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Report 9/89

METALLURGICAL ANALYSES OF FOURTEEN IRON KNIVES AND THREE OTHER IRON ARTEFACTS FROM CANNINGTON, SOMERSET.

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Summary

Fourteen iron knives from Roman, sub-Roman and undated contexts were analysed. The purpose was to determine the methods of knife manufacture, and by comparison with other data investigate the possibilities of distinguishing between knives of Roman and sub-Roman manufacture. The results were inconclusive, but there were three Type 2 knives present which were of much better quality than the other knives.

Three other artefacts, possible tools, were analysed to determine whether their metallurgical structure gave an indication of their function. Since they all had heterogeneous microstructures of ferrite/phosphoric iron and slow cooled, low carbon steel, no firm conclusion could be reached.

Author's address :-

J G McDonnell BTech PhD MIFA

Ancient Monuments Laboratory
English Heritage
23 Savile Row
London
W1X 2HE

Metallurgical analyses of 14 iron knives and 3 other iron artefacts from Cannington, Somerset.

By Dr Gerry McDonnell MIFA

1 Introduction

Metallurgical analyses were carried out to investigate the quality and methods of manufacture of the knives from Cannington. The material was not well dated, being either Late Roman or Post Roman and it was hoped that by comparison with analyses of artefacts from other dated sites some qualification of the dates could be obtained. There were 34 knives or fragments of knives, but due to their corroded state not all were available for analysis. The typological classification had been undertaken by Sue Hirst. The manufacturing typology (Figure 1) was a simplified version of that published by Tylecote (Tylecote and Gilmour 1986 p6). The technical terminology is that used in McDonnell (forthcoming), and full definitions can be found in Samuels (1980).

The possible hammer fragment and other objects were analysed to investigate any metallurgical evidence for their function.

2 Methods of Analyses

One single half-section was removed from the cutting edge of the knives and in two cases a second was removed from the knife back, (two blade sections were taken from one knife to clarify the method of manufacture). A section was removed from the face of the hammer and end sections cut from the other possible tools. All the sections were mounted in cold setting mounting compound and prepared and examined in the usual manner (McDonnell in Ottaway forthcoming). Micro-hardness measurements (uHV) were obtained using a 200gmf load applied for 30 seconds.

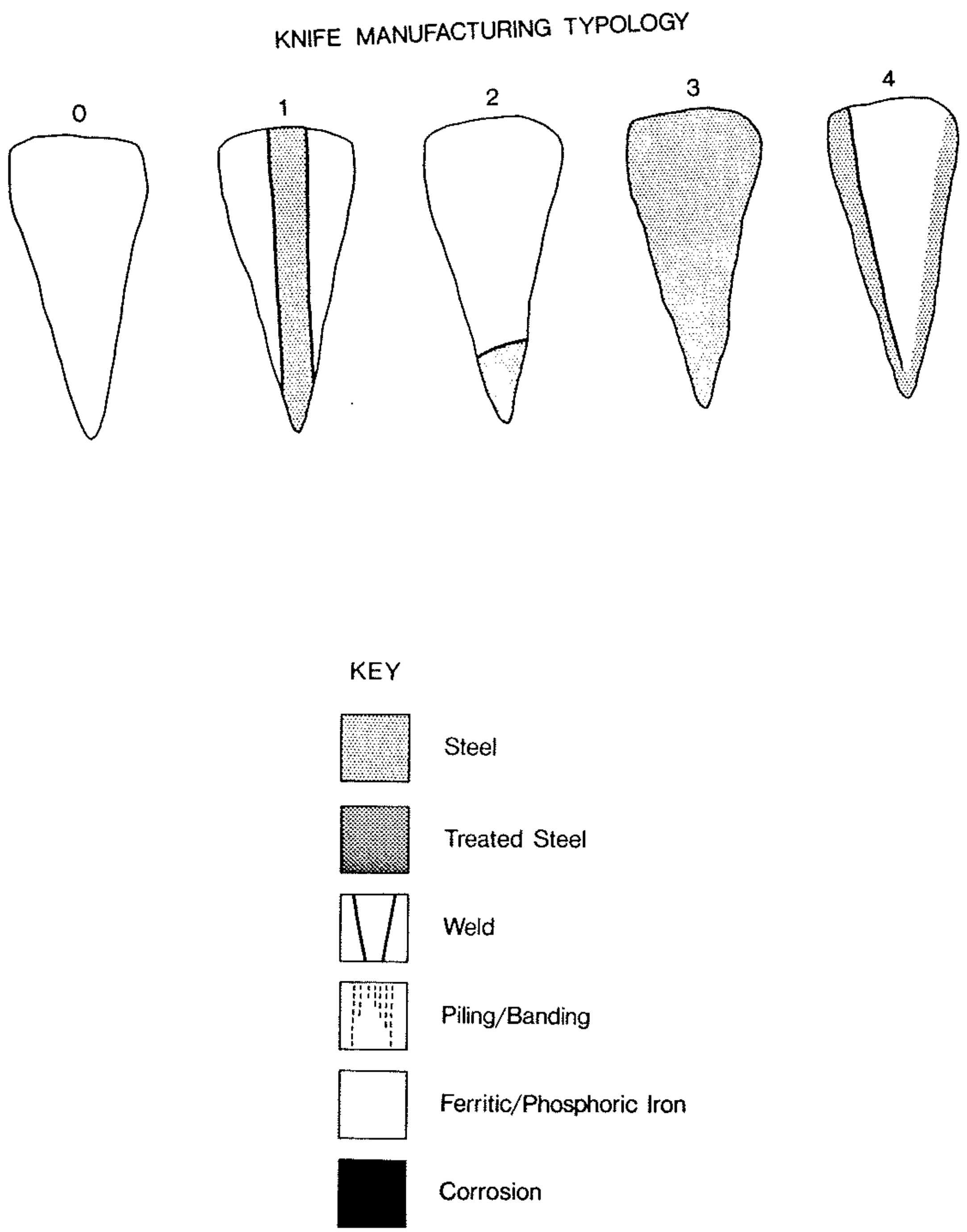


Figure 1 Methods of Knife Manufacture and Key

3 Results of the Analyses of the Knives

3.1 IR Number = 5; AML Number = 621520;
Typological Grouping = ?C; Typological Date = 7/8thC
Context Date = Undated

Knife 621520 was a fragment of a blade (Figure 2), from which a single half section was removed. In the unetched condition vertical slag banding was present, typical of Type 1 Manufacture. The blade was heavily effected by corrosion. Etching confirmed that it was of Type 1 manufacture (Figure 3). The sheaths were thin, possibly due to the effect of corrosion and were manufactured from ferritic/phosphoric iron (ghosting was present). The core was a low carbon steel (maximum of 0.2% C), with a varied microstructure of ferrite plus pearlite and ferrite plus grain boundary carbides. There was evidence of spherodisation of the pearlite. The knife had cooled under very slow conditions, perhaps being retained at about 500 oC for some time. There was no evidence in the surviving metal that any attempt at quenching had been tried. The hardness values confirmed the low quality of the knife (Table 1).

TABLE 1 Micro-Hardness Values for Knife 621520

	uHv
Sheath ferritic/phosphoric iron	238
" " " "	253
Core (Knife Back) ferrite + pearlite	194
" (Cutting Edge) pearlite + ferrite	175

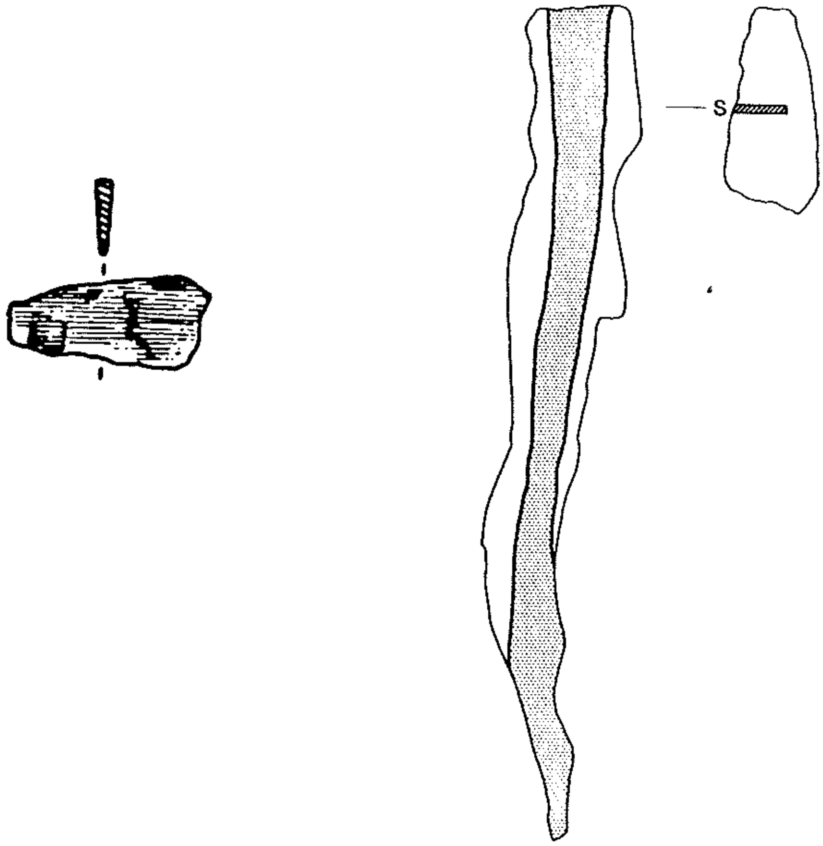


Figure 2 and **Figure 3** Knife IR=5, AML=621520
Location of Section (x 0.5) and Cross-Section (x 10)

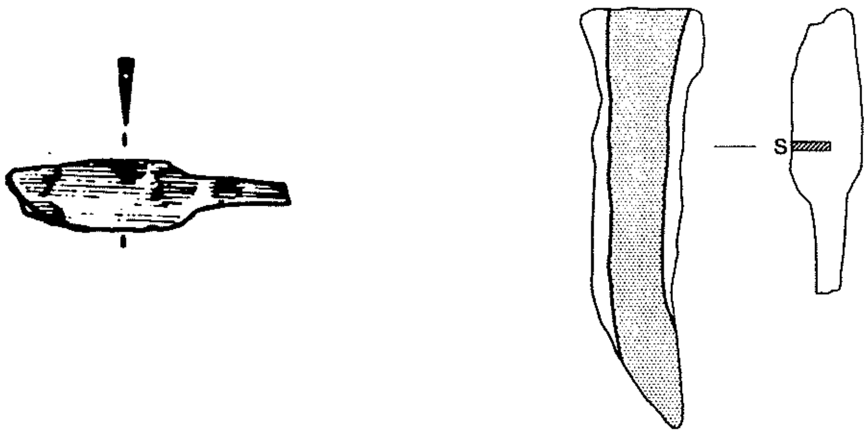


Figure 4 and **Figure 5** Knife IR=6, AML=621521
Location of Section (x 0.5) and Cross-Section (x 10)

3.2 IR Number = 6; AML Number = 621521;
Typological Grouping = ?B; Typological Date = Late 5th - 7thC
Context Date = Undated

A single half-section was removed from the knife (Figure 4). Examination in the unetched condition showed that the cutting edge was heavily corroded, and that there was some evidence of vertically orientated slag inclusions. Etching showed that the knife was of Type 1 manufacture (Figure 5) with thin ferritic/phosphoric sheaths and a low carbon (<0.2% C) core. The microstructure of the core was ferrite plus pearlite, indicative of a slow cool, with no attempt being made to quench the cutting edge. The hardness results (Table 2) confirm the poor quality of the knife.

TABLE 2 Micro Hardness Results for Knife 621521

	uHV
Sheath 1 (phosphoric/ferritic)	175
Sheath 2 (" ")	174
Core, Knife Back (pearlite)	202
Core, Cutting Edge (ferrite+pearlite)	181

3.3 IR Number = 9; AML Number = 621524;
Typological Grouping = C; Typological Date = 7/8th C
Context Date = Post-Roman

X-Radiographs showed that the knife (Figure 6) had a distinct butt weld running the length of the blade. A single half-section was removed, and in the unetched condition the transverse butt weld was clearly visible. Below the weld line the metal was clean, but above it there were vertically orientated fine slag lines. In the etched condition (Figure 7) the cutting edge (below the weld line) had a tempered martensitic microstructure, but with some nodular tempered martensite at the tip. Above the weld line there had been significant carbon diffusion into the (ferritic) knife back, giving a pearlite/bainite microstructure. The knife had been manufactured from a ferritic iron back (phosphoric iron would have impeded the carbon diffusion) welded to a hypoeutectoid carbon steel cutting edge (carbon content 0.6-0.8%C). The blade had been effectively quenched and tempered. This treatment is reflected in the hardness results (Table 3), the value obtained for the cutting edge is more typical of untempered martensite.

TABLE 3 Micro-Hardness Results for Knife 621524

	uHV
Knife Back (ferrite+pearlite)	177
Cutting Edge	
At the weld line (tempered martensite)	409
At the Cutting Tip (" ")	927

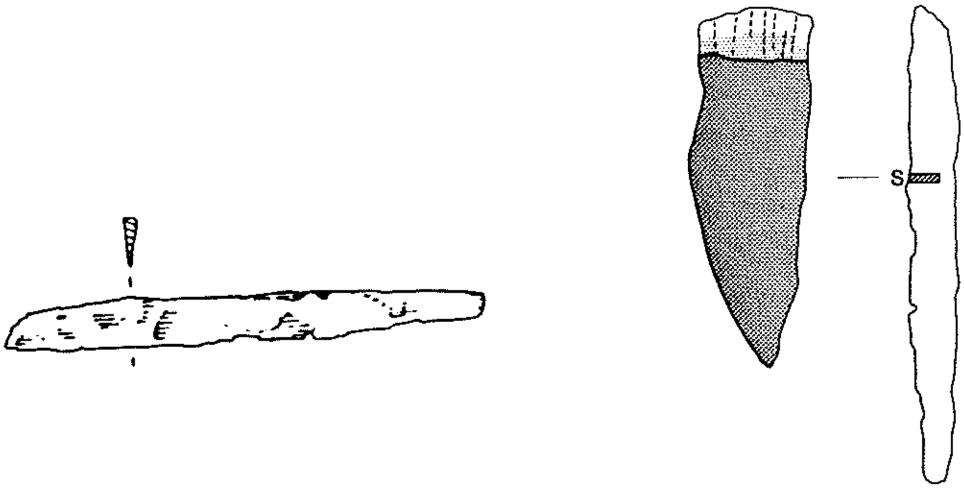


Figure 6 and **Figure 7** Knife IR=9, AML=621524
Location of Section (x 0.5) and Cross-Section (x 10)

Figure 8 and **Figure 9** Knife IR=12, AML=621527
Location of Section (x 0.5) and Section (x 10)

3.4 IR Number =12; AML Number = 621527;
Typological Grouping = B; Typological Date = Late 5th - 7th C?
Context Date = Undated

X-Radiography showed the presence of either a butt weld or a groove in the knife back. There was no evidence of the groove on the surface which was heavily corroded (Figure 8). A single half section was removed, and in the unetched condition showed vertically orientated slag lines, with a more dominant central line, which divided one third of the way down the section, in an inverted Y-shape. This is typical of a Type 1 manufactured knife in which the central core does not extend the full height of the blade; the steel cutting edge being inserted as a tongue into the knife back. Etching confirmed that this method of manufacture had been used but with an iron core rather than a steel one (Figure 9). The larger sheath had a heavily banded structure of ferrite and ferrite plus pearlite, in which the carbon content increased towards the outer surface. The second sheath had a piled or banded structure of varying ferrite grain size, but with some ferrite plus pearlite present. The differing grain size was probably indicative of variations in alloying elements, most probably phosphorus, but there was no ghosting present. The tongued cutting edge was small grained ferrite with some pearlite present. In the second sheath and the core the pearlite was concentrated at the weld lines within the piled or banded structure. The poor quality of the knife was confirmed by the hardness results (Table 4).

TABLE 4 Micro-Hardness Results for Knife 621527

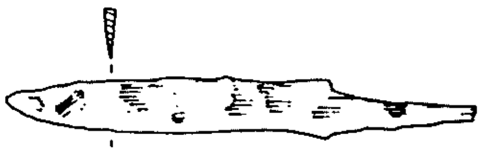
		uHV
Sheath 1	(pearlite+ferrite)	232
Sheath 2	(ferrite, large grained)	194
Core	(large grained ferrite)	170
Core	(pearlite+ferrite)	207

3.5 IR Number = 16; AML Number = 621531;
Typological Grouping = B; Typological Date = Late 5th - 7th C
Context Date = Post-Roman?

A single half-section was removed from the knife (Figure 10). In the unetched condition it showed a heavily piled or banded structure, indicated by the varying density of vertically orientated slag lines. In the etched condition (Figure 11) it showed a banded or piled structure of varying carbon content, and was therefore ascribed to an all steel type manufacture (Type 3). The microstructure varied from pearlite to ferrite, but pearlite plus ferrite bands predominated. There were some small localised areas of ferrite plus grain boundary carbide. At the tip the banded structure was present but the predominant structure was ferrite bands. There was no strong correlation between the carbon variation and the the variation in density of slag lines, ie some bands (ferrite or pearlite plus ferrite), were more heavily slagged than others. The overall poor quality of the knife is indicated by the hardness values (Table 5).

TABLE 5 Micro-Hardness Results for Knife 621531

		uHV
Knife Back	(ferrite+pearlite)	217
	(pearlite+ferrite)	299
	(ferrite, large grained)	187
	(pearlite+ferrite)	406
Cutting Edge	(ferrite, small grained)	191
	(" large ")	199
	(" at the knife tip)	223



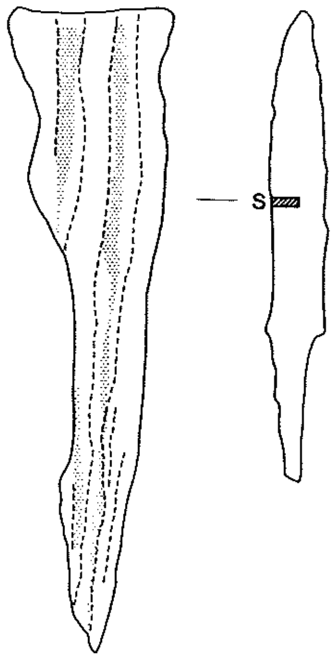


Figure 10 and **Figure 11** Knife IR=16, AML=621531
Location of Section (x 0.5) and Section (x 10)

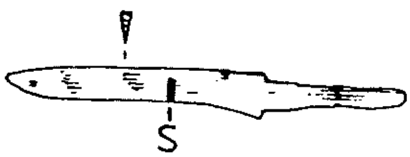


Figure 12 Knife IR=18, AML=621533
Location of Section (x 0.5)

3.6 IR Number = 18; AML Number = 621533;
Typological Grouping = B; Typological Date = Late 5th - 7th C
Context Date = Post-Roman?

X-Radiography indicated the presence of butt welds or strong longitudinal slag lines. The cutting edge was badly corroded and so a section could not be removed from the most suitable location (Figure 12). In the unetched condition there was no evidence of a transverse weld, except that some vertical slag lines stopped at the same level. In the etched condition the section had a pearlite plus proeutectoid ferrite microstructure (0.6-0.8% C). The carbon content varied across the section, so that on one side there was considerably more ferrite present than on the other. The structure is indicative of relatively rapid cooling from temperatures in the A1 to A3 range (c727-770 oC). The speed of cooling was just too slow to form martensites. There was no evidence of banding or of a transverse butt weld. The knife was therefore ascribed to Manufacturing Type 3. The section would have traversed the butt welds seen on the X-radiograph, and so they were probably longitudinal slag stringers. The hardness results show uniform results down the section (Table 6).

TABLE 6 Micro-Hardness Results for Knife 621533

		uHV
Top of section	(pearlite)	274
Middle of section	(")	286
Cutting edge	(")	257

3.7 IR Number =107; AML Number = 630906;
Typological Grouping = C; Typological Date = 7/8th C
Context Date = Post-Roman?

X-Radiography indicated that three components were apparently used in the manufacture of the knife (Figure 13); the knife back butt welded to a cutting edge which had been repaired at the tang end by the addition of a separate strip (but see below). Therefore two sections were removed from the knife (Figure 14). In the unetched condition both sections displayed severe corrosion damage, such that very little metal survived in the cutting edge section (Section 2). In Section 1 (the knife back) there were slag lines indicative of piling and folding. They did not form an overall pattern as in other knives, but were often folded back on themselves. There were points where several slag lines met giving a large cross section longitudinal slag line, this would accord with the apparent knife back/cutting edge weld line observed on the X-radiograph, a similar effect to knife 621533. There was no evidence of welds etc in Section 2. In the etched condition Section 1 had a ferrite and ferrite plus pearlite microstructure, the pearlite segregated at the weld lines and at the grain boundaries. There was ghosting within some

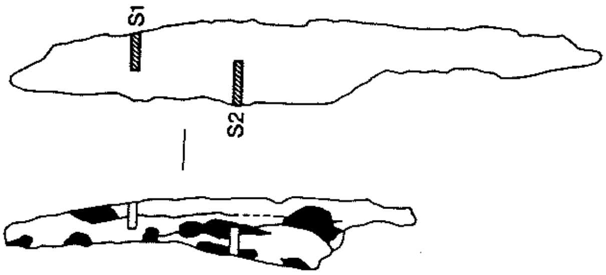


Figure 13 Knife IR=107, AML=630906
Interpretation of X-radiographs (x 0.5)
and Location of Section (x 0.5)

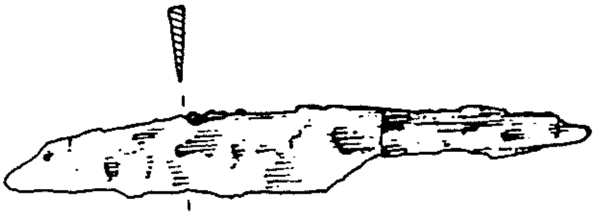


Figure 14 Knife IR=107, AML=630906

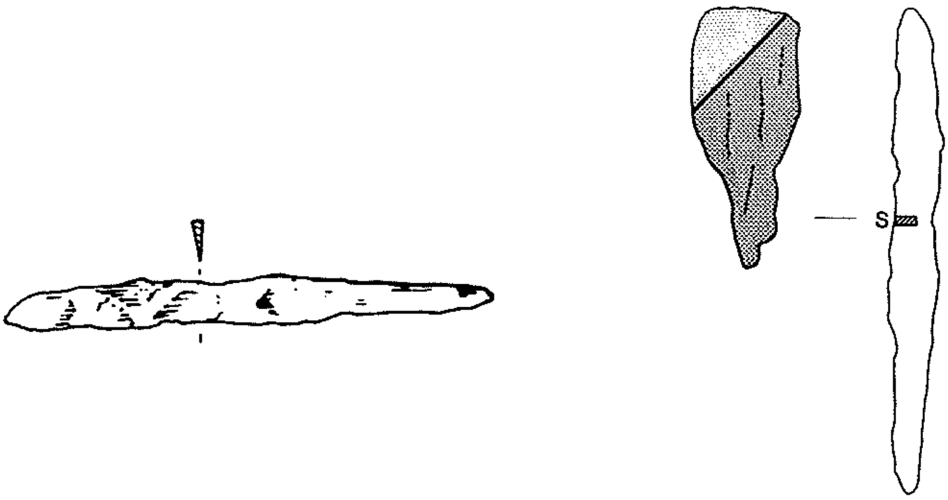


Figure 15 and **Figure 16** Knife IR=117, AML=630916
Location of Section (x 0.5) and Section (x 10)

grains indicative of the presence of phosphorus. Section 2 had a ferritic microstructure with some segregated carbides and age hardening etch pits. Since no distinct steel cutting edge could be identified the knife was ascribed to Manufacturing Typology 0. The hardness results are given in Table 7, and are typical of predominantly ferritic iron with zero or very low phosphorus contents. The radiographic evidence for a knife manufactured from three components conflicted with the metallographic study which showed that it was manufactured from a single piece of low carbon steel. It is possible that the third component, "the replaced cutting edge", was corrosion products with entrapped metal, The "weld line" between this strip and the knife "back" is the original cutting edge, which had suffered severe wear, to give a concave profile typical of Type 0 and 1 knives. The apparent weld line in the knife back was due to slag stringers or surface effects. The analysis of this knife demonstrates that radiographs can be mis-interpreted.

TABLE 7 Micro-Hardness Results for Knife 630906

	uHV
Section 1 Knife Back,	
Top of section (ferrite+grain boundary pearlite)	125
" " " (ferrite)	153
Section 2 Cutting Edge (ferrite+age hardening)	130

3.8 IR Number =117; AML Number = 630916;
Typological Grouping = C; Typological Date = 7/8th C
Context Date = Post-Roman?

X-radiography indicated the presence of a transverse weld. A single half-section was removed (Figure 15). In the unetched condition the metal appeared very clean and no transverse weld line could be observed. In one area at the top of the section there was some fine vertical slag banding. In the etched condition (Figure 16) a white/yellow diagonal weld line was visible (this effect is normally due to enrichment of certain elements eg As or Ni at the weld line due to preferential oxidation of the iron during welding). Above the weld line the microstructure ranged from ferrite at the top to pearlite at the weld line. This was due to carbon diffusion from the cutting edge into the ferritic iron back. Below the weld line the microstructure ranged from bainite at the weld line to tempered martensite plus cementite at the cutting edge. Within the cutting edge were more white weld lines, but vertically orientated. The knife was ascribed to manufacturing Type 2, it was of high quality, being slack quenched from above 727 oC. The presence of small amounts of free cementite are indicative of a hypoeutectoid composition (0.8-1.0% C). The hardness values are given in Table 8 and confirm the high quality of this knife.

TABLE 8 Micro-Hardness Results for Knife 630916

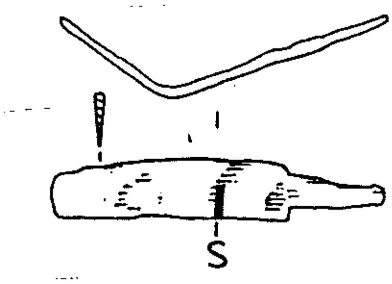
		uHV
Knife Back	(ferrite+pearlite)	163
" "	(pearlite)	349
Cutting Edge		
Below Weld Line	(bainite/tempered martensite)	412
mid-blade	(tempered martensite)	557
tip	(tempered martensite)	672

3.9 IR Number =123; AML Number = 630922;
Typological Grouping =?C; Typological Date = 7/8th C
Context Date = Undated

Knife 630922 was distinguished from the other knives by being bent through approximately 120 o, one third the way along its surviving length (Figure 17). A similarly bent knife was analysed from Coppergate, York (Knife 10227, McDonnell in Ottaway forthcoming). A single half-section was removed (Figure 17), which in the unetched condition showed vertical orientated slag lines on one side and a cleaner iron on the other. When etched the whole section was ferritic, and there was no significant difference between the heavily slagged area and the cleaner iron. Generally smaller ferrite grains were associated with slag inclusions throughout the structure. Most of the grains were sharply angular and showed no elongation or strain lines. This indicates a rapid cool, but not so fast as to cause the formation of widmanstatten structures. There was some age hardening present. The knife was ascribed to Manufacturing Type 0, with no steel cutting edge surviving. The hardness results (Table 9) indicate that there was no significant phosphorus content, but the variation in grain size does suggest some variation in chemical composition (probably in low levels of phosphorus).

TABLE 9 Micro-Hardness Results for Knife 630922

		uHV
Knife Back	(ferrite, small grained)	143
" "	(" large ")	160
" "	(" large ")	136
Cutting Edge Tip	(ferrite, medium grained)	130



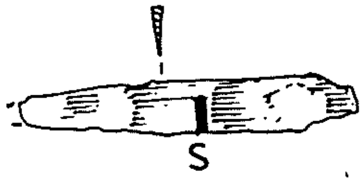
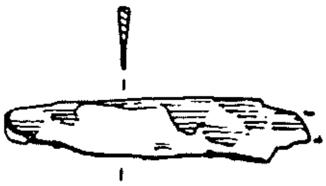


Figure 17 Knife IR=123
AML=630922
Location of Section (x 0.5)

Figure 18 Knife IR=129,
AML=630928
Location of Section (x 0.5)



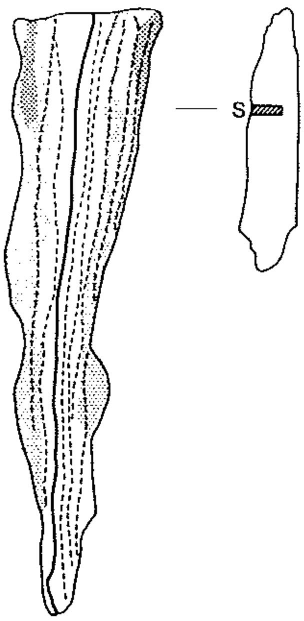


Figure 19 and **Figure 20** Knife IR=136, AML=630935
Location of Section (x 0.5) and Section (x 10)

3.10 IR Number =129; AML Number = 630928;
Typological Grouping = ?C; Typological Date = 7/8th C
Context Date = Undated

A single half section was cut from knife 630928 (Figure 18). In the unetched condition some vertically banded slag inclusions were observed. When etched it had an overall microstructure of ferrite plus grain boundary carbide/pearlite. It could be considered of Type 3 manufacture, ie a low carbon steel or of Type 0, with no applied steel cutting edge. The hardness results (Table 10) show no significant change in hardness throughout the section. Therefore no firm conclusion can be reached as to its method of manufacture, and it is thus ascribed to Type 0.

TABLE 10 Micro-Hardness Results for Knife 630928

		uHV
Top of Section ("Knife Back")		
	(pearlite+grain boundary ferrite)	199
	(ferrite+pearlite)	171
Cutting Edge	(" ")	198

3.11 IR Number =136; AML Number = 630935;
Typological Grouping = ?B; Typological Date = 5-7th C
Context Date = Undated

A single half-section was removed from the knife (Figure 19). Unetched, the section displayed vertically banded slag inclusions indicative of a Type 1 manufacture, ie two sheaths and a core. However, the inclusion lines were unequally distributed; one sheath was very clean, the core contained some slag banding and the second sheath was heavily slagged. There appeared to be two distinct welds on either side of the core, but they differed in quality, one being considered poor due to the voids and the size of the slag particles. In the etched condition (Figure 20) the overall structure did not conform with that interpreted from the slag banding. The clean sheath contained the highest carbon content (maximum content 0.6-0.8% C), giving tempered martensitic microstructures with some proeutectoid ferrite. This was joined to the remainder of the knife by a white/yellow weld line. Carbon had diffused across into the other half giving a range of microstructures, including tempered martensites, pearlite and ferrite as the carbon content decreased. The overall structure was considered a half-Type 1, ie a strip of steel welded to a piled sheath, the whole blade being quenched and tempered. The second weld line observed in the unetched condition was a poor weld deriving from the piling process. The hardness results (Table 11) confirm the quality of the manufacture.

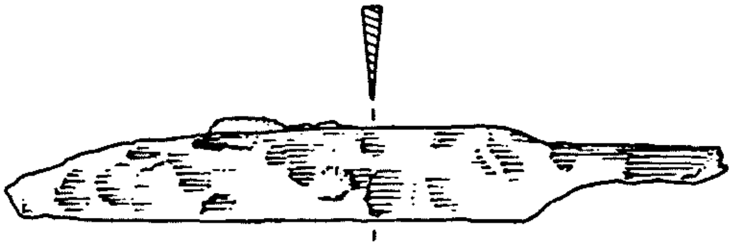
TABLE 11 Micro-Hardness Results for Knife 630935

		uHV
Piled Sheath (pearlite+ferrite)		381
" " (" ")		210
Cutting Edge Steel		
top of section	(tempered martensite)	498
cutting tip	(" ")	401

3.11 IR Number =159; AML Number = 630958;
Typological Grouping = C; Typological Date = 7/8th C
Context Date = Post-Roman

Knife 630958 was the largest knife in the group (Figure 21, surviving lengths: blade 142mm; tang 45mm). X-Radiography showed the presence of a butt weld, and the blade displayed a "stippled" effect typical of steel, whereas the knife back, above the weld line, had the more usual fibrous texture, induced by elongated slag inclusions. Initially two half-sections were removed from the knife, and later a second section was removed from the cutting edge to confirm the structure. The cutting edge section broke into an upper and a lower fragment indicating the presence of a weld. In the unetched condition the back section and the top half of the cutting edge section showed randomly distributed slag inclusions. The lower part of the cutting edge section was very clean, except for a crack running down from the top of the section. There were slag inclusions surviving at the failure point between the upper and lower parts of the cutting edge section, confirming that the failure occurred along a transverse weld line. In the etched condition (Figure 22) the top of the knife back had a microstructure of ferrite plus grain boundary pearlite. Towards the blade the carbon content increased, such that at the back/cutting edge butt weld, the microstructure was tempered martensite plus nodular pearlite. The cutting edge had a varied microstructure, at the tip and along one side it was martensitic (plus some retained austenite). Towards the centre of the blade it rapidly degraded to tempered martensites/bainites and finally to low carbon martensites due to decarburisation. The carbon content then increased towards the weld line giving tempered martensite and pearlite.

Knife 630958 was of Type 2 manufacture and rapidly quenched. The full benefit of quenching was not achieved because of the variation in carbon content of the tip. The high carbon areas of the cutting edge tip could be considered as over quenched, producing an edge that was very hard and brittle. The over quenching might have been a response to the insufficient hardness of the low carbon areas that would have



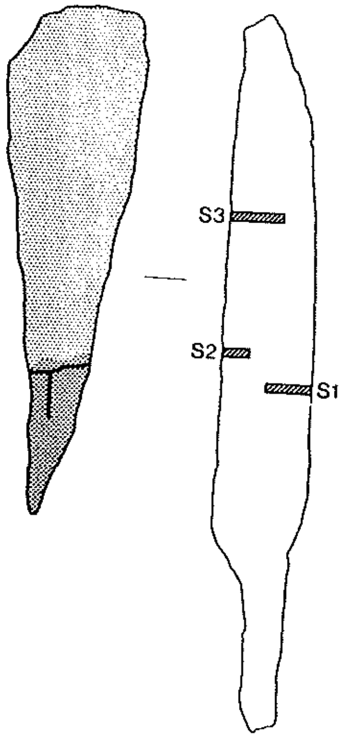


Figure 21 and Figure 22 Knife IR=159, AML=630958
Location of Section (x 0.5) and Section (x 10)

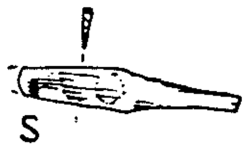


Figure 23 Knife IR=165, AML=630964
Location of Cross-Section (x 0.5)

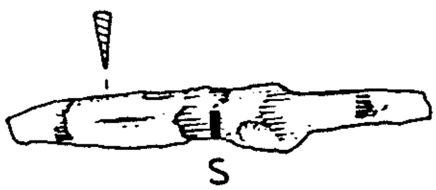


Figure 24 Knife IR=169, AML=630968
Location of Cross-Section (x 0.5)

been obtained by slack quenching. The cutting edge and the knife back was welded together badly, it was heavily slagged with little metal to metal contact. This resulted in its failure during sectioning. Overall therefore, the smith tried to manufacture the knife to the high standards observed in other Type 2 knives, both at Cannington and at other sites, but failed to do so, due in part to low quality steel and also inexpert technique.

TABLE 12 Micro-Hardness Results for Knife 630958

Knife Back	
	uHv
Pearlite Plus Ferrite (small grains)	183
Ferrite plus Pearlite	188
Pearlite	315
"	351
Cutting Edge	
Pearlite (below weld line)	362
Low Carbon Martensites	225
Martensite plus Retained Austenite	1072
Tempered Martensite	739

3.13 IR Number =165; AML Number = 630964;
Typological Grouping = ?C; Typological Date = ?7/8th C
Context Date = ?Late Roman

A single half-section was removed from the knife (Figure 23). In the unetched condition vertical slag banding was observed. Some of the welds/slag lines were heavily corroded. Etching showed that the knife was manufactured from phosphoric iron, and that there was no evidence of an applied cutting edge, it was therefore ascribed to manufacturing Type 0. The hardness results are given in Table 13 and confirm the presence of phosphorus (increased hardness).

TABLE 13 Micro-Hardness Results for Knife 630964

	uHV
Top of Section (large grained ferrite)	205
" " " (" " " +phosphorus ghost)	172
Cutting Edge (" " " " " ")	171

3.14 IR Number =169; AML Number = 630968;
Typological Grouping = ?C; Typological Date = ?7/8th C
Context Date = ?Post-Roman

A single half-section was removed from the knife (Figure 24). The section showed sever corrosion damage, including inter-granular corrosion. In the unetched condition fine slag lines were present, but no evidence for weld lines. Etching showed that the microstructure was wholly ferritic/phosphoric iron, and there was no evidence of an applied cutting edge. No remnant microstructures were identified in the adhering corrosion products. The hardness results (Table 14) are indicative of a low phosphorus content.

TABLE 14 Micro-Hardness Results for Knife 630968

	uHV
Top of Section (ferrite, small grained)	139
" " " (" large grained)	130
Cutting Edge (" small grained)	148

Other Artefacts

4 Other Tools

4.1 Possible Hammer IR Number =49; AML Number = 621563

A solid square sectioned iron piece, waisted at one end with a possible part of an eye socket at the other. A half-section was removed from the working face (the thinner end) and the longitudinal section examined. There was no evidence for structural welds in the unetched condition. There were areas of corrosion and some slag banding. In the etched condition the section displayed a varying microstructure of phosphoric iron, ferrite plus pearlite and pearlite. There was no evidence to suggest that this variation was deliberately produced to provide a working face. For example the highest carbon area occurred in the centre of the section. The ?hammer was manufactured from a heterogeneous piece of iron, and no attempt had been made too heat treat it. The effect of corrosion had removed the surface of the working edge, so that there was no evidence for how the hammer had been used, eg hot or cold working, as evidenced by grain size. The hardness results (Table 15) show a typical range of hardnesses for the microstructures described.

TABLE 15 Hardness Results For Hammer 621563

	uHv
Phosphoric Iron	171
Pearlite in Ferrite + Pearlite	260
Pearlite	193

4.2 Possible Tool IR Number =127; AML Number = 630926

A square sectioned rod or tool. A complete cross-section was cut from the possible working end. In the unetched condition two weld lines ran down the section, showing that the rod or tool had been manufactured from three strips of iron. In the outer strip there were relatively large inclusions, in the centre strip and in the other outer one there were smaller inclusions finely distributed. In the etched condition the first strip was predominantly ferritic (uHV=92.1), the centre was ferrite plus pearlite (uHV=151.4). The overall carbon content was low, probably <0.2% C. There was some phosphorus ghosting in both halves, especially close to the weld line. No attempt had been made to quench the artefact. The hardness values of the ferritic iron half indicate very pure iron, with no effect of mechanical working present.

4.3 Strip or possible Rod Shaped Blank
IR Number =164; AML Number = 630963;

A twisted strip of iron, which was analysed to determine whether or not it could possibly be a Rod Shaped Blank, ie a prepared strip of iron to be manufactured into a knife etc. The strip was heavily corroded, and the section broke into four fragments along corroded/failed weld lines. Two fragments were totally corroded with no remnant structures present. The other two were corroded but contained some metal which was ferritic of varying grain size. The mean hardness value of the small grained ferrite was uHV=93.2, and of the larger grained material, uHV=84.9. These very low values are indicative of very pure iron, the increased hardness in the smaller grained size iron was probably due to the effect mechanical working. Since there was no evidence that the strip was steel it could either have been used for part of a tool or as structural iron, eg spike or strapping.

5 Conclusion

5.1 Other Artefacts

The other artefacts had no separate steel components, and therefore the metallurgy cannot be used to confirm or refute the interpretation that they are tools.

5.2 Knives

The results show (Table 16) that only Types B and C were available for analysis, and therefore no correlation between Manufacturing Typology and Archaeological Typology can be investigated. The metallurgical results (Tables 17 and 18) demonstrate that the Type 2 knives were manufactured to a much higher quality than the other types. This is in accordance with data obtained from other sites, notably Hamwih, Southampton and 16-22 Coppergate, York (McDonnell 1989). These were the only knives that had been heat treated. They were all of Archaeological Type C, as were the 4 Type 0 knives, which could be interpreted as Type 2's that have lost their cutting edges through wear or corrosion.

The archaeological dating evidence is poor for all of the knives, but the knives can be coarsely dated stylistically . The results (Table 19) show that the earlier knives were either of Type 1 or 3 manufacture, whereas the later (7/8thC) knives are either Type 2 or 0, (which could be interpreted as worn Type 2's), with one example of Type 1 and 3 present. This distribution gives a higher mean hardness value to the later group of knives.

The quality of the Type 1 and 3 knives is poor, more typical of Roman knives, than 6-9th Centuries examples (McDonnell 1989). It could be postulated that the Type B knives are more likely to be Roman in date and the Type C knives Post-Roman.

Table 16 Classification of the Knives

Typology	Total Number	Number Analysed	% Analysed
A	-	-	-
B	10	5	50%
C	17	9	53%
D	1	0	0%
Unascribed	8	0	0%

Table 17 Summary of Knife Analyses

IR	AML Num	DATES Typology	Archaeology	Typol	Met Typ	uHV Back	uHV Edge
5	621520	7/8thC	Undated	?C	1	238	233
6	621521	Late 5-7thC	"	?B	1	174	182
9	621524	7/8thC	Post-Roman	C	2	178	927
12	621527	Late 5-7thC	Undated	B	1	220	224
16	621531	Late 5-7thC	Post-Roman?	B	3	270	204
18	621533	Late 5-7thC	" "	B	3	274	257
107	630906	7/8thC	" "	C	0	130	130
117	630916	7/8thC	" "	C	2	187	672
123	630922	7/8thC	Undated	?C	0	150	130
129	630928	7/8thC	"	?C	3	199	194
136	630935	5-7thC	"	B	1	200	400
159	630958	7/8thC	Post-Roman	C	2	260	1000
165	630964	?7/8thC	Late-Roman	?C	0	180	171
169	630968	?7/8thC	?Post-Roman	?C	0	139	148

Table 18 Relationship between Archaeological Typology and Manufacturing Typology

Typology	Manufacturing Typology 0	1	2	3	4
B	-	2	-	2	-
?B		1			
Mean Edge Hardness		269		230	
C	1	-	3	-	-
?C	3	1	-	1	
Mean Edge Hardness	145	233	866	194	
Overall Mean Edge Hardness	145	260	866	218	

Table 19 Relationship Between Metallurgical Typology and Typological Date

DATE	TYPOLOGY 0	1	2	3	4
5-7thC		1			
Late 5-7thC		2		2	
7/8thC	2	1	3	1	
?7/8thC	2				

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