Metallurgical Examination of Objects from Catsgore, Somerset.

Ferrous Material:

Knives.

Cat. 466 (12).

This knife has a variable carbon content of about 0.6% at the back decreasing to 0.3% at the centre and tip. There is a well-defined slag stringer starting at the tip and finishing about half way up the blade suggestive of welding. All the pearlite-ferrite structure is widmanstätten. The hardness at the centre is 158 HV and at the tip, 235 HV.

Clearly, the carbon distribution is unintentional but in some way the maker has managed to get a higher hardness at the tip than at the centre - possibly by cold work or a higher phosphorus content in the iron. Not a very efficient tool.

F 510 (16) Cat.1063.

A small piece from the blade of a knife. This has a completely and densely rusted cutting edge with a hardness of 575 HV1 (in rust). The rest consists of two steels joined down the centre. One side is 0.7-0.8% pearlitic carbon steel (250 HV1), and the other 0.2-0.3% C which consists of spheroidised carbides in ferrite (162 HV1).

F 407, Cat.795.

Mostly rust with a hardness of 630 HV but with a trace of unidentifiable metal.

F 300. Cat.402.

Fragment of a blade with a weld down the centre. On one side the structure is ferrite with a hardness of 153 HV1; the other side contains about 0.2% C in the form of fine pearlite giving a hardness of 200 HV. The edge on both sides is almost wholly ferrite and would not give a good cutting edge. The iron has a moderate phosphorus content.

F 408. Cat. 635.

A blade consisting wholly of ferrite and slag. The section cuts the slag stringers end-on but they are round showing that the blade has only been worked along its length and has not been worked towards the cutting edge. The hardness of 107 HV1 indicates a very low phosphorus level.

F 489. Cat. 878.

A piece from another blade. The iron was difficult to etch and is therefore probably phosphoric. The hardness is 159 HV1. There seem to be some signs of carbide in the grain boundaries.

F 155 (10). Cat. 1092.

A small piece from a large blade that was difficult to etch and therefore consists of high phosphorus ferrite. The hardness is 214 HV1.

F 153 (6) Cat. 349.

A piece from a blade consisting entirely of coarse-grained ferrite with a hardness of 225 HV1 which suggests a high phosphorus content.

F 375. Cat. 593.

Iron knife with lead-wrapped handle. A very thin blade consisting entirely of tempered martensite and slag with a hardness of 520 HV1.

Axe-heads?

F 176 (4) Cat. --.

Consists of piled strips of various carbon contents. The central area has a carbon content of 0.4% and a hardness of 190 HV1. The pearlite in the centre is spheroidised indicating a slow cooling rate through the 700-500°C range. The phosphorus content of the iron is low.

F ---(14). Cat. D.

This has a very even and high carbon content. It consists predominantly of fine pearlite with a little ferrite in the grain boundaries. The hardness is 320 HV1.

Other Objects.

F 505. Cat. 1062.

A punch or drift. A piece was removed from the tip of the tool. It proved hard to cut but on examination was found to be predominantly fine-grained ferrite with a hardness of 126 HV1; however, extensive areas of the surface were carburized up to 0.7% C. These areas consisted of fine lamellar pearlite with a hardness up to 250 HV1 although the actual tip of the tool was only 126 HV. It must be remembered that a considerable amount of the tool had been lost by rusting and what was examined may only represent the border-line between a heavily carburized surface and the ferritic core. It was clear that there had been no attempt to form the tip of the punch by welding on steel.

F --- (14). Cat.---.

A ring hinge. Very high phosphorus ferrite with a hardness of 284 HV1. This must contain over 1% P to produce such hard ferrite. The strength is more than adequate for the purpose.

Non-ferrous Material.

F 407. Cat. 801.

A piece removed from the bowl of a (?) tinned spoon. A heavily hot-worked structure with elongated slag inclusions. It consists of a fine-grained recrystallised structure and could have been finished by cold working followed by annealing. There were signs of strain markings indicating final cold working, and the hardness of 230 HV1 does suggest a high tin bronze with considerable cold work.. There was no sign of residual delta nor lead. Although this was a section, there was also no sign of a tin-rich layer. Perhaps it will be necessary to make a carefully mounted taper section from a good example to solve this problem.

F 152. Cat. 117.

A section trough the round handle of an untinned spoon. This consisted of a cast dendritic structure which had been cold worked throughout. There were some signs of destannification but no delta and no lead. The hardness was 127 HV1 which in view of the extent of the coldwork suggests that the tin content was probably not much greater than 8%.

F 919. Cat. 181.

A section through a piece of tubing. This is more corroded than the above but shows on one side metallic remains consisting of large twinned grains of solid solution. There is no evidence of cold work which in this case is borne out by the hardness of 135 HV 100g. This seems to be a fully annealed recrystallised alpha bronze with 10-13% tin or tin equivalent.

Conclusions.

The extent of the rusting makes the interpretation of the results of this investigation more difficult than usual. In all cases a considerable amount of the artifact was lost by the exfoliation of a thick corrosion scale when cutting for sampling. In the case of a knife with a welded edge or a punch with a carburized tip this might amount to the loss of all the carbon-containing part. But for high quality tools one would expect some heat-treatment, and the effects of this could be expected to extend beyond the carburized zone. Therefore one looks for evidence of heat-treatment and this is what is so lacking in this assemblage.

Examination of the summary given in the table shows that there is only one piece that has been heat-treated to give a hardness of 520 HV. All the others are ferrites or ferrite+pearlite steels with hardnesses in the range 107-320. None of these would make good cutting tools but an axe-head with a hardness of 320 ~~would~~ might be useful.

Again, we find that some of the hardest tools consist of high phosphorus ferrite - a common ferrous metal in Britain in all stages of the Iron Age.

If we take the standard here as being one good tool in eleven, and we compare this with Brancaster for example, we find the situation very much the same or worse (not one out of seven tools had been heat-treated). But if we look at Poundbury where we have knives covering Roman and post-Roman periods we notice that there is a big improvement in the post-Roman and unstratified groups. So this assemblage would appear to confirm the general poor level of ferrous metallurgy in the Roman period as compared with succeeding periods. What we do not yet know is whether the technical level of industrial settlements of this type is typical of the general level of metallurgy in the

Roman period.

The total of iron slag recovered from the site is only 21.91 kg which does not suggest a very high level of activity.

The spoons and the copper-base tube look very well made. It is unfortunate that the question of tinning has not been settled yet. I do not recall any other Roman bronze spoons that have been examined. Clearly these were cast in some sort of mould, probably of clay, all in one piece with the handle. The bowl has undergone considerable work - much of it hot - and has then been finished by cold working. The bowl seems to show longitudinal planishing marks. The handle has also been finished by cold working. It would be a good idea to cut some sections from the rest of the spoon to see if these conclusions are general.

One feels that the standard of non-ferrous metallurgy is a good deal better than that of the ferrous.

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R.F. Tylecote.

Table.

Summary of characteristics.

Object and No.	Max. C%	Max. HV	Comments.
Knives.			
Cat. 466	0.6 (at back)	235 (at tip)	No Heat-treatment.
Cat. 1063	0.8	250	" "
Cat. 402	0.2	200	" "
Cat. 635	nil	107	All ferrite + slag.
Cat. 875	nil	159	Mostly ferrite
Cat. 1092	nil	214	High phosphorus ferrite
Cat. 349	nil	225	" " "
Cat. 593	high	520	Tempered martensite
Axe-heads.			
F 176 (4)	0.4	190	Ferrite + pearlite
F -- (14)	0.7	320	" "
Punch.			
Cat. 1062	0.7	250	Pearlite.