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METALLURGY RESEARCH (ARCHAEOMETALLURGY)

DEPARTMENT OF PRODUCTION

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COPPERGATE YORK METALLURGY REPORT NUMBER 9

KNIFE 1982.22 15 (Described as Knife 15)

Knife 15 was recovered during the Watching Brief and is probably of Anglo-Scandinavian date. It is characterised by a 'rib' (R) running from the tang to the knife-back near the tip, The cutting edge was slightly bent in several places along its length. X-Radiography showed micro-cracks present in the cutting edge (Fig I), but no other details except for thickening of the knife along the rib. There was very little corrosion present. A single section was removed which included the 'rib', (Fig I).

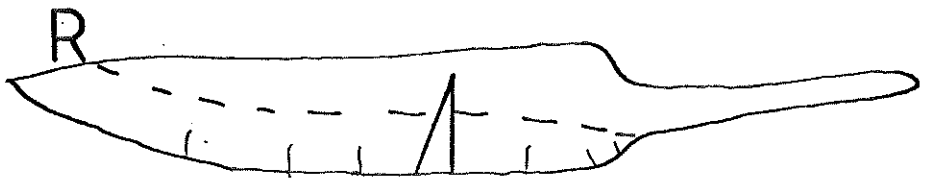
In the un-etched condition lines of small slag inclusions suggested some banding or piling. When etched the structure showed the knife to be made of three components, (Fig 2). Two strips had been welded together in the vertical direction, (ie half a sandwich), both were primarily ferritic although there was an increase in the carbon content in one of the strips towards the weld line giving rise to a structure of ferrite plus fine (nodular) pearlite. The third component, the cutting edge was then inserted along the weld line, this had a very fine grained structure of ferrite with grain boundary carbides This structure was also banded. The weld line between the cutting edge and the ferrite plus pearlite component of the back was a characteristic white weld line. The cutting tip had

been folded/bent giving a flattened cutting edge. The corrosion products at the tip contained unaltered grain boundary carbides. The hardness results (Table I) confirm the heavily worked structure of the knife.

TABLE I Knife 15 Hardness Results

	VICKERS HARDNESS	MICRO-HARDNESS
KNIFE BACK		
COMPONENT 1		
Ferrite		170
Ferrite + Pearlite		213
COMPONENT 2		
Ferrite	151	155
CUTTING EDGE		
COMPONENT 3		
Ferrite + Pearlite		160
Ferrite + Grain Boundary Carbides	120	195

Knife 15 was probably unfinished, the insertion of the cutting edge gave rise to the thickenning of the central rib, and the cutting edge had been heavily hot worked and rapidly quenched. The knife had been used in this condition giving rise to the bent cutting edge. Knife 15 is a form of Type 1.



KNIFE 15 (X1)

Fig 1

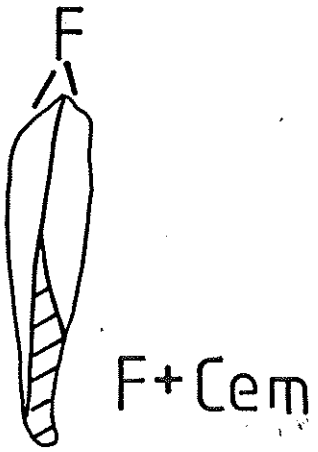


Fig 2

KNIFE 4070

Knife 4070 was ascribed to backform C, Plate II. It had suffered considerable corrosion, (Fig 3) as shown by x-radiography. A single half- section was cut at the rear of the blade. The unetched specimen showed very few slag inclusions and no evidence of banding. When etched (Fig 4) the overall structure was piled comprising of a broad band of coarse pearlite plus some ferrite. This became finer and degraded to ferrite at one side. The other side of the coarse band the overall structure was medium to fine grained ferrite with approximately nine thin bands of coarse pearlite running vertically through the structure. The bands merged together at the knife tip. The hardness values are given in Table II.

TABLE II Knife 4070 Vickers Hardness (V.P.N.) and Micro-Hardness (uH)

	V.P.N.	uH
Coarse Pearlite Band		193
Fine Ferrite	85	111
Pearlite (Tip)	139	201

The overall structure is a sandwich type manufacture, although the weld lines are indistinct. It is also possible that it was a 'half-sandwich' with the blade strip welded to a single back strip rather than being held between two strips.

The knife is of reasonable overall quality but it has been over tempered.

KNIFE 4070 (X1)

Fig 3

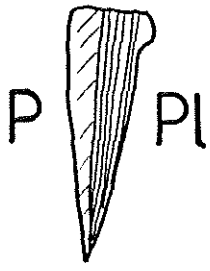


Fig 4

KNIFE 6770

Knife 6770 was ascribed to Backform A. It had a very sharp angle back, a decorative (?) incision, and a very concave cutting edge towards the tang. X-radiography identified corrosion of the cutting edge,(Fig 5) and also showed that the incised lines were not superimposed. A single half-section was cut from the knife. The unetched specimen showed vertically orientated single phase slag inclusions, but no evidence of banding. The etched specimen (Fig 6) showed the knife to be made of a single piece of steel.The microstructure was pearlitic with some nodular pearlite present. There was a slight carbon gradient from one side of the knife to the other, the amount of ferrite increasing slightly. The actual cutting edge was totally corroded and no remnant structure was present. The hardness values are shown in Table III. The knife is of good overall quality, perhaps slightly overtempered.

TABLE III KNIFE 6770 HARDNESS VALUES

		VPN 5	UHv
Knife Back	Pearlite		351
	Ferrite + Pearlite	174	195
TIP	Pearlite	216	262

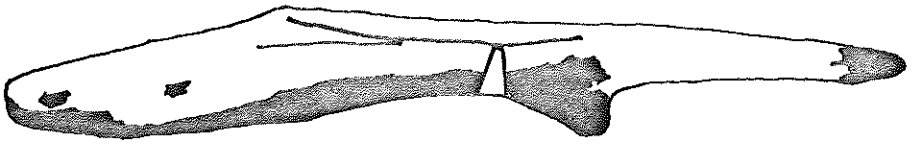


Fig 5 KNIFE 6770 (X1)

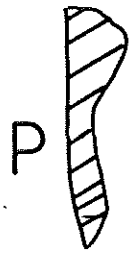


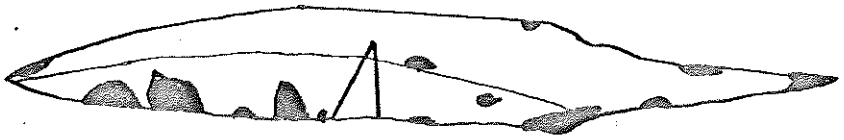
Fig 6

KNIFE 9055

Knife 9055 was ascribed to Backform E2. It had heavy surface corrosion which x-radiographs showed to have completely penetrated the knife in parts,(Fig 7). The corrosion had a sinusoidal pattern along the cutting edge towards the point. There was a probable weld line running in a curve from the tip towards the tang/blade interface. The section was cut to include the cutting edge and the possible weld line. In the unetched condition two irons coud be distinguished, a clean iron with few slag stringers forming the cutting edge and a dirtier iron with apparent banding delineated by vertical slag stringers. This structure was confirmed on etching,(Fig 8). The cutting edge was a high carbon steel with a martensitic microstructure at the tip degrading to bainite at the weld line, pro-eutcetoid cementite and vertically orientated white/yellow weld lines. The weld between the cutting edge and the knife back was also a white/yellow line, uncharacteristically corrosion had penetrated some distance down the weld. Some carbon had diffused across the weld line into the knife back which was predominantly ferritic with a little grain boundary carbide present. The hardness results are shown in Table IV. The overall knife structure is Type Two, (butt welded cutting edge), and the quality is good.

TABLE IV KNIFE 9055 HARDNESS RESULTS

	VPN 5	uHV
Knife Back Ferrite	166	243
Cutting Edge Bainite		493
Martensite	603	681



KNIFE 9055 (X1)

Fig 7

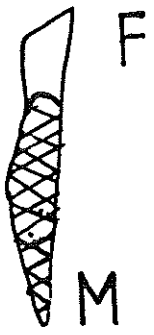


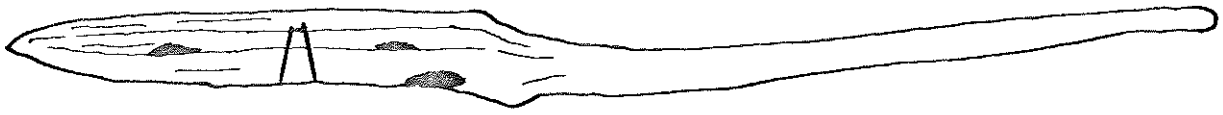
Fig 8

KNIFE 9845

Knife 9845 was ascribed to backform E1, but was of particular interest because of its long tang, (approximately 1.5 times the blade length). X-radiography showed the presence of horizontal banding in the blade, and a very solid clean tang, (Fig 9). The horizontal banding was not apparent in the section, but two vertical slag lines were present indicating a sandwich type structure (Type 1). When etched (Fig 10) this structure was confirmed but the central cutting edge did not run the full height of the blade. The knife back was principally ferritic with fine nodular carbide and some grain boundary pearlite present. The cutting edge was a tempered martensitic structure, becoming less tempered towards the cutting edge. The hardness results are shown in Table V. The overall structure is a variation of Type Two, and the quality is very good.

TABLE V KNIFE 9845 HARDNESS RESULTS

		VPN 5	uHV
Knife Back	Ferrite	207	227
Cutting Edge	Bainite		464
	Martensite	780	813



KNIFE 9845 (X1)

Fig 9

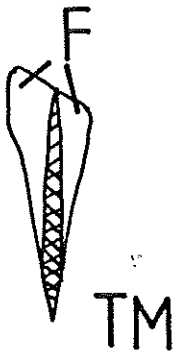


Fig 10

KNIFE 9892

Knife 9892 was ascribed to backform D, only one of three of this type recovered from the site. X-radiographs showed limited corrosion, and horizontal weld lines in the blade,(Fig 11). The unetched specimen showed no evidence of banding delineated by slag lines. The slag inclusions were coarse single phase inclusions of which some were vertically orientated and resulted from welding. In the etched condition,(Fig 12), the cutting edge was not a seperate piece of steel but the result of carburisation of the knife. Only a fragment of the original cutting tip was present, the remainder having coroded or worn away. It had a bainitic structure, the structures degraded to pearlite away from the tip, and the amount of ferrite increased untill the knifeback was purely ferritic. The carbon gradient was gradual and no transverse weld lines were present, hence carburisation must have been used. The hardness results which reflect the decreasing carbon content are shown in Table VI.

The form of the knife and its manufacture, (Type 2, carburised) distinguish it from other knives from the site.

TABLE VI KNIFE 9892 HARDNESS RESULTS

		VPN 5	uHV
Knife Back	Ferrite	66	133
Cutting Edge	Pearlite		215
	Bainite	321	478

KNIFE 9892 (X1)

Fig 11

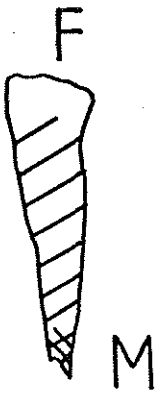


Fig 12

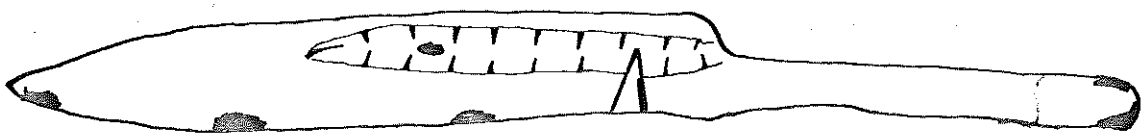
KNIFE 10168

Knife 10168 was ascribed to backform E3, and had concave 'scoops' running part of the length of the rear of both sides of the blade. No structures were visible on the radiographs, but there was some corrosion present,(Fig 13). The section removed extended from the cutting tip to the 'scoop'. The overall structure of a sandwiched cutting edge (Type 1) was apparent, since the welds between the three strips had failed except for the lower part of the section at the actual cutting edge. The weld seams had been further split by the penetration of corrosion. When etched,(Fig 14) the two outer sleeves were ferritic and the cutting edge was tempered martensite. The hardness values are shown in Table VII. The region of the scoop had a smaller ferritc grain size.

TABLE Vii KNIFE 10168 HARDNESS RESULTS

		VPN 5	uHV
Knife Back (sheath)	Ferrite	144	153
Cutting Edge (upper)	Bainite		473
(tip)	Martensite	501	530

The quality of the steel and iron used and the application of decoration (the scoop) would indicate a quality artefact but the welding of the three components was very poor.



KNIFE 10168 (X1) Fig 13

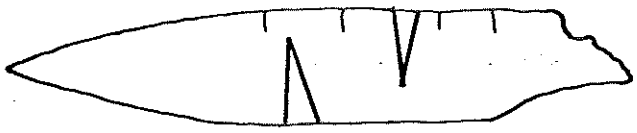
Fig 14

KNIFE 10272

Knife 10272 was ascribed to backform E1 and had oblique ridges on both sides of the blade. No structure was observed in the x-radiographs, the ridges were indicated by thickening of the knife,(Fig 15). At high intensity small cracks were identified running vertically down from the knifeback. A complete cross-section aws obtained from two half sections. Parallel 'banding' slag lines were observed in the unetched condition, there was a single central weld line that split into two one third of the way down the section. When etched,(Fig 16) the overall structure was the same as Knife 15, the cutting edge did not extend the full height of the blade but was held as a tongue between the two sheaths. The sheaths were ferritic with some vertically orientated slag inclusions. The cutting edge was a bainitic structure of varying (low) carbon composition. The knife was differentially worn (sharpened), the cutting edge being fully exposed on one side at the tip. The hardness results are shown in Table VIII , and reflect the low carbon content of the cutting edge.

TABLE VIII KNIFE 10272 HARDNESS VALUES

			VPN 1	uHV
Knife Back	Ferrite (mean values)		275	220
Cutting Edge	(upper)	Bainite	313	233
	(tip)	" plus pearlite	378	548



KNIFE 10272 (X1)

Fig 15

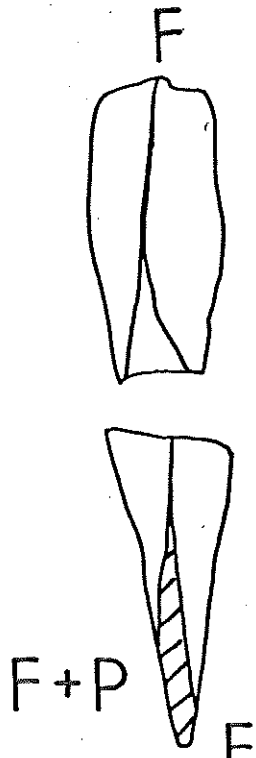


Fig 16

KNIFE 10277

Knife 10277 was ascribed to Backform E1, the tip was gently bent through about 90 degrees to the horizontal and covered by a blob of non-ferrous metal (tin?). X-radiography showed no structure and very little corrosion, (Fig 17). In the unetched condition the section displayed a banded distribution of fine single phase slag inclusions. The etched sample, (Fig 18) showed indistinct banding of the microstructure which was predominantly pearlitic. The banding arose from variation in ferrite content. As the blade narrowed to the tip the banding became compressed and less distinct. The knife can therefore be regarded as an all-steel knife (Type 4). The hardness results are shown in Table IX.

TABLE IX KNIFE 10277 HARDNESS RESULTS

		VPN 1	uHV
Bands	Ferrite (small grains) }	164	169
	" (large grains)		183
	" plus pearlite		311
Tip	Pearlite	289	394

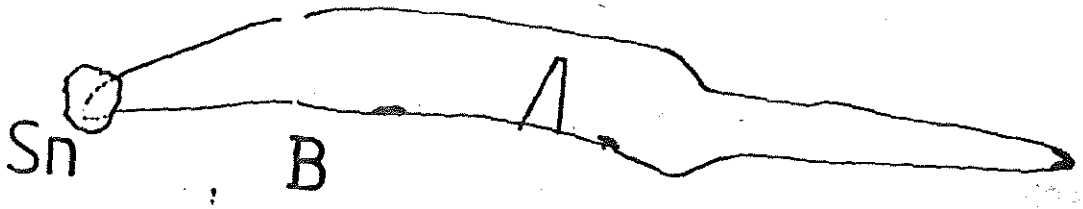


Fig 17 KNIFE 10277 (X1)

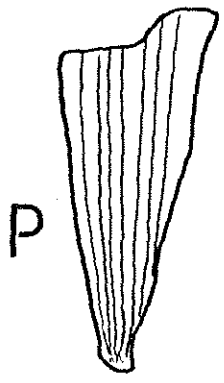


Fig 18

KNIFE 13404

Knife 13404 was ascribed to Backform E3, it had suffered some corrosion as shown by x-radiographs, but no overall structure was discerned,(Fig 19). A single half-section was removed and in the unetched condition it showed a very clean iron, and no apparent banding. When etched,(Fig 20) it had a pearlite plus ferrite microstucture, there were two faint white/yellow weld lines on each side, although the pearlitic structure traversed the welds there was an increased amount of ferrite present. On one side the structure became ferritic only. The carbon content was low and the pearlite very fine, and became finer at the tip. The hardness values are shown in Table X. Knife 13404 is a sandwich (Type 2) knife, but with a large core, and very well made.

TABLE X KNIFE 13404 HARDNESS RESULTS

		VPN 1	uHV
Knife Back (sheaths)	Ferrite	165	128
	" plus Pearlite	229	189
Cutting Edge (upper)	Ferrite plus Pearlite		297
(tip)	" "	482	366

KNIFE 13404 (X1)

Fig 19

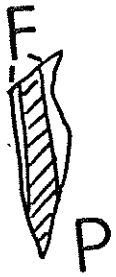


Fig 20