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Ancient Monuments Laboratory
Report 93/87

METALLURGICAL ANALYSES OF SIX IRON KNIVES FROM HAMWIH, SOUTHAMPTON.

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Summary

Six Anglo-Saxon iron knives from the excavations at Six Dials, Southampton were studied metallurgically. Five knives had butt welded steel cutting edges, the sixth had no steel edge. The quality of manufacture was high, and phosphoric iron was less abundant as compared with the analysis of the Viking Age knives from Coppergate, York.

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H.B.M.C.E. FUNDED ARCHAEOMETALLURGY CONTRACT

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METALLURGICAL ANALYSES OF SIX IRON KNIVES FROM HAMWIH, SOUTHAMPTON

KNIVES 30/173, 99/38, 99/92, 169/421, 169/610, 169/2407

Introduction

Metallographic analyses of iron edged tools provides an insight into the methods of fabrication, levels of technologicaly, and in some cases uses of the artefact. It therefore complements typological studies.

Methods of Analyses

The selection of artefacts for metallographic analysis is based on the corpus of artefacts available, their suitability for analysis, and the evidence from artefacts already sectioned.

The artefacts are subjected to detailed X-radiography to determine the extent of any corrosion present, and to examine any differences in metallurgical structure visible on the radiograph. One or two half sections are cut from the artefact using spark errosion. The location of the sections is based on the evidence of the X-Radiographs. One section is removed from the cutting edge, and the second (if made) is removed from the back of the artefact. The sections are mounted in conducting bakelite and prepared in the usual manner, finishing with a one micron diamond polish. They are examined under the metallurgical microscope in the unetched condition to record the distribution of slag

(nitric acid in alchohol) to show the microstructure. Other etchants may be used to examine phosphorus distribution etc.. The overall structure is recorded and photographed. Micro-hardness and Vickers Hardness values are taken for the different areas/phases present in the structure. A written description , a simplified drawing, and if necessary photo-micrographs form the report. The hardness values are given in brackets after the description of the microstructure, micro-hardness as uhv = *** (load=100gm), and Vickers Hardness as Hv = *** (load=2.5 kg).

Knife Reports

The knives are identified by the site code number and the finds number, in the form S.C.N./F.N., e.g. 30/173. Seven knives were selected for analyses. Knife 31/1147 was totally corroded, and no metallic iron was present, and, therefore, no analysis was carried out.

Knife 30/173

Knife 30/173 was 135mm long and 15mm wide at the widest point. The corrosion products had only been removed from the blade. There was a groove on each side of the knife just below the back, they ran approximately two-thirds of the length of the knife from the tang.

The X-radiographs showed some corrosion of the cutting edge. The presence of two 'irons' was indicated, Iron I forming the knife back, and Iron II, the cutting edge. The division between them was midway between the cutting edge and the back. Two

sections were removed, the cutting edge section avoided the corrosion, and the back section included the grooves, (Figure 1).

In the unetched condition slag lines were present running diagonally across the lower (cutting edge) section. In the upper section the slag lines ran transversely across the specimen in an inverted U-shape. There were fewer slag lines in the upper part of the section (the back of the knife).

In the etched condition (Figure 2) the two sections displayed different microstructures. The upper section was ferritic (uhv = 154, Hv = 157), with some grain-boundary pearlite,(uhv = 222), and areas of high phosphorus (ghost phases) present (uhv = 185). The grain size of the ferrite varied, depending on the presence of pearlite and phosphorus. The lower section had a tempered martensite cutting edge (uhv = 743, Hv = 548) that degraded to pearlite plus some ferrite at the top of the section (uhv = 376, Hv = 306). White weld lines ran vertically through the section, indicating that the steel had been repeatedly folded and welded, or was manufactured from several strips of steel.

The difference in microstructure between the upper and lower section indicates that the cutting edge had been butt welded to the knife back; the weld was not present because the two sections did not overlap sufficiently.

The knife was of good quality with a quenched and tempered cutting edge, butt welded to a (predominantly) phosphoric iron knife back.

Knife 99/38

The tip of Knife 99/38 was absent, it did not have a distinct shoulder at the tang/blade interface. The surviving length was 100mm, and 12mm wide at the widest point.

The X-Radiographs showed extensive corrosion of the knife, only the middle portion was unaffected. This part showed evidence of horizontal bands running the length of the blade. Two half-sections were cut from the uncorroded central portion of the knife (Figure 3).

In the unetched condition some corrosion penetration was visible in both sections. The back section showed divergent slag lines running at an angle across the section. The cutting edge section showed a more varied slag stringer distribution. In the upper part of this section the same slag distribution was observed as was present in the back section, (the two sections overlapped). In the mid-part of the cutting edge section the slag stringers faded out, and vertical stringers were present at the cutting edge. This would indicate that the cutting edge was a seperate strip of iron welded to the back, but there was no obvious weld line presence indicated by slag inclusions.

Etching (Figure 4) showed the back section and the upper part of the cutting edge section were ferritic with some pearlite present (uhv = 186, Hv = 140). The cutting edge was formed by a steel strip welded to the back. The weld line was present as a white/yellow line, and vertical white/yellow lines were also present. The cutting edge had a tempered martensitic structure (uhv = 772, Hv = 572)which degraded to pearlite plus some grain boundary ferrite at the weld line (uhv = 345, Hv = 317). There

had been some carbon diffusion across the weld line into the ferrite back.

Knife 99/38 was a good quality knife with a quenched and tempered cutting edge, butt welded to a ferritic back.

Knife 99/92

Knife 99/92 had grooves similar to knife 30/173, the tang was incomplete. The blade length was 100mm, and the surviving tang length 25mm, the maximum width was 13mm.

The knife was heavily corroded for a distance of 30mm from the tip; a fracture occurred across the corroded region, and the tip broke from the body of the knife. Some corrosion was present along the cutting edge. Two sections were removed from the undamaged section of the knife, (Figure 5).

In the unetched condition vertical slag lines were present in both sections. In the cutting edge section there were some inter-granular quench cracks. In the etched condition both sections showed a predominantly ferritic microstructure, with some small fields of grain boundary pearlite, and there were some areas of high phosphorus iron. The hardness values are shown in Table 1.

Table 1 Knife 99/92 Hardness Values

		uhv(100gm)	Hv(2.5Kg)
Cutting Edge	ferrite	216	160
" "	ferrite + pearlite	235	
Knife back	ferrite	178	160
" "	"	174	170

The sections show that there was no steel edge applied to the knife. There was no evidence that the cutting edge had preferentially corroded away. The poor quality of this knife contrasts with the previous examples.

Knife 169/421

Knife 169/421 was an 'angle backed knife', with horizontal grooves running two thirds the length of the blade. The corrosion products had not been removed from the tang. The overall length was 137mm and the maximum width was 15mm.

X-Radiographs showed corrosion along the whole length of the cutting edge in a sinusoidal form. There was a thin band of corrosion running diagonally downwards from the knife back towards the tang, which had suffered extensive corrosion, (Figure 6).

A single section was prepared from the cutting edge, which caused the knife to break in half. The opportunity was taken to prepare a complete cross-section from the fractured surface. The first half section when prepared showed no evidence of a cutting edge, and was purely ferritic. In the unetched condition the complete cross-section showed the corrosion band running completely across the section. The metal was heavily slagged with vertical slag lines, and there was a distinct transverse welding line at the cutting edge. The metal used for the cutting edge was less heavily slagged than the knife back.

In the etched condition (Figure 7) the knife back could be seen to be ferritic (uhv = 198, Hv = 130, and uhv = 207, and hv =

172) with some areas of ferrite and pearlite. The cutting edge was pearlitic (of varying carbon content) (uhv = 158, Hv = 160) with some vertically orientated ferritic bands. Towards the weld line the structure degraded to ferrite plus pearlite, (uhv = 146).

Knife 169/421 was well manufactured, but the cutting edge had not been heat treated.

Knife 169/610

Knife 169/610 was a parallel sided knife, the length was 112mm and the maximum width was 9mm. The corrosion products had not been removed from the tang.

The X-Radiographs indicated banding in the upper part of the knife back, and there was no evidence for extensive corrosion (Figure 8).

In the unetched condition the back section was heavily slagged with curving vertically orientated slag lines. The upper part of the cutting edge section contained medium sized inclusions as vertical slag lines. These were interupted by two very large inclusions, and the lower part contained few small vertically orientated inclusions.

In the etched condition (Figure 9) the knife back section was ferritic (uhv = 126, Hv = 101) with some pearlite present. At the bottom of the section, grain boundary pearlite was present (uhv = 157, Hv = 140). The cutting edge section was a steel with varying microstructure. The tip was tempered martensite (uhv = 585, Hv = 333) that degraded to pearlite (uhv = 488, Hv = 297) at the top of the section. There was no evidence of a weld in the

cutting edge section, and therefore it is believed that the weld line occurred between the two sections.

Knife 169/610 was a well manufactured knife with a quench and tempered steel cutting edge.

Knife 169/2407

Knife 169/2407 was a small knife 105mm long with a maximum width of 10mm. There was extensive corrosion of the tang and at the tang/blade interface. The X-radiographs showed no other contrasts (Figure 10).

In the unetched condition vertically orientated bands of fine slag inclusions were present in all sections.

In the etched condition (Figure 11) there was an increasing carbon content from the back towards the tip. The back was ferritic with pools of carbide (uhv = 202, Hv = 166), the mid-section was ferritic with grain boundary carbides (uhv = 198, Hv = 168). At the cutting edge the microstructure was ferrite and nodular carbide (uhv = 185, Hv = 153).

The knife was probably a ferritic knife that had been pack carburised, and subsequently heavily overtempered.

Conclusions

The six knives analysed show methods of manufacture that are known from other sites, e.g. Coppergate, York. Comparing the Hamwih with the larger corpus from Coppergate the microstructures are comparable. There are two principal differences.

1 Core or sandwich knives are absent (i.e. with the steel

cutting edge running the full length of the knife welded between two 'iron' back strips), this was the commonest form of manufacture at York, and therefore to encounter only butt welded knives is significant.

2 The microscopical evidence suggests that the Hamwih ferritic iron contains a lower phosphorus content than the Coppergate knives.

For these reasons more knives (10 -15) should be sectioned to confirm or refute these conclusions.

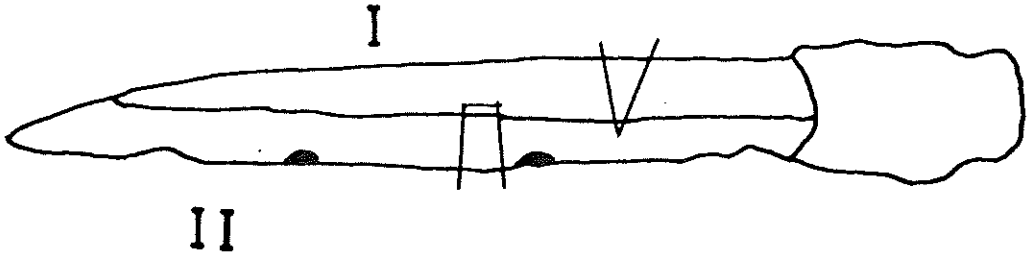
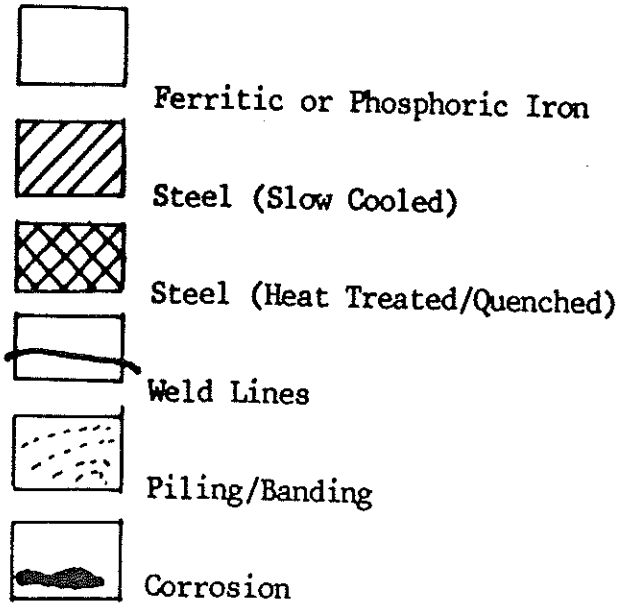


FIGURE 1 KNIFE 30/173 INTERPRETATION OF X-RADIOGRAPHS (X1)

FIGURE 2 KNIFE 30/173 CROSS-SECTION (X5)
(Weld line is conjectural)



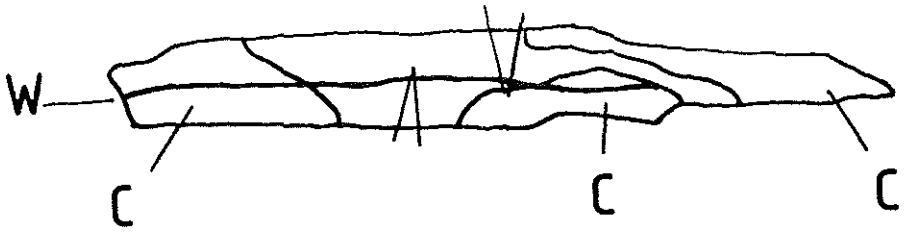


FIGURE 3 KNIFE 99/38 INTERPRETATION OF X-RADIOGRAPHS (X1)
(C = CORROSION)

FIGURE 4 KNIFE 99/38 CROSS-SECTION (X5)

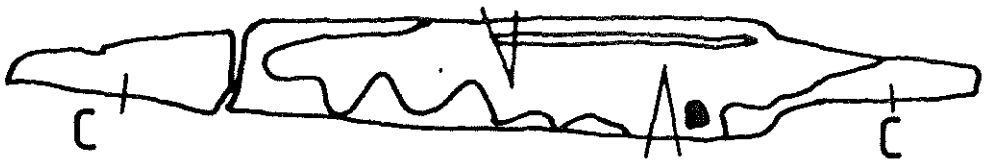


FIGURE 5 KNIFE 99/92 INTERPRETATION OF X-RADIOGRAPHS (X1)

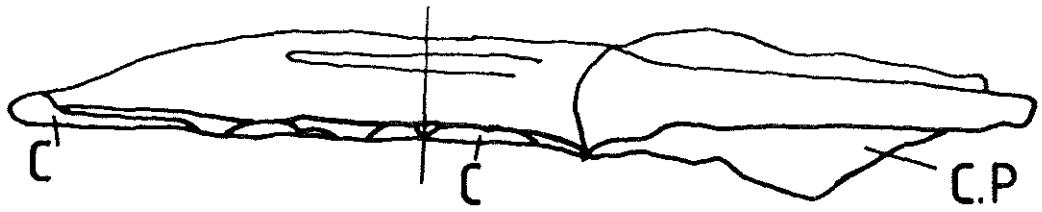


FIGURE 6 KNIFE 169/421 INTERPRETATION OF X-RADIOGRAPHS (X1)

FIGURE 7 KNIFE 169/421 CROSS-SECTION (X5)

FIGURE 8 KNIFE 169/610 INTERPRETATION OF X-RADIOGRAPHS (X1)

FIGURE 9 KNIFE 169/610 CROSS-SECTION (X5)

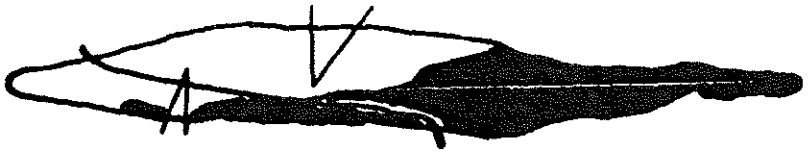


FIGURE 10 KNIFE 169/2407 INTERPRETATION OF X-RADIOGRAPHS (X1)

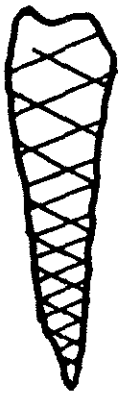


FIGURE 11 KNIFE 169/2407 CROSS-SECTION (X5)