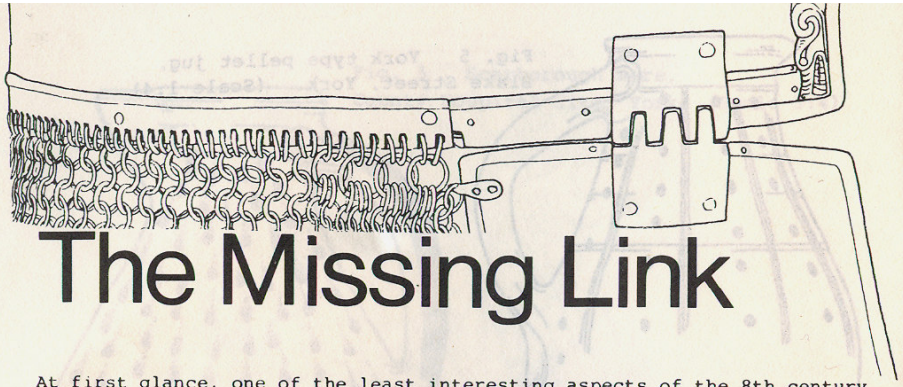

The Missing Link

At first glance, one of the least interesting aspects of the 8th century Coppergate Anglian helmet (INTERIM vol 8 no 4) would appear to be the remains of the iron mail neck-guard. Much has already been written about the construction of the helmet, the fine decoration of the nasal, and parallels for the inscription, but the lump of rusty mail was politely passed over. However, weeks of painstaking work has revealed this most unpromising item to be technologically the helmet's most interesting and enigmatic feature. Coming from a waterlogged site, the mail is exceptionally well preserved compared with the handful of other examples from this period, such as those from Vendel and Valsgärde in Sweden, Morken and Cologne in Germany or the mail shirt from the Sutton Hoo ship burial in Suffolk. The first hint which we had of the existence of the mail was a view of what looked like knitted iron as we peered into the helmet through the area damaged by the mechanical digger (fig. 1), but it was not until the computer tomograms were studied that we began to understand what it was (INTERIM vol 8 no 4 pp31-4). Julie Jones' careful excavation of the helmet's interior finally revealed the crumpled mass of iron mail cemented together with iron corrosion and soil, still attached to the helmet by a couple of large iron links at the right hand side (fig. 2). At first it was thought that these links were undamaged, but close examination showed that although complete they were open. This was very fortunate as it allowed us, after recording and marking the appropriate links, gently to slip the bulk of the mail out of these links and to remove it for treatment separately (fig. 3).

As with the helmet itself, it was decided not to use any chemicals in the cleaning of the mail, but to use purely mechanical techniques. This decision was taken for several reasons:

1. Chemicals which will soften or remove the obscuring corrosion would unfortunately, also attack the corrosion which composed much of what remained of the mail.

2. We did not know if metals other than iron would be found within the mail, which might be damaged by chemical cleaning of the iron.

3. The use of chemicals might have biased the results of the chemical analysis which we were proposing to carry out.

With the aid of a binocular microscope, and using a scalpel and mounted needle, the debris was cleared from around each link before it was gently eased away from its neighbour. Extraneous corrosion was then chipped away to reveal the detail of the link, the original surface of the corroded link being marked by a change of colour and texture from that of the obscuring corrosion products. As each major fold was freed the mail was photographed, and bit by bit the shape and size of the neck-

Fig. 1 View of mail through the damaged area of the helmet.

guard emerged. Eventually just a few areas, particularly those which had lain against the helmet, remained 'frozen' by thick, hard, shiny lumps of black corrosion. Tackling these areas required a change of tools. In the areas where the links had a good core of iron, an electrically powered vibrating needle (the 'vibrotool') was used to shatter the brittle corrosion and to cleave it away from the original surfaces of the links. However, in the less well preserved areas the vibration would have shattered the links, and here the corrosion had to be gently worn away by a stream of abrasive particles in a jet of compressed air generated by a piece of equipment called an airbrasive. Both of these processes were also carried out under a binocular microscope as care had to be taken not to mark or damage the links in any way. At last, after some 150 hours, every link was free to articulate with its neighbours and it was possible to begin the study of the mail (fig. 4).

It seems that when the helmet was deposited it had been partially dismantled. The left-hand cheek-piece had been removed and placed inside the crown of the helmet along with the partially detached mail neck-guard. What remains of the mail, between 1950 and 2000 links, are arranged in 28 rows, the longest row containing 81 links. Each link has an external diameter of approximately 8mm, is made from a wire approximately 1mm thick and is threaded through two links in the row above and two in the row below. Laid out flat the mail has a maximum length of 47cm and a maximum depth of 10.5cm. A chart has been made of the mail

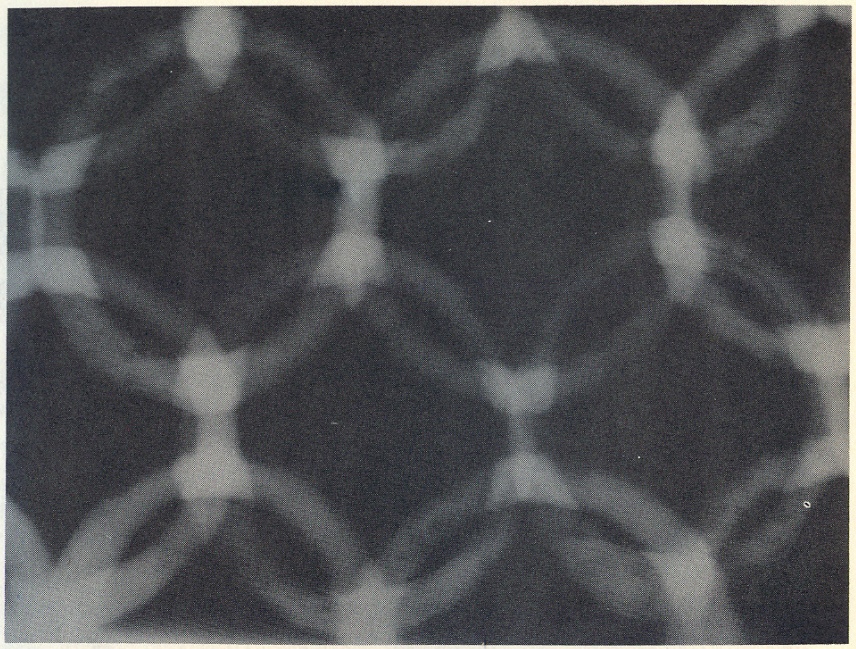

Fig. 5 High definition x-radiograph.

within the body of the mail and also a couple of what look like repairs, where one slightly deformed, lapped and rivetted link has been used to take the place of two links.

To learn more about the mail several investigative techniques were employed. Conventional x-radiography, kindly done by Non-Destructive Testers Ltd of Sheffield, indicated the best preserved areas of the mail, clearly showing the features of the lapped and rivetted links and something of the internal structure of the wire. What was not clear, however, was the method by which the other type of link was closed. The conventional x-radiographs gave an image the same size as the object being examined, but we needed something which would give a bigger image with more detail within the links themselves. To achieve this we employed a new radiographic technique, never before used on archaeological material, which produces high definition images at up to x20 magnification. Agfa Gevaert Ltd, NDT Systems, arranged for us to use the very latest high definition, micro focus, industrial x-ray equipment at Errington Laboratories Ltd, Duffield, Derby. The resultant x-radiographs showed internal details far beyond anything we had ever seen before (fig. 5). Two features in particular stand out. Firstly, some of the links have dark lines running through the wire, a feature consistent with slag inclusions left in the wire from the forging process. Secondly, although the detail of the lapped and rivetted links is very clear the only possible indication of a join on the other links is a faint diagonal line which is visible on a few of them. If these links had just been bent round and butted together, the gap between the ends would have been obvious on the radiograph. If solder had been used

to close them this also would have shown up as a whiter area on the links. However, as neither was the case the only alternative would appear to be that the links were welded closed using heat and pressure. For a good weld to be made very 'clean', high quality iron, with no slag inclusions, would need to be used and it was remarkable that only the lapped and rivetted links showed the dark fault lines on the radiographs. It would be reasonable to suggest, then, that the mail was constructed of rows of closed, welded, links, linked together by alternate rows of lapped links which were rivetted closed in situ. It is hoped that proposed metalographic analysis of one of each type of link will confirm these observations.

In determining how the mail neck guard was attached to and distributed around the back of the helmet there are many more problems. Rivetted around the base of the helmet there is the remains of half the U-shaped copper-alloy suspension strip (fig. 6). This strip has slits cut across it at regular intervals into which are slotted a row of copper-alloy rings similar in size and shape to the welded iron links of the mail. These rings have been soldered closed and are held in place by an iron wire which lies inside the suspension strip and passes through each ring. Linked through the first few surviving rings are five of the links from the first row of the mail. The first three of these links are very large (around 10 to 12mm) lapped and rivetted iron links, and are hung from pairs of suspension rings. The other two links are similar in size to those in the bulk of the mail and are hung only from single suspension rings, although it is possible that they may have hung from two originally. The first one is iron and, although now broken, had also been lapped and rivetted. The only other link in this row is still attached to the opposite end of the mail. It is iron, slightly smaller and thicker than any of the other links but being broken it is difficult at present to see how it was closed. When found the mail was only attached to the helmet via the first two large iron links. The first one held three links from the next row of the mail (a row of welded links) and the second only one but as it was sprung open it may originally have held more.

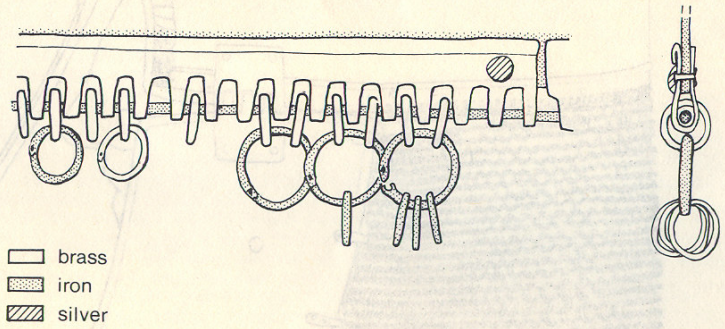

Fig. 6 Diagram of neck-guard suspension.

It is possible that the mail was joined to the smaller links in the first row on a one to one basis but was gathered into the larger links near the cheek piece. Because of the size difference between these links the following rows would have been distorted, ie higher around the back of the helmet. To compensate for this it would have been necessary to insert a partial row of links between the small links of the first row and the rest of the mail. There are the remains of four copper-alloy loops down the side of the cheek-pieces, which presumably held the edge of the mail neck-guard to the cheek-piece. To allow movement of the cheek-pieces, particularly when the helmet was being put on or taken off, the fullness created by this gathering of the mail would have been necessary. As the cheek-pieces curve forward at the bottom it seems reasonable to expect the rows of mail to get longer towards the bottom of the neck-guard so that they will reach the loops on the cheek-pieces. This

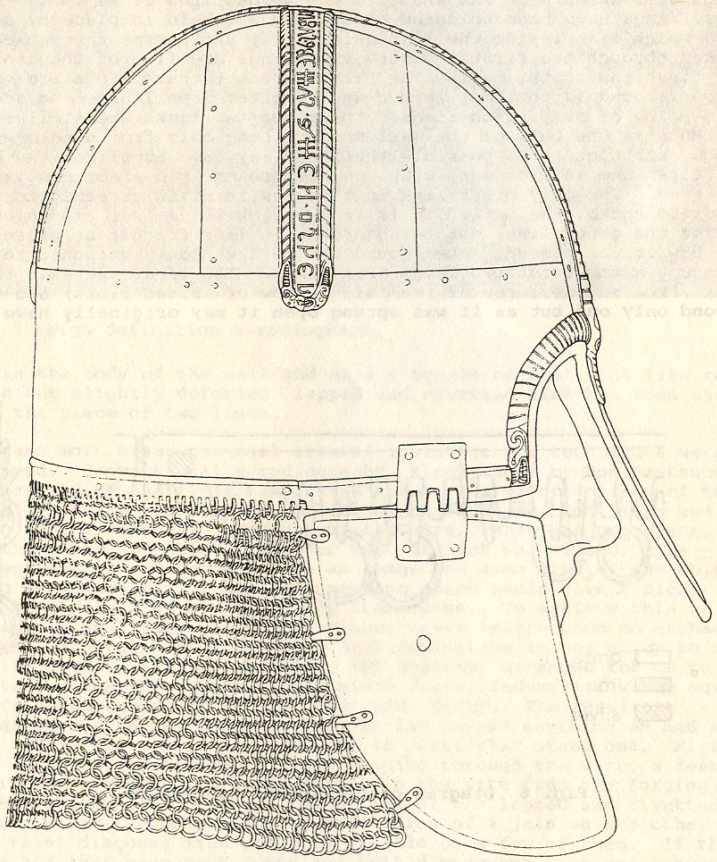

Fig. 7 Possible reconstruction of mail neck-guard.

shaping is certainly absent from the right-hand edge of the neck-guard although the left-hand appears to show it. Furthermore, if the first row of iron links are linked one to one with the rest of the mail but hang from pairs of suspension rings, assuming that the missing half of the suspension strip was virtually the same as the half that remains, the left-hand end of the mail would have fitted neatly up against the edge of the left-hand cheek-piece. There are, however, problems with this hypothesis and other reconstructions may be proposed in the future which better fit the evidence.

There is one more feature of the neck-guard for which there is no ready explanation. The lower two rows of the mail are represented by only three links; two in the 27th row and one in the 28th. They are all of a similar size to the links in the bulk of the mail but are copper-alloy, lapped and rivetted links. They are not, apparently, in the centre of the neck-guard. There is nothing to suggest that they are the sole survivors of two complete rows but as the iron helmet is trimmed in copper-alloy might not the neck-guard be also? (fig. 7).

It must be concluded that the mail is not complete, that we do not necessarily have the full length or depth of the neck-guard represented. The one area of attachment and the scanty evidence we have for the character of the rest of the links in that first row is not sufficient for us to use as a base for an accurate reconstruction. However, as a result of careful cleaning and examination during conservation we now have far more information about the form and manufacture of mail of this period.

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