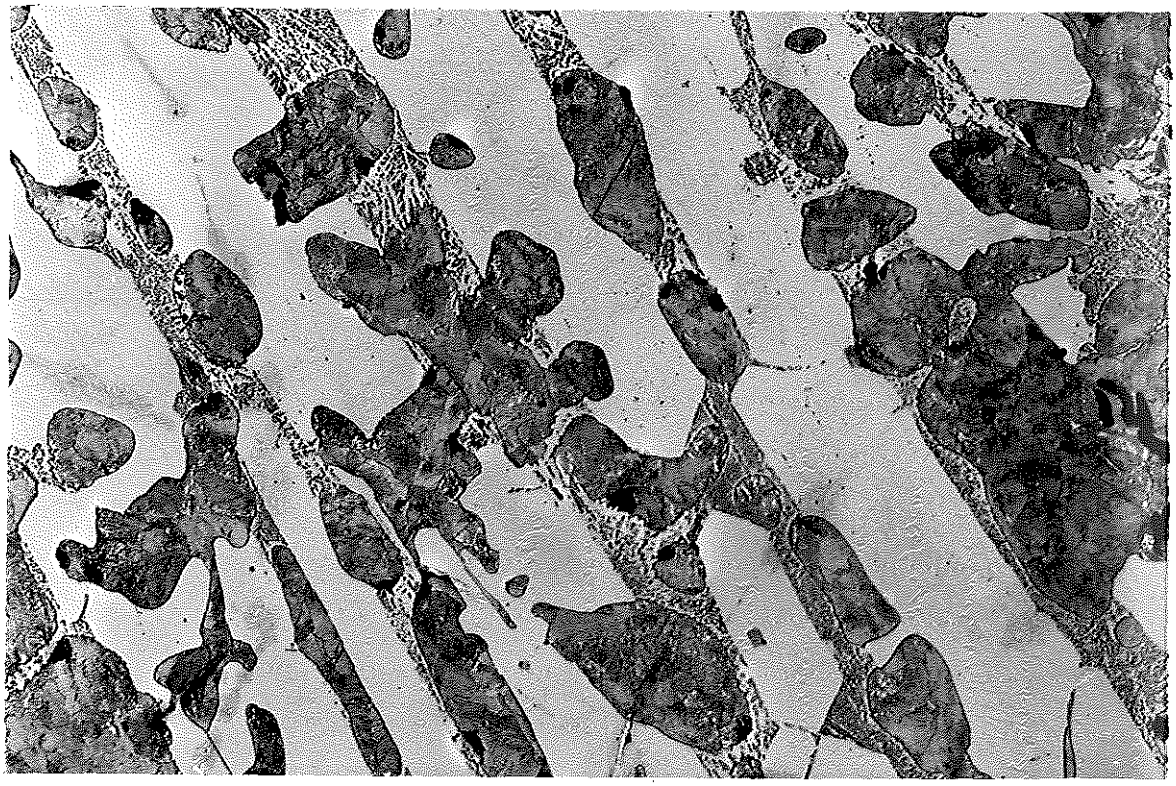

Plate 2 Micrograph of etched structure x200. Pearlite (dark), cementite (white) and phosphide eutectic (two phase).