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Ancient Monuments Laboratory
Report 32/95

CONSERVATION OF A MOSAIC FROM ALDBOROUGH IN NORTH YORKSHIRE

A Cselik

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Summary

A brief history of a late third or early fourth century mosaic, with a Greek inscription, is given. The results of analyses, including those of stone and glass tesserae are presented. As the mosaic was in three sections, two of which had been backed in cement and concrete, the conservation treatment centres on methods for the removal of the old backing; rejoining of the three sections; and the application of a new backing.

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Acknowledgements

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Martin Allfrey, Matthew Canti, Bob Child, Mike Corfield, Nerina de Silva, Glynis Edwards, Bob Entwhistle, Paul Highnam, Mark Jones, Harry Kenward, Bill Martin and the people at the stone studio, Cath Mortimer, Valerie Munday, Jeremy Richards, David Sherlock, Sharon Strong and many colleagues at the AML for helping to carry the mosaic around and cut aluminium mesh.

Special thanks go to David S Neal and Colin Slack.

Contents

Conservation of a mosaic from Aldborough in North Yorkshire

Anna Cselik

This mosaic formed part of the floor of a town house (Figure 1). It is of a reasonable standard of quality and dates to the late third or early fourth century AD. It consists of the lower part of a female figure in a girdled tunic bordered by guilloche decoration on her left. Her left arm is bent and holds one end of an open scroll. To the right of the figure is what may be a stylized chair or rock. A Greek inscription is set in blue glass tesserae between this and her elbow. The word is split on to two lines and reads EΛH/KWN - HELICON (Figure 2). It is believed that originally there were nine figured panels each figure representing one of the Nine Muses of Mount Helicon. This figure with the inscribed panel is thought to be Clio, the Muse of History.

History

Discovery

The first record of this mosaic was made in 1846 by Henry Ecroyd Smith. In 1852 he published his notes in a book, `*The Reliquiae Isurianae*'. He estimated that about nine-tenths of its surface had been destroyed. The mosaic ends abruptly on the eastern side. This marked the boundary of a garden. Ecroyd Smith believed the adjoining tenant to have destroyed the remains which he presumed had existed `until recent times'.

Excavations

Information about the mosaic is not exactly clear but based on the notes of Stephen Johnson a summary is given below.

Dorothy Charlesworth 1975: The condition of the mosaic had deteriorated since its discovery in 1846. Ecroyd Smith had mentioned two partially existing figures, but only parts of one had survived. The inscription in blue glass tesserae had become detached from its position and was removed and encased in plaster of Paris. After the excavation the mosaics were recorded by David Neal.

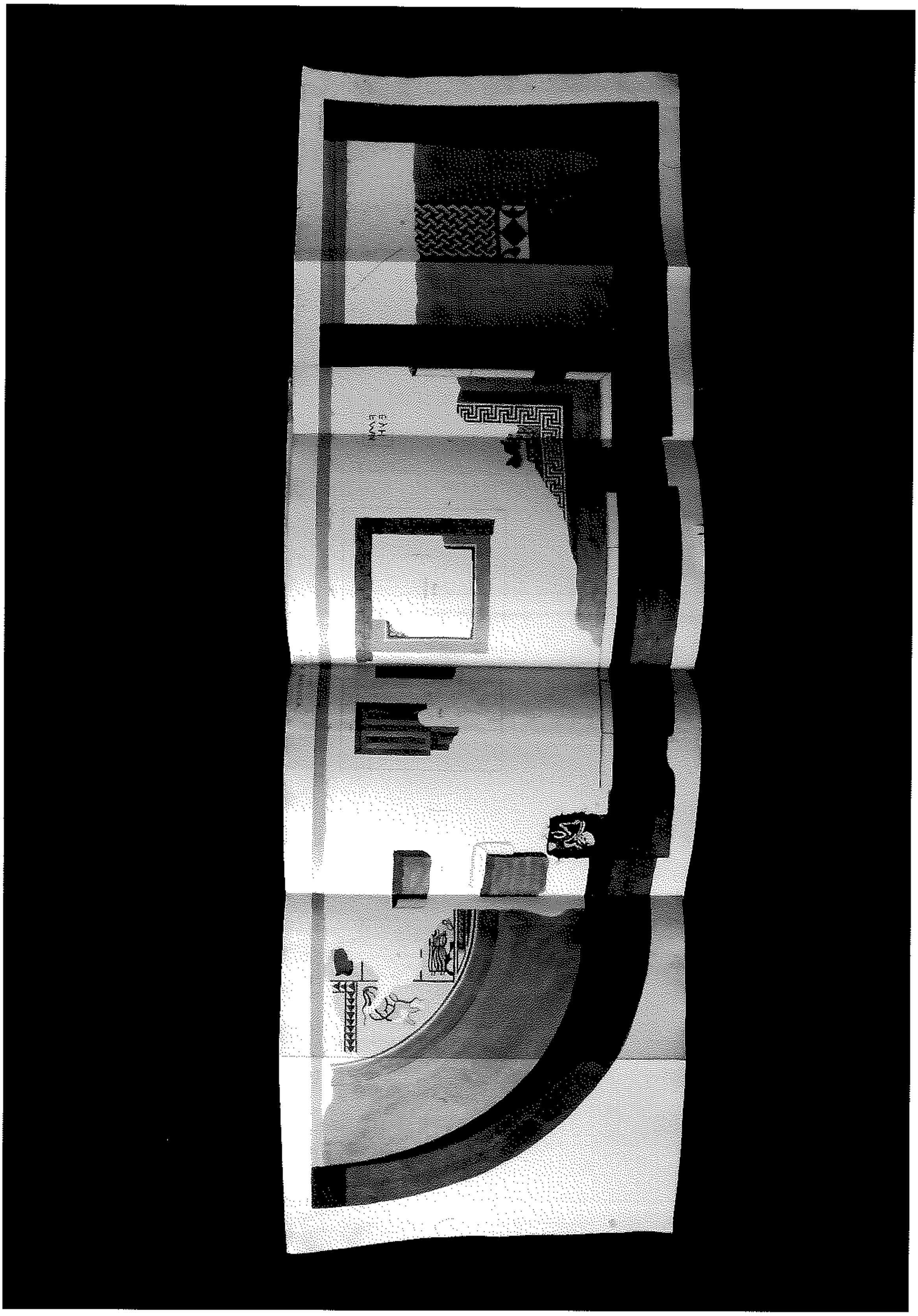

FIG 1. Henry Ecroyd Smith's illustration of the mosaic floor of which this mosaic is a part. Taken from his book *'The Reliquiae Isurianae'*.

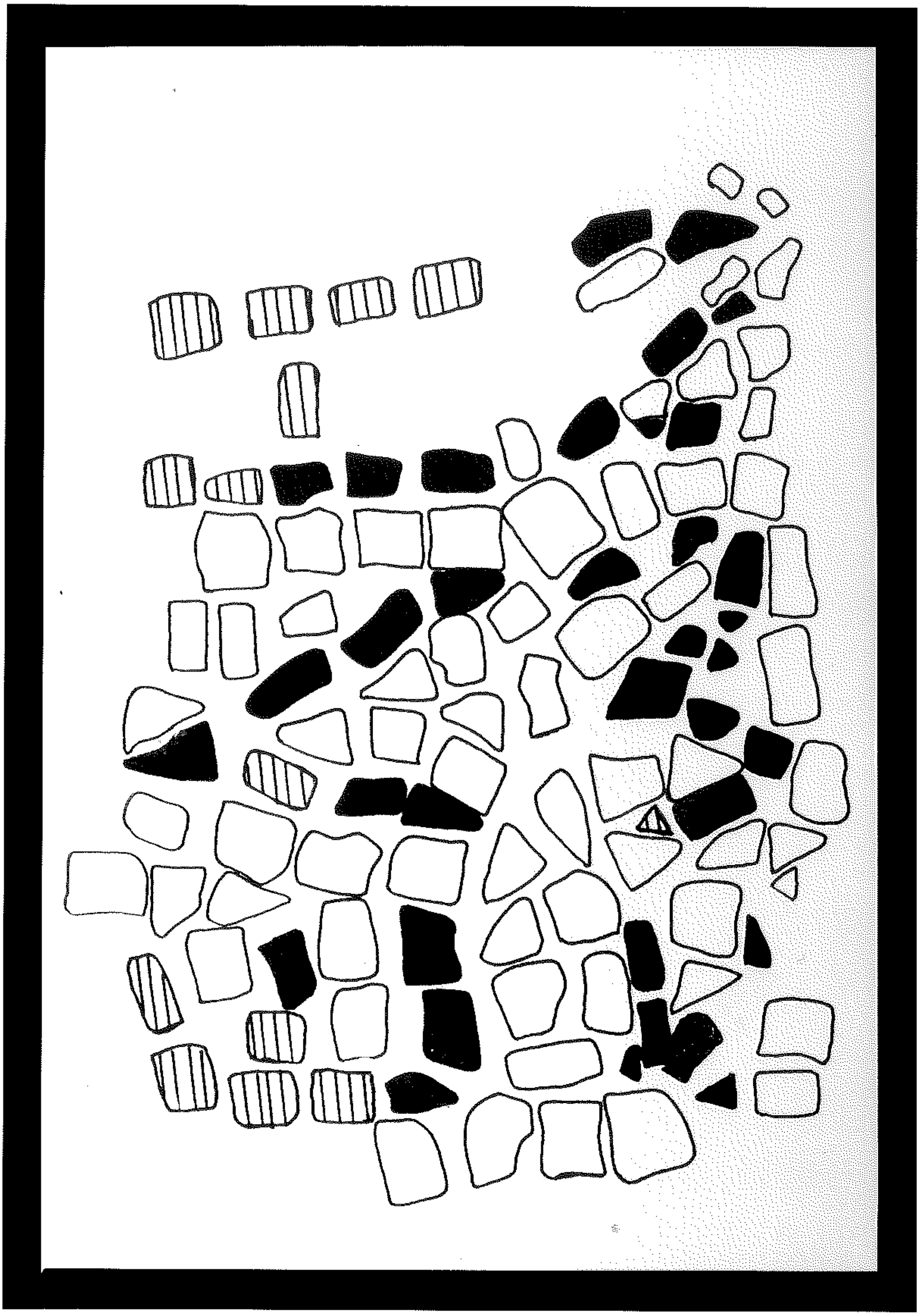

FIG 2. Greek inscription reading EΛH/KWN (HELICON). The hatched tesserae are missing.

Stephen Johnson 1979: The helicon mosaic was found surrounded with tiles and brick set in a hard white mortar. This was thought to be part of a consolidation process carried out in the nineteenth century. It was not clear whether the mosaic had been lifted and reset at the same time.

The mosaic had to be lifted before further excavation was possible. According to unpublished notes, available in the AML site files, the lifting involved backing the tunic and guilloche sections with cement and concrete reinforced with aluminium wire and brushing the surface with wire brushes.

Condition

The mosaic was in three main sections:

1) Helicon Section - AML no. 801303 (Figure 3)

The helicon section differed from the other two sections in that it had not been backed in cement and concrete but cement, adhesive and gauze. A lot of soil was present even on the upper surfaces of the tesserae. This being the case is seems unlikely that an adhesive was applied to and removed from the upper surface of the mosaic during lifting. It is, therefore, possible that it was simply sandwiched between two boards during lifting and turned over, the gauze applied to the back and then the section flipped over right way up again. The blue glass tesserae, forming the inscription, were loose and had thin layers of white corrosion on their surfaces. Many of the other tesserae were loose and the gauze had buckled so that part of this section had folded over itself. Some pale pink mortar, possibly *opus signinum,* was visible in places.

2) Tunic Section - AML no. 78108369 (Figure 4)

The tesserae were slightly shiny. Various cements, mortars, plasters and adhesives obscured the tesserae in places. Some of the tesserae were very badly set, for example on their sides or even upside down. Many were obviously not in their original positions such as several different coloured tesserae in a lilac field and a row of red tesserae placed a little below the feet of the figure. Some tesserae were cracked and fragmented. Dead insect remains and cobwebs were found in the bottom of the wooden tray in which it arrived together with the guilloche section. Some areas of pinkish mortar, possibly *opus signinum*, were visible in between some of the tesserae. The backing seemed to consist of a layer of mortar underneath the tesserae followed by a layer of neat Portland cement and then finally a layer of concrete.

3) Guilloche Section - AML no. 78108369 (Figure 5)

Some of the tesserae were loose, cracked and covered with cement and/or adhesive. Several tesserae were set on their sides. Photographs taken in May 1986 show deep cracks in this section but there were no separate fragments. By 1991 several fragments had become detached. It is possible that the cement and concrete backing

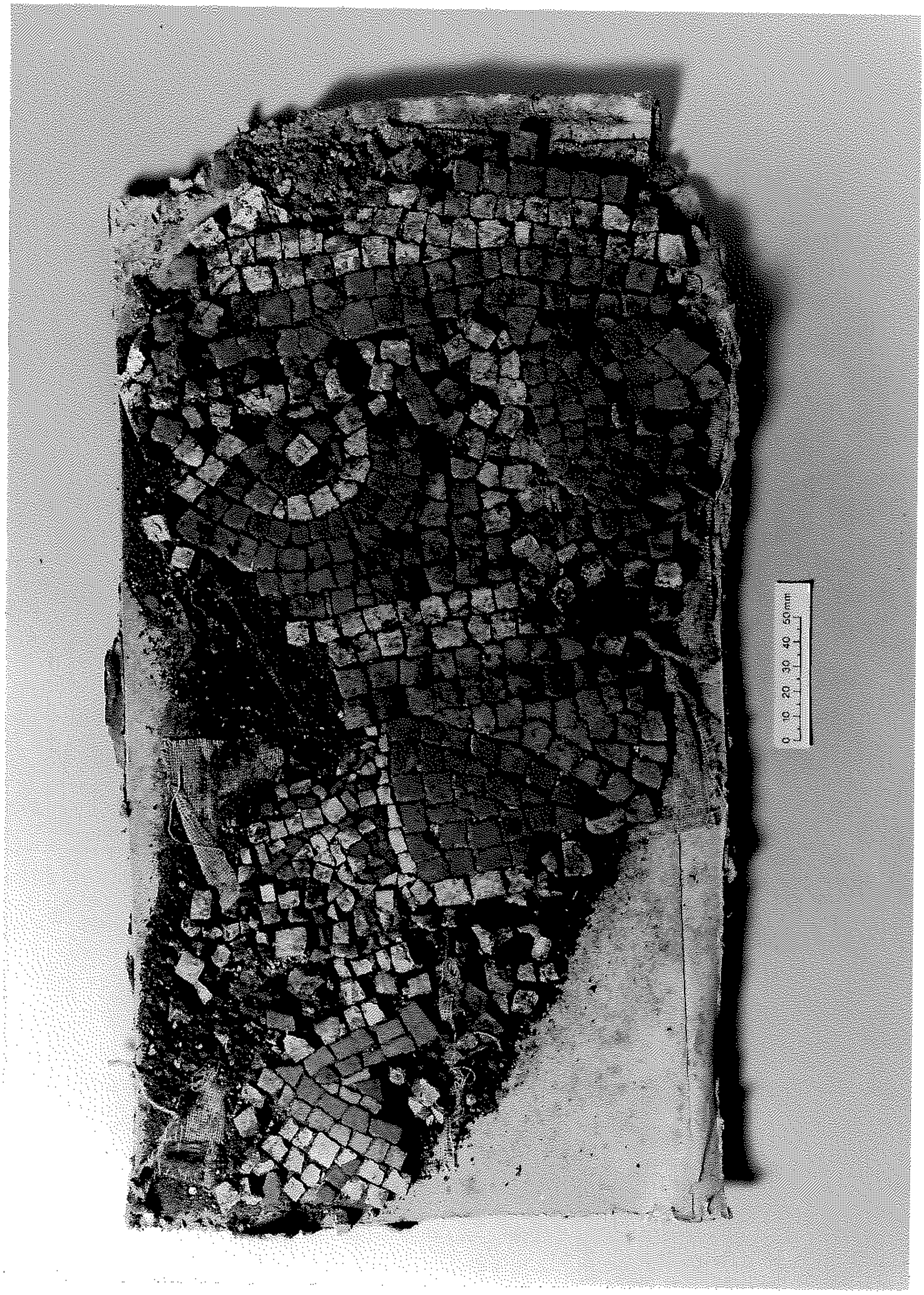

FIG 3. The section with the `Helicon' inscription before treatment.

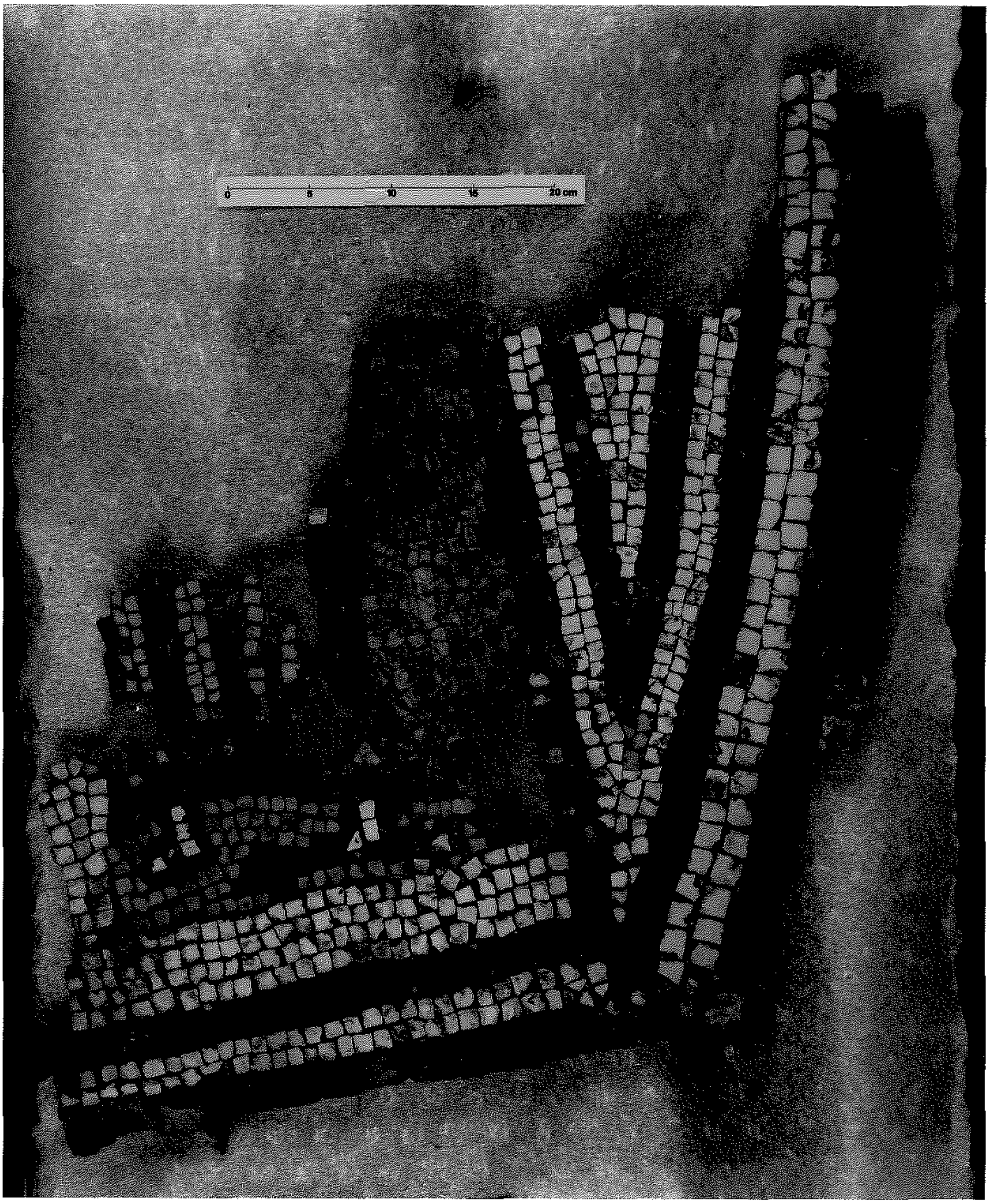

FIG 4. Tunic section before treatment.

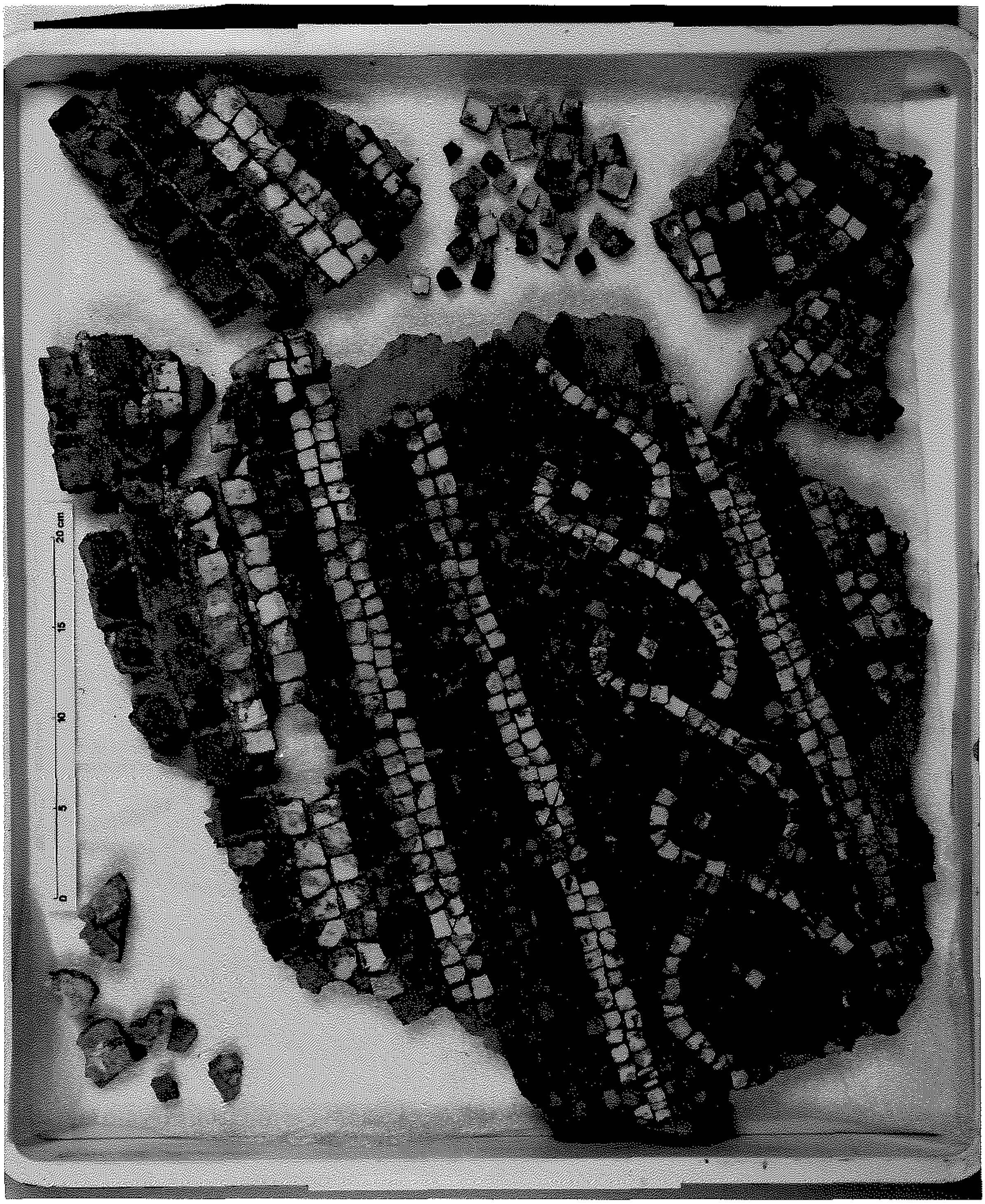

FIG 5. Guilloche section before treatment.

caused a build up of mechanical stress which forced apart pieces of this section. One of the cracks actually split some tesserae in half. The backing consisted of a layer of mortar underneath the tesserae followed by a layer of neat Portland cement. Deep scratches, at various orientations, were visible on the tesserae. This could have been caused by the wire brushes employed during the lifting process.

Analysis

Insect Infestation

During initial cleaning some tiny insects were seen in the cracks of the mosaic sections backed with cement and concrete. One of the insects was caught and sent to Harry Kenward for identification. It was identified as a booklouse. Booklice live in damp conditions and feed on animal and plant detritus, book-paste, foodstuffs, insect collections and some feed on fungi growing on books or similar objects. It seemed that the damp conditions in which the tunic and guilloche sections had been stored together with the insect remains had provided conditions suitable for the survival of the booklice. The insect remains were removed soon after arrival and with the drier conditions of the laboratory no adults were visible after a few weeks. Insect `Trappit' traps were placed on the mosaic and monitored over a period of several weeks. No insects were ever caught.

Stone Tesserae

White, blue-black and light green tesserae were sent to Messrs Sandberg for analysis. The white tessera was found to be of hard chalk while the blue-black and light green tesserae were of very high limestone. The full results of the analyses are included as an appendix (Appendix I).

Glass Tesserae

A small fragment of glass tessera was embedded in a resin, polished and carbon coated. Silver dag was used to fix the resin block to the scanning electron microscope (SEM) stage and acted as a conductor. Three areas of the glass were quantitatively analysed using an energy dispersive X-ray (EDX) analyser with the help of Cath Mortimer. The results are given below together with the average percentage compositions. The spectrum of area 2 is also shown in Figure 6 as it is typical of all three areas.

The results (Table 1) show that the tessera is a soda glass. This is typical of Roman glass. The colourant in the glass is likely to be cobalt as only a minute amount is needed (0.1%) to provide a blue colour. Had copper been the colourant there would have been a more pronounced copper peak in Figure 6. The glass would have had a lighter blue colour. The other oxides present, such as calcium, aluminium, magnesium and iron, are probably impurities in the sand used to make the glass. The carbon peak is from the carbon coating.

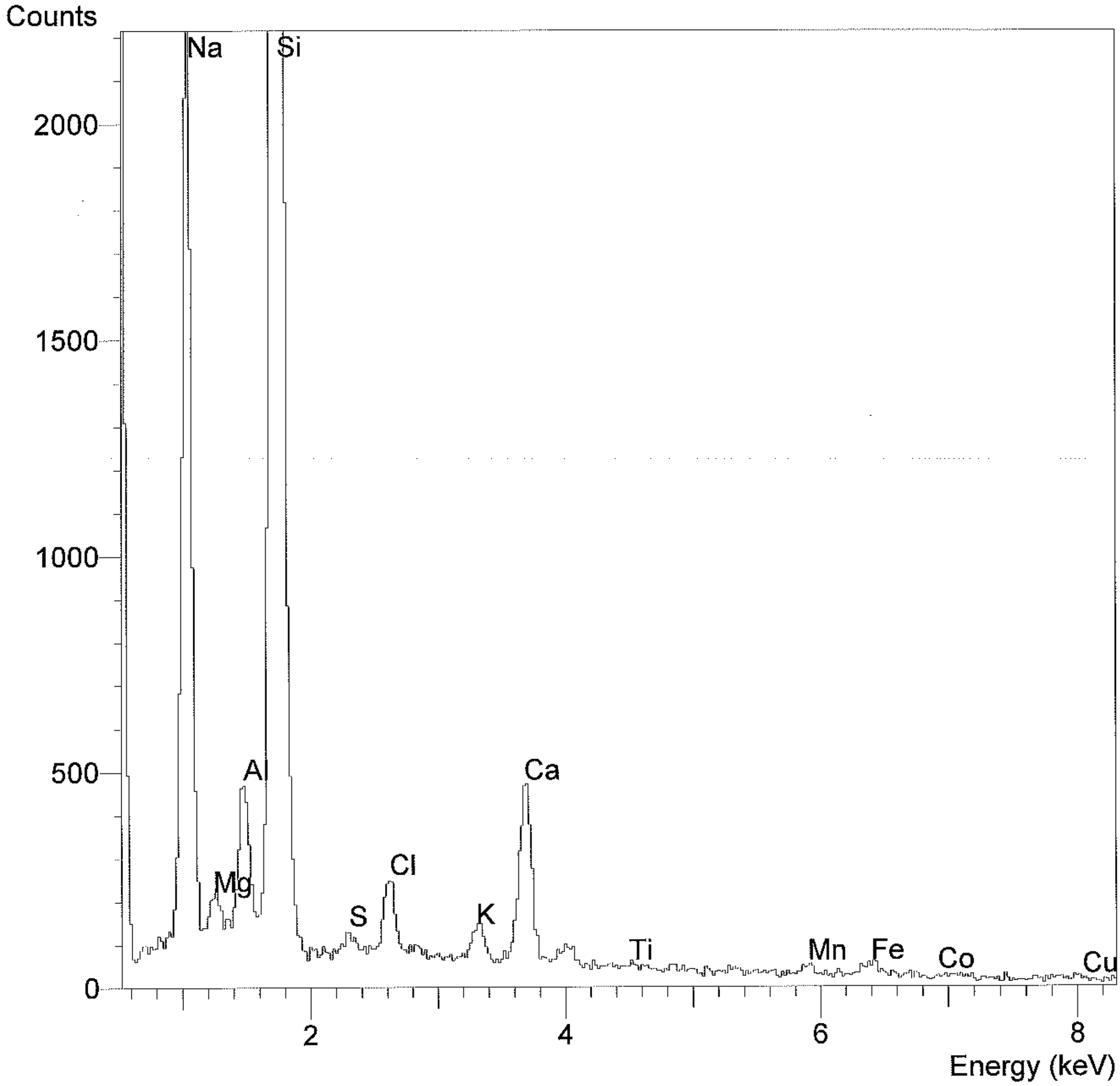

FIG 6. An energy-dispersive X-ray (EDX) analysis spectrum of a fragment from a blue glass tessera.

TABLE 1. Results of EDX analysis of the areas of a fragment of a blue glass tessera and the average percentage composition.

Compound	Compound % area 1	Compound % area 2	Compound % area 3	Average %
Na_2O	16.1	16.0	16.3	16.1
MgO	1.2	1.1	1.2	1.2
Al_2O_3	2.1	2.0	2.1	2.1
SiO_2	67.6	66.3	69.2	67.7
P_2O_5	0.4	0.5	0.4	0.4
SO_3	0.6	0.7	0.6	0.6
K_2O	0.9	1.0	0.9	0.9
CaO	4.6	4.6	5.1	4.8
TiO_2	n.d.	n.d.	n.d.	-
MnO	0.6	0.7	0.7	0.7
FeO	1.1	1.3	0.9	1.1
CoO	n.d.	n.d.	n.d.	-
Total	95.2	94.2	97.4	95.6

n.d. = not detected - reflects the minimum detectable levels which are 0.1% for CoO and 0.2% for TiO_2

Treatment

The Helicon Section - Cleaning and Positioning of the Tesserae

A tracing was made on a sheet of Melinex (polyester film) of the position and shape of each individual tessera. The loose tesserae were removed and attached to the tracing with HMG (cellulose nitrate) adhesive. As each tessera was removed it was cleaned with cotton wool swabs moistened with distilled water. Once all the loose tesserae had been removed the section was cleaned. Soil was removed from between the tesserae with a scalpel a soft brush and a puffer. This was followed by cleaning with cotton wool swabs moistened with distilled water.

Any tesserae fragments were joined with HMG adhesive. One glass fragment was consolidated with an approximately 15% solution of Paraloid B72 (ethyl methacrylate copolymer) in toluene applied with a pipette.

A layer of PVA (polyvinyl acetate) was applied over the surface with a brush and left to dry. Another coat of PVA was applied. A layer of scrim was pressed into the PVA whilst it was still damp and then another layer of PVA was applied and left to dry.

Correx (propylene/ethylene copolymer board) sheet of the appropriate size. Another sheet of Correx was placed on top and the section flipped over. The top Correx sheet was then removed to reveal the back of the mosaic section.

Some soil was present. In places neat cement had seeped into the old scrim. In other areas the reverses of the tesserae were covered either by the cement alone or by some scrim and an adhesive. The adhesive was found to be soluble in acetone. This was used to soften the adhesive and remove the scrim rather than water as water seemed to soften the grey tesserae. Some cement was found underneath the scrim. A Vibrotool proved ineffective at removing the cement so a scalpel was used. Fragments of tesserae that came loose were reattached with HMG adhesive. The remaining old adhesive was removed by first softening it with acetone and then picking it off with a scalpel. The last traces of adhesive were removed with cotton wool swabs moistened with acetone. A scalpel and brush were used to remove soil from between the tesserae. A vacuum cleaner with a hose covered with netting was used to suck up the dirt and cement fragments.

Loose fragments were returned to their probable positions. Photographs and drawings were referred to throughout. The scrim had to be cut in places as this section had obviously warped.

Mortar, which was possibly *opus signinum* was consolidated in places with a 20% solution of Paraloid B72 in toluene. Very fragmented mortar was consolidated with a 40% solution of Paraloid B72 in acetone.

The tesserae needed to be rearranged so as to be in their correct positions. A soft but firm material would be necessary for this. A couple of tesserae were pressed into some brown Plasticine (chalk, mixed oils, colouring), both with and without Clingfilm (polyester) as a separating layer. The Plasticine did not hold the tesserae at all well. Without the Clingfilm the Plasticine left a pink sticky residue which was difficult to remove.

The Helicon section was divided into three parts: the inscription, semi circles and tunic. It was decided that Superfine Modelling Clay would be used as it had the required properties. A layer of the Windsor & Newton Superfine Modelling clay was rolled out and placed on the back of the inscription. The inscription was sandwiched between two layers of Correx and flipped over. The Correx was removed. The PVA was softened with distilled water and the gauze was removed. Any remaining PVA was removed with a scalpel and cotton wool swabs moistened with water. The tesserae were arranged according to photographs and drawings. As the clay was so easy to work, the rest of the Helicon section was embedded in clay as described above and the gauze and PVA likewise removed. All three parts of the Helicon section were joined together and final adjustments made to the positions of the tesserae.

The Tunic and Guilloche Sections - Cleaning and Removal of the Old Backing

Loose dirt was brushed off the guilloche and tunic sections. Any obtrusive adhesive was removed with a scalpel and needle. Harder materials which obscured the tesserae, such as adhesive and cement, were removed with a scalpel. All loose dirt was removed with a vacuum cleaner with a narrow rubber tube taped to the hose. A plastic gauze was placed over the end of the rubber tubing. This was a precaution against any loose tesserae fragments being sucked into the vacuum cleaner.

When these two sections were placed together, it was found that the Helicon section did not fit correctly. It was decided that the cement and concrete backing should be removed and be replaced with an epoxy resin and Micafil (ferrous aluminium magnesium silicate) mixture. Before being faced up some of the tesserae, which were obviously in the wrong position, were loosened from the backing with a pneumatic drill.

A brush was used to coat the two sections with a layer of Evo-stick wood adhesive resin `w' (cross-linked polyvinyl acetate emulsion - PVA) and left to dry. Another layer of the Evo-tick was applied and cotton scrim placed on top of it followed by another layer of Evo-stick. Once thoroughly dry the sections were sandwiched between boards and turned over.

A fine chisel shaped dentists' tool, a fine chisel and a hammer were used to remove the backing from the guilloche section (Figure 7). The brittleness of the neat cement facilitated its removal. Some of the surfaces from the back of the tesserae came off with the cement, especially from the red (ceramic) and white (limestone) tesserae. These surface layers were often extremely thin and could not be reattached. Any surface flakes that could be joined were reattached with HMG adhesive.

The dental tool and chisel proved relatively ineffective with the softer sandy concrete layer of backing of the tunic section so an electric grinder was used. This was done out of doors as a great deal of dust was produced. Parallel grooves were cut into the concrete. A hammer and chisel were then used to remove the strips that were left proud.

In places the neat cement was either very thin or nonexistent so great care had to be taken in these areas. The procedure was made more difficult by a random dispersement of twisted aluminium alloy wires under the surface of the concrete. When the grinder came in to contact with these wires sparks were produced so caution was necessary. Once the concrete had been removed, the neat cement was removed with a fine chisel and a hammer. As with the Helicon section the red and white tesserae seemed particularly fragile. Any surface flakes which became detached were reattached with HMG adhesive. A vacuum cleaner, with a net over the rubber tube attachment, was used to remove any dust and fragments of cement.

FIG 7. Removal of the cement backing.

Adjustment of the Tesserae

As much as possible of the remainder of the cement and old adhesive were removed with a scalpel. The backs of the tesserae were then coated twice with an approximately 20% solution of Paraloid B72 in acetone. This acted as a separating layer.

A table was covered with sheets of Melinex joined together with masking tape. A layer of softened Windsor & Newton Superfine Modelling Clay, approximately 2.5 cm thick, was rolled out on to the table. The tunic and guilloche sections were sandwiched between two boards and flipped over. They were then eased off the boards on to the clay, positioned as accurately as possible and then pressed into the clay. Considerable help was provided by David S Neal during this process. The clay needed to be kept soft and moist so the mosaic was covered with Polythene sheets when not being worked on. This did present problems with fungal growth. A black and pink mould seemed to appear from time to time. Any fungal growth was removed with cotton wool swabs. In some places small spots of purple staining remained after the fungus was removed.

The gauze facing was removed by softening the PVA with warm water and gently peeling off the gauze. Any remaining PVA was removed with warm water and a scalpel. In areas some of the Paraloid B72 was removed with acetone so as to release some of the cement chippings that had fallen down between the tesserae.

The positions of the tesserae were adjusted as appropriate by David S Neal. Lines of tesserae which had become distorted were straightened. Tesserae which were obviously placed incorrectly were removed altogether such as a line of large red tesserae underneath the feet of the Muse.

Once the tunic and guilloche sections were correctly aligned the distance between the `eyes' of the guilloche were measured. The average distance was 90cm. The `eye' of the guilloche in the helicon section was then positioned at approximately 180cm from the last guilloche. This was because a guilloche pattern was missing between the two sections. The rest of the helicon section was then aligned with both of the other two sections (Figure 8). Once all the sections had been aligned satisfactorily, the whole mosaic was faced up with gauze and PVA as described above.

The Backing

It was known that the mosaic would be displayed on the floor of the site museum rather than on a wall as this is more in keeping with the context of the mosaic. This also simplified the backing method to be employed. A metal frame support, which would be required if the mosaic were to be displayed vertically, would not be necessary. A backing strong enough to support the mosaic when lifted and moved would be sufficient. To this end a simple backing system was chosen using expanded aluminium and an epoxy resin as the support. In order to

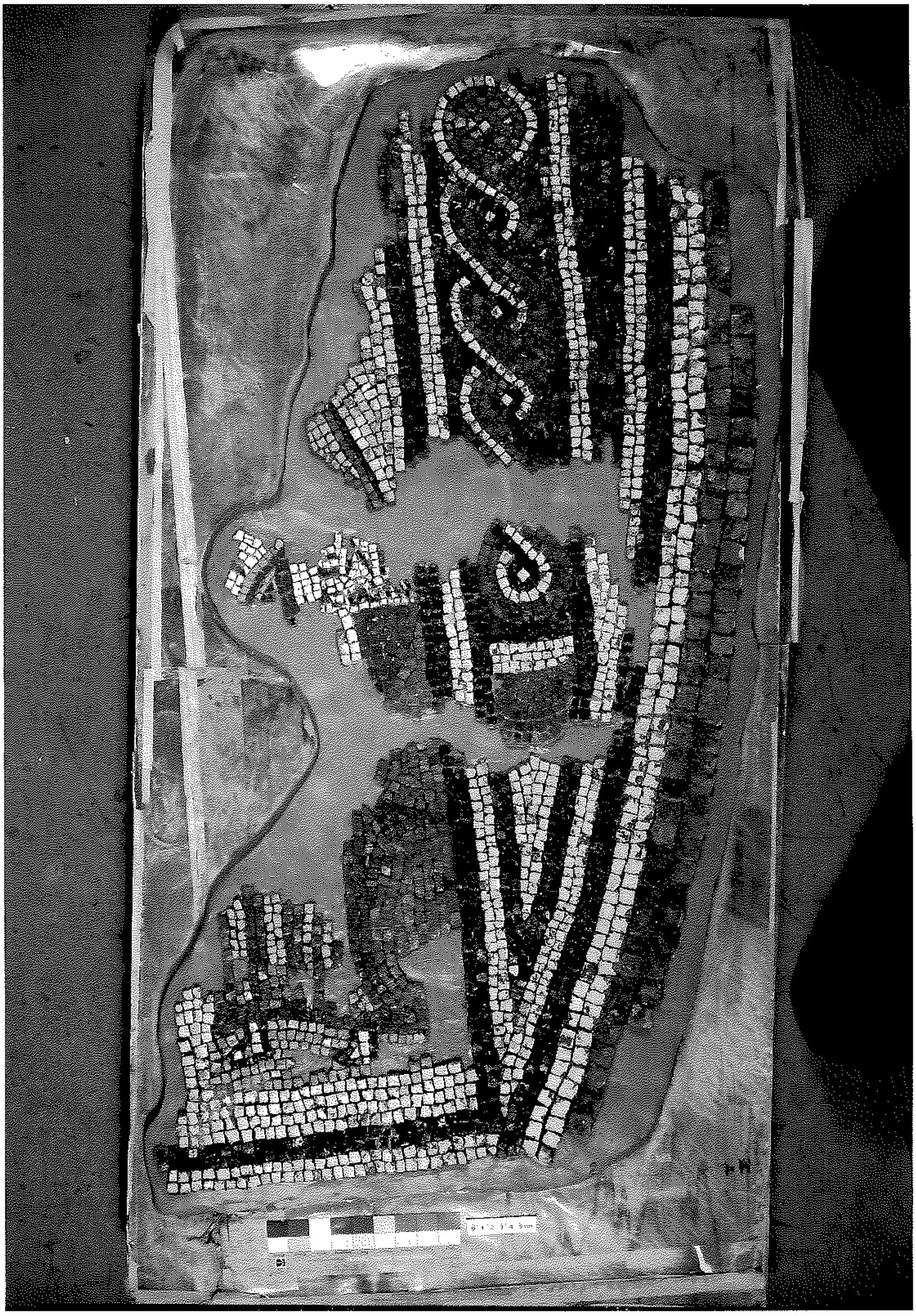

FIG 8. The mosaic in the clay after the three sections were aligned and the tesserae adjusted.

reduce the weight of the backing Micafil was chosen as a bulking agent for the resin. It was decided that the backing should project beyond the edge of the mosaic so as to provide extra protection to the tesserae along the edge, especially the blue glass tesserae of the inscription.

Jiffy foam (polyethylene) was used to protect the mosaic. A collapsable table was placed on top of the mosaic. Wide brown tape was used to secure the two tables together. The two tables were then turned over. The tape, upper table and Jiffy foam were removed. The temporary clay backing was now uppermost. Most of the clay was removed with metal spatulas and scalpels. The fine layer of clay left behind was removed with cotton wool swabs moistened with water. The back was left for several days to make sure the tesserae were completely dry before two layers of 20% solution of Paraloid B72 in acetone was applied to the backs of the tesserae with a brush.

Larger gaps in the design were filled with a thin layer, approximately 1mm, of Newplast (a type of Plasticine but less oily). This was so that the backing would be slightly recessed below the surface of the mosaic.

A wall of cardboard was constructed around the mosaic approximately one inch from the edge of the mosaic. Thin cardboard was cut into strips of about 6cm in width and lined on one side with wide brown tape. Experiments with the cardboard, tape and resin showed that the tape was a suitable separating agent which would facilitate the removal of the cardboard wall after backing was completed. The wall was held in place and supported by Plasticine. A thin layer of modelling clay was placed in the gap between the edge of the mosaic and the wall to recess the backing (Figure 9).

A thin layer, approximately 1-2mm, of plaster of Paris (incompletely hydrated calcium sulphate) was put on to the back of the mosaic in sections. The previous section of plaster was still damp when the next was added. The plaster was then left to set (Figure 10).

Expanded aluminium was cut to the shape of the mosaic but slightly smaller so that it did not reach the edge of the backing. Another sheet of expanded aluminium was then cut to the same size but the orientation of the diamond shaped openings was at 45° to the other sheet. This would provide extra rigidity and strength to the backing.

Araldite MY573, Araldite hardener HY956 (epoxy resin) and Micafil were mixed by weight in the following proportions: 100 of Araldite MY573 to 20 of hardener HY956 and 22% Micafil. Generally the backing was made up in batches. A bucket was filled with 396g of Micafil. Two disposable polyethylene beakers were filled with 1800g of Araldite MY573 and 360g of hardener HY956 respectively. The two were mixed together thoroughly and then mixed with the Micafil. The batches of mixture were smoothed on to the plaster with a wooden spatula. They were applied within about 10 minutes of one another until the back of the mosaic was completely covered with a layer of the mixture.

FIG 9. Surround and gaps filled with a thin layer of Newplast.

FIG 10. Plaster of Paris used as a separating layer between the mosaic and the epoxy resin.

FIG 11. Application of the epoxy resin and Micafil mixture on to the aluminium support.

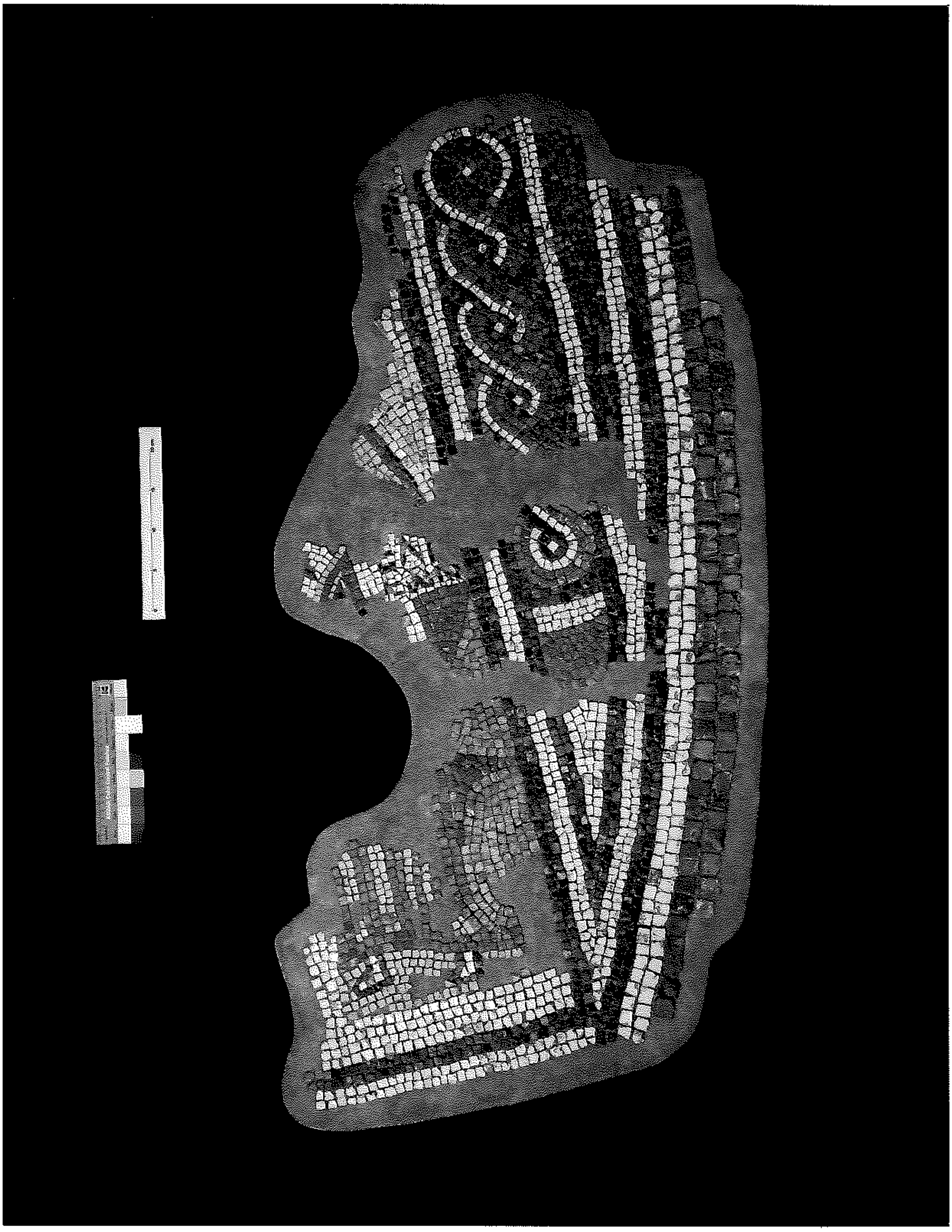

FIG 12. Mosaic after treatment. The surround and gapfills with a roughened surface finish.

The first sheet of expanded aluminium was put in place and a second layer of Araldite and Micafil was applied using the method described above. The second sheet of expanded aluminium was put in place with the mesh at a 45° angle to first to give added strength and then a third layer of Araldite and Micafil was applied (Figure 11). A final layer of Araldite and Micafil was applied but proportionally more Araldite to Micafil was used in the mixture as the backing seemed quite `dry'. This was probably because the Araldite was settling lower down than expected.

Once the final layer had set, the cardboard was removed from the edges of the backing. The mosaic was turned over so that it rested on its backing. Where the plaster gapfills and surround were a little high in areas, they were sanded down with various grades of emery and silicon carbide paper.

Sand, no more than 500μ in size, was mixed with enough 20% Paraloid B72 in acetone to form a fairly thin runny mixture. This was used to fill larger gaps between tesserae. As the acetone evaporated a thicker mixture was formed which was applied over the plaster gapfills and the edge of the backing to give a rougher surface appearance (Figure12).

The shiny layer of Paraloid B72 on the surface of the tesserae was removed with acetone. The acetone was brushed on to the tesserae and then soaked up with paper towels.

Display

The object was put on display at the site museum in Aldborough. It was displayed on the floor in a specially constructed glass case which will help keep it dust free and prevent insect infestation and debris. The object should be kept at a steady relative humidity, ideally at around 50%.

Appendix one

SANDBERG

REPORT K/3642/C/3

EXAMINATION OF ROMAN TESSERAE FROM

HELICON MOSAIC

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REPORT K/3642/C/3

EXAMINATION OF ROMAN TESSERAE FROM HELICON MOSAIC ALDBOROUGH, NEAR RIPON, YORKSHIRE

Reference: Your letter of instruction dated 3 February 1992.

1. INTRODUCTION

Three samples, each comprising a single tessera from the above site, were received in our laboratory on 10 February 1992 and subjected to examination in accordance with your instructions. We were particularly asked to determine the types of materials present and their provenance.

We were advised that one of the tesserae exhibited traces of green colouring and were additionally requested to determine whether this was organic growth, pigment or other.

2. SAMPLES RECEIVED

Sandberg Reference	Approx. Wt Rec'd, g	Sample Details
C17137	1.5	White Tessera, Helicon Mosaic, Aldborough
C17138	1.6	Blue/Black Tessera, Helicon Mosaic, Aldborough
C17139	2.2	Green Tessera, Helicon Mosaic, Aldborough

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3. LABORATORY EXAMINATION METHODS

3.1 Petrographical Examination

The three submitted samples were each subjected to a petrographical examination in general accordance with the method described in BS 5930:1981 [1] and ISRM [2] for rocks.

Each sample was first examined using a low-power stereoscopic microscope prior to being split longitudinally through the surface. One half of each specimen was then set in resin and highly polished prior to examination with a high-power petrological microscope employing magnifications up to x1200.

After the polished specimen examination, each sample was then used to prepare a thin-section for examination with a high-power light petrological microscope employing magnifications up to x400.

3.2 Microscopical Examination Using Mineral Oils

An immersion mount was prepared from material scraped from the surface of the green tessera, Sample C17139. The immersion oil used had a refractive index of 1.5155 and the mount was examined at various magnifications up to x1000 using a high-power transmitted light petrological microscope.

4. RESULTS

4.1 Petrographical Examination

Sample C17137/White Tessera

White, finely crystalline CHALK which was found to be relatively hard, and broke with an almost conchoidal fracture. Approximately 90% of the chalk comprised calcite of sub -2μm size (micrite). The remaining 10% comprised fossil remains, chiefly of globeriginid foraminiferans with some echinoderm plates and spines.

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1. BS 5930:1981. Code of Practice for Site Investigation. Part 104, Description and classification of rocks for Engineering purposes.

2. ISRM Suggested Methods. Rock Characterisation, Testing and Monitoring. Suggested Method for Petrographic Description of Rocks, March 1977.

Traces of mortar were visible upon two of the tessera sides, this comprising fine quartz sand within a completely carbonated hardened cement. The quartz particles reached a maximum of 120μm in diameter and included some polycrystalline quartz (quartzite).Sample C17138/Blue/Black Tessera

Sample C17138/Blue/Black Tessera

Dark grey, finely crystalline LIMESTONE which was found to be very hard. The limestone comprised chiefly microcrystalline calcite between 2μm and 10μm in size enclosing opaque black particles of possible organic origin (1% of total volume) and deep orange red particles of probable iron oxides (1% of total volume). The deep colour of the limestone was apparently due to sub-microscopic opaque materials between individual crystal grains. Abundant fossils within the limestone have been completely replaced with streaks visible due to the presence of slightly more coarsely crystalline calcite.

Traces of mortar were visible upon the sides of the tessera, this comprising fine quartz sand within a completely carbonated hardened cement. The cement appeared to be iron-rich and at the interface with the tessera, an up to 50μm wide zone was visible where the cement had possibly reacted with and altered the limestone.

Sample C17139/Green Tessera

Dark grey, finely crystalline LIMESTONE which was found to be very hard. This limestone was essentially the same as that described above for Sample C17138 with these additional remarks. The fossil content formerly comprised approximately 25% of the limestone. The fossil crystal size varied, reaching up to 50μm. Individual fossils were commonly elongated, between 20μm and 70μm in width and reaching up to 1.5mm in length.

Traces of mortar were visible up to the sides and the base of the tessera, this comprising fine sand within a carbonated hardened cement. The sand comprised chiefly quartz with some feldspar, quartzite and a trace of zircon. Particle size reached up to 160μm. Opaque fragments were visible within the cement matrix which itself had sometimes recrystallised to a dark, microcrystalline material forming a layer up to 150μm thick adjacent to the tessera and within the cement. Some voids exhibited slightly more coarsely crystalline sprays of carbonate minerals.

The top surface of the tessera comprised a layer of finely crystalline material which appeared olive green in some places, these areas were isotropic. Calcite crystals were variably grown within the layer and spore cases had also been included. Approximately 2μm-sized angular green particles were visible within the layer, these comprising the merest trace.

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4.2 Immersion Mount

Sample C17139 - Green Tessera

Green material was clearly visible within the scraping taken from the top surface, usually as particulate accumulations. Close examination of these particles and of surrounding materials indicated that the green colour was chiefly due to particles between 2μm and 5μm in size which were isotropic. Many of these particles appeared to be angular to irregular in shape.

Frequent organic particles were present in the form of spore cases, these spherical in outline, of deep brown colour and often broken open. Such spores varied between 5μm and 25μm in size.

Crystalline fragments were visible, these probably derived from the tessera but also from a possible surface finish. The exact nature of these fragments is not known but may include both quartz and calcite.

5. DISCUSSION OF FINDINGS

Sample C17137, the white tessera, was found to comprise hard CHALK common in southern and eastern England. In relation to Aldborough the nearest rocks of this type are found eastwards forming an approximate 20 mile wide strip down the east coast of England extending from just south of Scarborough to The Wash.

Samples C17138 and C17139, the blue/black and green tesserae were found to be essentially the same comprising dark grey, fossiliferous limestone. Several different limestone types form much of the strata within a 50 mile radius of Aldborough, these mostly of light colours and/or exhibiting characteristic arrangements of variable constituents. The only dark limestones of note are found within the Lower Carboniferous sequences which form much of the Pennines to the west and north-west of Aldborough.

Sample C17139 was found to exhibit a surface layer comprising a variety of crystalline materials which formed part of an apparent finish. Part of the layer was coloured green, however, there was no apparent associated structure. Occasionally within the layer were very small deep green particles which might have in part produced the coloration. These green particles were isotropic and might be a type of metal oxide (perhaps copper), possibly used as a pigment. Spore cases were also present, these were brown coloured and not associated with the green appearance of the layer.

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6. REMARKS

The findings from the laboratory examination of the three submitted tesserae has indicated that they comprise carbonate rock types which may have been derived from fairly locally quarried stone. The presence of a green coloration upon one of the tesserae appears to be from a pigment added to a surface finish. The nature of these surface materials is not accurately known but might be confirmed using scanning electron microscopy.

These results and comments conclude the examination requested for the submitted samples. If you have any comments or queries concerning this or any other matter please do not hesitate to contact us.

Materials, samples and test specimens are retained for a period of 2 months from the issue of the final report. Your attention is drawn to the enclosed sample retention form and we would be grateful if you could complete the form and return it within one month from the date of the report.

English Heritage
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FOR MESSRS SANDBERG

J L Pickering

J L Pickering

For the attention of Mr Iain McCaig

25 March 1992

BJH/BFM/Chem81/km

Appendix two

Materials

acetone	
Araldite MY573 hardener HY956	epoxy resin
Clingfilm	polyester
Correx	propylene/ethylene copolymer board
distilled water	
emery and silicone carbide paper	
Evo-stick wood adhesive resin `w'	cross-linked polyvinyl acetate emulsion
expanded aluminium	
HMG adhesive	cellulose nitrate
Jiffy foam	polyethylene
Melinex	polyester film
Micafil	Ferrous aluminium magnesium silicate
Newplast (a type of less oily Plasticine)	
Paraloid B72	ethyl methacrylate copolymer
plaster of Paris	incompletely hydrated calcium sulphate
Plasticine	chalk, mixed oils, colouring
Polythene	polyethylene
PVA	polyvinyl acetate
Silver sand	
Superfine modelling clay (Windsor & Newton)	
toluene	

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