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X-RADIOGRAPHIC AND METALLOGRAPHIC EXAMINATION OF AN ANGLO-SAXON PATTERN-WELDED FITTING FROM ABBOTS WORTHY HAMPSHIRE (1983).

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Summary

X-radiography of an iron fitting, possibly a hinge-plate fragment, revealed a complex pattern-welded structure. Stereo-X-radiography suggested a double construction of at least five composite rods welded side by side. Metallography confirmed the double patterned construction and also revealed a central core.

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Introduction

Excavations at Abbots Worthy, Itchen Valley, Hampshire (SU 5044 3266), a Saxon occupation site, produced a small quantity of metalwork. One item (M3.83/W79 F.7345/7378 SF379) was an iron fitting with three iron nails in situ, possibly a hinge-plate fragment (Fig. 1). The fitting was well-preserved but incomplete. The surfaces of the fitting and the nails were covered with a substantial layer of red iron corrosion products, identified as haematite, above a layer of magnetite and the metal core. No suggestion of the structural composition was visible on the surfaces of the fitting.

X-radiography suggested that the fitting was pattern-welded, with elements orientated longitudinally to the axis of the fitting. Stereo-X-radiography partially resolved the structure, separating the image into a double construction of composite straight rods and composite twisted rods. Lengths of both straight elements and twisted elements were traceable on both sides of the double construction, with straight elements opposite twisted elements on the second side. At least five, and possibly six, composite elements were visible along the central axis of the fitting but no structure was visible at the edges of the broadest part. The small size of the fitting and distortion by the crudely formed nail holes make the precise number of elements uncertain. Plate 2 shows one side of the double construction to consist of a central element of straight rods at the top (above the nails) between two pairs of alternately twisted elements (which form a chevron pattern on both sides of the central element). Below the nails (more visible in Plate 1), the central element is twisted and lays between straight composite rods. The pattern is reversed on the second side of the construction. The possible sixth element is just visible as an untwisted composite rod above the right nail in Plate 1.

A sample for metallographic examination was taken to investigate the construction and the density differences visible on the X-radiographs.

Methods of metallographic examination

A transverse sample was taken mid-way along the fitting, 2mm into the metal. The section was mounted and polished to 1μm fineness in the normal manner and examined in the unetched and etched (1% nital) conditions at magnifications up to X500. Hardness values are averaged Vickers pyramidal hardness readings (HV) obtained using a 500g indenter load.

Results of the metallographic examination

Etching revealed a straight central ferrite core between alternate and diagonally orientated bands of ferrite and broader zones of carburized iron (Fig. 3, Plate 3). The carburized zones were of low carbon content, c. 0.1%C, and consisted of ferrite and pearlite (Plate 4). Grains were equiaxed, slightly larger in the ferrite regions (ASTM 4) compared with the carburized regions (ASTM 5). Qualitative phosphorus estimation by scanning electron microscopy with energy-dispersive X-ray analysis detected phosphorus in the ferrite regions whereas none was detected in the carburized regions. Slag inclusions (Fig. 2) were single-phased and duplex and these were more abundant, larger and angular within the ferrite core. Stringers were well-broken and alignments corresponded with the banding visible upon etching. Hardness of the central ferrite core was 112 HV, ferrite band 117 HV, carburized zone 103 HV.

Discussion

Metallographic examination confirmed the double construction suggested by the X-radiographs and also revealed a central ferrite core which had not been detected on the X-radiographs. The adjacent ferrite bands and carburized zones visible at the edges of the metallographic section (upper and lower sides of the fitting) correspond to the individual strips of the composite rods of the pattern-welding, with the central ferrite core interposed between the double pattern construction. Judging from the orientations visible on the section, the upper row of ferrite bands and carburized zones in Fig. 3 and Plate 3 probably corresponds to part of a twisted composite element of the pattern-welding whereas the lower row probably corresponds to part of a straight composite element. The presence of the haematite corrosion products on the fitting suggests that it had been heated in an oxidising atmosphere after breakage and discard. Reheating could account for the low hardnesses which were recorded and the equiaxed form of the grains.

The fitting was presumably devised from a discarded pattern-welded weapon blade. The fitting had been roughly devised and it seems unlikely that the original pattern-welding of the blade had been altered other than by reduction in thickness. Perhaps a blade fragment was simply heated and forged down to the necessary thinness, cut to shape, and pierced to form the nail holes. The plain structureless areas at the edges of the broadest part of the fitting may be the remains of the cutting edges of the original blade.

The metallurgical composition of the Abbots Worthy fitting is consistent with Anglo-Saxon pattern-welded blades. A combination of phosphoric ferritic elements and carburized elements is typical of pattern-welded blades and is considered to be responsible for the visual effects in a finished blade (Tylecote and Gilmour 1986, 251). The density differences visible on X-radiographs of pattern-welded items are due primarily to differential corrosion during burial (Tylecote and Gilmour 1986, 251), although other factors such as variable volume fraction and alignments of slag stringers may have contributed to the effect in the Abbots Worthy fitting.

The pattern-welding in Anglo-Saxon weapon blades usually consists of two to four composite rods welded side by side, sometimes of double construction (Anstee and Biek 1961, Table 1; Tylecote and Gilmour 1986, Part 2 , Fig. 103). Ager and Gilmour (1988, 22) suggest that weapons formed from welding more than four composite rods side by side are extremely uncommon in Britain, a sword from Lovedon Hill being the only known example of five elements and a sword from Acklam Wold being the only known example of six elements. They further suggest that a central core is known only in double constructions where three or less composite rods were welded side by side, although Anstee and Biek (1961, Table 1), basing their evidence on X-radiography, record examples where a core was present when four elements were welded side by side. Much evidence of pattern-welded constructions, such as the Acklam Wold sword, has been derived from X-radiography alone: the presence of the ferrite core within the Abbots Worthy fitting was realised only by metallography. The Abbots Worthy fitting appears to have been devised from a more complex structural type of pattern-welding than has yet been recognised in an Anglo-Saxon blade.

Acknowledgements
Permission to sample the fitting was kindly granted by the excavator, Peter Fasham, and David Allen, Keeper of Archaeology, Hampshire County Museum Service. I am grateful also to Paul Wilthew (AML) for X-ray diffraction analysis of the iron corrosion products and for phosphorus determinations of the section, and to Leo Biek, who recognised the complexity of the pattern-welding, and for persistent encouragement.

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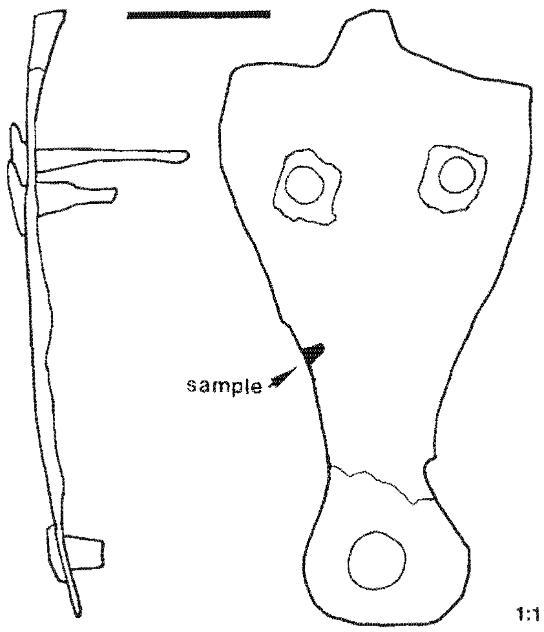

FIGURE 1. Abbots Worthy fitting SF379

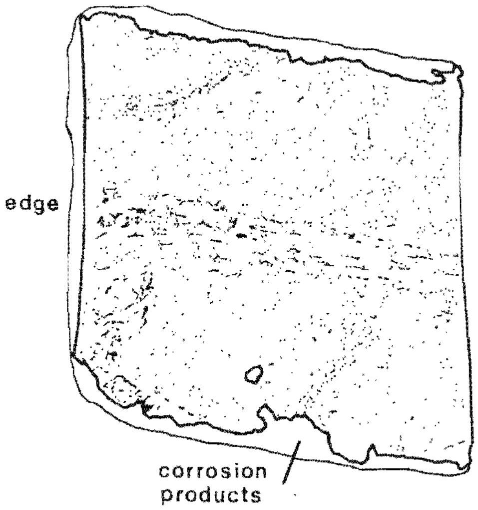

FIGURE 2. Diagram of section showing slag distribution, X30

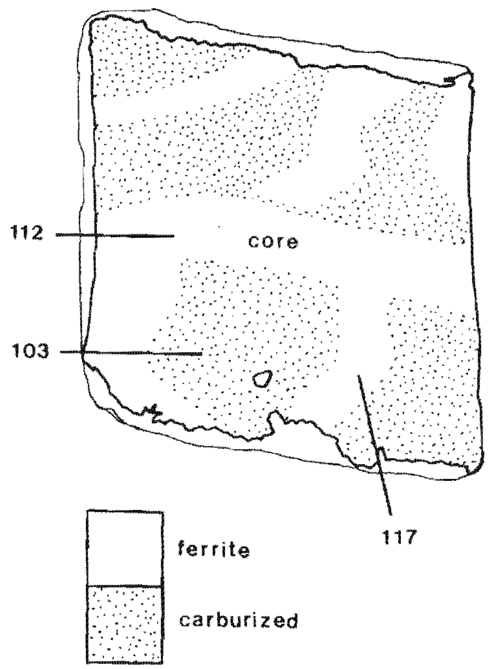

FIGURE 3. Diagram of section showing composition and hardness (HV), X30

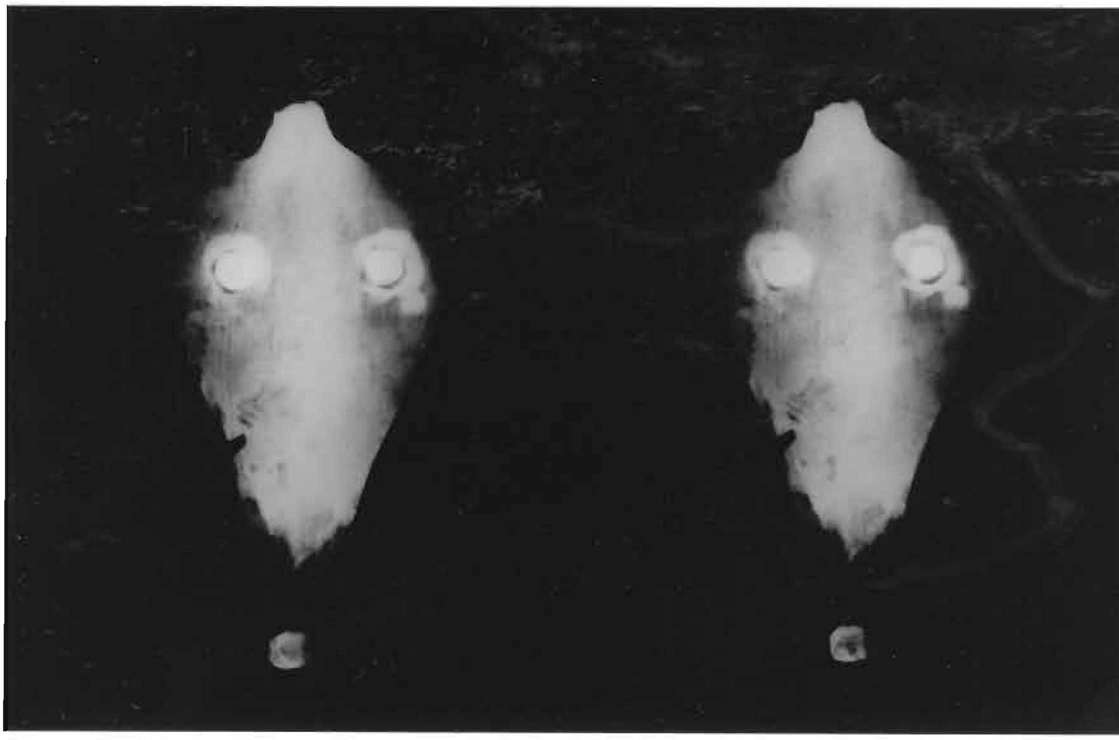

PLATE 1. Stereo pair of X-radiographs.

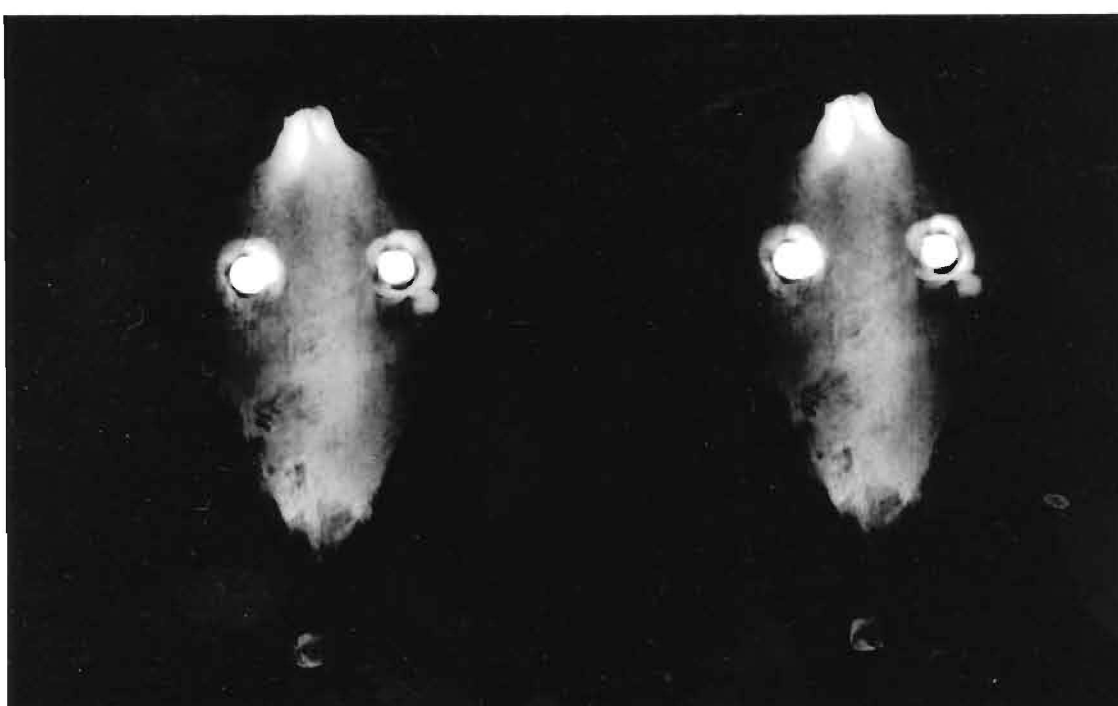

PLATE 2. Stereo pair of X-radiographs. The exposure was increased to show the pattern-welded structure in the thicker parts of the fitting.

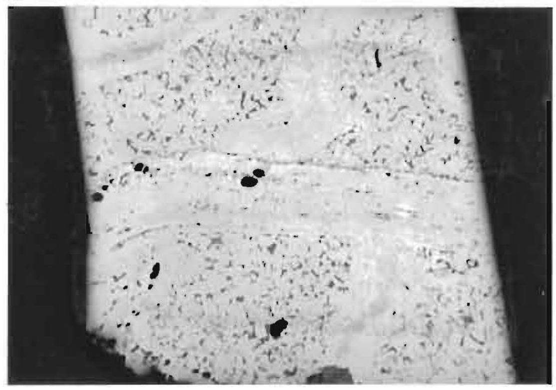

PLATE 3. Photomicrograph of section, X30

PLATE 4. Detail of a carburized region, X150