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Ancient Monuments Laboratory
Report 21/94

THE INVESTIGATION OF A GROUP OF ENAMELS FROM BIRDOSWALD

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Summary

Six copper alloy artefacts with enamelled decoration were discovered in excavations, carried out by the Central Archaeology Service (CAS), at the Roman fort of Birdoswald on Hadrian's Wall. Investigative conservation of these artefacts was carried out at the Ancient Monuments Laboratory by Holly Ferguson, Barbara Niemeyer and Siobhan Watts. The aim of this project was to discuss the group of enamels as a whole, taking into account the typology of the decoration in comparison with parallels from other Roman sites. In addition, the condition of the enamel and the metal in each artefact was noted, to compare the degree of preservation, and investigate possible deterioration mechanisms.

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1. Disc brooch with enamelled sunburst decoration.
(AML No. 8905735)

DESCRIPTION. This was the most complete artefact in the group of enamels, so the original 2/1 drawing is included to illustrate the detail (Figure 1). The 'sunburst pattern' on this brooch is thought to have been popular as a result of its association with the Mithraic cult of the 'sol invictus', or unconquerable sun (Hattatt 1982). A series of loops radiated from a centre boss which represents the sun. Mithraism is thought to have originated from Persia, and developed a large following among the army on the Danube, the Rhine and in Britain.

On this brooch, the inner circle of loops are inlayed with yellow enamel, and yellow and blue enamel alternates in the outer loops. In two of the enamel fields, yellow enamel has 'spilled over' from adjacent loops, showing a slight degree of carelessness in their manufacture - this is quite common in these brooches (Bayley 1987). Each set of loops is surrounded by a continous enamel field; the enamel in the large fields now appears a muddy green colour, but is likely to have been a red enamel which has decayed (J.Bayley pers.comm.).

CONDITION. Half of the brooch was initially covered with hard, concreted soil and corrosion (Figure 2). Over most of the metal, a smooth, even, mid-green patina survived; in a few places green crystalline corrosion products were disrupting the patina. The yellow and blue enamel was in good condition and has generally retained its glassy nature, apart from a few areas where the colour had dulled slightly and the surface of the enamel had started to craze. This slight deterioration only occured on the part of the brooch which was originally exposed, and not on the area initially covered by hard corrosion. The colour and condition of the green enamel varied from dark green areas, which are relatively hard, to a lighter green powdery material. Again, the deterioration was more severe in the exposed areas of the brooch.

TREATMENT. Loose soil and corrosion were removed mechanically using a scalpel, pin vice and soft brush. The hard concretion was gently dislodged with a vibrotool, so that all the enamel fields were revealed. Some extremely hard corrosion was left in situ, in case its removal damaged the brooch. Some soil stains were cleaned using industrial methylated spirits (IMS), applied with cotton wool swabs. No consolidation of the enamel was carried out - even the more powdery enamel was well compacted, and there was little danger of it being dislodged from the field. Figure 3 is a photograph of the brooch after the corrosion had been removed, and all the enamel fields could be seen.

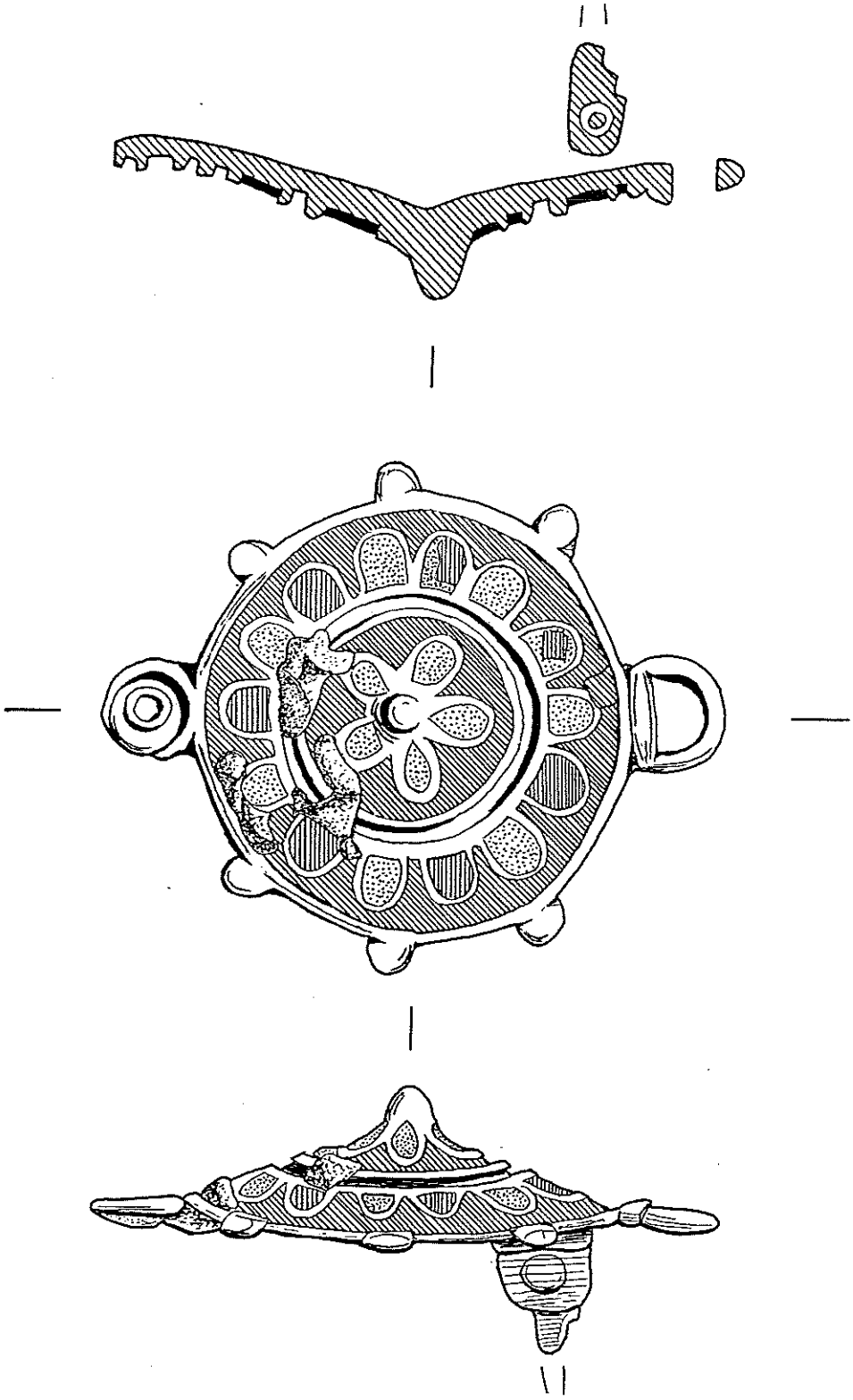

Figure 1: Illustration of 890735

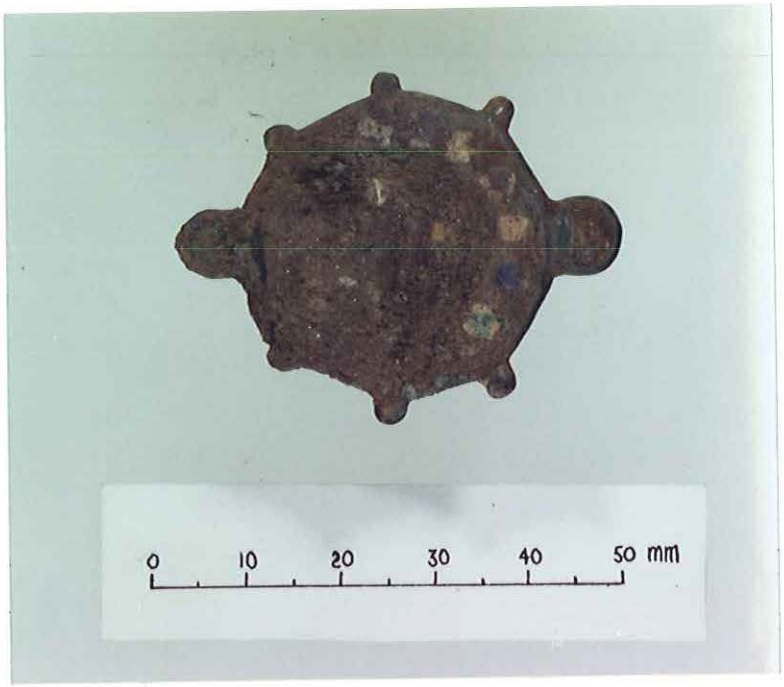

Figure 2: 8905735 before treatment

Figure 3: 8905735 after removal of corrosion

2. Disc brooch with angular sunburst enamel pattern.
(AML No. 9014037)

DESCRIPTION. (Figure 4) This pattern was also a common feature on Roman enamelled brooches, and may be an adulterated version of the sunburst pattern, where the loops are pointed so that they form a star (Hattatt 1982). There were three different colours of enamel - the exterior fields had alternate blue and turquoise coloured enamel, and the inner star-shaped field contained decayed green enamel which is thought to have originally been red (J.Bayley pers.comm.) A parallel to this brooch was described by Hattatt (1985), and had an identical colour scheme, with red enamel in the inner field.

Black corrosion products were noted in one area around the edge of the brooch. This was analysed using EDXRF analysis and silver was detected, which may indicate that silver wires were soldered to the metal at the edge of the enamel field (J.Bayley pers.comm.).

CONDITION. Voluminous bright green copper alloy corrosion products obscured the surface (Figure 5). Underneath this, a dark surface layer survived, which was pitted in places, so that light green powdery corrosion could be seen. The blue enamel was in good condition with a glassy appearance. The turquoise enamel was slightly pitted and cracked, and was difficult to distinguish from the copper corrosion products in some areas. The green enamel in the star-shaped field was a murky colour, and had a powdery texture.

TREATMENT. Compacted soil and corrosion were removed using hand tools. The enamel was consolidated using 10% Paraloid B72 in industrial methylated spirits (IMS), applied with a brush. Figure 6 shows the brooch after removal of the corrosion - the surface is pitted, and some hard corrosion has been left in situ, but the enamel fields and the decoration can be seen.

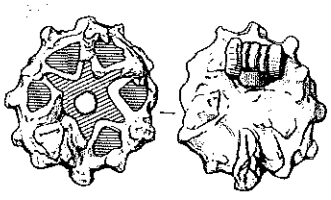

Figure 4: Illustration of 9014037, courtesy of the CAS drawing office. Drawn 2/1 and reduced to actual size.

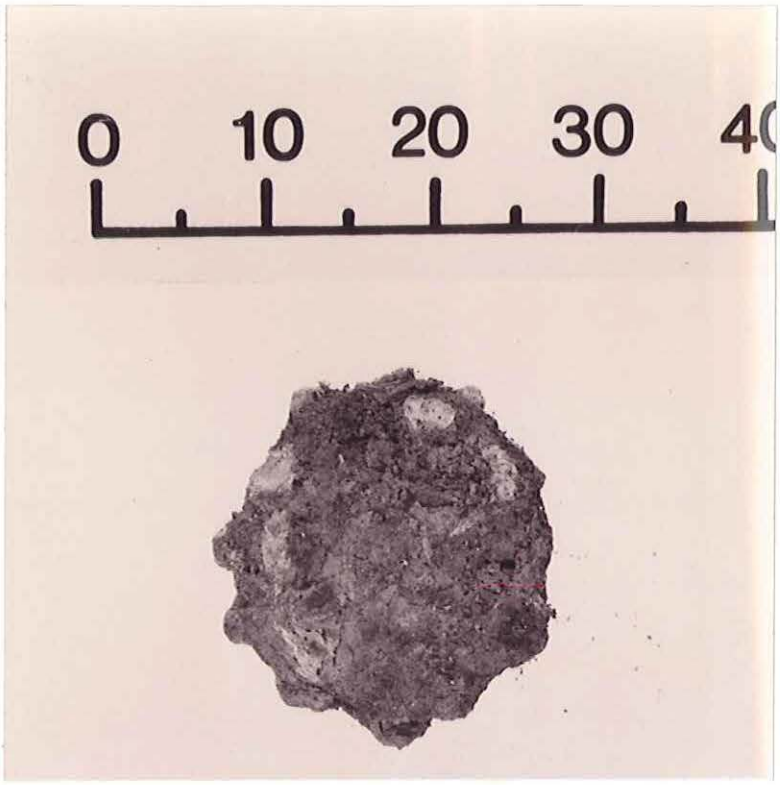

Figure 5: 9014037 before treatment

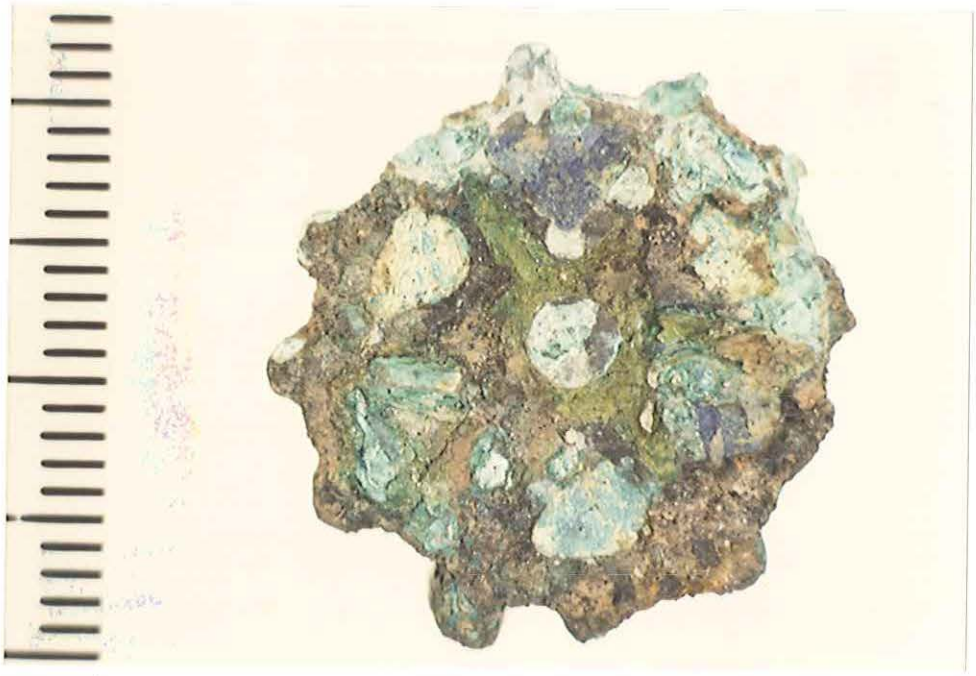

Figure 6: 9014037 after removal of corrosion

3. Enamelled disc brooch.
(AML No. 8812209)

DESCRIPTION. The blue enamel decoration on this brooch was set in a radial 'wheel-spoke' pattern (Figure 7). Traces of white metal were noted on the surface, and an EDXRF analysis confirmed the presence of silver, though it is unclear whether this was a surface coating, or soldered silver wires. Some organic material was preserved in the corrosion products, but it appeared to be random, with no obvious structure, and may be organic debris from the burial environment.

CONDITION. The copper alloy had almost completely mineralised, extruding hard, voluminous dark green corrosion products over one half of the brooch (Figure 8). There was a pitted, dark surface layer. The enamel was in good condition, retaining its glassy nature. In some areas, a green translucent layer overlay the blue enamel, and may represent a layer of deteriorated enamel.

TREATMENT. Corrosion was removed mechanically to reveal about two thirds of the brooch (Figure 9). Hand tools were used initially, but where necessary, a vibratool was employed to dislodge areas of extremely hard corrosion. Enough corrosion was removed to clarify the decoration, so that the brooch could be illustrated. At this stage it was considered unnecessary to do more.

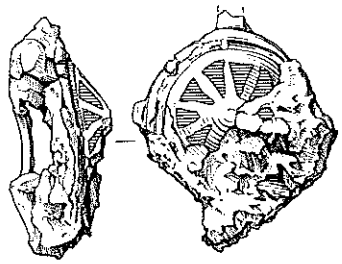

Figure 7: Illustration of 8812209, courtesy of the CAS drawing office. Drawn 2/1 and reduced to actual size.

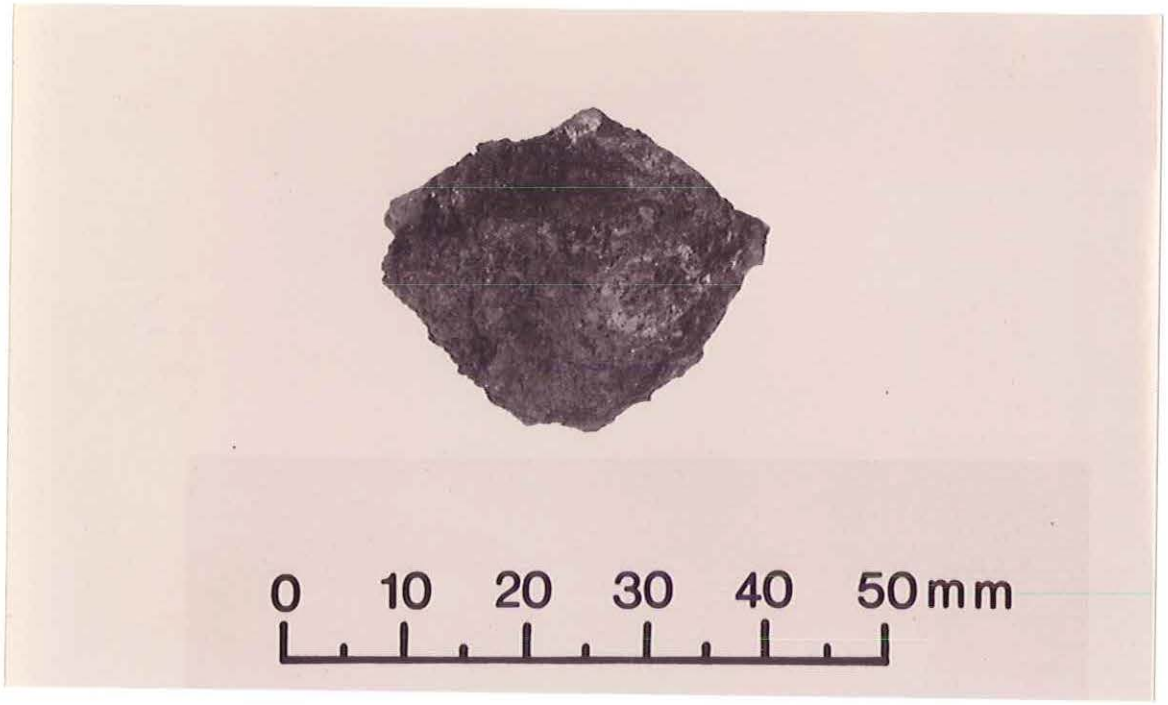

Figure 8: 8812209 before treatment

Figure 9: 8812209 after removal of corrosion

4. Stepped disc brooch with millefiori decoration.
(AML No. 8909083)

DESCIPTION. The disc brooch form developed from flat circular plate brooches (such as AML No. 9014037) to domed or stepped shapes, often with a centre boss, such as this stepped form (Figure 10). This brooch had a wide circular enamel field, containing green enamel with chequered green and white/yellow millefiori decoration. One piece of millefiori had obviously been cut at an angle, as the decoration was elongated - a phenomenon which has been noted before (Bayley 1987). The copper alloy was decorated with regular incised marks on the raised edges of the enamel field.

CONDITION. Compacted soil, light green powdery copper corrosion products, and some hard crystalline corrosion covered much of the surface (Figure 11). A dark green patchy patina survived in most areas. The metal had almost completely mineralised and was very fragile. Where the enamel survives, it is in very good condition, and is still glassy. Much of the enamel had fallen out, and there appeared to be some lack of cohesion between the enamel and the copper alloy. The enamel does not appear to have been dislodged by the metal corroding underneath it, so it is possible that the correct fusion temperatures were not reached in its manufacture. The brooch was initially packed in a plastic bag, supported by 'jiffy' foam. This method was obviously insufficient to support the brooch and when it was unpacked several months after treatment and illustration, it was found to have fractured into several pieces. Much of the thin centre band of corroded copper alloy had turned to powder.

TREATMENT. Dirt and corrosion were removed to reveal as much detail of the millefiori and incised decoration on the copper alloy as possible. Some of the corrosion was left in place, as removal would have damaged the thin, mineralised structure that remained. After the brooch fractured, the remaining fragments were adhered using dilute HMG cellulose nitrate adhesive, and the joins were backed with nylon mesh fabric to provide some structural support. Figure 12 is a photograph of the reconstructed brooch. The brooch was repacked into a crystal box, with 'jiffy' foam cut to fit its shape.

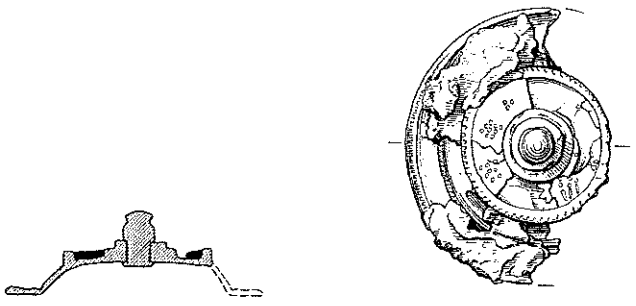

Figure 10: Illustration of 8909083, courtesy of the CAS drawing office. Drawn 2/1 and reduced to actual size.

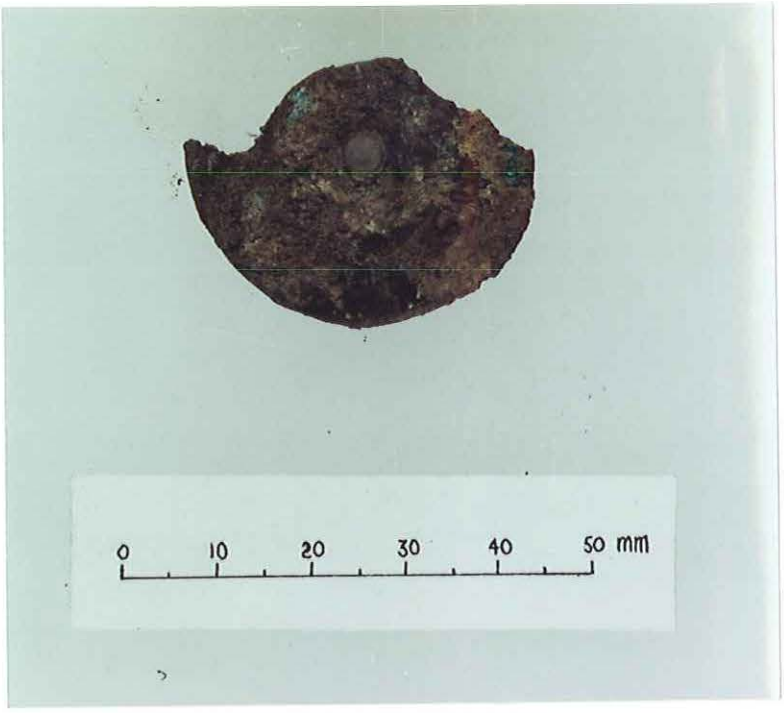

Figure 11: 8909083 before treatment

Figure 12: 8909083 after removal of corrosion

5. Disc-and-trumpet brooch.
(AML No. 8905593)

DESCRIPTION. The disc-and-trumpet brooch is a form native to Britain - very few are found abroad (Hattatt 1982). It is believed to be derived from the Celtic-style zoomorphic brooch, and sometimes has 'eyes' inset on the trumpet head. This example (figure 13) did not have the 'eyes', but it did have traces of wire, which had been soldered along the spine, and small 'beads' of white metal on the edge of the 'tail'. XRF analysis confirmed the presence of silver in these areas. The enamelled disc had a centre of dark green enamel, surrounded by red enamel.

CONDITION. The brooch was originally covered with a layer of loose soil (Figure 14). Underneath this, a smooth dark green patina survives, but this is broken in places to reveal light green, powdery corrosion products. The area around the catch-plate (or what remains of it) is very brittle. The central, dark green enamel is hard and glassy, and in good condition. The surrounding enamel has deteriorated, so that a thin crust of red/brown material overlies dull green powdery material. It is thought to represent decayed red enamel (J.Bayley, pers. comm.).

TREATMENT. The layer of soil was mechanically removed using a scalpel to reveal the form and detail of the the brooch (Figure 15). No consolidation of the enamel was carried out; although deteriorated, the enamel was compact and there was little risk of it being loosened and becoming dislodged from its field.

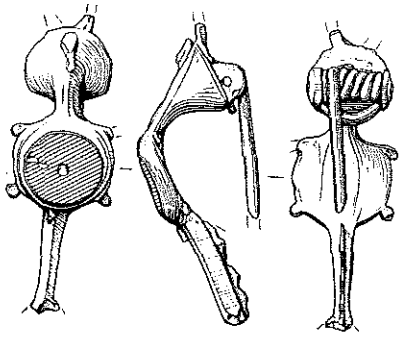

Figure 13: Illustration of 8905593, courtesy of the CAS drawing office. Drawn 2/1 and reduced to actual size.

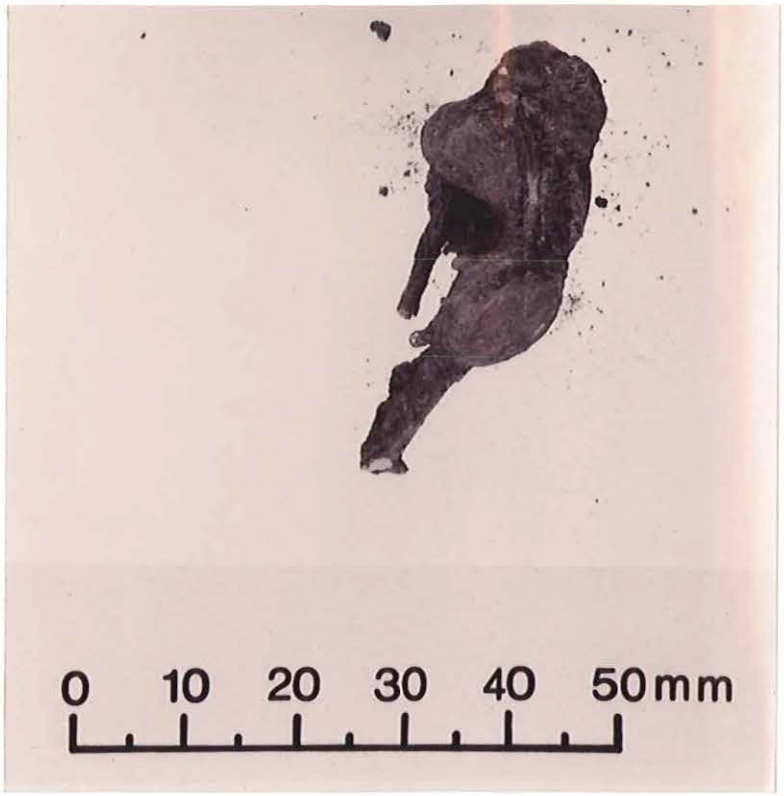

Figure 14: 8905593 before treatment

Figure 15: 8905593 after removal of corrosion

6. Copper alloy stud with millefiori decoration.
(AML No. 9014090)

DESCRIPTION. This stud had concentric bands of millefiori enamel separated by copper alloy ribs (Figure 16). The enamel survived in two of the bands, and these had different millefiori patterns. The outer band had a blue enamel background with white and red millefiori 'flowers'. The middle band was red, with a white and blue chequered pattern. The stud was a similar form to one found at South Shields Roman Fort (Allason-Jones and Miket 1984).

CONDITION. The stud was initially covered with a layer of soil and loose corrosion (Figure 17). The copper alloy was encrusted with hard dark green crystalline corrosion products. The enamel that survived was brightly coloured and glassy, so had undergone little chemical deterioration. However, much of the enamel had fallen out, and what remained had little cohesion with the underlying metal. It seemed that the corrosion products which have formed in the recessed surfaces of the metal had dislodged the enamel. Close examination of the enamel showed a network of fine cracks, especially in the red enamel (Figure 18), and these may have been the result of the build up of stress as the underlying metal corroded.

TREATMENT. The soil and loose corrosion was mechanically removed to reveal the form of the stud and the millefiori enamel (Figure 19). The enamel was then consolidated using 10% Paraloid B72 in IMS, applied with a brush.

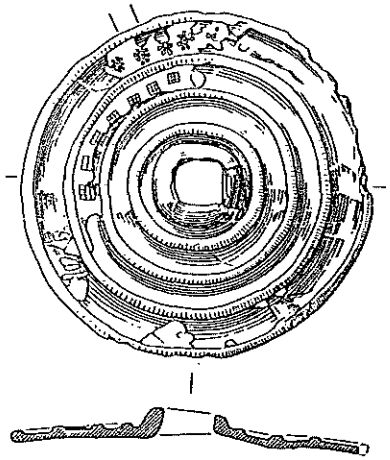

Figure 16: Illustration of 9014090, courtesy of the CAS drawing office. Drawn 2/1 and reduced to actual size.

Figure 17: 9014090 before treatment

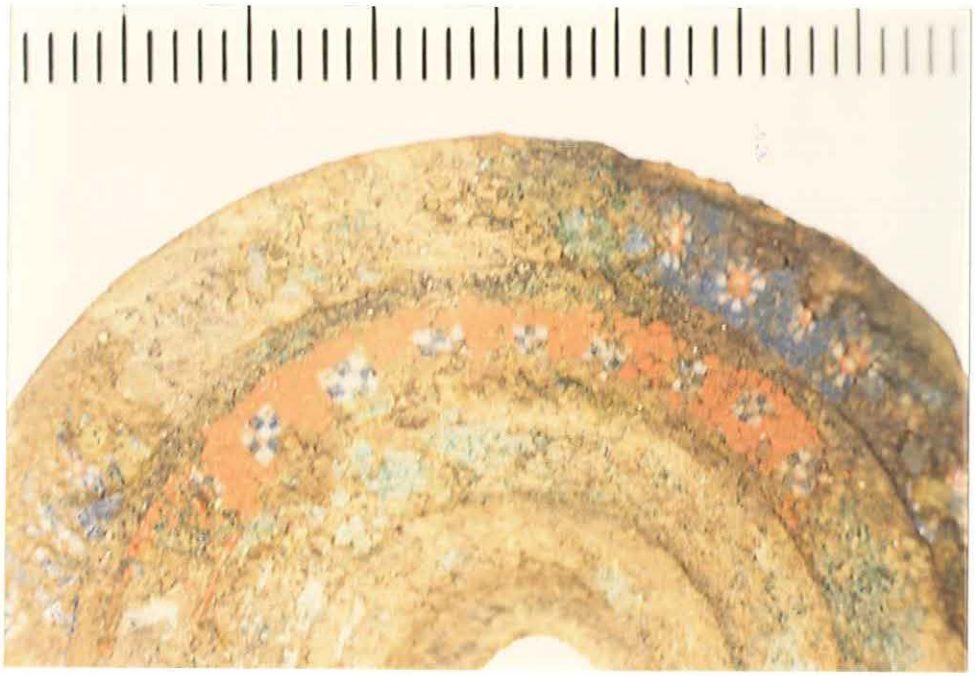

Figure 18: 9014090 fine cracks in enamel

Figure 19: 9014090 after removal of corrosion

Discussion

1. **DETERIORATION OF ENAMEL.** The above summaries of the condition of these artefacts have made observations on their state of preservation, but have not outlined mechanisms for the deterioration that was seen. Some interesting points about possible deterioration mechanisms can be made by comparing the different states of preservation that were observed.

The burial environment was considered initially, and information about the contexts from which the artefacts were excavated was obtained. All the soils on the site were acidic, so this would have favoured enamel preservation since the alkalis in the glass structure are leached out more quickly in alkaline conditions (Newton 1989). All the contexts were well drained, except the context of the disc brooch 8812209 (no.3), which was damp. The presence of water is one of the most important factors in the deterioration of any glass, but in this case has had little effect, since the enamel on the brooch in question is relatively undeteriorated. Burial environment does not, therefore, appear to have been a determining factor in the enamel deterioration.

There appears to be some relationship between the original colour of the enamel and its susceptibility to decay. With the exception of the red enamel in the stud 9014090 (no.6), enamel which was thought to have originally been red has undergone the most severe deterioration. The mechanism for this change to dull green, powdery enamel is described by Hughes (1987). The original red colour of the enamel was due to the presence either of finely divided copper metal, or copper in the reduced (copper I) state. When alkalis and alkaline earths are leached out of the enamel structure, an open network of hydrated silica remains, and the copper and copper (I) is exposed and oxidised to the copper (II) state. Often, it is then precipitated as copper salts similar to the corrosion products commonly found on copper alloy artefacts. It is not likely to be the colourant of the enamel which causes its instability, as the oxidation of the copper is a result of earlier deterioration. Some other aspect of the composition may be responsible, such as the proportion of lime (CaO) or other stabiliser.

One difficult aspect of assessing the condition of enamelled artefacts is deciding whether physical deterioration, such as crazing and dislodgement of the enamel, is the result of stresses built up by chemical deterioration of the enamel itself, by the corrosion of the copper alloy into which the enamel is set, or due to original faults in the manufacturing process. The disruption of the enamel on the stud 9014090 (no.6) appears to have resulted from corrosion of the underlying metal, and this type of deterioration has been noted before - on the Lincoln Hanging Bowl, for example (Hunter & Foley 1987). This can be compared to the enamel in the stepped disc brooch, which suffers from lack of cohesion with the underlying metal, even though there is no evidence of copper alloy corrosion intruding into the enamel field. It is possible that the temperature in the manufacturing process was

not high enough to actually fuse the enamel to the copper alloy. Crazing can also be indicative of manufacturing faults - an enamel with an expansion coefficent which differs to that of the metal will crack on cooling.

2.TREATMENT. The investigative conservation of these artefacts posed some interesting problems. The general approach was one of 'minimum intervention', since this was freshly excavated archaeological material that needed to be investigated so that details of the construction and decoration could be clarified, and the artefacts drawn for the site report. As yet, none of the artefacts were required for display. By attempting to remove the minimum amount of corrosion necessary to reveal the information needed, it is hoped that there may be scope for further information to be retrieved in the future. With enamelled artefacts, more corrosion removal than usual is necessary, since the shape of the enamel fields and the colour of the enamel needs to be determined. X-radiographs were taken of all the artefacts in this study before investigation was commenced; this technique reveals the shape of the recessess in the metal, but does not indicate whether enamel is present.

With this approach, the decision of whether or not to consolidate the enamel was not always clearcut. Application of a consolidant darkens the colour of the enamel. It also means that if any analysis of the enamel is required in the future (eg sampling for compositional analysis), the consolidant has to be removed, and this subjects the artefact to further stress. Consolidants were only applied to enamel that was in immediate danger of being dislodged. Where the enamel was powdery, but was firmly compacted into its field, no consolidation was carried out. In these cases, a note of the enamel condition was made on the conservation record card so that the problem could be monitored in the future.

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