# The Conservation of the Orpheus Mosaic at Paphos, Cyprus

The Getty Conservation Institute

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THE GETTY CONSERVATION INSTITUTE

*Cover: Detail of the Orpheus mosaic after conservation. Photo by Guillermo Aldana.*

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Typography: Adobe Postscript Charlemagne and Janson Text
Printing: Westland Graphics, Burbank, California

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Library of Congress Cataloging-In-Publication Data

The Conservation of the Orpheus Mosaic at Paphos, Cyprus.
p. cm.
ISBN 0-89236-188-3 (paperback)
1. Orpheus mosaic (New Paphos) 2. Orpheus (Greek mythology)--Art. 3. Mosaics, Roman--Conservation and restoration--Cyprus--New Paphos (Ancient city) 4. Pavements, Mosaic--Conservation and restoration--Cyprus--New Paphos (Ancient city) I. Getty Conservation Institute
NA3770.C65 1991
738.5'2--dc20 91-19192
CIP

# The Getty Conservation Institute

The Getty Conservation Institute, an operating program of the J. Paul Getty Trust, was created in 1982 to address the conservation needs of our cultural heritage. The Institute conducts worldwide, interdisciplinary professional programs in scientific research, training, and documentation. This is accomplished through a combination of in-house projects and collaborative ventures with other organizations in the USA and abroad. Special activities such as field projects, international conferences, and publications strengthen the role of the Institute.

# Contents

# FOREWORD

In recent decades, considerable progress has been made in the field of mosaics conservation, both in the preservation of mosaics in situ and in the development of new supports for mosaics that have been lifted. The tools and materials that conservators have at their disposal today are considerably more sophisticated than those available to their predecessors and provide a broader range of treatment options.

While the rolling technique used for lifting the Orpheus mosaic will not be applicable to all mosaics, and the cost or unavailability of specialized materials might be prohibitive in some cases, we consider it very important that conservators be made aware of this method. Increased familiarity with the technique will not only allow conservators to make more educated decisions in mosaics preservation, it may also serve as the basis for future developments and improvements in the technique.

*Paolo Mora*

# PREFACE: DEVELOPMENT OF THE PROJECT

The Project on Mosaics Conservation took place in Paphos, Cyprus, in 1988 and 1989. It was jointly organized by the Getty Conservation Institute (GCI) and the Department of Antiquities of Cyprus, following an initiative for a collaborative project proposed by Dr. Vassos Karageorghis, then Director of Antiquities, Dr. John Walsh, Director of the J. Paul Getty Museum, and Marion True, Curator of Antiquities of the J. Paul Getty Museum.

Luis Monreal, then Director of the GCI, took up the offer of collaboration with the Department of Antiquities by organizing a meeting in Cyprus, in June of 1988, to define the scope and aims of the project. A number of mosaics specialists were invited in addition to members of the Department of Antiquities, the GCI, and the J. Paul Getty Museum.

In agreeing with the Department of Antiquities to undertake the conservation of the Orpheus mosaic, the GCI proposed from the outset that the opportunity be used as a training project. Since it was decided to use the relatively uncommon rolling technique for detaching the mosaic, the project provided an ideal opportunity to train other conservators from the Mediterranean region in this method.

In August of 1988, Professor Paolo Mora, accompanied by conservators Jan Kosinka, Giorgio Capriotti, and Lorenza D'Alessandro, inspected the mosaic and planned the lifting operation with Demetrios Michaelides (Archaeological Officer for Paphos, Department of Antiquities) and the present writer. The photodocumentation work described on page 13 was carried out during this visit.

From September 5 to October 14, 1988, Phase 1 of the project took place, combining on-site work on the mosaic with more formal instruction on mosaics conservation for the project participants. The conservators responsible for the work on the mosaic also held lectures and exercises that put the Orpheus project in a broader context of mosaics conservation. In general, each day was divided equally between on-site work and formal instruction.

In addition to being fully involved in the on-site work, the project participants took part in exercises designed to cover other aspects of mosaics conservation. These included condition reporting, biocide and cleaning tests (see

Appendix A), and the making of mosaic samples. The need to work closely with site archaeologists was also stressed.

Phase 1 saw the completion of the lifting of the mosaic and most of the preparatory work for the new support. The final cleaning of the back of the mosaic and the application of the new mortar bed was carried out by Jan Kosinka on May 1–6, 1989. The mosaic was protected during the intervening months by the interim shelter described on pages 26–28.

Phase 2 of the project, from May 28 to June 23, 1989, saw the reinstallation of the mosaic in situ on its new support. This campaign was devoted entirely to work on-site, directed by Jan Kosinka with the help of the mosaics conservators who had participated in Phase 1 the previous year.

On August 16–22, J. Claire Dean, who had coordinated local arrangements for Phases 1 and 2 of the project, finished the infilling of lacunae in the mosaic and carried out the limited consolidation work that had been decided upon. With this work complete, final photodocumentation of the conserved mosaic was carried out on October 17–20, 1989, by Guillermo Aldana, with assistance from Dean. The aim of this work was twofold: to document the mosaic section-by-section for comparison with photographs taken prior to conservation, and to provide definitive overhead photographs of the complete mosaic (see Pl. 1).

The temporary shelter, constructed by the Department of Antiquities over the Orpheus mosaic following its reinstallation, was removed to make this photography possible. It was removed permanently once the hexashelter (see pp. 36–41) was built in November under the direction of Neville Agnew and Richard Coffman of the GCI. The hexashelter now covers both the Orpheus mosaic and the Hercules and Amazon mosaic adjacent to it.

See Table 1 (facing page) for a summary of the chronological development of the project.

*Nicholas Stanley Price*

*Table 1. Chronology of the Project on Mosaics Conservation, 1988–1989.*

| | |
|---|---|
| *June 1988* | Symposium on Conservation of Mosaics<br>Training Project, Paphos |
| *August 1988* | Inspection of the condition of the mosaic<br>Photodocumentation |
| *September to October 1988* | **Phase 1**<br>Documentation<br>Lifting of the mosaic<br>Removal of the old mortar |
| *May 1989* | Completion of the cleaning<br>Application of the new mortar |
| *May to June 1989* | **Phase 2**<br>Construction of the new support<br>Excavation under the original site<br>Reinstallation of the mosaic |
| *August 1989* | Completion of the infilling of lacunae |
| *October 1989* | Final photodocumentation of<br>the conserved mosaic |
| *November 1989* | Erection of the hexashelter |

# Acknowledgments

The success of the Project on Mosaics Conservation owes much to the excellent cooperation of the Department of Antiquities, directed by Vassos Karageorghis and by his successor, Athanasios Papageorghiou. Demetrios Michaelides, as Archaeological Officer for the Paphos District and as excavator of the Orpheus mosaic, was instrumental in providing archaeological guidance and in ensuring the fullest collaboration of the Department in logistical and organizational matters. Andreas Georghiades, Evangelos Hadjistephanou, Giorgios Tapakoudes, and Neoptolemos Demetriou, also of the Antiquities Department, were particularly helpful.

For the planning and implementation of the fieldwork, Dr. Paolo Mora, former Chief Restorer of the Istituto Centrale del Restauro in Rome, was asked to direct the project. We are indebted to him for agreeing to undertake it, and for teaching during the Phase 1 campaign along with Mrs. Laura Mora and the other instructors listed in Appendix B. To all of these we are grateful for their skillful instruction in addition to carrying out the conservation field operations so successfully.

We also owe a particular debt to J. Claire Dean, who acted as field coordinator throughout the two field campaigns, and who completed conservation and documentation work on the mosaic after its reinstallation. Guillermo Aldana was responsible for photography of the mosaic before and after its conservation.

The hexashelter was developed by Neville Agnew, of the GCI, and was constructed in kit form by Jim Davies at the Institute's workshop. To these individuals, and all those whose names are unlisted but who contributed so much to the success of the project, we are deeply grateful.

*Marta de la Torre*

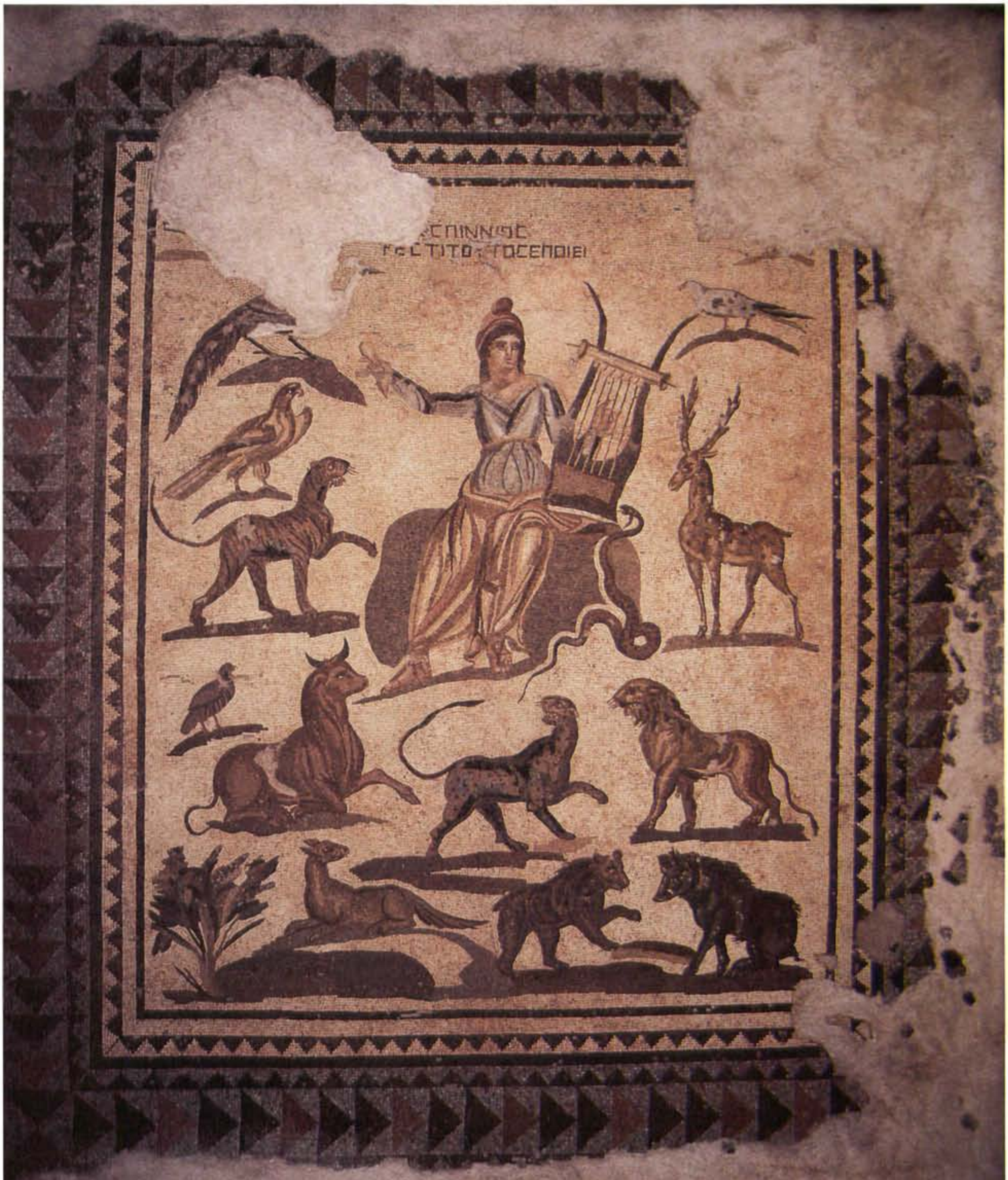


*Plate 1. The Orpheus Mosaic after conservation.*

*Plate 2. The Orpheus Mosaic before conservation.*

*Plate 3 (right). Detail of the Orpheus Mosaic.*

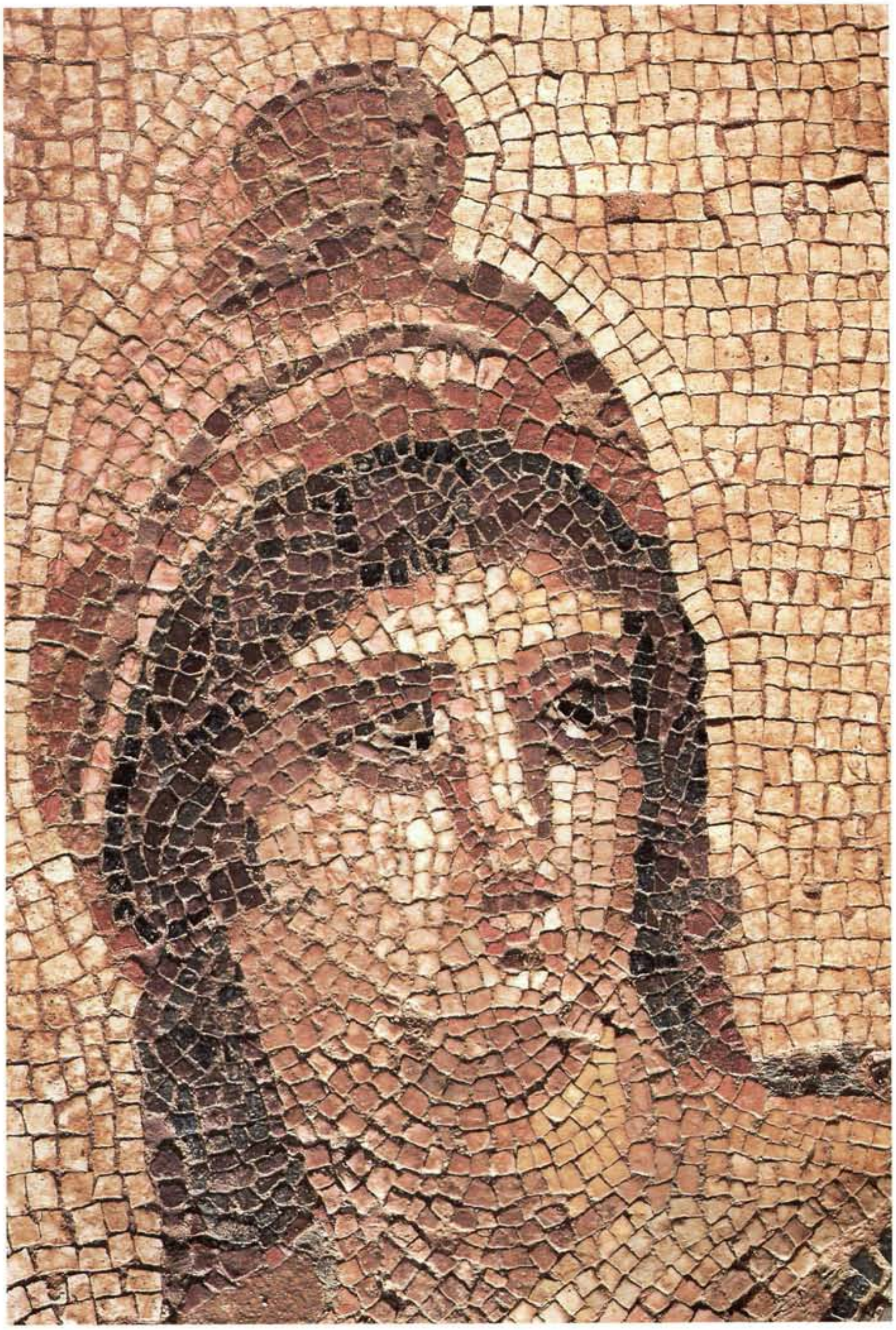
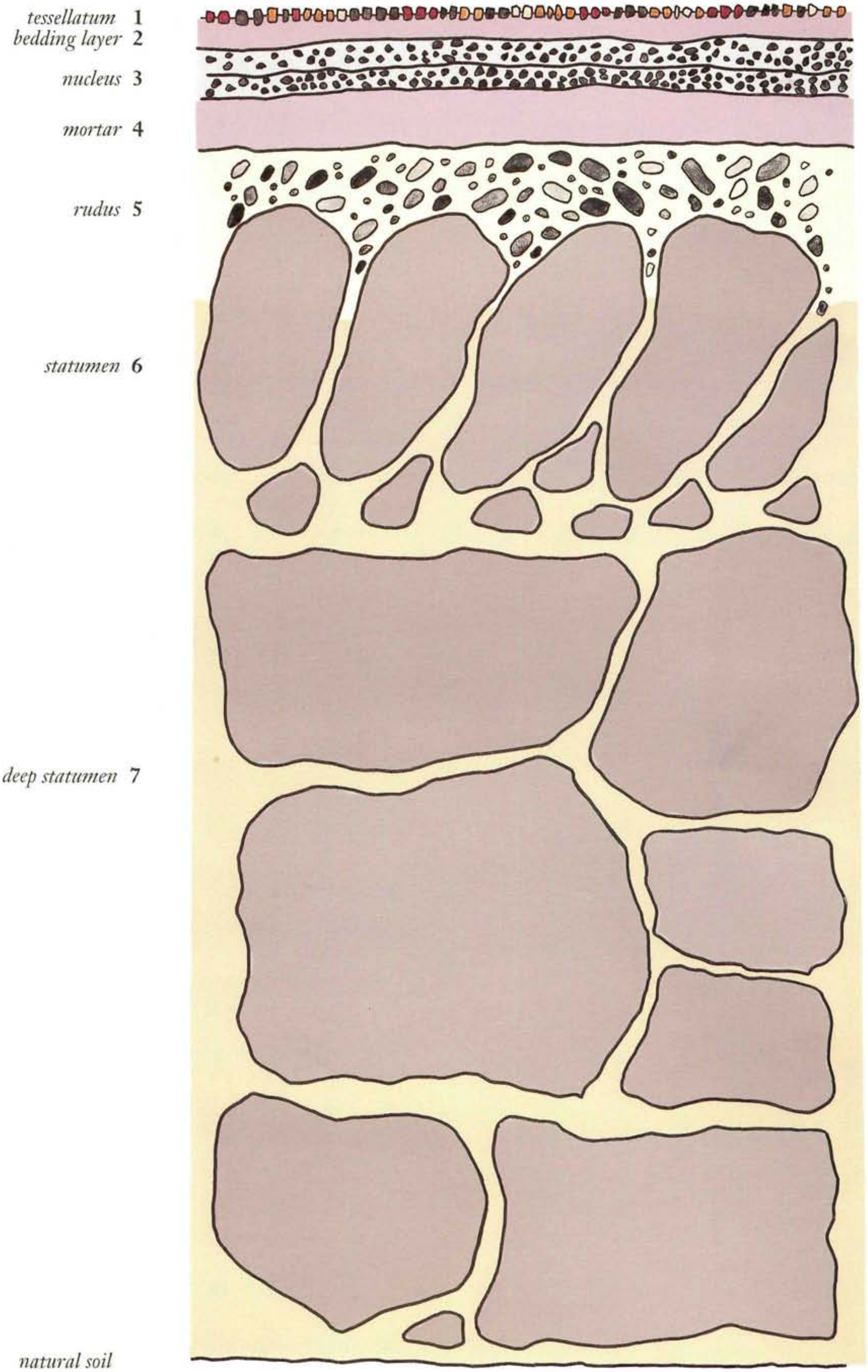


*Plate 4 (right). Amazon panel, House of Orpheus.*

*Plate 5 (opposite). Stratigraphy of the support layers of the Orpheus mosaic. (Not to scale.)*

## *Stratigraphy of the Preparatory Layers*



## *Support Layers*

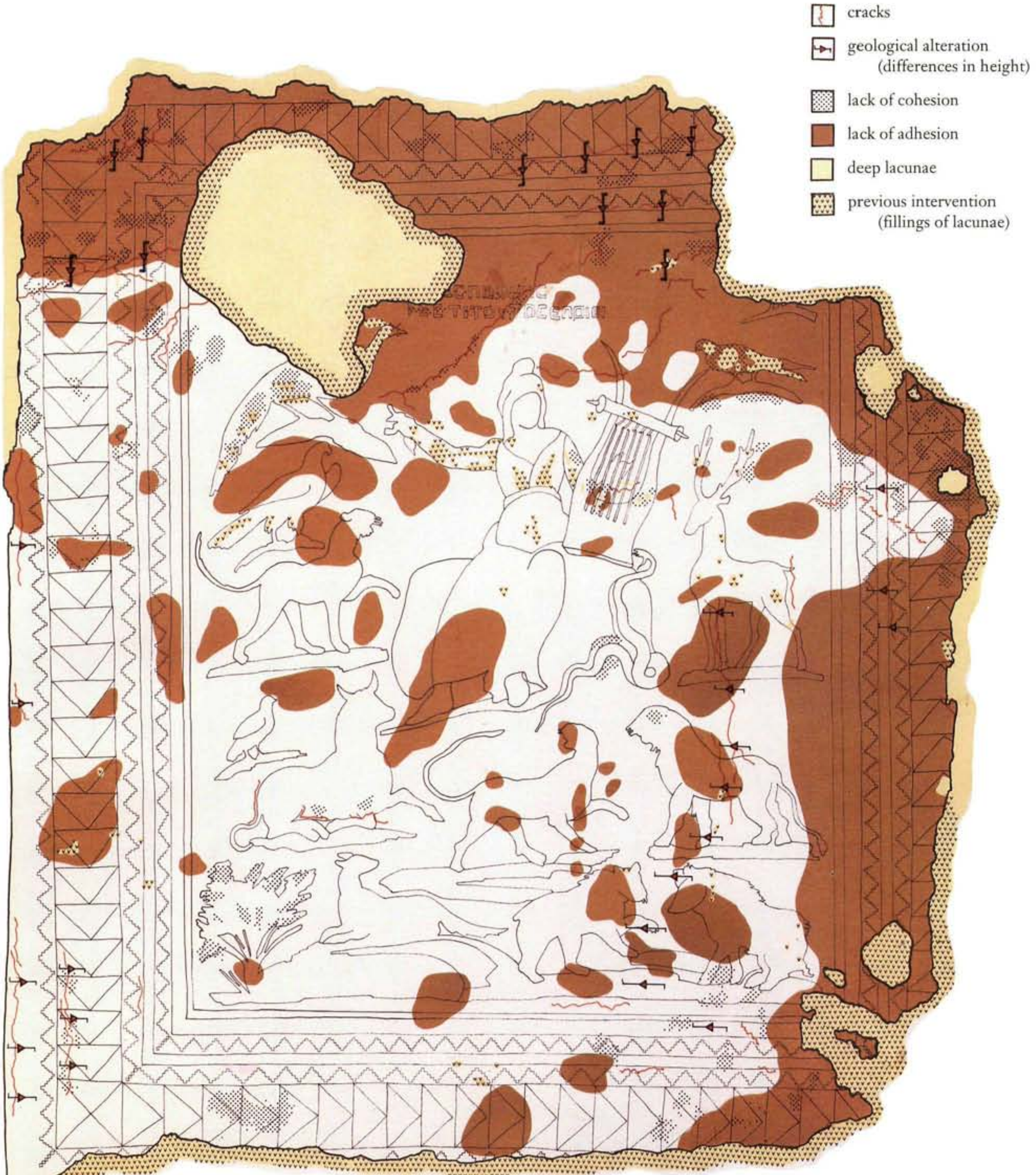



*Plate 6. Condition of the support layers of the Orpheus mosaic prior to conservation.*

## *Tessellatum*


*Plate 7. Condition of the tessellatum of the Orpheus mosaic prior to conservation.*

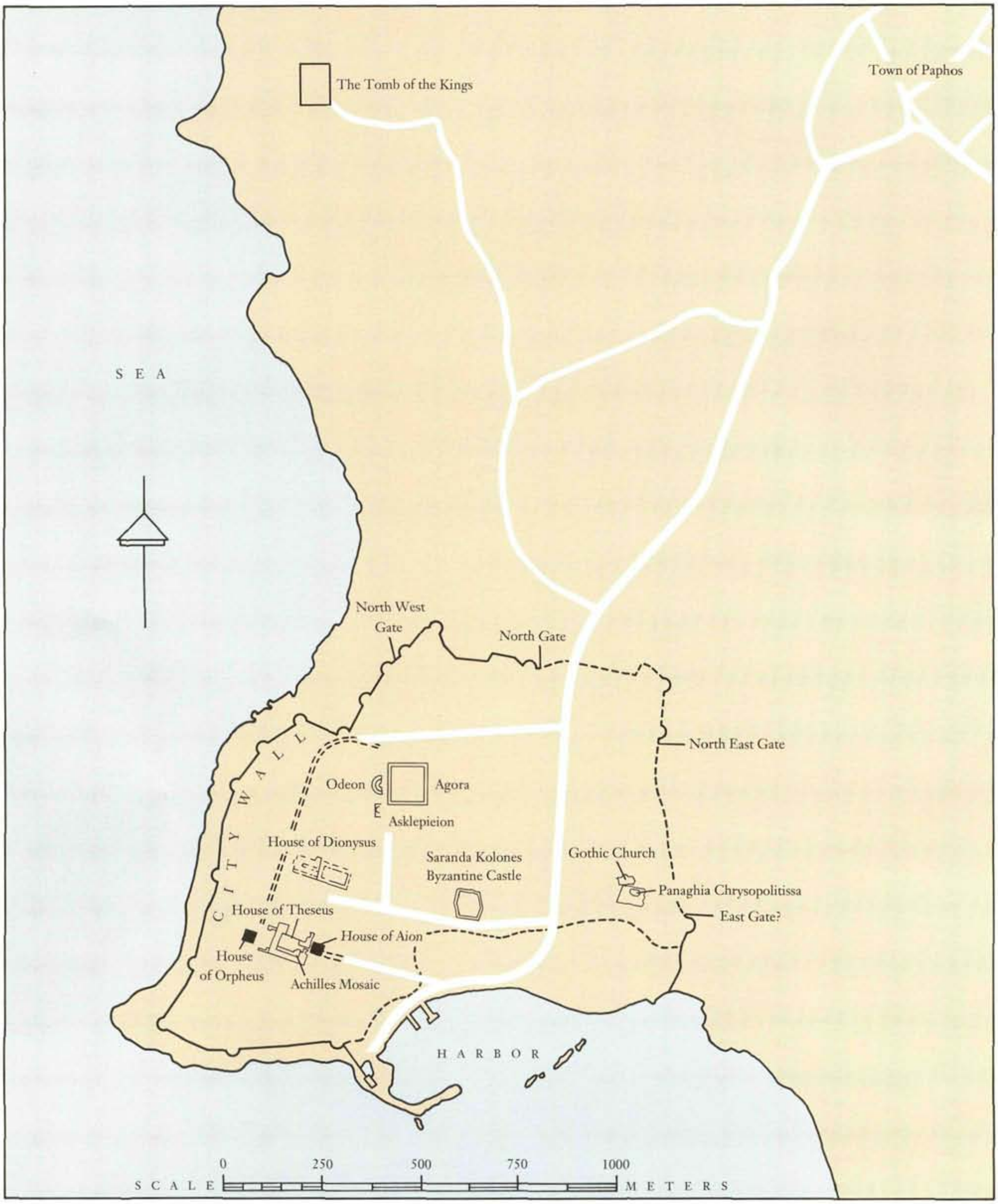



*Figure 1. Map of Nea Paphos. (After the Department of Antiquities, Cyprus.)*

# Nea Paphos: Historical Background

*Demetrios Michaelides*

Modern Paphos, capital of the eponymous district, is situated on the southwest coast of Cyprus (see map, Fig. 1). It was founded towards the end of the fourth century B.C., and was originally called Nea Paphos (New Paphos) to distinguish it from Palaepaphos (Old Paphos), a town about 16 km to the southeast, famous since Homeric times as a center for the cult of Aphrodite. The town was founded by Nicocles, king of Palaepaphos, and although the reasons that led him to this are not entirely clear, the proximity of an excellent harbor would certainly have been a factor.

Soon after the foundation of Nea Paphos, Cyprus came under the rule of Ptolemy, one of Alexander the Great's successful generals, who had by then become king of Egypt. The island was to remain under Ptolemaic rule for most of the Hellenistic period, up to 58 B.C. when the island was annexed by Rome. The Ptolemies showed great care in the administration of Cyprus. The island was of paramount importance to them, as their primary military and naval base outside of Egypt and as an important source of shipbuilding timber, minerals (especially copper), and grain. These factors favored the newly founded city of Nea Paphos; in addition to its harbor, which was an easy sail from the Ptolemaic capital of Alexandria, the city was situated near the mountains, source of the timber and minerals so valuable to the Ptolemies.

For these reasons the city grew rapidly in size and importance. By the late second century B.C. it had become the capital of the island. The city continued to prosper throughout the Hellenistic and Roman periods, and seems to have reached its peak in the later second and third centuries A.D., receiving (probably under the emperor Septimius Severus, A.D. 193–211) the most elaborate and important title of its history: "Sebaste Claudia Flavia Paphos, the sacred metropolis of all the towns of Cyprus." Many of the most spectacular remains now visible in Paphos date from this period, including several private houses with costly and elaborate floor mosaics, such as the House of Dionysus and the House of Orpheus.

The first signs of decline became apparent in the late third and early fourth centuries A.D. The disastrous earthquakes of the first half of the fourth century contributed to this decline, and the final blow came with the transfer of the capital from Paphos to Salamis, a town on the eastern coast of Cyprus.

With the triumph of the Christian faith, Nea Paphos became the seat of the most important bishop of the island. (The city was, after all, the setting for the "Blinding of Elymas," the miracle through which St. Paul converted Sergius Paulus, the Roman proconsul of the island, to Christianity.) In spite of the fact that this privilege, too, was soon lost to Salamis, the town can boast several basilicas built between the fourth and the sixth century that are among the finest and most opulent in the Early Christian world. The floors of the earlier basilicas are decorated with large expanses of mosaic, while the later ones combined mosaic with *opus sectile* (multicolored, patterned marble) decoration.

From the mid-seventh to the tenth century Cyprus was under Arab-Byzantine condominium. During this period Paphos, like the rest of the island, sank into relative obscurity, although its harbor continued to be a fairly busy port of call. The importance of the harbor increased when Cyprus was ruled by the Lusignans (1192–1489) and the Venetians (1489–1570), when it was used by pilgrims traveling to and from the Holy Land, as well as by merchants. The decline of the town, however, was irremediable and reached its lowest point during the Turkish occupation of the island (1570–1878).

Paphos remained the capital of the district under British Colonial rule (1878–1960) and even later when Cyprus became an independent republic, but it continued to be small, poor, and remote. In 1974, with the Turkish invasion and occupation of the northern part of the island and the consequent loss of the big holiday resorts of Kyrenia and Famagusta, the tourist industry turned its attention to the then unspoiled region of Paphos. The tourist boom soon threatened to encroach into the archaeological zone but, thanks to a systematic program of land acquisition by the Department of Antiquities, the largest part of the 950,000 square meters enclosed within the Hellenistic walls of the city is now free of modern buildings and preserved for archaeological research. Since 1981, moreover, the ancient city of Nea Paphos, a considerable part of its necropolis, and the area of the Sanctuary of Aphrodite at Palaepaphos, have been included in UNESCO's World Cultural Heritage List.

# The House of Orpheus

*Demetrios Michaelides*

The site of the House of Orpheus has been known since World War II. In 1942, men of the Royal Air Force digging an air raid shelter uncovered a mosaic depicting Hercules and the Lion. At the time, not much importance was accorded to this find—the mosaic was reburied and the site abandoned. Some twenty years later, the discovery of mosaics in the nearby House of Dionysus prompted their excavator, the late Kyriakos Nicolaou, to search for the "lost" Hercules mosaic. Although he eventually located the mosaic after several trials, he did not attempt the systematic excavation of the site. This was undertaken in 1982 by the present writer, and is still in progress.

These excavations, lasting one to two months a year, have revealed a substantial portion of the structure of the House of Orpheus, covering an area of approximately 32 m x 42 m. Even so, the general outline and plan of the house are by no means clear (Fig. 2). Its eastern and northern limits are clearly defined by two important public roads. The western limit of the house, however, is presently undefined and may have been completely obliterated when the area was under cultivation. Furthermore, to the south, later rebuildings and subdivisions of the *insula* (building block) seem to have changed the original aspect of the house. A monochrome geometric mosaic decorates a room in the southwest corner of the excavated area and may belong to one of these later alterations.

As the building now stands, it appears to have one entrance on the east side, from the road that separates it from the Villa of Theseus, a palatial building believed to have been the residence of the Roman proconsul. A rectangular atrium near the entrance retains part of its peristyle; this has rectangular pillars at the corners, with engaged half-columns, and columns in the spaces between the pillars. The intercolumnia (spaces between the columns) were blocked with a rough-built stone wall at a later stage, at which time an adjacent room to the south was converted into a storage area, as the four large *pithoi* (earthenware pots) found in situ show.

The rooms west of the atrium are smaller and appear to be more private in character (perhaps serving as bedrooms). The northern wing of the building has some of the best preserved features. The northeast corner is occupied by a small bath complex. Two rooms are heated by a hypocaust (an underground furnace); one of these has hydraulic plaster and three-quarter moulding. There

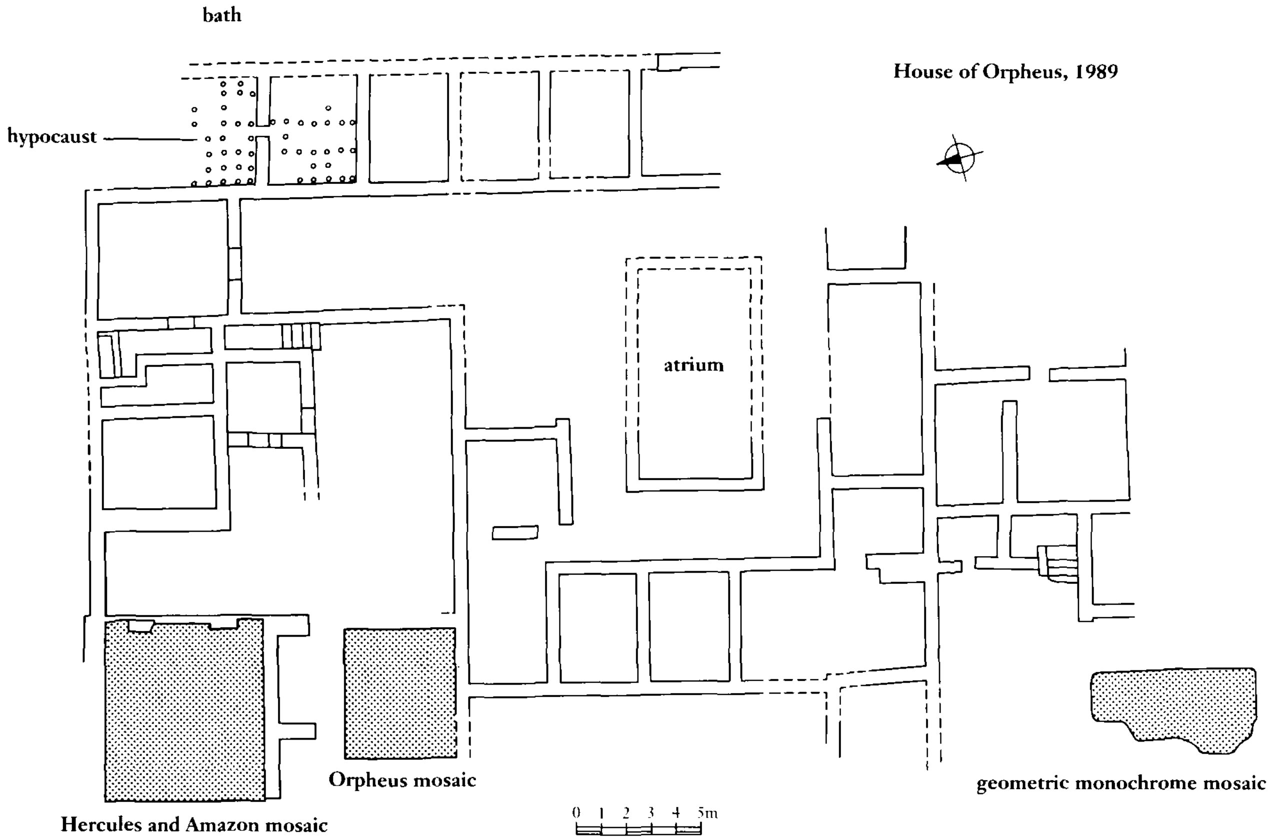



*Figure 2. Plan of the House of Orpheus. (Redrawn after the Department of Antiquities, Cyprus.)*

are also inlets and outlets for water and a number of basins. The *praefurnium* (stoking room), apparently entered from the street to the north, has not yet been excavated. Large discharge channels and ducts show that water used in the baths eventually flowed into one of the main sewers of the town, running under the main east-west road towards the sea.

Two rooms decorated with figural mosaic floors are found west of the baths, on the westernmost limit of the investigated part of the house. The largest room, adjacent to the east-west road, has two figural panels set in a large geometric field: the Hercules panel, mentioned earlier, and another depicting an Amazon. To the south of this room there is a small rectangular chamber, the floor of which has not survived, and further south is the room with the mosaic of Orpheus and the Beasts.

These mosaics, like the rest of the house, date to the late second or early third century A.D., but they represent only the last of a series of structures on the same site. There are clearly visible remains of an earlier building throughout the site, and several walls are built on foundations or stumps of earlier walls. The existence of this and other even earlier structures was confirmed after the lifting of the Orpheus mosaic permitted excavation of the underlying strata. Immediately under the floor was a wall that corresponded to a room, with a hard beaten-earth floor, which formed part of an early Roman house buried under the mosaic. A small trench cut through this earlier floor revealed part of an even earlier structure, with a more rudimentary earthen floor, dating to the mid-Hellenistic period.

Soundings below this level reached bedrock at a depth of 1.55 m below the mosaic floor. The bedrock showed clear signs of quarrying, while the fill between it and the earliest floor included pottery sherds that can be dated to the late fourth century B.C. and are thus contemporaneous with the foundation of Nea Paphos.

Originally, the house must have had more mosaic decoration than the three floors described below, since small fragments have been found in several parts of the site, especially the area of the baths. None of these fragments, however, includes more than a short length of one or another decorative pattern common in Paphos throughout the Roman period.

All the mosaics, complete or fragmentary, are made of tesserae cut from local stone, primarily limestones and basalts. A small quantity of imported bluish-grey marble is used in the background of the Amazon panel and as a background to the band of superposed triangles framing the Orpheus mosaic. Even rarer is the use of tesserae made of glass. None is used in the Hercules panel, while its use in the Amazon panel is restricted to the reins of the horse and details of the Amazon's head. More glass tesserae are used in the Orpheus panel. Single tesserae highlight the eyes of some animals, while the plumage of some birds (most notably the parrot and peacock), and the garments of Orpheus (especially those covering his torso) were largely made of glass. Unfortunately, a large portion of the glass tesserae had disintegrated long before the mosaic came to light.

## The Room of the Hercules and Amazon Mosaic

Of the three surviving mosaic floors, the largest is the one decorated with two panels, one representing Hercules and the lion, the other an Amazon and her horse (Fig. 3). These are set in a geometric field with a polychrome running-pelta pattern, the whole framed by a series of geometric borders and measuring approximately 7 m x 6.5 m. The room is approached from the east through a tri-partite opening formed by two rectangular stone pillars. The two figural panels are arranged in this field in a rather asymmetric manner. That of Hercules is opposite the central door on the east, and one would face it on entering the room. It is not, however, situated on the east-west axis. The Amazon panel acts as a more or less central pseudoemblema, and is situated on the east-west axis. It is, however, off-center and closer to the door on the east. It is also upside-down in relation to the Hercules panel and is meant to be viewed from inside the room. This, and the positioning of the panels, would indicate that the room was a triclinium (dining room). When used as such the three wide areas, on all but the entrance side, would be occupied by couches, leaving an unobstructed view of the Amazon panel in the center.

The Hercules panel (Fig. 4) is rectangular, measuring 1.60 m x 0.69 m, and is framed by a band of grey serrated saw-tooth triangles against a white background. It depicts Hercules' First Labor, his combat with the Lion of Nemea. The naked hero, having discarded his club, is about to grab the attacking lion and throttle it with his bare hands. It is this detail that renders the mosaic unique, because although Hercules and the Lion are commonly represented in ancient art, normal iconography shows the two protagonists already engaged in the fight. In this respect, the scene is iconographically closer to the Hunting Mosaics of the nearby House of Dionysus than to other mosaic depictions of Hercules.

The iconography of the adjacent panel (Pl. 4) is equally unorthodox. Amazons, a common theme in mosaic art, are almost always depicted riding on horseback and either hunting animals or fighting the Greeks. By contrast, this Amazon is standing, almost immobile, in front of her horse. With one hand she holds the reins of the horse, with the other a double axe, the Amazons' favorite weapon. The Phrygian cap on her head is a reminder of her oriental birthplace in northeast Asia Minor. The Amazon panel is almost square, measuring 1.40 m x 1.11 m, and is framed by a wave pattern, red on blue.

*Figure 3. The Hercules and Amazon Mosaic.*

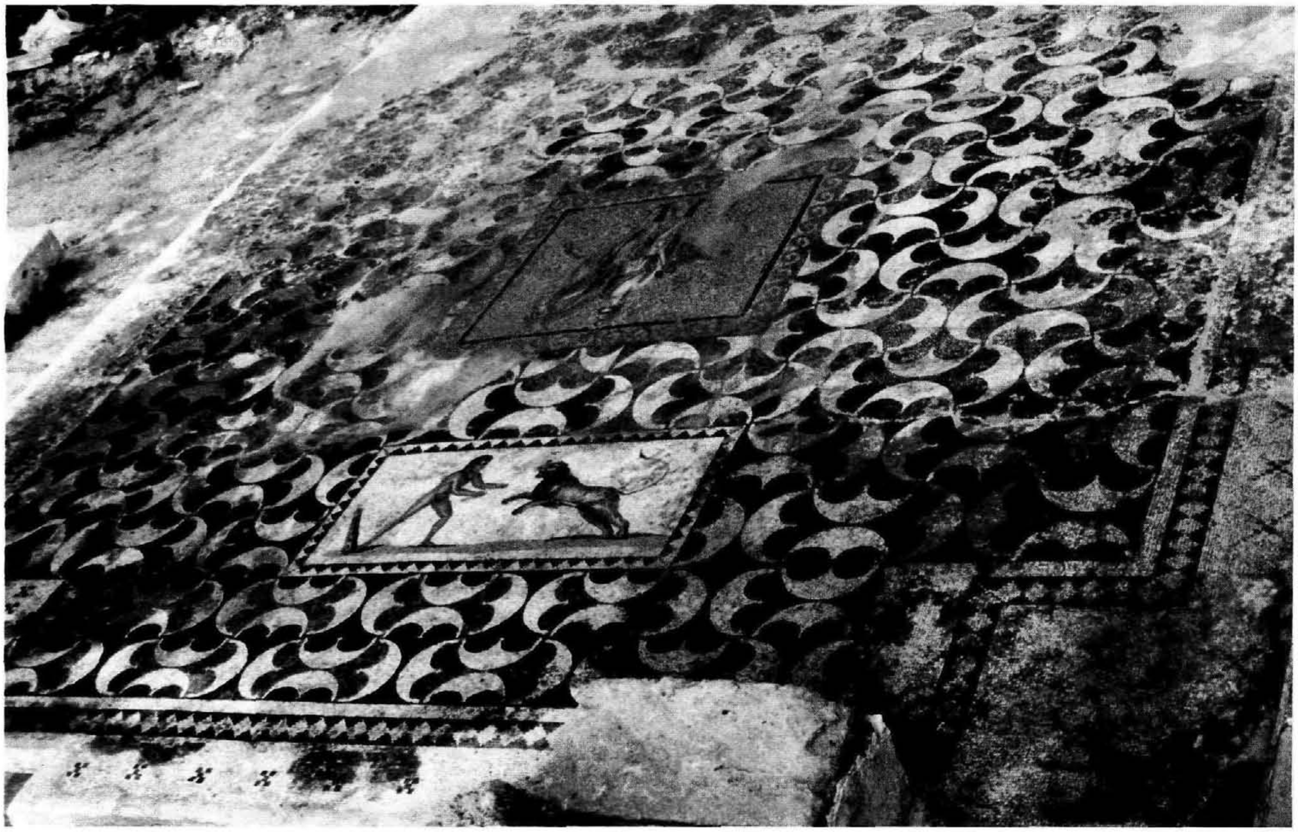


*Figure 4. The Hercules panel.*

In the past, a great number of fresco fragments have been recovered each time another section of this mosaic was exposed. Unfortunately, it is impossible to say much about them except that they show elaborate polychrome floral and geometric designs. Some narrow strips surviving on the north wall, on top of the edge of the mosaic, show that the painted decoration had a red dado and that it was applied after the mosaic had been laid. Larger areas of fresco survive on some broken sections of the rectangular pillars of the tripartite entrance to the east. These show a brightly colored, floral scroll design.

## The Room of the Monochrome Geometric Mosaic

Although the largest part of this mosaic, found at the southernmost limit of the excavated area, was destroyed when the area was under cultivation, the bedding shows that the room must have measured approximately 6.45 m x 4.9 m. It consisted of a central field of adjacent octagons (containing concentric circles) forming squares, the whole framed by a series of unusually wide borders. The technique used in this mosaic is highly unusual. It is monochrome, made entirely of pale greenish-grey tesserae, and the patterns therefore are traced not by color but by the way the tesserae are set. No other mosaic of this kind is known in Cyprus, and merely a handful have been found anywhere in the world.

Because of ploughing activities in the past, and the shallow depth of soil, only a relatively small number of fresco fragments, primarily red, were found above the mosaic. But when the mosaic was lifted for conservation and the underlying area excavated, a surprising discovery was made: a layer of fresco fragments immediately under the mosaic bedding. This layer became deeper towards the center of the room, where a pit 1.0 m deep and 1.3 m in diameter was absolutely filled with fresco fragments. This was clearly dug for the express purpose of holding these fragments, since it contained no soil and little else except a few lamps and some large oyster shells. Evidently these fresco fragments constitute the original decoration of the room, which (either because it was damaged, perhaps during an earthquake, or because the owners wanted something new) was diligently scraped off the walls, buried in the pit, and covered by the mosaic.

There are literally thousands of mostly very small fragments that are presently being sorted by a team of volunteers. It will be years before it is possible to tell whether the entire decorative scheme can be reconstructed, but already it is clear that there are panels with figural decoration in addition to the usual geometric and floral designs. The lamps found together with these fragments give us the end of the first century A.D. as a *terminus ante* for the fresco, and as a *terminus post* for the laying of the mosaic.

## The Room of the Orpheus Mosaic

This room is not particularly large, measuring approximately 4.25 m x 5.10 m. Even so, the mosaic depicting Orpheus and the Beasts is the largest single (non-composite) figural representation so far known on the island (Pls. 1,2). The panel itself (exclusive of the border) measures 2.82 m x 3.40 m, and its frame consists of the following elements: a triple maroon filet; a plain white band; a band of serrated saw-tooth maroon triangles on a white background; a plain black band; a band of serrated saw-tooth blue triangles on a maroon background; a row of superposed right-angled, isosceles triangles, randomly light pink, pink, maroon or brown against a blue background; and finally a band of serrated saw-tooth maroon triangles against a blue background, which extends to form the surround of the mosaic.

The panel has a white background and, in its upper center, Orpheus is depicted sitting on a rock. Of the incidents associated with Orpheus, the mythical poet and musician from Thrace, the most famous is his descent into the Underworld to rescue his dead wife Eurydice. The most commonly represented, however, is the scene depicting the moment when every sort of living creature, tame or wild, gathered to listen peacefully to the magic of Orpheus' divine music (Pl. 1). He is wearing a high-waisted, long-sleeved tunic, a Phrygian cap, and possibly *anaxyrides* (baggy trousers); these denote his oriental origin. Orpheus' half-open mouth shows that he is singing, accompanying himself on a large six-stringed cithara (lyre) propped on the rock to his left. He holds the plectrum in his outstretched right hand, but instead of plucking the strings he seems to be pointing to the effect of his music on the fifteen creatures that have gathered around him. There are eight mammals (fox, bear, boar, bull, leopard, lion, tiger, deer), one reptile (a snake coiling up the rock towards the cithara), and six birds (partridge, eagle, peacock, parrot, and two mostly destroyed, unidentifiable ones). Each creature stands or sits on its own ground line, the mammals in the lower foreground and beside Orpheus, and the birds, logically, at the top of the panel. All except the bear are turned towards Orpheus, and some raise their paws in reverence. A small shrub, in the lower left corner, completes the picture.

No bird or other creature is represented above Orpheus' head, in the top center of the panel, as this space was reserved for an inscription. This, written in large Greek capitals, constitutes the most important feature of the mosaic. The beginning is missing but the rest reads [...]ΟC ΠΙΝΙΟC ΡΕCΤΙΤΟΥΤΟC ΕΠΟΙΕΙ. The first word can easily be interpreted as either [ΤΙΤ]ΟC or [ΓΑΙ]ΟC. This literally means "Titus (or Gaius) Pinnius Restitutus made it," but there are reasons to believe that the man named is not the mosaicist but rather the owner of the house who commissioned and paid for the mosaic. Whatever the meaning, this is a rare type of inscription which remains, so far, unique in Roman Cyprus.

The iconography of the mosaic is also rare. Representations of Orpheus and the Beasts were in great demand during the Roman period, a popularity they owed, to some extent, to the opportunity for depicting a variety of exotic birds and animals. There are nearly ninety known examples of Orpheus mosaics from the Roman world, two of which come from Cyprus: the present example and another (now destroyed) from Salamis. The Paphos mosaic, with Orpheus and the Beasts together in a single panel, adheres to an iconographic tradition common throughout the Mediterranean basin, quite different from those found in northern Europe and Great Britain. It belongs, however, to a rare variety where Orpheus' right hand is not plucking the strings of the cithara, but is outstretched to the right.

In addition to the large number of fresco fragments excavated in the layer above the mosaic, the southern wall of this room preserves a small section of the fresco in place (see Pl. 2). It shows a red dado, 45 cm high, above which there is an 8-cm-wide band of yellow ochre. Further up there are traces, up to 6 cm wide, of yet another red element. This may not be much, but it is a rare and welcome feature in a site such as Paphos which, plundered by stone robbers for centuries, has lost practically all walls and their decoration. When excavated, the brilliance of the colors of the fresco was already reduced, apparently from exposure. A better indication of their original tone is provided by broken fragments found on top of the mosaic. These also show that, further up, the walls were decorated with more intricate geometric as well as floral designs.

The part of the fresco still adhering to the wall provides evidence that it was applied after the mosaic was laid. The mouth of an amphora neck, incorporated in the lowest part of the fresco and leading to a drain on the other side of the wall, suggests that, when in use, the floor was washed with large quantities of water.

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**W. A. Daszewski**

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# The Condition of the Orpheus Mosaic Following Excavation

*Demetrios Michaelides*

The Orpheus mosaic was first located in the excavation season of 1984. After a small area of it had been cleared, it was reburied until resources were available to undertake its full excavation in 1985.

At the time of its excavation, the Orpheus mosaic appeared to be in good condition. The depiction of two birds at the top (west) end of the mosaic had been destroyed by the root action of bushes, leaving large lacunae (see Pls. 1,2). Other roots had dislodged the tesserae and passed under most of the inscription and Orpheus' extended right hand, where the tesserae lacked any firm attachment.

Further damage to the mosaic was evident on the southeast and west sides, where stone-robbing from the walls of the room had destroyed the edges of the mosaic. Most of the walls had been robbed to below their foundations, with the exception of that to the south where the area of wall-painting was still preserved. The mosaic appeared otherwise to be in good condition, despite lying only a few centimeters below the ground surface. It was not uniformly flat, however; a hump running the entire length of the north side of the mosaic was later confirmed to be the result of an underlying wall.

The subsidence caused by the partial support of the mosaic on this underlying wall became more pronounced as the subsoil dried out following excavation, and minor cracking began to appear. It was also suspected (as proved to be the case) that much of the mortar of the setting-bed had lost its cohesion (see condition drawings, Pls.6,7). A consolidation of the mosaic in situ would therefore have been of limited effectiveness, and it was decided to lift the Orpheus mosaic and to provide it with a new support that would be impermeable to capillary rise of moisture before replacing it in situ. In the meantime, the lacunae and the broken edges of the mosaic were mortared for protection.

The decision to use the rolling technique for lifting the mosaic was taken for both practical and didactic reasons. This technique, the general principles of which have been described elsewhere (Barov 1985; Wihr 1978,1983), is particularly appropriate for use when the mosaic to be lifted is (1) easily accessible without surrounding high walls, (2) of a single pictorial composition without regular subdivisions into smaller panels, and (3) in good condition without serious lacunae or preexisting cracks. Each of these criteria was met by the Orpheus mosaic and it was decided, therefore, to lift the mosaic in one piece using the rolling technique, rather than to cut it into arbitrary pieces for individual lifting. At the same time, the operation would provide a good opportunity to train other mosaics conservators in the technique.

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# Photodocumentation of the Orpheus Mosaic

*Giorgio Capriotti and Lorenza D'Alessandro*

Careful documentation is a critical component of any conservation intervention. Before beginning any operation, the object must be studied and analyzed and a range of information recorded, including the technique of excavation and the materials used, as well as the present state of conservation. The choice of "base" document (e.g., drawing, photograph, etc.) and scale of reproduction is determined by the nature of the object, its state of conservation, and the means (equipment) available.

For the Orpheus mosaic, photography proved to be practical, quick, and sufficiently accurate in its results. A complete, detailed image of the mosaic, for documentation purposes, was obtained by subdividing the area into a series of quadrants (each 80 cm x 80 cm), photographing each quadrant with identical methods, and then assembling the individual photographs to form a complete view of the mosaic.

To photograph these quadrants, a wooden structure (Fig. 5) was built to hold the camera (35 mm Canon AE1, 35 mm lens, FP4 film). Each quadrant was photographed with the camera always positioned the same distance from the ground, on axis with the center of the quadrant. The images were printed at a scale of 1:10, following the metric reference provided by tapes delimiting each quadrant. The photographs were then joined to obtain a complete image of the mosaic, the general design of which was traced onto transparent paper. This drawing served as the basis for the final condition drawings.

*Figure 5. Photographing quadrants of the Orpheus mosaic using a camera mounted on a wooden frame.*

The same photographs were used for field documentation purposes, by placing sheets of acetate film over them. Course participants recorded all relevant data on the acetate overlays, using a symbol key devised after close analysis of the work to be documented. Data referring to the preparatory layers and to the mosaic surface were recorded separately.

Finally, the collected information was transferred onto the condition drawings, using the tracing of the mosaic made earlier and standard drafting conventions. The condition drawings are reproduced here as Plates 6 and 7.

# Facing and Consolidation of the Mosaic

*Giorgio Capriotti and Lorenza D'Alessandro*

Before proceeding with the application of a facing to the mosaic, it was necessary to preconsolidate those areas lacking cohesion (see Pl. 7). On fragile red stone tesserae where lack of cohesion was particularly severe, Paraloid B72 (ethyl methacrylate–methyl acrylate copolymer) in Chlorothene (1,1,1 trichloroethane) was infiltrated in different concentrations (3% to 6%) until complete saturation and reestablishment of cohesion was achieved. Similar operations, using ethyl silicate as a consolidant, were carried out on the tesserae of glass affected by flaking phenomena.

Once cohesion was reestablished in the weaker areas, the preliminary operations for the complete facing of the mosaic were carried out. Superficial deposits (earth, remains of mortar from previous interventions, loose incrustations) were cleaned, to allow good adhesion between the tesserae and the layers of facing, and loose residues in the interstitial spaces between the tesserae were extracted with a vacuum cleaner. Areas of detached tesserae were temporarily reinforced with a very thin mortar, composed of one part lime and four parts marble powder in water, which was packed into the spaces between the tesserae using palette knives, scalpels, and fingers.

Strengthened tesserae (of fragile red stone and glass) were faced with thin strips of Japanese tissue and acrylic resin in solution (Paraloid B72 in nitro thinner at 15%). This provided better protection for the more fragile areas by preventing direct contact with the adhesive of the facing material, which was tenacious and difficult to remove. Subsidences in the pavement were faced with small pieces of gauze and acrylic/vinyl resin in emulsion. This emulsion was composed of equal parts vinyl resin (Vinavil NPC, 3:1 in water) and acrylic resin (Primal AC33, also 3:1 in water).

The mosaic surface was then completely faced with two layers of cotton gauze and two of hemp cloth using the same acrylic/vinyl resin. (The cotton gauze and hemp cloth had been washed and ironed and their edges had been trimmed in advance.) Each layer of facing was allowed to dry completely and uniformly, to ensure proper adhesion of successive layers.

The layers of facing were applied without tension, following as far as possible the depressions and deformations of the surface. Particular care was taken to avoid forming folds or overlaps of the borders of the cloth, which would have left uneven impressions in the surface of the mosaic during rolling.

The last two layers were applied so as to leave approximately 50 cm of cloth free along the short ends (east and west), which could be attached with staples to the drum at the beginning and end of the rolling operation (see pp. 17–21). Strips of cloth were sewn along the edges of the long sides of the facing materials to allow attachment of the edges of the mosaic to the drum during transport.

# Detachment of the Wall Painting

*Giorgio Capriotti and Lorenza D'Alessandro*

Before the mosaic could be rolled, fragments of fresco surviving on the one wall still standing on the south side of the mosaic had to be temporarily removed. The fresco, simple bichrome decoration (yellow and red) about 230 cm x 50 cm in size (see Pl. 2), showed extensive loss of cohesion in the surface layers and detachment of the plaster from the stone wall (built of an irregular mix of large and small stones).

The first step in detachment of the fresco was the reestablishment of cohesion in the superficial layers (paint surface and/or plaster) by impregnation with acrylic resin in solution (Paraloid B72 in Chlorothene, from 3% to 6%). Areas of well-preserved paint film were then faced with layers of thin Japanese tissue and acrylic resin in solution (Paraloid B72 in nitro thinner at 10%). The Japanese tissue in this case acted as a protective layer between the paint surface and successive layers of facing, preventing any impression of weave on the paint film.

The entire area was first faced with thin cotton gauze and acrylic resin in solution (Paraloid B72 in nitro thinner at 15%), then with medium-weight hemp cloth (using Paraloid B72 in nitro thinner at 20%). A border of approximately 40 cm was left along the upper edge of the fresco; this was attached to a plank that would support the weight of the fragments during detachment.

The fresco was divided into three sections along the lines of existing cracks, to allow easier detachment and transportation of the fragments; the gauze and cloth were cut along these lines. The mortared borders of the fragment, applied in the past to anchor it to the wall, were removed mechanically. The three sections of the fresco were detached using steel rods with sharpened blades and chisels, working from the bottom towards the top to avoid creating dangerous pockets of detritus. The thickness of the detached fresco fragments varied from 2 cm to 4 cm. Fresco fragments were transferred onto flat panels cut to size and were packed where necessary with layers of cotton.

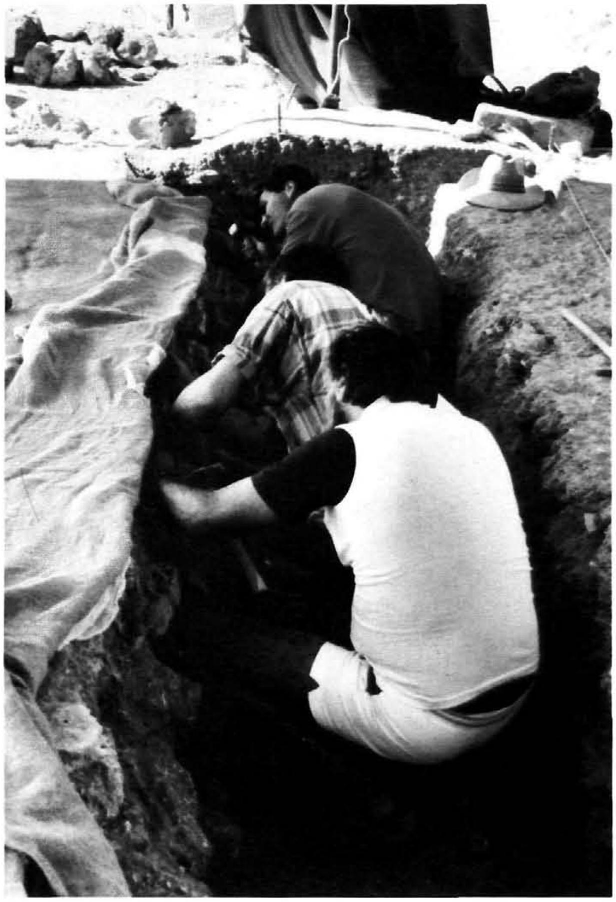
The detachment operation succeeded perfectly, without any loss of fragments. Interesting fragments of arriccio (the support layer behind the wall painting), similar to those from adjacent parts of the site, were also discovered. In addition, two complete rows of mosaic tesserae were recovered at the base of the fresco, indicating that the pavement mosaic had already been completed before the wall was plastered and painted.

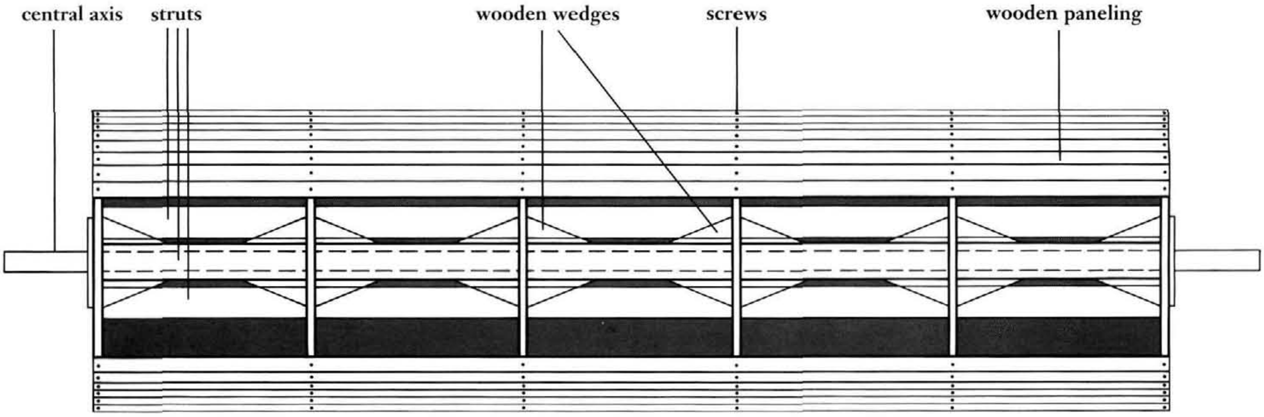
# Detachment and Rolling of the Mosaic

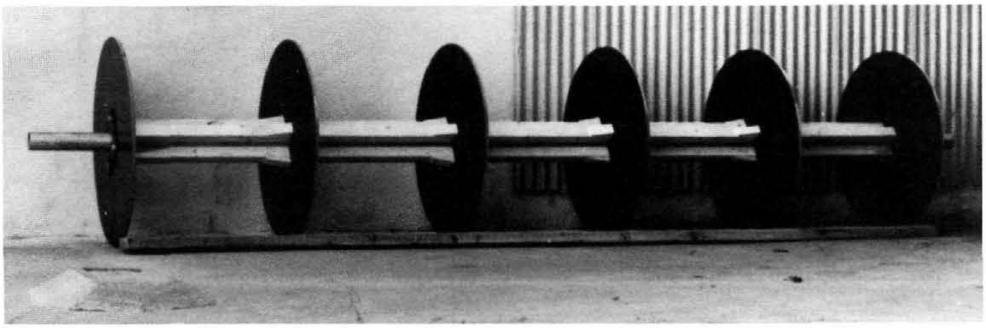
*Jan Kosinka*

In order to begin detachment of the mosaic from the west end, it was necessary to excavate a trench to have access to the bedding layers of the mosaic (Fig. 6). This trench, running the length of the west side of the mosaic, was excavated with appropriate archaeological techniques under the supervision of Demetrios Michaelides. Once the bedding layers were undercut and the tessellatum began to be detached, the drum was rolled into position and the cloth overlap extending from the mosaic surface was stapled to the drum to start taking up the detached tessellatum.

*Figure 6. Initial undercutting of the mosaic from the west end.*





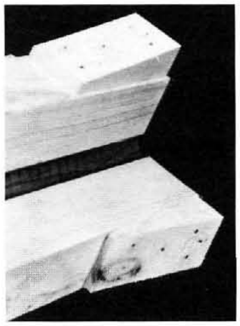


*Figure 7 (top). Internal construction of the drum. (Redrawn after Jan Kosinka. Not to scale.)*

*Figure 8 (above). (a, left) Internal structure of the drum, showing struts and disks. (b, right) Wooden wedges attached to struts to provide additional support.*

The construction of the drum used for rolling the Orpheus mosaic depends on four internal horizontal struts that constitute its point of principal force (see Fig. 7). These are attached to the ends of the drum, parallel to, and at a minimal distance from, the metal pipe (7.5 cm in diameter) that serves as the axis. On the struts is fixed a series of discs, made of coated plywood 1.8 cm thick and spaced about 1 m apart (Fig. 8a). The outer circumference of the drum is covered with boards, 5 cm wide and 2 cm thick, attached to the discs with screws. Strong wedges of wood[1] placed in the angles between the internal struts and the discs (Fig. 8b) give the joints a greater capacity to withstand the force exerted on the drum during the rolling of the mosaic. The central pipe is fixed to the ends of the drum by means of two metal sheets, screwed onto the wooden discs at each end and soldered onto the metal pipe (Fig. 9).

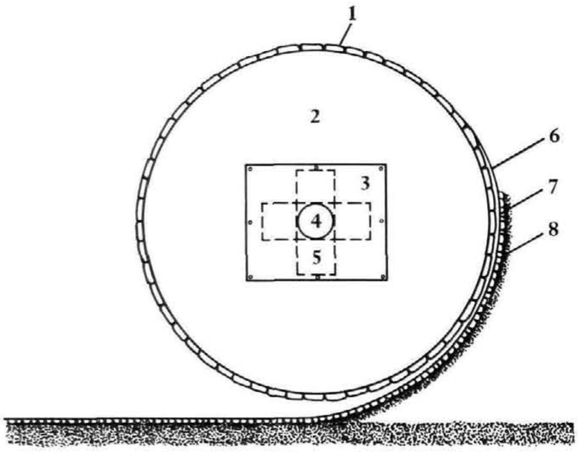
The projecting ends of the metal pipe that serves as the drum's axis rest on wooden side-rails constructed on the north and south sides of the mosaic floor (Figs. 9–11). The side-rails are constructed on an ascending slope so that the drum, as it is rolled forward gathering the mosaic and therefore increasing in bulk and weight, never rests upon the mosaic surface. The risk of damaging the tesserae on parts of the mosaic yet to be rolled is therefore greatly diminished.

The rolling operation was made easier by exploiting the presence of the two lacunae at the west end of the mosaic, the end from which the rolling

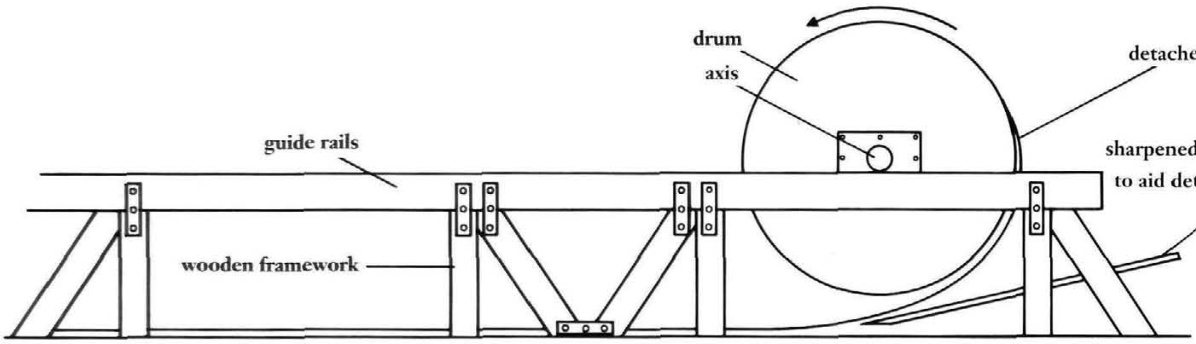
*Figure 9 (right). End view of the drum. (Redrawn after Jan Kosinka. Not to scale.)*

*Figure 10 (below). Drum sitting on wooden rails, as originally designed. The presence of the south wall prohibited the use of this design; rails were laid atop stone pilings, as illustrated below. (Redrawn after Jan Kosinka. Not to scale.)*

*Figure 11 (bottom). The drum in its locked position on the wooden rails, with canvas facings attached.*




1. external paneling
2. wooden disk
3. metal sheet soldered to axis and screwed to end of drum
4. axis (metal tube)
5. wooden struts
6. canvas attached to drum with metal staples
7. tessellatum
8. remains of mortar

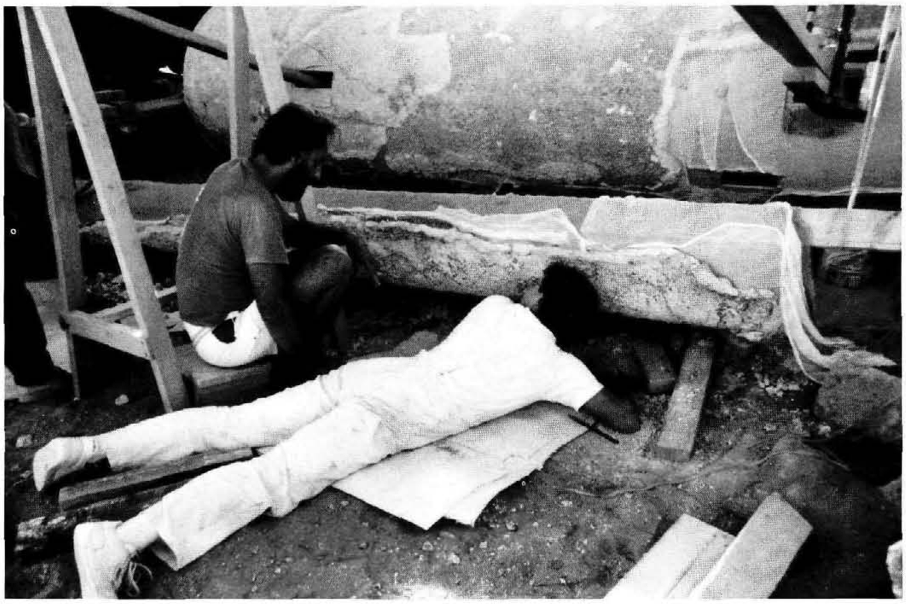


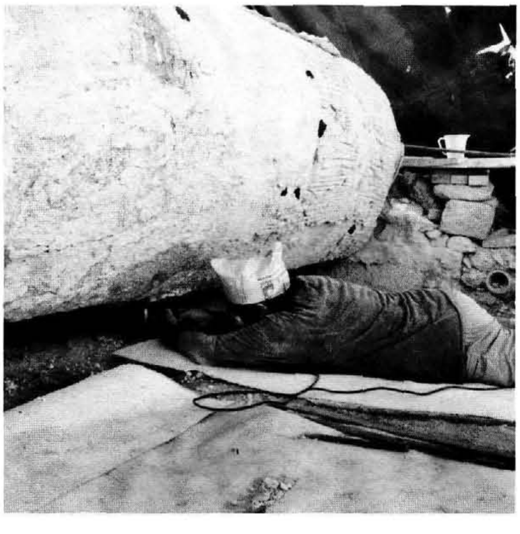

operation commenced. Once the area with these lacunae had been rolled onto the drum, it was possible to cut through the facing fabric, the temporary mortar consolidation, and the wooden panels of the drum, in order to insert wooden poles radially into the drum (Fig. 12). These acted as levers and greatly facilitated the turning of the drum. When the detachment and rolling operation reached a point about 1 m from the east end of the mosaic, it was decided to simplify and speed up the process by working simultaneously from both sides of the drum.

Detachment of the south side of the mosaic proved quite difficult. In this area, flanking the surviving wall, the ancient mortar was in good condition and tenaciously resisted attempts to separate it from the mosaic surface. It was necessary to carry out the cutting with a fraise (a tool with a rotating disk for cutting

*Figure 12 (right). Detachment of the mosaic from the east end. The drum is stabilized with supports exploiting lacunae in the mosaic surface.*

*Figure 13 (below right). Undercutting the mosaic using a fraise.*

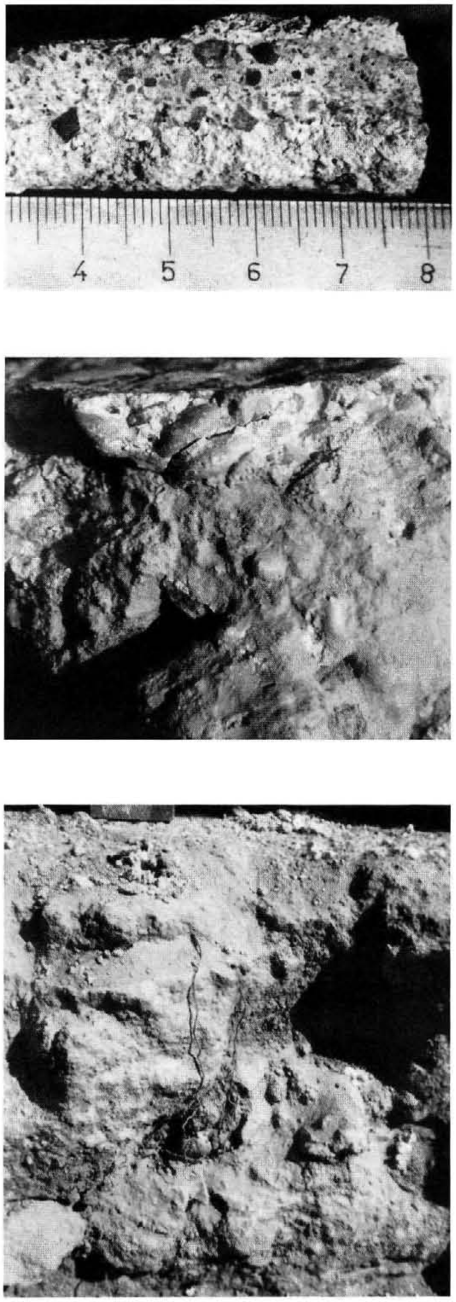




stone material) from underneath, cutting the mortar in rectangles and thereby facilitating the rolling of the mosaic (Fig. 13).

In the course of the detachment operation, the preparatory layers underlying the Orpheus mosaic were recorded (Fig. 14; Pl. 5).[2] Of particular note are fragments, approximately 2 cm x 1 cm, found between levels 2 and 3; these show traces of red coloring material and were probably part of the preparatory design drawing (sinopia) to define the spaces of the mosaic floor. Another fragment, found between levels 3 and 4, shows evidence of freshly incised rectilinear lines.

*Figure 14. Stratification of the preparatory layers. See Pl. 5 for a schematic diagram of these layers. (a, top) Levels 2 (bedding layer), 3 (nucleus), and 4 (mortar). (b, middle) Levels 5 (rudus) and 6 (statumen). (c, bottom) Levels 6 and 7 (deep statumen).*



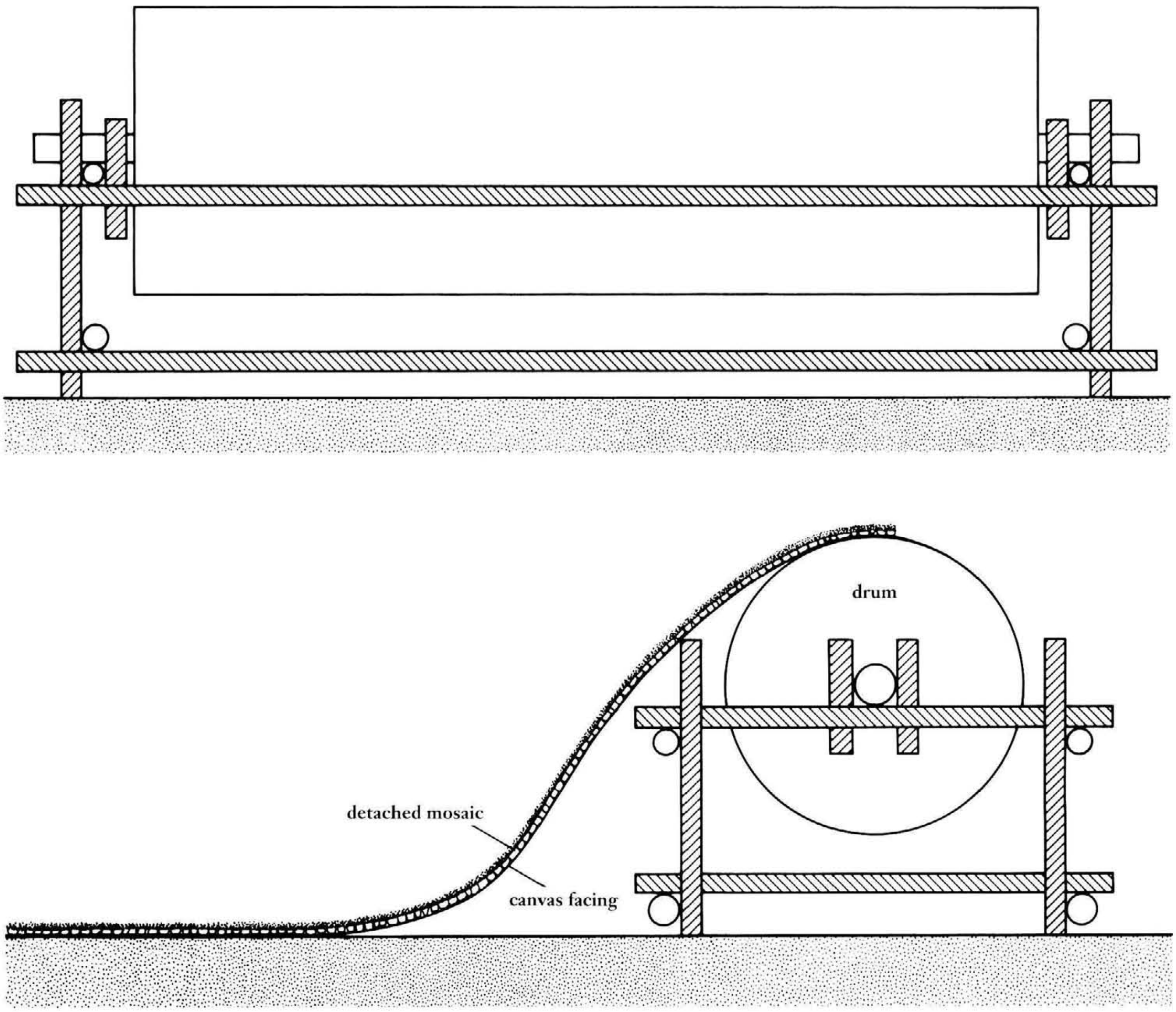



*Figure 15. (a, top) Temporary support for the drum, built of scaffolding. Scaffolding clamps are fixed at every point where tubes cross. (b, above) Unrolling the detached mosaic from the drum. (Redrawn after Jan Kosinka. Not to scale)*

When detachment of the tessellatum was complete, the drum was relocated to its original position at the start of the side rails, to allow heavy machinery easier access to the mosaic. A bulldozer with a large, maneuverable scoop, from which the ropes attached to the drum could be suspended, was used to transport the mosaic.

The drum and mosaic were transported to a concrete platform that had been constructed by the Department of Antiquities approximately 50 m away. It was placed on a temporary support built of scaffolding tubing (Fig. 15), then unrolled face down with a sheet of polyethylene between the concrete platform and the mosaic (Figs. 16,17). It is very important that the polyethylene sheet be stretched completely flat prior to unrolling the mosaic, as any creases in the sheeting will be permanently impressed in the surface of the tesserae.

*Figures 16 and 17. Unrolling the mosaic on the concrete platform.*

**Notes**

1. The suggestion to place the wedges in the angles between the internal struts and discs was made by Aristodemos Mikellis, the carpenter of the Department of Antiquities, who constructed the drum. His skill at overcoming numerous obstacles in meeting design requirements with local resources was of great value to the project.

2. Recording of the preparatory layers was carried out by Giorgio Capriotti and Lorenza D'Alessandro, who provided the information and photographs in this section.

# Cleaning the Back of the Mosaic

*Paolo Pastorello and Werner Schmid*

Technical considerations required that all disintegrated material still present on the back of the mosaic surface be removed, since it might prevent good adhesion between the tesserae and the new preparatory layers. The mortars of the preparatory layers of the Orpheus mosaic were all found to be in an advanced state of deterioration, due to loss of internal cohesion and lack of adhesion between the various layers. During the detachment of the mosaic surface from the original support, it was confirmed that a large part of the mortar of the rudus and of the nucleus, lacking any adhesion to the tessellatum, had already separated from the back of the mosaic.

Those areas that retained greater internal cohesion and perfect adhesion to the tesserae were thinned down and cut in a rectangular pattern using a fraise (see pp. 20–21, Fig. 13); this allowed the tessellatum to adapt to the curved surface of the drum with less chance of damage. Before transferring the mosaic onto the concrete platform that would serve as a work area, the thickest areas of the setting-bed mortar were removed using a hammer and metal chisels, to lighten as much as possible the drum and its fragile load (Fig. 18).

After unrolling the mosaic face down on the concrete platform, the back was cleaned using the following tools: wood chisels of various sizes, small saws, rasps, stainless steel brushes, natural and synthetic hard-fiber brushes, and scalpels. The aim was to remove all residual material of the mortar layers down to the thin stratum of the setting-bed as delicately and gradually as possible. Manual

*Figure 18. Removal of thicker residues of mortar with hammer and chisels before lifting the detached mosaic.*

tools, which allowed greater control over the depth of the work to avoid damaging the underside of the tesserae (particularly the very fragile glass tesserae), were therefore preferred.

After using abrasive and cutting tools to remove the disintegrated mortars of the preparatory layers, cleaning of the back of the mosaic continued using more precise tools. This operation is traditionally called the *spillatura* because it is carried out using *spilli*, small metal awls, although these are now supplemented with precision electrical instruments. The tools used on the Orpheus mosaic included fine stainless steel awls, dental drills with microfraises (rotating cutters), and vibrating cutters with the tip modified to a chisel-shape (Fig. 19).

The aim of this operation was to free the interstitial spaces of the tesserae of residues from the disintegrated setting-bed and of all traces of organic matter and earth accumulated between the tesserae during burial, which might interfere with adhesion between the mosaic and its new support. The residues from the cleaning operations were removed using a vacuum cleaner (Fig. 20). Finally, the back of the mosaic was disinfected using a biocide (Metatin N 5870/101, see p. 59) applied by brush.

*Figure 19 (above). Section of mosaic back after* spillatura.

*Figure 20 (above right). Vacuuming the back of the mosaic.*

# INSTALLATION OF A PROVISIONAL SHELTER FOR THE MOSAIC

*Paolo Pastorello and Werner Schmid*

Because of the possibility of substantial winter rains in the interval before the new support would be completed, the mosaic was covered with a thick protective layer of inert material, in contact with the underside of the tesserae, and then with a protective shelter.

The structure of the roof shelter was built of steel tubing of the kind used in scaffolding, assembled by means of coupling clamps and covered with corrugated sheets of galvanized steel (Fig. 21). The shelter roof was built at an angle that would assure efficient run-off of rainwater, but not offer too large a

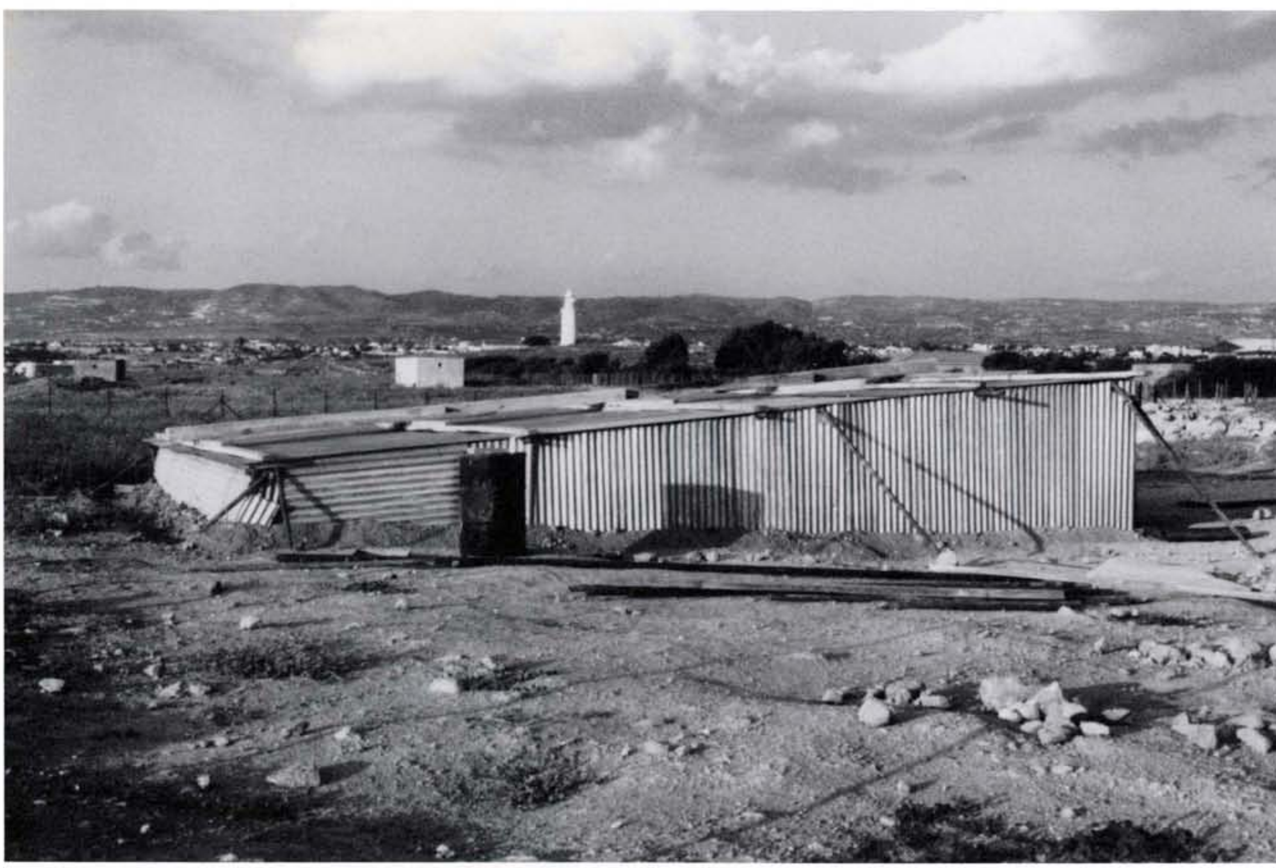
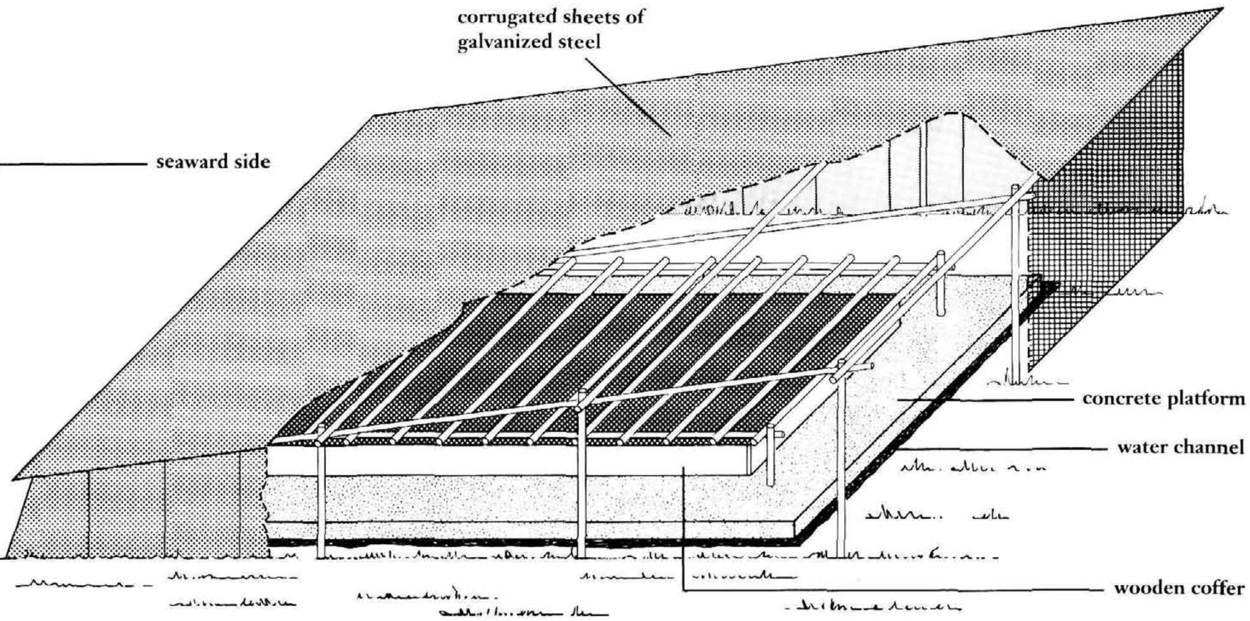


*Figure 21. Temporary shelter over the Orpheus mosaic.*



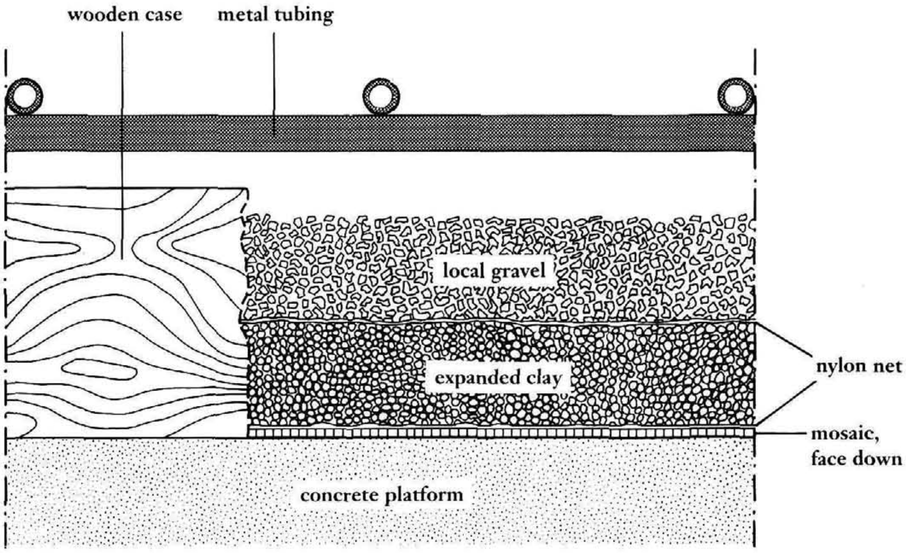




*Figure 22 (top). Cut-away view of the temporary shelter. (Redrawn after W. Schmid)*

*Figure 23 (above). Cross-section of the layers of inert material over the mosaic. (Redrawn after W. Schmid)*

surface area to wind gusts. It was considerably larger than the platform on which the mosaic lay and was enclosed on the three sides exposed to local winds so as to avoid water infiltration (Fig. 22). It was open on the east side to guarantee good airflow, but a fine-mesh plastic net was installed to close off this side and to exclude animals and birds. Strata of inert material were laid over the back of the mosaic to further protect it from weather, biological attack, vandalism, and possible theft (Fig. 23).

A sheet of polyethylene had previously been laid down between the mosaic and the concrete platform, and a broad-spectrum biocide had been applied to the back of the tesserae. A fine-mesh nylon net was then stretched over the mosaic and over the edges of the wooden coffer that surrounded it, to facilitate later removal of the first layer of inert isolating material. This material, a layer (approximately 20 cm) of expanded clay pellets (Fig. 24), has been tested many times in similar situations.

A second nylon net was laid over the expanded clay, followed by a layer of 20 cm of local gravel which, because of its weight, represented a reasonable deterrent to potential theft. A reticular structure, of the same tubular scaffolding elements used for the roof, was then constructed a few centimeters above the second protective layer for added security (Fig. 25).

*Figure 24 (right). Spreading clay pellets over the nylon net.*

*Figure 25 (below right). Structure of scaffolding poles constructed over the mosaic for additional security.*

# Reinstallation of the Mosaic

*Jan Kosinka*

## Preparatory Work

Following removal of the material used for winter protection and further cleaning of the back of the mosaic, all glass tesserae and those of one particularly friable stone material were consolidated. The consolidant used was Paraloid B72 dissolved in toluene in an initial percentage of about 3%, increased until a concentration of 10% was reached. The applications were continued until the material was fully saturated.

The lacunae that could be reintegrated were filled with mosaic material recovered during excavation and detachment operations. Lacunae that were difficult to reintegrate (e.g., inner figures, extensive areas) were filled with a "thin" mortar composed of slaked lime, marble powder, and a small quantity of white cement sufficient to give the mortar a greater coherence.

A mortar consisting of five parts white cement, two parts marble powder, one part brick dust, one part aerated pozzolana, and one part Lafarge hydraulic lime was then applied to the back of the mosaic (Fig. 26). The mosaic was fully wetted, to improve adherence, and the mortar was made to penetrate as far as possible into the interstices of the tesserae to provide greater strength. The mortar was beaten with trowels and finally thinned down, to reduce weight and improve flex-

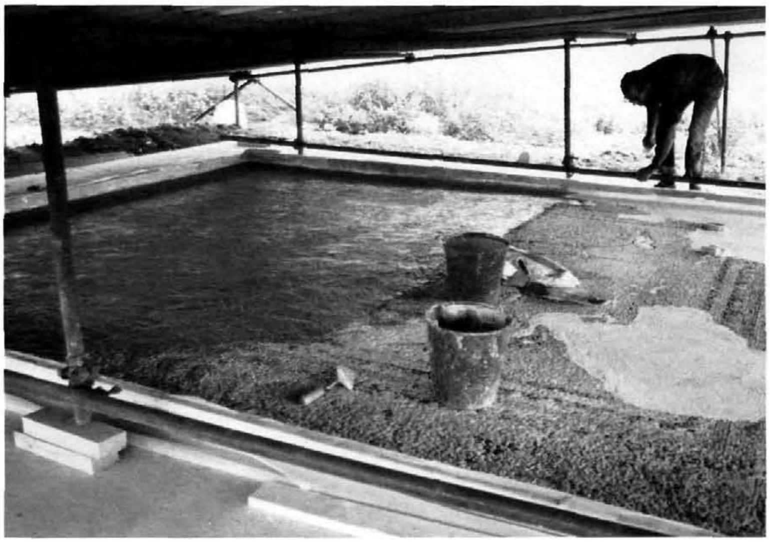


*Figure 26. Applying the new mortar to the reverse of the mosaic.*

ibility during the process of turning the mosaic over. The mortar was wetted continuously for one week and then left to set slowly over a three-week period.

The mortar applied to the back was leveled and thinned using a mechanical grinder. This operation removed the thin crust that had formed on the cement and eventually reduced the thickness of the mortar to the point where the higher tesserae were visible.

The wooden coffer was dismantled and replaced with another, also of wood covered with plastic.

## The New Support

The panels making up the new support are Aerolam lightweight "F"-boards manufactured and supplied by Ciba-Geigy (UK). Each board is 2.44 m x 1.22 m and approximately 5 cm thick. They are ready-made bonded honeycomb sandwich panels, consisting of a core of Aeroweb aluminum honeycomb between plastic skins reinforced with woven glass fiber.

The honeycomb panels were cut to size and small insets (approximately 5 cm x 5 cm) were cut into the panels, distributed around the edges at regular intervals of about 50 cm; these were used for injecting resin into the joins between panels. The frame of the support was made of lengths of reinforced aluminum, T-shaped in section, inserted in the joins between panels. Perforations were made in the aluminum, corresponding to the insets on the edges of the honeycomb panels, for self-threading Parker screws (Fig. 27).

The entire structure described above was tested several times "dry" to ensure that all joins and measurements were correct (Fig. 28). The necessary quantity of chopped mat fiberglass (weight: 330 g per $m^2$) was then cut to size, and the appropriate quantity of resin was mixed. Epoxy resin from Ciba-Geigy

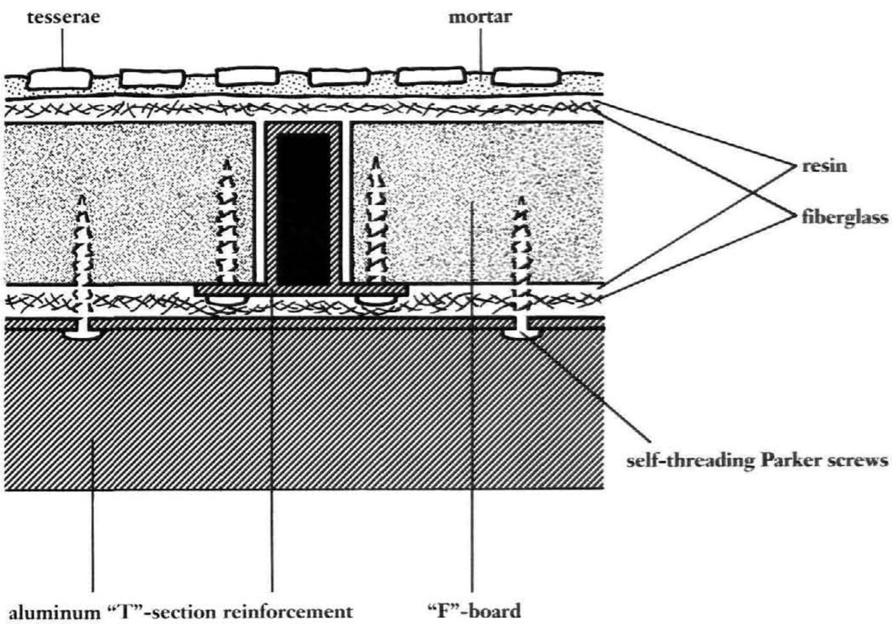



*Figure 27. Cross-section of the mosaic support. (Redrawn after J. Claire Dean. Not to scale.)*

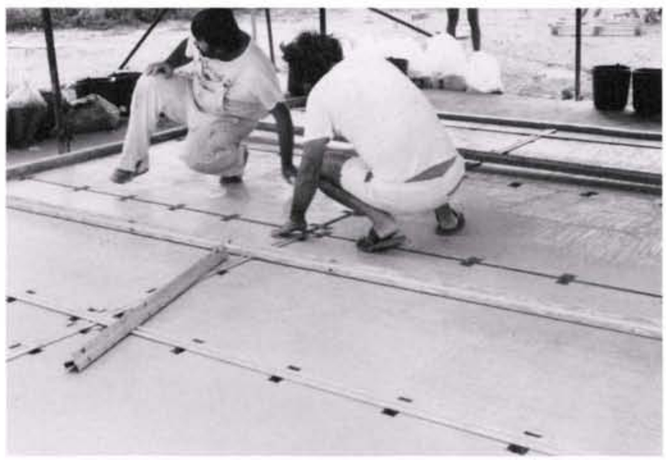
(LY560 with hardener HY560) was used, in a ratio of five parts resin to one part hardener. This was poured into buckets and mixed, using mixing paddles affixed to heavy-duty drills, with marble powder (roughly 1 part marble to 2 parts epoxy) that had been sieved using window screen.

The resin was spread on the back of the mosaic in bands no wider than a sheet of fiberglass (Fig. 29). The fiberglass sheets were laid in place and another coat of resin applied. After the epoxy/fiberglass layer had cured, its surface was roughened with a mechanical grinder, as were the surfaces of the panels (Fig. 30) and the aluminum reinforcements. The aluminum was also degreased with acetone.

*Figure 28 (right). Testing the support "dry" to ensure that all joins and measurements are correct.*

*Figure 29 (below). Applying the first layer of epoxy to the back of the mosaic.*

*Figure 30 (below right). Roughening the surface of one of the panels.*



The panels were positioned on the mosaic, then each was lifted in turn, the epoxy was applied beneath it, and it was replaced in position. The aluminum reinforcements were then put in place. The next day, after the epoxy beneath the panels had cured, the inserts around the reinforcements were filled with more epoxy (Fig. 31).

The following day an additional layer of epoxy and fiberglass was applied (Fig. 32). Once that had cured, a second set of inserts was cut to allow attachment of another set of aluminum reinforcements, installed perpendicular to the first and fixed in place with screws and epoxy (Fig. 33). These allowed the mosaic to sit clear of the concrete slab.

The outer wooden coffer was removed and the edges of the backing were trimmed and tidied. L-shaped aluminum sections were cut and attached around the edge of the mosaic to form a frame, adding stability to the edge as well as giving it a more finished look.

*Figure 31 (above). Pouring epoxy into the inserts in the panels.*

*Figure 32 (above right). Applying the final layer of fiberglass and epoxy.*

*Figure 33 (right). Installing the second set of aluminum reinforcements.*

*Figure 34. The mosaic, with its new support, being lowered onto its original site.*

When the resin had cured, the panel was turned over, first with the assistance of levers and a mechanical hoist, and then with the help of a crane (Fig. 34).[1] The weight of the mosaic pavement without mortar is estimated at 20 kg/m$^2$. The combined weight of the whole panel (pavement and support) is a little over 1000 kg (see Table 2 for the weight of the support materials).

*Table 2. Materials used for the new support, with an estimate of their weight.*

| | |
|---|---|
| Epoxy resin LY 560 | 200 kg |
| Hardener HY 560 | 50 kg |
| Honeycomb panels (8 panels) | 140 kg |
| Marble powder | 100 kg |
| Aluminum T- and L-sections | 50 kg |
| Fiberglass, 50 m$^2$ | 20 kg |
| Hydraulic lime | 20 kg |
| Aerated pozzolana | 10 kg |
| White cement | 50 kg |
| Brick powder | 10 kg |
| Total | 650 kg |

## Reinstallation of the Mosaic

Once the mosaic had been lifted, and the underlying area fully excavated, the excavated remains were protected with a polyethylene sheet and the trench backfilled with excavated stone material (Fig. 35). This provided a strong foundation for the concrete slab, prepared by the Department of Antiquities, on which the mosaic was reinstalled. Wooden boards placed on the slab beneath the mosaic allowed workers to shift the mosaic into its exact original position, after which they were removed.

With the mosaic in place, the facings were removed. To facilitate this, compresses of wetted foam rubber were applied to the mosaic surface. These were left in place for between 48 and 60 hours—sufficient time to reswell the adhesive of the cloth layers and to make them lose their adhesion to the mosaic surface. The cloth was gradually removed using a steady pulling force parallel to the surface (Fig. 36).

The next phase of work consisted of cleaning the remains of the glue from the interstices of the tesserae. At the same time the temporary mortar in the lacunae was removed. To clean the small lacunae more carefully, a very small pneumatic hammer was used.

The large lacunae were integrated with a mortar composed of eight parts marble powder, eight parts yellow sand, four parts black sand, one part brick powder, four parts white cement, and four parts Lafarge lime. Small lacunae were integrated with a darker mortar composed of four parts black sand, eight parts yellow sand, one part brick powder, one part marble powder, two parts white cement, and two parts Lafarge lime; this was felt to be less visually obtrusive in the interior areas of the mosaic.

A number of fragments from the geometric border of the mosaic had been discovered during excavation of the site after the mosaic had been lifted. The majority came from the north side, and only a few from the west and east

*Figure 35. The excavated area backfilled and prepared for the pouring of the concrete slab.*

*Figure 36. Removal of facings from the mosaic surface.*

sides. None of the fragments joined directly with the main mosaic, but their probable positions were estimated by matching the color and pattern of the fragment with existing borders. The fragments were then inserted into the temporary mortar fill, using Mastice polyester liquid (manufactured by Bellazoni of Milan, Italy) mixed with 1% hardener and filled with talc to form a paste. A separation layer of Paraloid B72 resin in toluene at 15% was applied to the underside of the tesserae in case the fragments need to be removed in the future.[2]

A very low wall-stub was built around the restored mosaic, extending a few centimeters beyond its perimeter; this hides the edges of the support and provides a more finished appearance.

The final step in the operation was to decide whether or not a final consolidation of the mosaic surface was necessary. Consolidation, in the sense of a more or less reversible layer of synthetic material, makes sense when applied to friable materials that will be particularly vulnerable to wear with time. The application of a consolidant to the entire surface, on the other hand, is motivated not by conservation needs but rather by aesthetic requirements—improving the clarity of the image for the public. It was decided, therefore, not to carry out a final consolidation of the whole of the mosaic surface, but rather to undertake local consolidation only in zones that had lost their cohesion.

## Notes

1. Use of the crane, arranged by the Department of Antiquities, was generously provided by Florentiades Concrete (Paphos) Ltd.

2. Reintegration of the border fragments was carried out by J. Claire Dean, who supplied the information in this section.

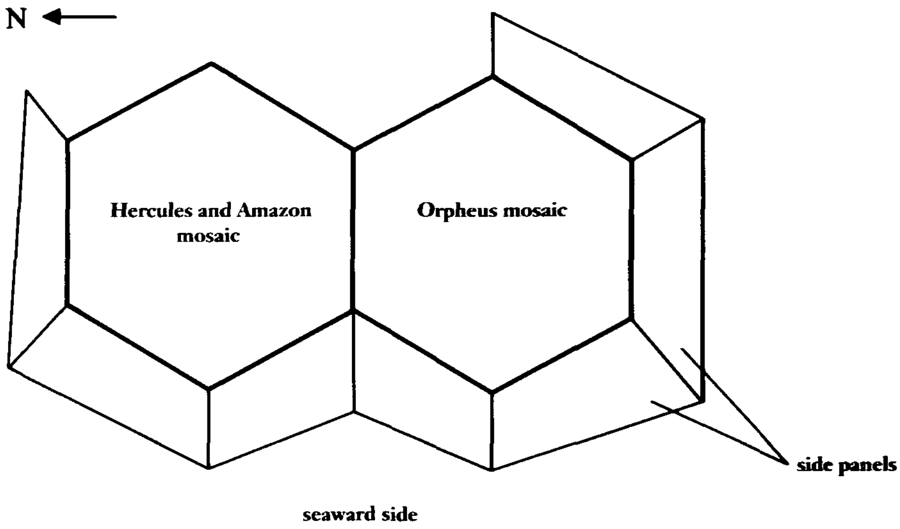
# Development and Evaluation of the Hexashelter

*Neville Agnew and Richard Coffman*

In 1989, a lightweight, temporary shelter was constructed over both the Orpheus and the Hercules and Amazon mosaics. This structure is a prototype shelter designed to protect certain categories of archaeological sites. The premise behind the shelter is that it be lightweight, modular, easy to erect, relatively inexpensive compared to a conventional structure, and temporary if desired. The design allows for easy expansion of a protected area depending upon the needs of the site. It is less expensive than a conventional permanent structure and does not require a large work crew to erect. It can also be built over irregular topography and minimizes the impact to the surface and subsurface of archaeologically sensitive areas by using concrete anchor blocks of appropriate size (approximately 1 $m^3$ each) and mass. When the shelter is no longer needed it can be quickly and easily dismantled with a minimum of equipment and personnel, and once dismantled leaves little or no evidence of its prior existence.

The framework of the structure has a zig-zag profile and six sides; the name "hexashelter," therefore, derives from the hexagonal shape of each module. The framework is aluminum tubing (10 cm diameter for vertical supports; 7.5 cm diameter for roof members) with a fabric roof and side panels. Because it is modular, it can easily be expanded by building laterally from any one of the hexagonal sides. The shelter at Paphos is a dual-ring structure (Figs. 37, 38); one ring is centered over the Orpheus mosaic and the other over the Hercules and

*Figure 37. Schematic plan of the two-ring hexashelter.*



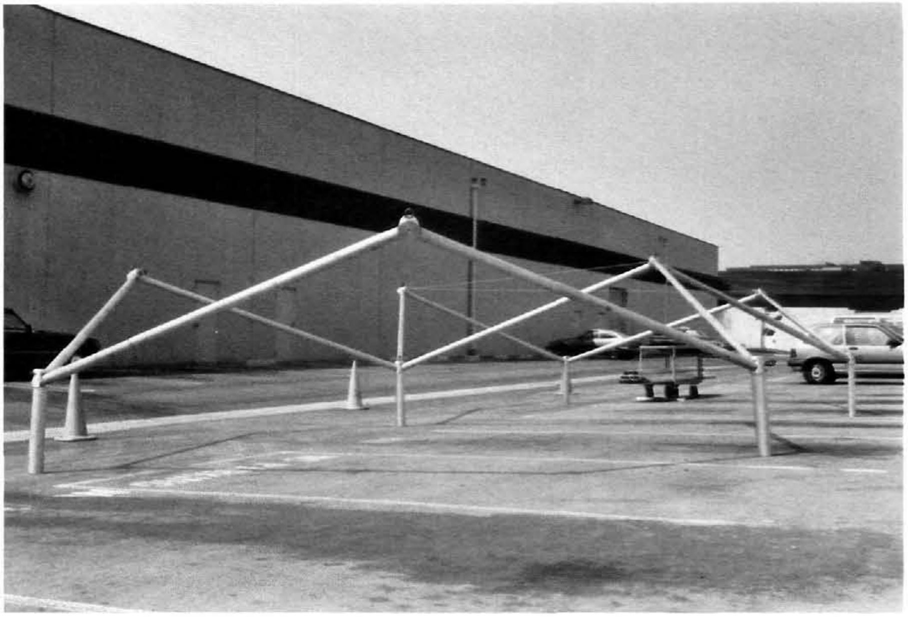


*Figure 38 (top). Trial assembly of the hexashelter, using short support legs for convenience. Note the stabilizing cable linking the three high points of the far ring.*

*Figure 39 (right). Construction of the hexashelter in November 1989. The Orpheus mosaic (covered) is in the foreground.*

Amazon mosaic. The shelter was erected in November of 1989 by the authors and a work crew of five from the Department of Antiquities (Fig. 39). Construction took approximately three weeks, without the use of heavy equipment except for a concrete truck that delivered and poured concrete for the footings and anchor blocks. New impermeable roof membranes were installed in 1990, to provide better protection against rain; this work was completed in two weeks.

As noted above, the structure has six sides, with a zig-zag profile of alternating high and low points. Each connecting point is a solid aluminum hub, 15 cm in diameter (Fig. 40), machined to an internal angle of a tetrahedron (109.5°). The solid cylindrical stock was also through-drilled to provide a fifth point of attachment for an eyebolt for cabling. When connected by six members, the hubs create a zig-zag profile that is more stable against torquing stresses than a flat hexagon. Thus, the structure acts both as a support for the roofing material and as its own stabilizing truss.

The hubs were drilled to accept threaded steel rods to which the horizontal and vertical members and the eyebolts were attached. At each low point is connected a vertical aluminum tube, approximately 1.85 m long, that extends to the ground. Thus each hexashelter module has three legs supporting the structure. This design was chosen because it is the most stable configuration with a minimum of vertical supports. When two hexashelter modules are connected, as at Paphos, they share one side and one leg, resulting in a structure with ten sides supported by five legs. Each arm is 5.23 m in length and is made of two pieces of aluminum tubing connected internally by means of solid aluminum stock six inches long and secured by means of steel set screws. The same technique is used to attach the arms and legs to the hubs, with slight modifications. The aluminum studs and hubs were tapped and threaded to a steel rod to permit the different members to be screwed together. The aluminum tube slides over these studs and the steel set screws clamp the pieces together. At each high and low point a steel eyebolt was also installed through which the perimeter cables were attached and the stabilizing cables strung. The total area covered by the two hexagonal rings is 156 $m^2$. An upper limit to the size of the individual arms is estimated to be 6.15 m; lengths greater than this would create a ring too large for structural stability.

Each leg was embedded in a support footing of concrete approximately 1 $m^3$. Because the structure was installed on an archaeological site, the concrete footings sit on the ground and do not intrude subsurface. In addition, the structure required nine concrete anchors (each approximately 0.5 $m^3$), also placed

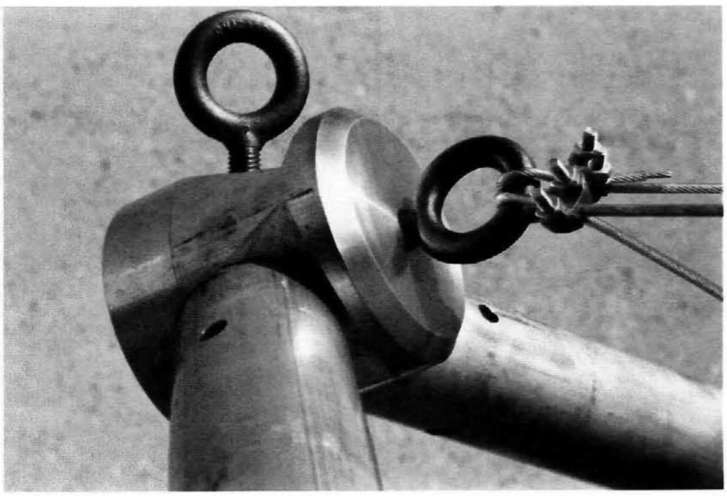


*Figure 40. Solid aluminum hub showing two tubing arms in place and two eyebolts. Cables shown connect the three high points of each ring; the other eyebolt is for cabling to concrete anchor blocks. Recessed locking screws secure the arms to the studs threaded to the hub.*

above ground, to which the steel support cables were attached. These anchors, located from 1 to 5 m (horizontal distance) from the high and low points, each have two hooked, mild-steel reinforcing bars embedded in them to which the steel support cables are attached. The cables are attached to the high and low points via the eyebolts and provide structural support and a means of tensioning the structure, accomplished by means of turnbuckles attached to each support cable. Additional steel cabling was attached to the high points of each module through the eyebolts, forming a triangle above each ring and providing a means of counter-tensioning the structure. The support cables from the high and low points to the anchor blocks were also used to attach the knitted aerotextile side panels to the shelter. An additional steel cable was strung around the perimeter of each ring through the eyebolts as a means of attaching the roof membrane.

Stainless steel cable (6 mm) and fittings were used as much as possible in the structure. In instances where mild steel or poorly galvanized material was used, severe corrosion occurred within a year because of the proximity to the sea.

The Paphos hexashelter was originally covered with a polyethylene, open-knit, "aerotextile" material commonly used in the horticultural industry as shade cloth. The fabric, manufactured by Weathashade, Inc., of Australia, is tan colored with a 70% shade "density." It is a low-cost, durable material, which does not rip since it is knitted rather than woven. It is supplied in rolls of 1.85 m x 50 m. The fabric was cut and sewn into large panels using polyethylene cord supplied by the manufacturer. The roof membrane and side panels were assembled within a few days by local workers from the Department of Antiquities. After assembly, the roofs and side panels were attached to the perimeter and support cables using plastic cinch ties and butterfly clips provided by the manufacturer. This was accomplished by attaching one edge of the fabric to one of the cables, then pulling the other sides taut and attaching ties and clips. Only seven side panels were installed, leaving the remaining three sides open on the sheltered side (facing away from the sea) so that visitors could approach and view the mosaics (Fig. 41).

Because of the open knit, the aerotextile fabric does not provide adequate protection against rain when used as the roof membrane. In planning the project, it was decided to waterproof the fabric in situ; tests and aging experiments were conducted in the laboratory to determine the most durable material for the purpose. Thus, an attempt was made to waterproof or "impermeabilize" the roof membrane over the Orpheus mosaic by applying a GEC silicone gel to the fabric after the structure had been erected. This proved to be time consuming and difficult since the gel could not be coated evenly and was forced through the fabric holes as it was applied. Numerous pinholes developed, allowing rain water to seep through the fabric. Wind-driven rain could also pass through the side

*Figure 41. The hexashelter in November 1989, with three sides left open for visitor access.*

panels, which were not treated with silicone, although this was not as serious an issue as the water-permeable roof.

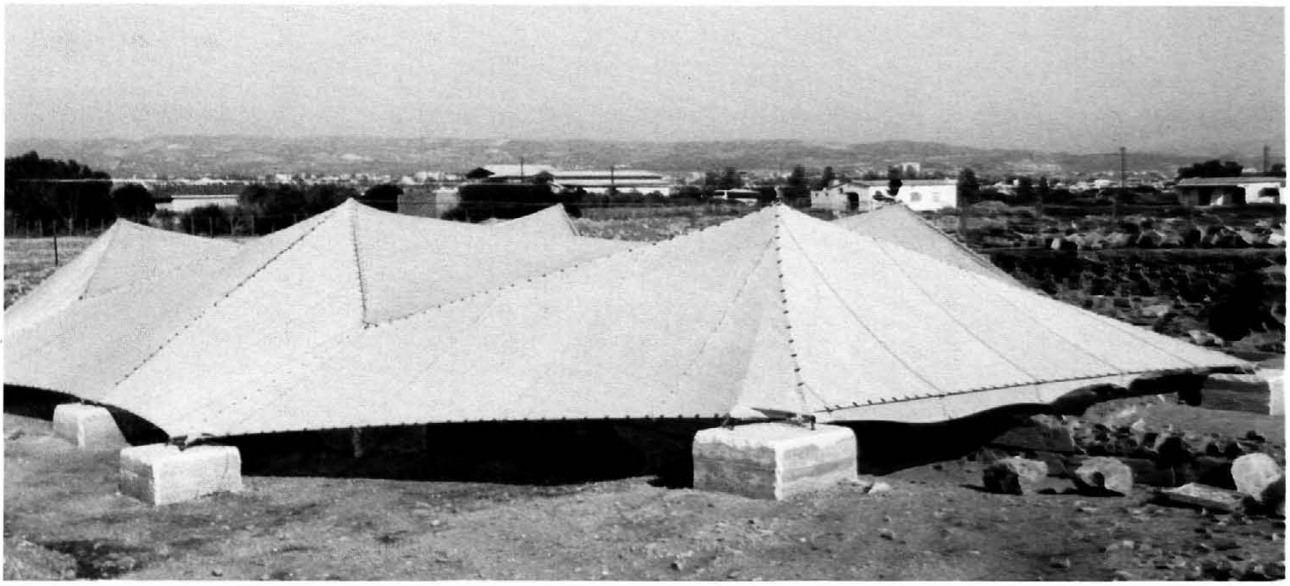
The roof problem was solved by designing a prefabricated impermeable roof membrane which was customized for the Paphos hexashelter. The new membrane was constructed from a tri-laminated vinyl material made from polyester scrim sandwiched between two layers of vinyl fabric. Additional features of the new roof membrane include perimeter sleeves with built-in cabling to prevent friction between the cabling and the fabric, S-hooks and turnbuckles to permit tensioning of the membrane, nylon webbed straps to assist in attaching the roof to the high points, and perimeter flaps with grommets to permit better attachment to the hexashelter arms. These new membranes were installed on the hexashelter in November of 1990. New, better-fitting side panels which extended lower down to the anchors and overlapped at their edges were also installed at this time (Fig. 42). While driving rain can still penetrate the side panels, these provide better protection than did the first set. If required, a final refinement will comprise the installation of free-hanging aerotextile drapes inside the side panels and attached to the arms of the shelter. These vertically hanging drapes, if fitted on the seaward side, will provide an additional level of protection against wind-driven rain.

Should the shelter be required to function for several years, pending a permanent roofing solution for the mosaics, a solution will be developed for drainage of the site and water disposal from the shelter roof. This will probably involve the use of small concrete channels, surface-laid below the drip line of the hexashelter arms, to carry water away from the mosaics.

The hexashelter is a prototype still in the developmental stage. It has a number of appealing features: It is a relatively low cost structure in terms of materials, fabrication, and erection (see Appendix C); it is aesthetically compatible with an archaeological landscape such as the Paphos mosaics site; anchorage on the surface of the ground with concrete footings does not disturb subsurface archaeological materials; it can easily be dismantled and moved for reuse elsewhere; it is adaptable to a variety of site terrains; and it can be extended laterally by construction of additional rings to cover new excavations.

On the other hand the shelter does not provide total protection against the weather. The open-weave side panels break the force of wind and rain, but do not exclude water completely. A water disposal system for roof run-off has yet to be designed and implemented. The Paphos mosaic site is located on a promontory and is therefore exposed. The performance of the hexashelter under severe weather conditions, especially the high winds that occur during winter gales, has yet to be established.

*Figure 42. The hexashelter in November 1990 with a new roof membrane and more extensive, overlapping side panels.*



# Environmental Monitoring of the Paphos Mosaics

*Neville Agnew and Po-Ming Lin*

Paphos has a typical Mediterranean climate with hot, dry summers and cool, wet winters. The fifty-year average rainfall (1908 to 1957) of the Paphos area ranges from 400 mm at the coastal plain to 600 mm further inland (Hadjistavrinou and Aphrodisis 1969). The mosaic site at Paphos is on a low promontory (see map, Fig.1) exposed to the force of westerly gales in the winter.

Fragile, excavated mosaics are extremely susceptible to deterioration due to alternate seasonal wetting and severe drying and heating; to physical disruption of tesserae by plant growth (Villa 1978, Saiz-Jaminez 1990); and to exposure to wind, salt, and spray. It has, therefore, long been recognized by the Department of Antiquities that sheltering is essential to prevent rapid disintegration, and a number of shelters of different architectural styles and degrees of effectiveness have been constructed at various times over the more important mosaics.

When the project to lift and reinstall the Orpheus mosaic was planned it was deemed advisable to begin temperature and relative humidity (RH) monitoring in several of the shelters and at the Orpheus mosaic itself. In September 1988, four small, portable recording instruments (Shinyei THR-2) were installed in wooden cases, standing several inches off the ground, with only the dual-purpose temperature and relative humidity sensors protruding through a small hole. These instruments, while reliable in the laboratory, proved to be susceptible to a number of environmental factors (mainly dust and insect infestation) in the outdoors, and thus yielded only intermittent results.

Subsequent to malfunction, three of the recording instruments were reconditioned, recalibrated, and installed at the Aion, Achilles, and Hercules and Amazon mosaics (see Table 3). Although tight-fitting perspex cases had been installed within the wooden cabinets, malfunctions continued to occur. Analysis of data from the recording instruments showed that the accuracy of the RH sensor was soon affected by dust and the harsh climate and frequent calibration against saturated salts solutions would therefore be necessary for reliability. With only an annual visit to the site (November 1988, 1989, and 1990), it was impossible to assure the proper functioning and calibration of the recorders.

In order to supplement the chart recorder data, a hand-held, battery-powered temperature and RH measuring instrument (General Eastern Digital

Thermohygrometer, Model 880) was used for spot measurements by Department of Antiquities staff. Measurements were taken at about 7:30 A.M. and again during the hottest part of the day, around 1:30 P.M.

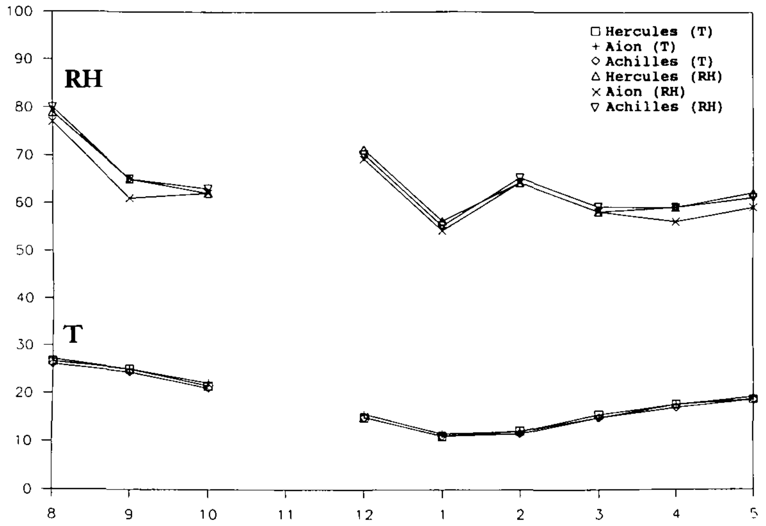
Representative data given here (Figs. 43,44) are thus incomplete and were derived only from the hand-held instrument for the months of August 1989 through May 1990. Nonetheless, certain trends are quite clear. The data show that there is little difference between the three mosaic sites, whether or not the mosaics are fully sheltered or fully exposed. The seasonal changes in temperature and RH are much as would be expected from the temperate climate—at least over the nine months of monitoring presented here. Likewise, the small differences between early morning and early afternoon are within the expected variations. The RH range of 80% to 48% and the temperature range of 33 to 10 °C in seasonal and daily variation, respectively, are not excessive and cannot be seen as major contributors to deterioration.

As stated above, one of the main causes of deterioration is periodic wetting from rain followed by severe drying. Exposure to the environment and consequent plant growth is also extremely damaging to mosaics. Capillary rise of salt-carrying moisture in the soil, by lateral movement of water from outside the shelter, is likewise harmful although probably not as aggressive a cause of deterioration as is direct wetting and drying. Thus, those shelters at Paphos with side walls or panels to prevent wetting during periods of rain function quite effectively as protective structures even though they are relatively open and allow free air movement. The Aion structure, a fully enclosed building, is frequently criticized by visitors in the summer as being unbearably hot. However, the RH and temperature data do not support this—the temperature in Aion is not higher than that in the other, more open, shelters. The explanation for visitor discomfort probably lies in the fact that there is no air movement (and therefore no evaporative cooling effect) in a fully enclosed structure.

*Table 3. Sites chosen for environmental monitoring with both the recording instruments and the hand-held instrument.*

| *Site* | *Type of Structure* | *Location of Instruments* |
|---|---|---|
| Aion mosaic<br>House of Aion | protective building<br>erected in 1987<br>total enclosure | under the walkway between the two mosaics |
| Achilles mosaic<br>House of Theseus | shelter with side walls<br>erected in 1970s<br>partial protection | under the far end of the visitor walkway |
| Hercules and Amazon mosaic<br>House of Orpheus | unsheltered | between stone blocks adjacent to the northeast corner of the mosaic (location remained exposed after erection of the hexashelter in Nov. 1989) |

**Temperature (T) and Relative Humidity (RH) at 7:30 A.M.**




**Temperature (T) and Relative Humidity (RH) at 1:30 P.M.**

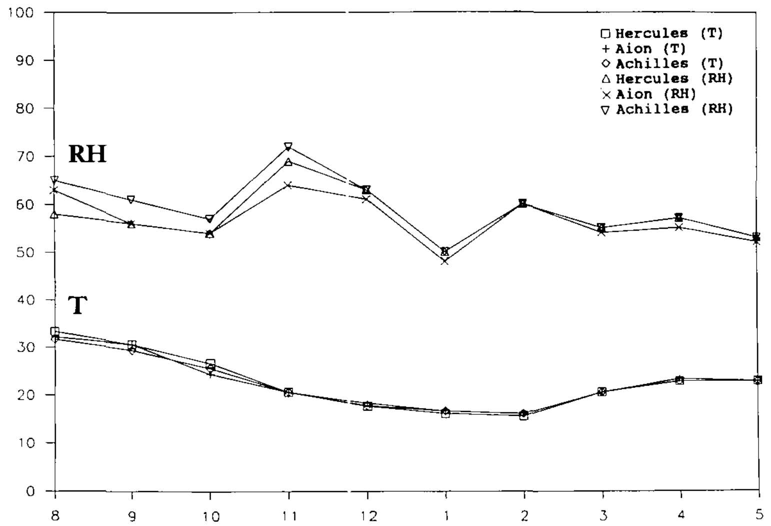



*Figure 43 (above right). Temperature and RH measured at 7:30 A.M. Data not available for 11/89.*

*Figure 44 (right). Temperature and RH measured at 1:30 P.M.*

Finally, the chloride content of ground water in the Paphos area is relatively high and can vary from 100 to 3000 ppm[2]. The water table is above sea-level everywhere in the area (0.18 meters in Paphos) and, as expected in limestone geology, is neutral to alkaline (pH 7.0 to 8.5). Whether salts, mainly sodium chloride, are responsible for deterioration of the mosaics is not well established at Paphos. The existence of strong, seasonal, onshore winds bearing salt spray makes the question of salt crystallization and its role in deterioration a legitimate one. However, those mosaics that are exposed are frequently also flushed with fresh rain water, and hence in these cases the deterioration due to salt crystallization is probably minimal.

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# Evaluation of Tesserae from the Paphos Mosaics

*Eric Doehne*

Tesserae from the Paphos mosaics, as well as a few samples from the Early Christian Basilica of Chrysopolitissa in Lower Paphos (see map, Fig. 1), were analyzed for composition, structure, and the presence of deterioration products such as soluble salts and weathering crusts. Of particular concern were color changes in different parts of treated and untreated mosaics. Stained tesserae were present in mosaics from the Houses of Theseus, Orpheus, and Dionysus. White salts were also found in the Dionysus mosaic, and yellowing was observed in the Orpheus tesserae. Such changes may be due to weathering, previous treatment, salt crystallization, or mineral staining. X-ray diffraction and electron microprobe data on the tesserae are presented here, along with suggested mechanisms for the observed color changes. Additional information on the deterioration of the Cyprus mosaics is found elsewhere in this volume (see pp. 59–60) and in other published articles (Papageorghiou 1985).

## Analytical Strategy

The samples were examined with a binocular microscope to determine the position of the original surfaces. In several samples it was difficult to tell whether a crust was simply remnant mortar or a weathering crust. The samples were then cross-sectioned, polished, coated with a conductive carbon layer, and analyzed with an electron microprobe. Several samples and both mortars were analyzed by X-ray diffraction to confirm their mineral chemistry. Petrographic observations were used to determine the rock name of each sample and to describe the features and textures present. Energy dispersive X-ray analysis was used to determine composition and scanning electron micrographs were taken to document the observed textures.

## Results

The results for the study of the Roman tesserae are presented in Figures 45–58 and in Table 4. The results for the analysis of the study collection samples from the Basilica of Chrysopolitissa are summarized in Figures 60–65 and Table 4. Energy dispersive X-ray spectra of selected samples are shown in Figures 66–72. Two samples of mortar from the Orpheus mosaic were analyzed, one recent and one ancient (Fig. 59, Table 4).

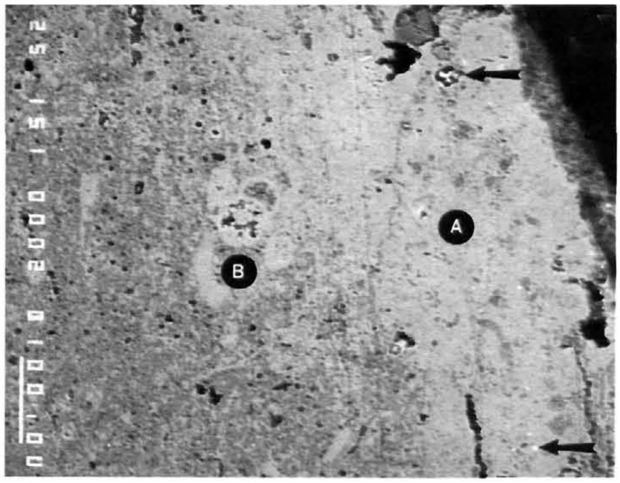



*Figure 45[1] (top). Sample 2. Calcareous limestone with more dense cementation (A) near the surface of the tessera (right). Small bright areas at the surface of the tessera are iron oxide grains (arrows). At the center is a foraminifera fossil (B). Note fine-grained texture. Scale bar is 100 µm.*

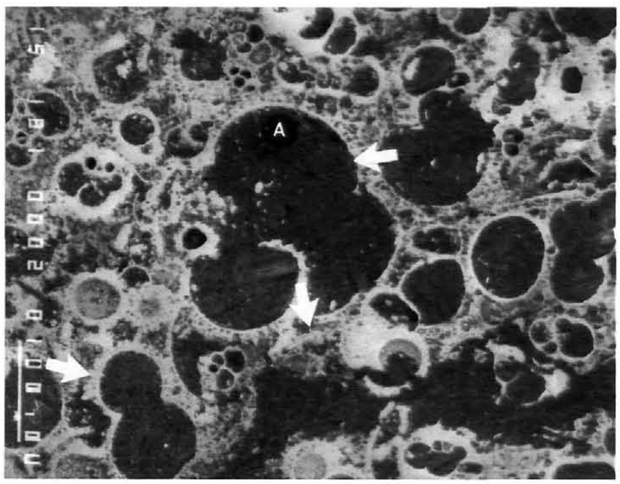



*Figure 46 (middle). Sample 3. Foraminiferal limestone with abundant porosity and foraminifera fossils (A) lightly cemented with calcite (arrows). This tessera is fragile and friable. Scale bar is 100 µm.*

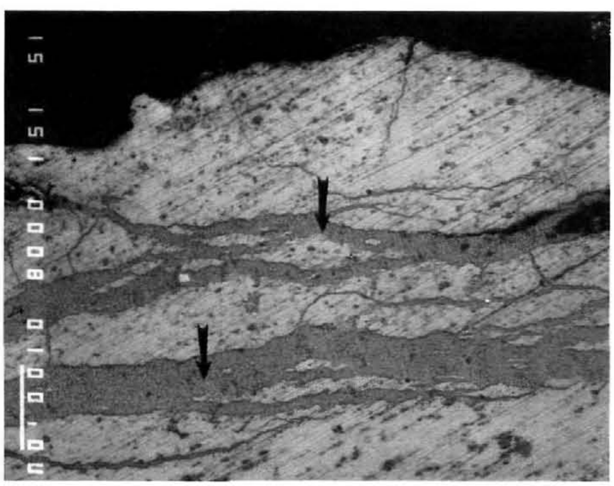


*Figure 47 (lower left). Sample 4. Calcareous limestone with bands of gypsum (arrows) parallel to the surface (top). The gypsum is weak and the surface is flaky. Scale bar is 100 µm.*

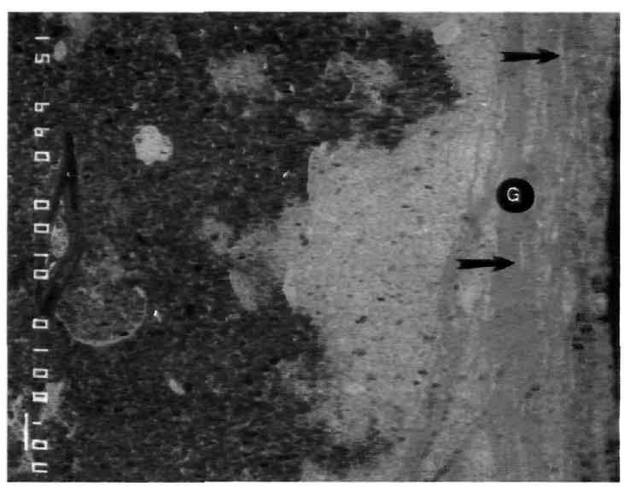
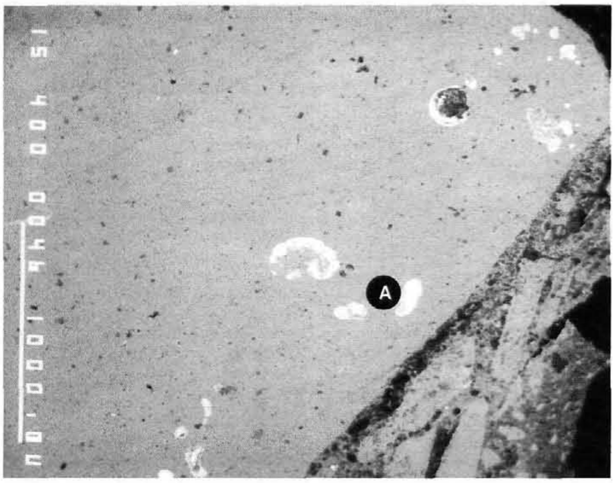



*Figure 48 (lower right). Sample 8. Porous calcareous limestone with bands of gypsum (G, arrows) parallel to the surface (right). The gypsum is weak and the surface is flaky. Scale bar is 100 µm.*



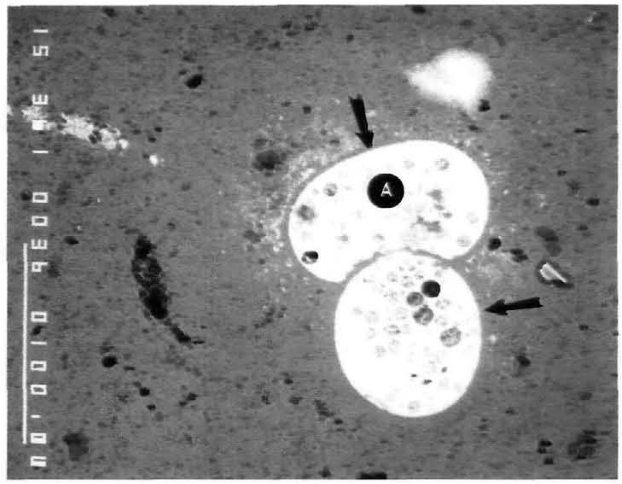




*Figure 49 (upper left). Sample 19. Calcareous limestone with iron oxides inside foraminifera (A). Scale bar is 1000 µm.*

*Figure 50 (upper right). Sample 19. Close-up of iron oxides (A) inside foraminifera. Note outline of former shell (arrows). Scale bar is 100 µm.*

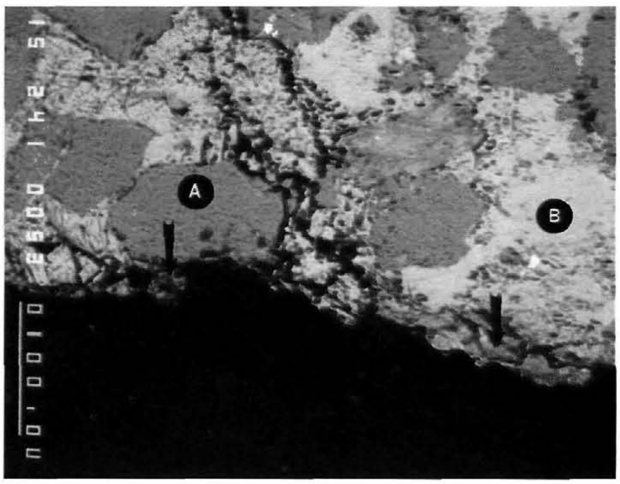



*Figure 51 (middle). Sample 21. Sandy, recrystallized limestone. Surface crust is at the bottom of the micrograph and contains gypsum (arrows). Darker grey grains are quartz sand (A); lighter grey is calcite (B). Scale bar is 100 µm.*

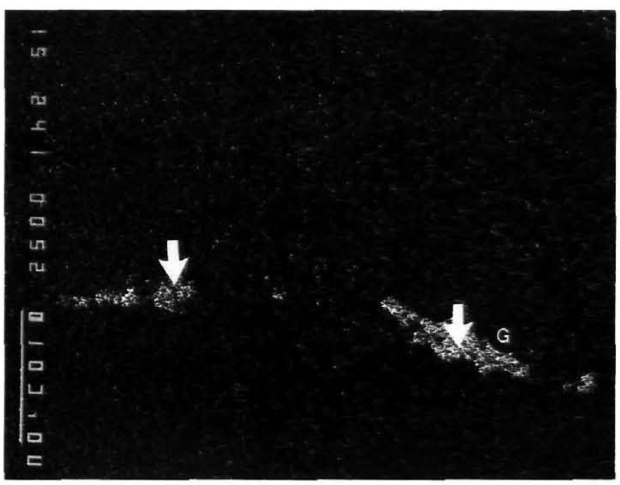


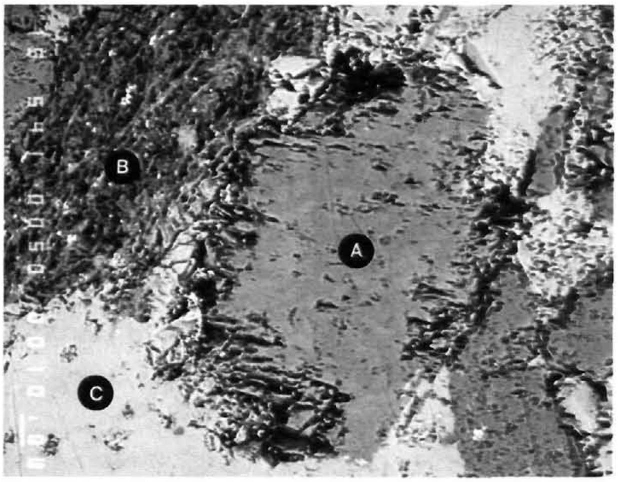

*Figure 52 (bottom). X-ray distribution map for sulfur. Sample 21. Note concentration of sulfur (G for gypsum) at surface crust (bottom of micrograph). Same area as Figure 54. Scale bar is 100 µm.*

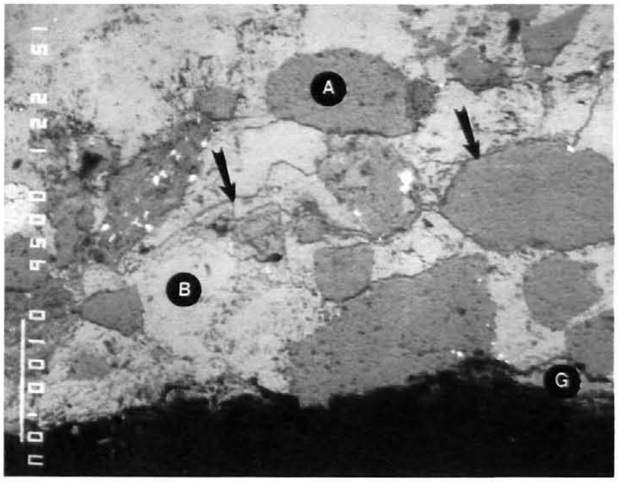
*Figure 53 (top). Sample 21. Partially dissolved feldspar (A) and clay grains (B) in calcite matrix (C). Scale bar is 100 μm.*

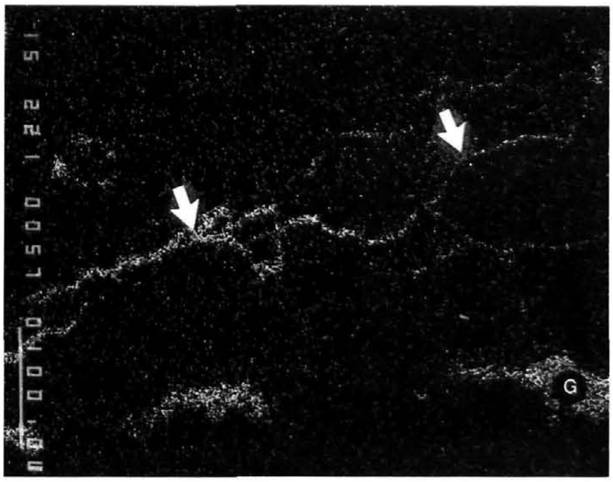
*Figure 54 (middle). Sample 21. Sandy, recrystallized limestone. Darker grey grains are quartz sand (A); lighter grey is calcite (B). Note how gypsum follows around quartz grains (intergranular porosity). Scale bar is 100 μm.*

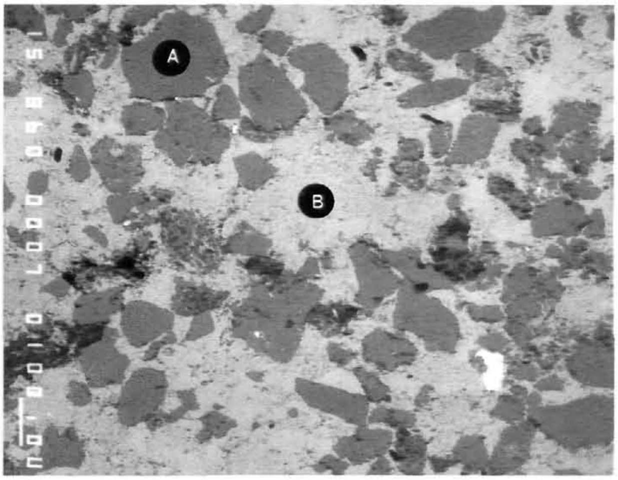
*Figure 55 (lower left). X-ray distribution map for sulfur. Sample 21. Concentrations of sulfur (gypsum) penetrate 200–300 μm beneath the surface crust (bottom of micrograph). Same area as Fig. 57. Scale bar is 100 μm.*

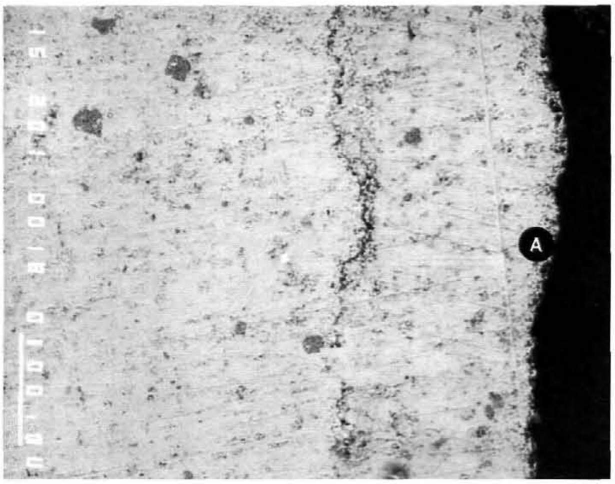
*Figure 56 (lower right). Sample 21. Sandy, recrystallized limestone. Low magnification image of darker quartz grains (A) surrounded by lighter calcite (B). Scale bar is 100 μm.*

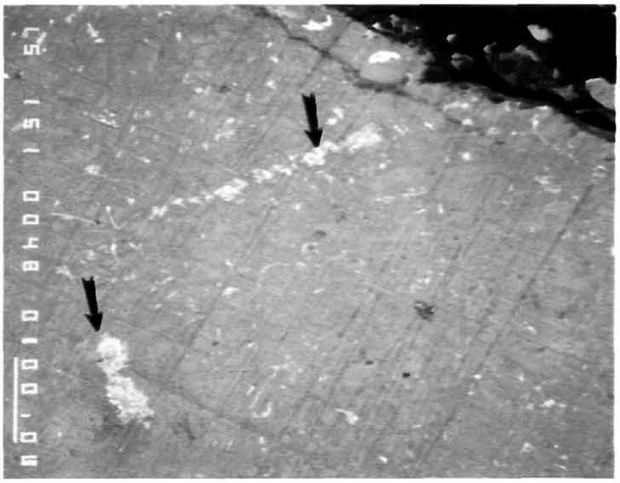


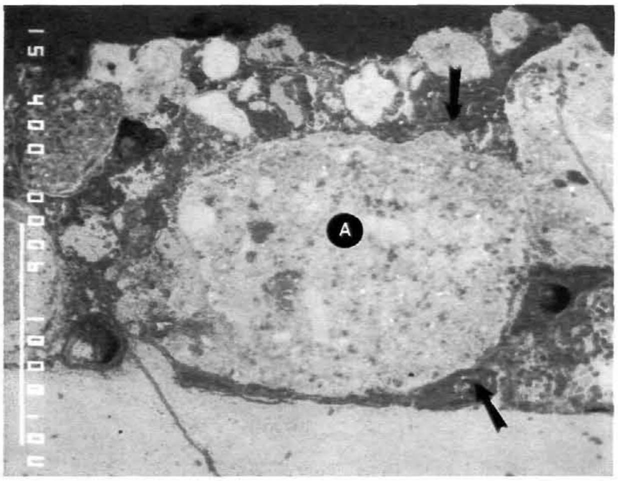







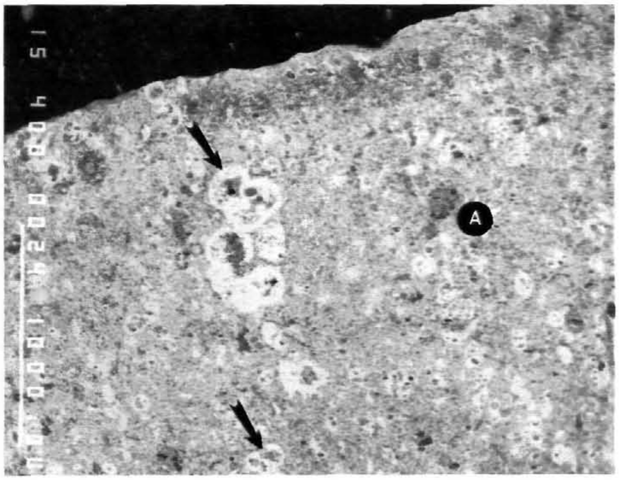
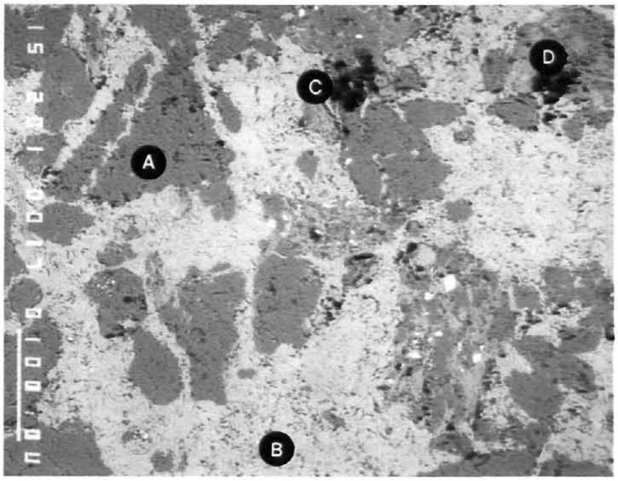



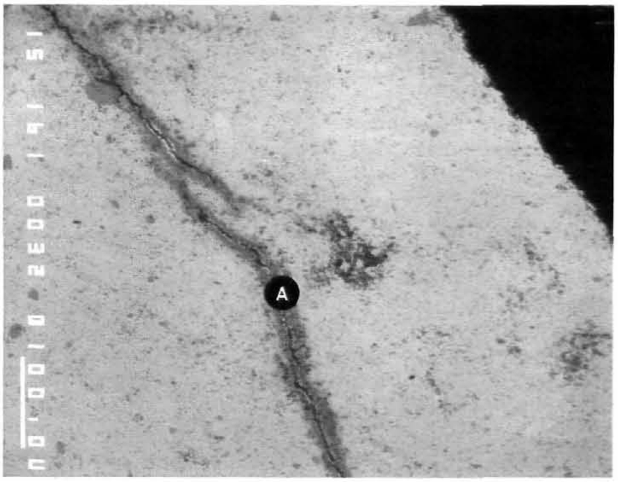

*Figure 57 (upper left). Sample 23. Calcareous limestone with weathering crust (A, right). Scale bar is 100 µm.*

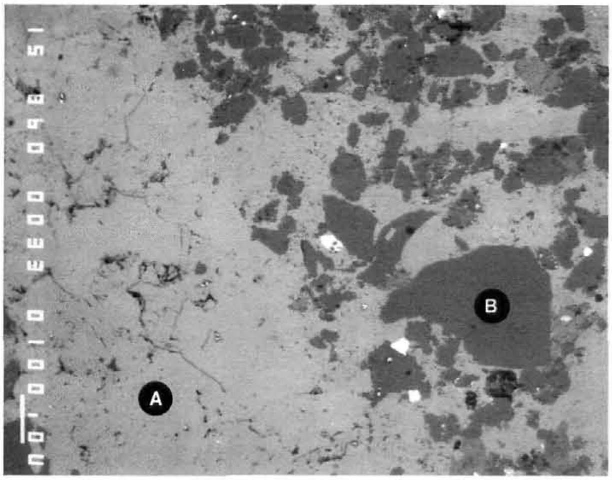
*Figure 58 (upper right). Sample 26. Serpentinite with iron oxides (bright particles, arrows). Scale bar is 100 µm.*

*Figure 59 (middle). Sample B. Ancient mortar sample with large grains of calcareous sand (A) cemented by lime mortar (arrows). Scale bar is 1000 µm.*

*Figure 60 (bottom). Sample SC1. Calcareous limestone with foraminifera fossils (arrows) and rare quartz grains (A). Note fine-grained structure. Scale bar is 1000 µm.*



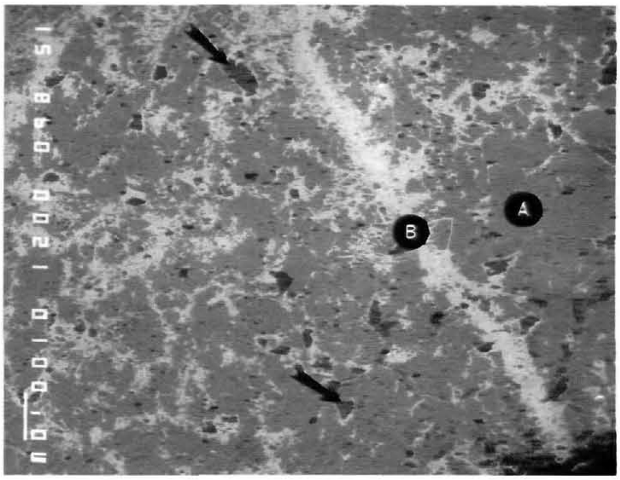
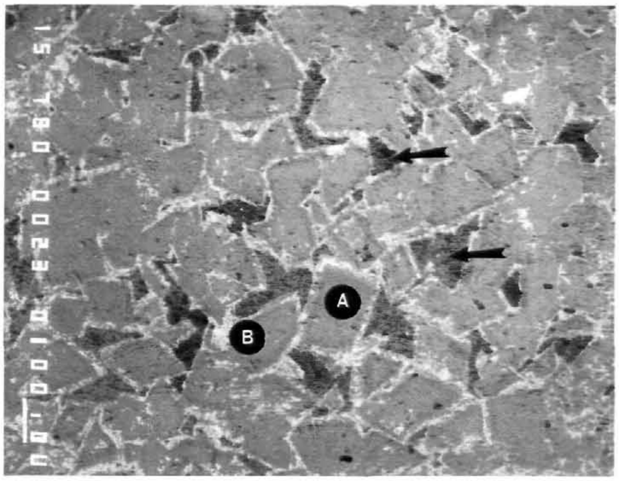



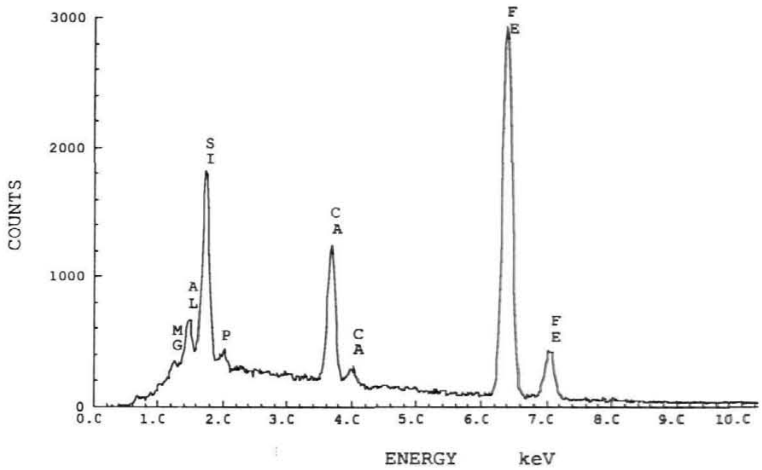

*Figure 61 (top). Sample SC2. Sandy recrystallized limestone with quartz (A), calcite (B), clay (C), and albite (D). Scale bar is 100 μm.*

*Figure 62 (middle). Sample SC2. Clay seam (A, center) in limestone, forming a weak zone. Scale bar is 100 μm.*

*Figure 63 (lower left). Sample SC3. Recrystallized sandy limestone. Area to left is a vein of coarsely crystalline calcite (A). Quartz grains are to the right (B). Scale bar is 100 μm.*

*Figure 64 (lower right). Sample SC4. Dolomite (A). Area in center is a calcite vein (B). Etched quartz grains are also present (arrows). Scale bar is 100 μm.*





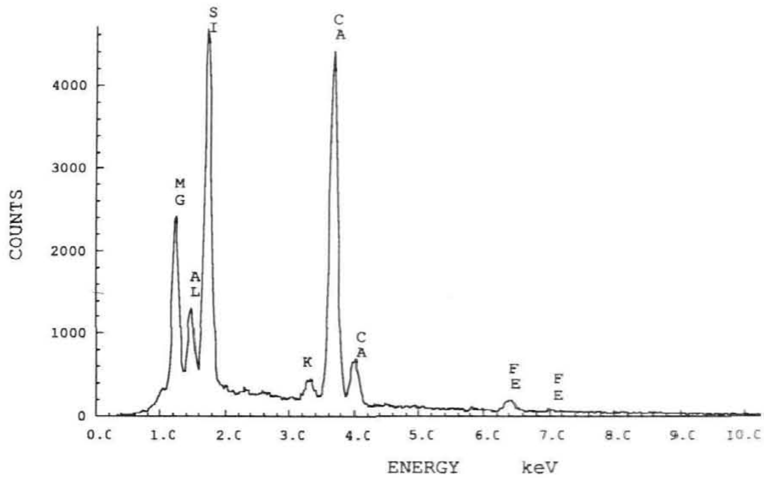




*Figure 65 (top). Sample SC6. Dolomite (A) with light colored calcite rims (B) and darker grey etched quartz grains (arrows). Scale bar is 100 µm.*

*Figure 66 (middle). Sample 19. Energy dispersive X-ray spectrum of iron oxide found in a white stained tessera.*

*Figure 67 (bottom). Sample 19. Energy dispersive X-ray spectrum of clay layer found in a white stained tessera. The high magnesium content of the clay suggests a mixed layer smectite/illite composition.*

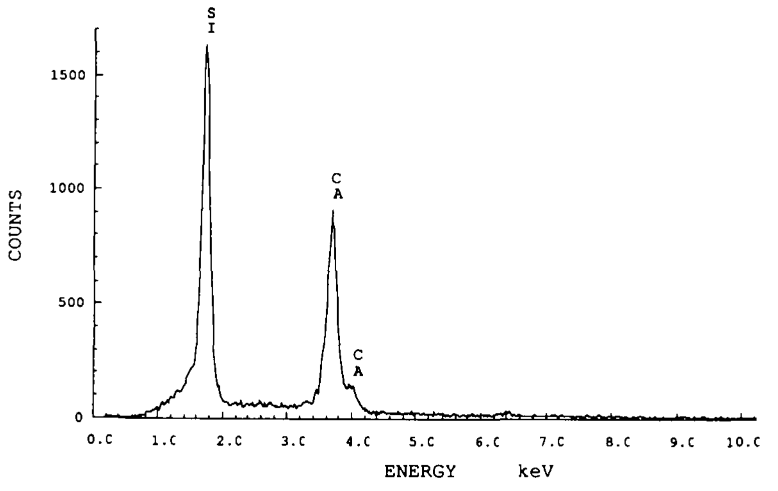
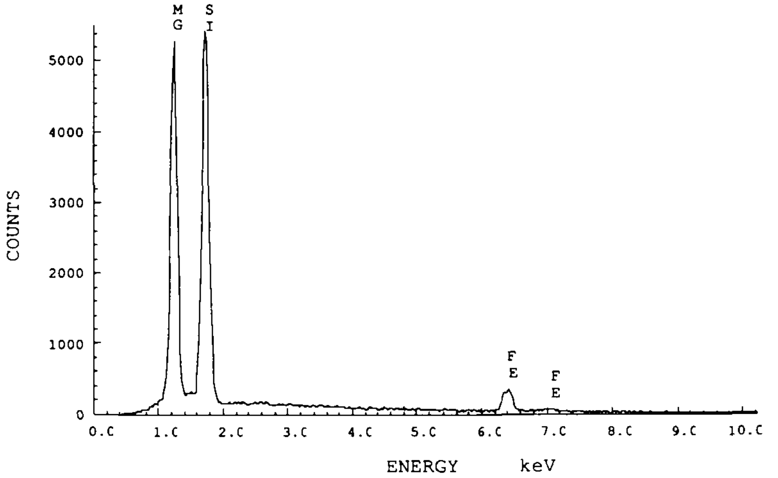
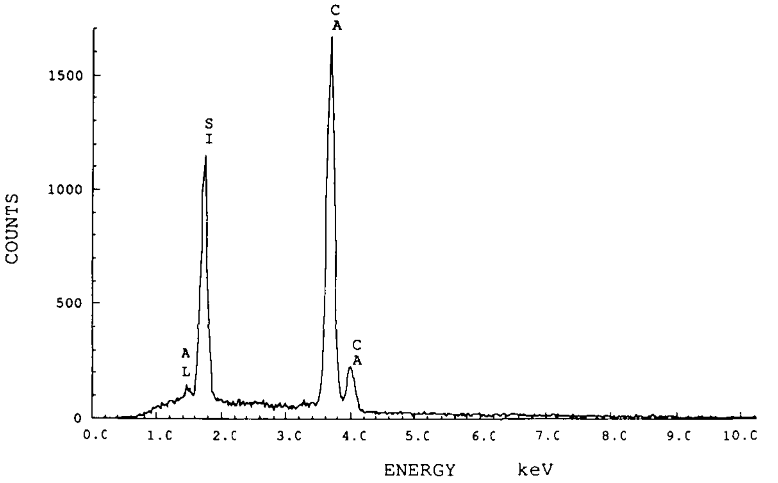



*Figure 68 (top). Sample 23. Energy dispersive X-ray spectrum of calcite and quartz in a black unaffected tessera. The high background noise is probably due to organic material responsible for the dark color.*

*Figure 69 (middle). Sample 26. Energy dispersive X-ray spectrum of a problematic greenish black tessera. The Mg, Si, Fe composition identifies this stone as serpentinite, a common metamorphic rock.*

*Figure 70 (bottom). Sample SC1. Energy dispersive X-ray spectrum of a white tessera. The stone contains primarily calcite and some quartz.*



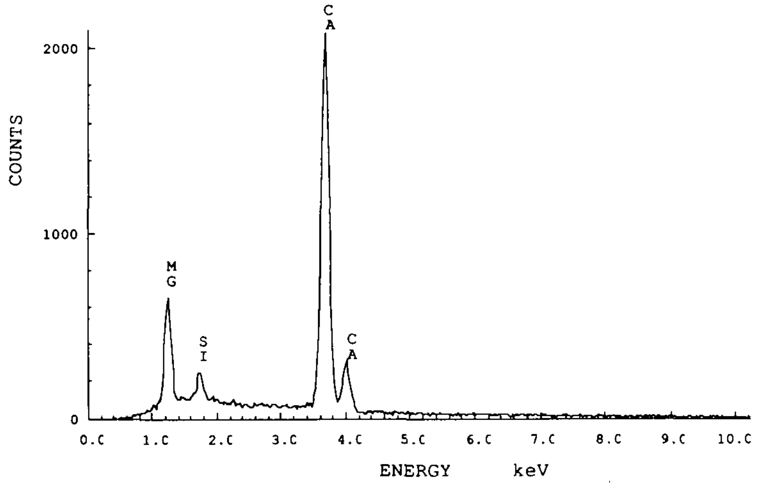



*Figure 71 (top). Sample SC4. Energy dispersive X-ray spectrum of a brown tessera. The stone contains primarily dolomite, calcite, and some quartz.*

*Figure 72 (right). Sample SC6. Energy dispersive X-ray spectrum of a light pink tessera. The stone is composed of dolomite rhombs with calcite rims and quartz.*

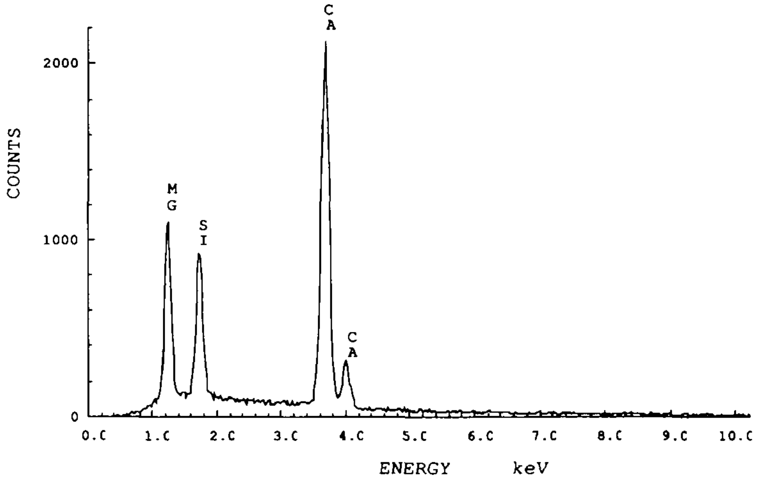



*Table 4. Identification of tesserae and mortar samples collected from Roman mosaics at Paphos and tesserae collected from the Early Christian Basilica at Chrysopolitissa.*

### *Tesserae Samples from the Houses of Dionysus, Orpheus, and Theseus*

| | |
|---|---|
| Sample 2 | House of Dionysus, Room of Narcissus; heavily restored. Stained white tessera. Calcareous limestone with staining. Stain appears to be iron-rich calcite with iron oxide along grain boundaries. |
| Sample 3 | House of Dionysus, Room of Narcissus; heavily restored. White tessera with white salts. Foraminiferal limestone (marine), very porous. Thin layer on top of tessera contains calcite, some gypsum and rare halite. |
| Sample 4 | House of Dionysus, South Portico, Hunting Scene (above deer); treated area. White stained tessera. Calcareous limestone with gypsum between flaky surface layers. |
| Sample 6 | House of Dionysus, South Portico, Hunting Scene (above deer); treated area. Unaffected white tessera. Calcareous limestone. Fairly well cemented (unaffected). |

| | |
|---|---|
| Sample 8 | House of Dionysus, geometric mosaic with circles, west side. Untreated, unaffected white tessera. Porous calcareous limestone with gypsum between flaky surface layers. |
| Sample 17 | House of Orpheus, Hercules mosaic, geometric frame. Yellowed tessera from area between Hercules and the Amazon, treated in 1984. White calcareous limestone, with thin yellowed surface layer of glue. |
| Sample 19 | House of Theseus, Achilles Room, geometric frame on east; lifted area, reset under shelter. Stained white tessera. White calcareous limestone stained with iron oxide (oxidized pyrite inside foraminifera fossils). |
| Sample 21 | House of Theseus, Achilles Room, geometric frame on east; untreated area under shelter. Worn and salt-covered black tessera. Sandy, recrystallized limestone with rare iron oxide. Black may be due to organic material. |
| Sample 23 | House of Theseus, Achilles Room, geometric frame on east; lifted area, reset under shelter. Black tessera, apparently unaffected. Calcareous limestone with weathered calcite crust. |
| Sample 25 | House of Dionysus, circular mosaic to the east. Problematic white tessera. Fine grained limestone with little cement between grains (friable). |
| Sample 26 | House of Dionysus, Vintage mosaic. Problematic greenish-black tessera. Serpentinite. Mg, Si, and Fe are the major elements in the black tessera. This tessera has iron oxide grains along grain boundaries. Probably from hydrated ultramafic rocks on the island. |

### *Mortar Samples (based on X-ray diffusion and microprobe data)*

| | |
|---|---|
| Sample A | New mortar from Orpheus mosaic. Contains calcite, quartz, feldspar, and trace gypsum. |
| Sample B | Ancient mortar from Orpheus mosaic. Contains calcite, quartz, feldspar, and sandy limestone fragments. |

### *Tesserae Samples from the Early Christian Basilica of Chrysopolitissa*[2]

| | |
|---|---|
| Sample SC1 | White tessera. Calcareous limestone containing foraminifera fossils, barite ($BaSO_4$), and quartz. |
| Sample SC2 | Grey-black tessera. Sandy recrystallized limestone containing albite and clay veins. Trace of dolomite found on left side. Etched quartz grains (40%) with rare accessory minerals such as monazite, rutile, and zircon. |
| Sample SC3 | Reddish-brown tessera. Recrystallized limestone with quartz and feldspar, minor ilmanite. Calcite vein runs across sample. |
| Sample SC4 | Brown tessera. Dolomite with calcite rims and etched quartz. |
| Sample SC5 | Dark pink tessera. Recrystallized limestone with white calcite surface crust. |
| Sample SC6 | Light pink tessera. Recrystallized dolomite with calcite rims and etched quartz grains. |

## Color Changes

There are several explanations for the color changes and degradation of the tesserae at Paphos. The type of alteration appears to depend largely on the mineralogy and physical properties of the original stone. The white tesserae at Paphos are limestone, which is more porous than marble and has far less mechanical strength. The red tesserae are fairly dense recrystallized limestone, with hematite between calcite grain boundaries responsible for the coloring. Some of the black tesserae are serpentinite, a metamorphic rock common on the island.[3] The rest of the tesserae are generally fairly dense recrystallized limestone or dolomite with varying impurities, such as organic material.

Color changes in the tesserae appear to be the result of at least five major factors:

*1. Porous marine limestone.* Soluble salts in the limestone migrate from within stone and mortar to the surface, forming a fragile whitish efflorescence. Unstable carbonate minerals, such as aragonite, may dissolve and reprecipitate at the surface. This fragile surface layer may be spalled off during the lifting and relaying process.

*2. Fine-grained limestone.* The fine grains are less well cemented than those in the more coarsely crystalline limestones and have less mechanical stability. They are subject to erosion by water and wind.

*3. Pyrite-containing limestone* (white stained tesserae, see samples 2 and 19). The pyrite was formed in the limestone soon after burial and later oxidized to hematite (iron oxide, red) or goethite (hydrated iron oxide, brown) during normal weathering (Schwertmann 1985, 119–120). In tesserae that are porous, water will bring the iron oxide to the surface. Tesserae that are not stained by iron oxides are generally well cemented and iron-poor.

*4. Gypsum.* Gypsum was found between flaky surface layers of white limestone tesserae from the House of Dionysus mosaic. The origin of the gypsum is not yet known, although potential sources include: gypsum precipitation from saline groundwaters, natural sulfation from groundwater sulfate, biological attack, or remobilized wind-born sulfate during surface weathering. Gypsum crusts are common in Cyprus and other semi-arid regions of the world (Watson 1989:133-161).

*5. Glue.* One sample (17) was found to have glue left on the surface from a treatment in 1984. The glue was confirmed by FTIR analysis of the surface. The glue resulted in a yellowed appearance of the white limestone tesserae.

## Conclusions

The color changes observed in the tesserae are the result of different processes for different stones. The white tesserae are limestone of varying quality; some are very porous and friable while others are highly crystalline and dense. Brownish stains are caused by the presence of iron oxides derived from the oxidation of pyrite in some tesserae. Thin, flaky layers of gypsum, observed in several samples, cause color changes and are easily dissolved or eroded. The ancient and modern mortars are porous and can be expected to transmit moisture through to the mosaics[4]. The new mortar contains trace amounts of gypsum, which may have a deleterious effect in the future as it dissolves and is transported to the surface of the tesserae. Glue is present on some of the yellowed tesserae and should be removed.

## Notes

1. All photographs are backscattered electron micrographs, unless otherwise noted.

2. Tesserae samples from the Basilica of Chrysopolitissa were collected by Demetrios Michaelides in June 1988.

3. E. Moores, personal communication.

4. The new support constructed for the Orpheus mosaic is completely impermeable to water and, therefore, eliminates the problem of moisture transmission through the mortar.

## References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1985 "The Mosaics of Cyprus: Problems of Conservation." In *Conservation in Situ, Aquileia, 1983*. Rome: ICCROM.

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1985 "Formation of Secondary Iron Oxides in Various Environments." In J. I. Drever (ed.), *The Chemistry of Weathering*. Holland: Reidel.

**Watson, A.**

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# APPENDIX A: CLEANING TESTS ON OTHER MOSAICS AT PAPHOS

## Cleaning Tests Using Biocides

*Giorgio Capriotti and Lorenza D'Alessandro*

Biological cleaning tests were carried out on pavement mosaic surfaces with two-color geometric decoration exposed in the open air in the Villa of Theseus. Technicians of the Department of Antiquities in Paphos had observed extensive growth of microorganisms (mosses and algae) following the use of plastic sheeting on the mosaics as a seasonal protective measure. The following cleaning tests were carried out on the areas of biodeteriogen attack, still visible as dark stains, as a series of demonstrations for the participants in the training course.

### Test 1: Desogen

Desogen (quaternary ammonium salts; Ciba-Geigy) is a surface active agent with mild disinfectant properties; it is useful for any stage of biological removal.

*Procedure:* Biodeteriogens were mechanically removed with a solution of 10 cc Desogen in 1 liter distilled water, applied with sponges and brushes with wetted bristles, followed by rinsing with distilled water.

*Result:* Stains disappeared.

### Test 2: Lito 3

Lito 3 (active agent Fluometuron; Ciba-Geigy) aids in the removal of algae, mosses, and lichens found on stone surfaces.

*Procedure:* Biodeteriogens were mechanically removed as in Test 1; rinsing with distilled water was followed by spray application of a solution of 30 g Lito 3 in 1 liter water.

*Result:* Stains disappeared. Minor residues of white powder were detected which, if left in situ, reactivate with rain water to inhibit biological growth for up to four months.

### Test 3: Metatin

Metatin (N 5810/101; active ingredient Tri-N-Butyltin Napthenate; Acima Chemical) is a biocide active on bacteria, algae, mosses, and lichens.

*Procedure:* Biodeteriogens were removed as in tests 1 and 2; rinsing with distilled water was followed by spray application of a solution of 10 g Metatin in 1 liter water.

*Result:* Stains disappeared. Metatin showed good inhibitory properties, without residues.

As of December 1990, two years after the application of the biocides, no further biological growth on the tested areas had been observed.[1] It should be emphasized, however, that these results are still preliminary and are subject to long-term verification, particularly with regard to seasonal cycles. With this caveat in mind, a program of periodic maintenance could be designed for the conservation of the exposed sites.

## Cleaning Tests in the House of Dionysus

*Paolo Pastorello and Werner Schmid*

Some cleaning tests were carried out on the floor mosaics in the House of Dionysus for teaching purposes. The aim was to demonstrate the materials—chemical reagents and thixotropic support materials for compresses—that are used for cleaning mosaic surfaces and the way in which they are normally prepared.

The mosaics are currently protected in a specially constructed building that offers protection from rain and, to a limited degree, soluble salts from the sea. The mosaics have been detached and reinstalled on a foundation similar to the original one. The preparatory layers (statumen, rudus, nucleus, and setting-bed) have been constructed in situ with local, natural materials similar to the ancient ones, without the use of cement.[2]

Visual inspection of the mosaics reveals that the surfaces are covered with a whitish film and some zones show yellow staining, particularly visible on the tesserae of white limestone. See pages 46–57 for the results of analytical tests regarding these phenomena.

In many zones the tesserae appear to be in an advanced state of deterioration, with surface corrosion and an appreciable loss of cohesion of the constituent material (especially the glass and a white, rather fragile limestone). The deteriorated zones, easily recognizable in a raking light, alternate with zones in optimal condition. Verbal communication with staff employed in the restoration suggests a possible connection between the deterioration phenomena and past use of dilute hydrochloric acid to clean calcareous incrustations on the mosaic surfaces.

Once the state of conservation had been assessed, a number of cleaning tests were carried out. In the zones of salt efflorescence, compresses with distilled water in sepiolite (absorbent clay in powder form) were used to redissolve the soluble salts on the surface and extract those within the stone material of the tesserae. Japanese tissue was first applied to the tesserae, to avoid interstitial infiltration of the clay; the compress was then applied to a thickness of 2 cm and left in place for six hours. It was removed when the sepiolite showed diffuse cracking and shrinking as it dried out, taking with it the solubilized salts. The zone was then washed with distilled water. After complete drying, a noticeable reduction in the efflorescence and a greater brilliance of the colored tesserae were observed. The treatment would then be repeated many times and the quantity of soluble salts monitored with conductivity tests on the compress.

In the zones with superficial yellow staining due to the altered residues of animal glue, cleaning tests were carried out. A compress of ammonium carbonate and Desogen (a surface active agent) in cellulose pulp was applied to various areas for different periods of time, and was covered with a sheet of aluminum foil to avoid premature evaporation of the water. The optimal time of application was established to be two hours, at the end of which the compress was removed and the area tested was washed with the aid of brushes and water with a surface-active agent. The treatment proved positive, with a notable improvement in the surface color. Residual salts possibly deriving from the chemical substances used for the test were extracted using compresses of deionized water in sepiolite.

## Notes

1. The absence of further biological growth on tested areas was reported by Demetrios Michaelides, Department of Antiquities.

2. Information concerning materials used in the previous restoration was obtained from various workers who had participated in that project.

# APPENDIX B INSTRUCTORS AND PARTICIPANTS IN THE PROJECT

**Instructors in the Field Project**

| | |
|---|---|
| 1988 | Giorgio Capriotti<br>Private Conservator<br>Rome, Italy |
| 1988 | Lorenza D'Alessandro<br>Private Conservator<br>Rome, Italy |
| 1988/1989 | J. Claire Dean<br>Field Coordinator for the Project<br>University of North Dakota<br>Grand Forks, North Dakota, USA |
| 1988 | Maya Elston<br>J. Paul Getty Museum<br>Malibu, California, USA |
| 1988/1989 | Jan Kosinka<br>Private Conservator<br>Rome, Italy |
| 1988/1989 | Demetrios Michaelides<br>Department of Antiquities<br>Nicosia, Cyprus |
| 1988 | Laura Mora<br>Istituto Centrale del Restauro<br>Rome, Italy |
| 1988 | Paolo Mora<br>formerly Chief Conservator, Istituto Centrale del Restauro<br>Rome, Italy |

| | |
|---|---|
| 1988 | Paolo Pastorello<br>Private Conservator<br>Rome, Italy |
| 1988 | Werner Schmid<br>Private Conservator<br>Rome, Italy |
| 1988 | David Scott<br>Getty Conservation Institute<br>Marina del Rey, California, USA |

## Participants in the Field Project

| | |
|---|---|
| 1988 | Dimitrios Chryssopoulos<br>Department of Conservation of Antiquities<br>Ministry of Culture<br>Athens, Greece |
| 1988/1989 | John Daglis<br>Department of Conservation of Antiquities<br>Ministry of Culture<br>Athens, Greece |
| 1988/1989 | Andreas Georgiades<br>Department of Antiquities<br>Nicosia, Cyprus |
| 1988/1989 | Evangelos Hadjistephanou<br>Department of Antiquities<br>Nicosia, Cyprus |
| 1988/1989 | Giorgios Tapakoudes<br>Department of Antiquities<br>Nicosia, Cyprus |
| 1988 | Dodo Shenhav<br>Restoration Laboratory, Israel Museum<br>Jerusalem, Israel |

| | |
|---|---|
| 1989 | Andrei Vainer<br>Restoration Laboratory, Israel Museum<br>Jerusalem, Israel |
| 1988/1989 | Reyes Silvestre<br>Departamento de Restauración<br>Centro Conservación de Bienes Culturales<br>Castellon, Spain |
| 1988/1989 | Leandro de la Vega<br>Departamento de Restauración<br>Centro Conservación de Bienes Culturales<br>Castellon, Spain |

## Participants[1] in the Planning Meeting, June 1988

Vassos Karageorghis
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Nicosia, Cyprus

Luis Monreal
Director, Getty Conservation Institute
Marina del Rey, California, USA

Margaret Alexander
Professor Emerita, School of Art and Art History
The University of Iowa
Iowa City, Iowa, USA

Miguel Angel Corzo
Director, Special Projects
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Marta de la Torre
Director, Training Program
Getty Conservation Institute
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Paolo Mora
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Athanasios Papageorghiou
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Frank Preusser
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Andreas Tapakoudes, Department of Antiquities, Cyprus
Georgios Tapakoudes, Department of Antiquities, Cyprus
Evangelos Hadjidstephanou, Department of Antiquities, Cyprus
J. Claire Dean, J. Paul Getty Museum, Malibu, California, USA

## Note

1. Titles and affiliations listed for participants in the planning meeting are those held by the participants in June 1988, at the time of the meeting.

# APPENDIX C COSTS OF THE PROJECT

## The Mosaic

The gross costs of the materials, equipment, and other supplies used during the operation of lifting the Orpheus mosaic, providing it with a new support, and reinstalling it, exclusive of labor and shipping costs, were as follows:

| Material | $US |
|---|---|
| Eight honeycomb panels (Ciba-Geigy, U.K.)* | $4,236 |
| 375 kg resin and hardener (Ciba-Geigy, U.K.)* | 3,352 |
| Various supplies (chemicals, small tools, mortar ingredients) purchased in Italy* | 2,470 |
| Various supplies (fiberglass, aluminum, solvents, tools) purchased in Cyprus | 2,100 |
| Construction of wooden drum | 405 |
| Total Cost | $12,563 |

*All materials supplied from the U.K. and Italy were purchased free of local value-added taxes, and were imported free of Customs duties through the Department of Antiquities of Cyprus.

## The Hexashelter

Costs of constructing the hexashelter (materials and tools), exclusive of labor and shipping costs, were as follows:

| Material | $US |
|---|---|
| Aluminum tubing (3" & 4" diameter, 1/4" wall) | $4,030 |
| Aluminum bars for hubs, studs, and connectors | 800 |
| Laminated vinyl for roof membranes | 1,277 |
| Fabrication of roof membranes | 2,188 |
| Hardware, cable, and fittings | 1,381 |
| Anodizing of aluminum | 2,000 |
| Concrete for footings | 425 |
| Tools for construction | 250 |
| Total Cost | $12,351 |

# LIST OF AUTHORS


| | |
|---|---|
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| *Giorgio Capriotti* | Private Conservator<br>Rome, Italy |
| *Lorenza D'Alessandro* | Private Conservator<br>Rome, Italy |
| *Jan Kosinka* | Private Conservator<br>Rome, Italy |
| *Paolo Pastorello* | Private Conservator<br>Rome, Italy |
| *Werner Schmid* | Private Conservator<br>Rome, Italy |
| *Neville Agnew* | Getty Conservation Institute<br>Marina del Rey, California, USA |
| *Richard Coffman* | Getty Conservation Institute<br>Marina del Rey, California, USA |
| *Po-Ming Lin* | Getty Conservation Institute<br>Marina del Rey, California, USA |
| *Eric Doehne* | Getty Conservation Institute<br>Marina del Rey, California, USA |

# PHOTO CREDITS

*Neville Agnew*
Figures 38–42

*Guillermo Aldana*
Plates 1,2,3; Figures 4,73

*Giorgio Capriotti and Lorenza D'Alessandro*
Figure 14

*J. Claire Dean*
Figures 5,6,12,16,17,20,21,28–36

*Department of Antiquities, Cyprus*
Plate 4; Figures 3,4

*Jan Kosinka*
Figure 26

*Demetrios Michaelides*
Figures 8a,b

*Paolo Pastorello*
Figures 13,18,19,24,25

*Nicholas Stanley Price*
Figure 11

*Figure 73. J. Claire Dean atop the scaffolding designed by Dean, Guillermo Aldana, and staff of the Department of Antiquities, from which Aldana took the overall view of the Orpheus mosaic (see cover photo and Pl. 1).*