In Situ Mosaic Preservation of Three Glass and Marble Opus Sectile Panels at the Roman Villa of Faragola (Ascoli Satriano, Italy)

Maria Concetta Laurenti* Archaeologist
and Elisabeth Huber Conservator
Istituto Superiore per la Conservazione ed il Restauro Rome, Italy
mclaurenti.icr@beniculturali.it

Antonella Martinelli Conservator
Alfa Restauro Opere d’Arte Bari, Italy

Introduction
Excavations at Faragola, near Ascoli Satriano, which the University of Foggia has been conducting since 2003, have brought to light part of a luxurious villa of late imperial age on the site of a farm of the late republican era and an earlier Daunian settlement (fourth to third centuries B.C.) (De Felice and others 2008). It was situated on the spurs that trace the valley of the Carapelle River, five kilometers from Ausculum, to whose territory it belonged.

The villa dates to the final phase of late antiquity (fourth to sixth centuries A.D.). The area identified as a summer cenatio was provided with a stibadium (semicircular seat) made of masonry clad in opus sectile and of a finely preserved pavement—in marble slabs partly reused from earlier buildings—that was embellished, along its central axis, by three panels (hereafter referred to as Panels 1, 2, and 3) in opus sectile made of colored marble and glass elements (Laurenti and others 2008).

Although the panels are stylistically similar (Fig. 1), they are different in their manufacturing techniques and dimensions. Panels 1 and 2 (137 x 84 cm) suggest close technical and iconographical analogies with panels discovered in Kenchreai, the port of ancient Corinth, for which an Egyptian provenance has been suggested. However, the mixture of glass and stone elements found at
Faragola does not exist in the Kenchreai panels (Ibrahim, Scranton, and Brill 1976).

Panel 3 (170 x 108 cm) more closely resembles the production of *emblemata* with nonrepetitive patterns, and it contains a type of *breccia corallina*, a stone comparable to that used in the pavement of the *cenatio*, which was quarried locally. The date of the three panels has been proposed as late fourth century A.D. because of their similarity to the Kenchreai panels, and this seems to strengthen the hypothesis that they were reused in the *cenatio*, which, based on stratigraphic evidence, has been dated to the sixth century A.D. A small sample, taken to help clarify the execution of the *opus sectile* panels and their stratigraphic relationship with the archaeological context, revealed that the pavement of the *cenatio* was laid over an earlier polychrome mosaic pavement about five centimeters below the level of the *sectilia* (Laurenti and others 2008). This pavement, based on stylistic comparisons, can be dated to the late fourth or early fifth century, and it belongs to an earlier construction phase.

Since the panels were discovered, their nature has posed problems for their conservation because the principles of modern archaeological conservation (Laurenti 1998; Michaelides 2001; Melucco Vaccaro 2003) dissuade us from removing decorative elements from their context, and because the integrity of the mosaic complex must be safeguarded. In fact, if we were to proceed with the detachment of the panels, we would be faced with the difficult
task of doing it without damaging either the underlying mosaic or the slabs of breccia adjoining the sectilia, some of which would have to be removed to create the space necessary to detach the panels. The extremely poor condition of the slabs would not permit this operation without seriously damaging them in the process. The studies carried out by the Istituto Superiore per la Conservazione ed il Restauro (ISCR) since 2006 have therefore focused on assessing the feasibility of the in situ conservation of the panels and identifying possible solutions.

The erection of a provisional shelter and temporary reburial, organized by the University of Foggia since the first excavation campaign, turned out to be insufficient to curb the progressive deterioration, particularly of the glass materials in the opus sectile panels of the cenatio. For this reason, a program of investigations was established to identify the causes of this deterioration and to determine the most effective methods of conservation. It was deemed necessary to proceed with the restoration of the decorative fixtures of the cenatio while a new shelter that would provide an effective in situ museum display solution was being planned.

The studies carried out since 2007 include two microclimatic monitoring campaigns of the area outside and under the shelter, first in 2007–2008, when the temporary shelter was still present, and then in 2009, when the new shelter had been erected. There were also thermographic and georadar surveys, and the moisture in the soil below the cenatio paving was measured. In addition, a system to safeguard the panels was set up and is still in use.

**Execution Techniques**

**Glass Elements**
The majority of the glass tesserae were cut from slabs. These were obtained by pouring the molten glass onto a smooth surface. After this, the slabs could be cut with a hot iron tool to create the shapes of the individual elements that make up the sectile (Verità and others 2008), according to a procedure that has been described by Theophilus (2000).

Other elements, all elongated and partly curved, were made by stretching hot glass. The colored glass mass was poured into rectangular molds. The bars fashioned in this way were then reheated and elongated with pliers until the desired thickness was achieved. Then, when heated, the rods could be easily cut and manipulated into the desired shape and size so as to produce the curved forms found in Panels 1 and 2.

Most of the glass tesserae were made of monochrome opaque glass. The colors used were white, pale yellow, orange, red, black, and different shades of turquoise, ranging from light blue to green. Only on Panel 3 do we also find blue glass elements.

Gold tesserae appear in the sectilia. They were made by placing the gold leaf between two layers of transparent glass, an ancient method that is still employed to this day. The technique involves attaching the gold leaf to a generally transparent colorless glass support and then protecting it with a glass cover (cartellina).

Some of the glass is “marbled”; it was created by manipulating the preformed multicolored glass bars while hot until an effect similar to that of polychrome marble resulted.

With regard to the chemical composition of the glass, we can refer to published analyses (Santagostino Barbone and others 2008; Gliozzo and others 2010). The examined batches are based on silicon, sodium, and calcium; the vitrifying agent is a silica sand; the flux is plant ash for the red glass, in which a higher calcium content was found as a stabilizer, and natron for all of the other colors (orange, yellow, green, blue, and blackish). On the basis of these considerations, the types of glass employed at Fara-gola would seem to have compositions different from those of the Kenchreai panels (Turchiano 2008).

**Stratigraphy of the Panels**

As was mentioned above, the pavement of the cenatio was constructed over a mosaic pavement, located about five

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1. The thermographic survey of Panels 1 and 3 show that the underlying layers are seriously affected by the infiltration of water; this probably led to the formation of pockets of moisture, causing diverse thermal inertia in the surface materials.

2. Analysis of the data confirmed the already described stratigraphy and helped to identify a layer, 10 to 50 centimeters thick, consisting of earth and fine-grained filling material and saturated with water with numerous voids, at a depth of about 10 centimeters.

3. The moisture, in samples taken from up to 90 centimeters in depth, is around 20%–22% (percentage of dry mass).

4. The analysis of the glass slabs was carried out by the Department of Earth Sciences of the University of Siena.
centimeters below the level of the sectilia. Above this mosaic is a layer of pozzolanic mortar about three centimeters thick, on which are placed amphora fragments that form the support of Panels 1 and 2. The amphorae have been cut lengthwise, and the ceramic fragments, positioned in a radial pattern with their inner surfaces facing upward, cover the whole area of the panel. This support was then covered by a layer of mortar in which the marble

Figure 2
The glass appears completely opaque because of the presence of degradation layers. The tesserae, pulled with heat, have a pattern of decay that coincides with the direction in which the glass was stretched to obtain the bars. (Photo: Angelo Rubino)

Figure 3
Reconstruction of the color scheme (left) of Panel 1 (right). (Design: Elisabeth Huber)
and glass elements were embedded. This method of assembly could confirm the assumption that these emble mata were not constructed directly on-site, but in a workshop; this hypothesis has already been formulated in scientific publications (Laurenti and others 2008; Turchiano 2008). Panel 3 seems to have been assembled on the site, on an underlying layer of mortar with large stone and ceramic aggregates arranged in a less regular way than in the other two panels.

**Conservation Condition**

When they were discovered in 2003, the three panels contained numerous lacunae. Panel 2, having lost most of its inlay materials, reveals almost all of the underlying layer of ceramic fragments, while the decorated surfaces of Panels 1 and 3, though incomplete, are more legible.

The glass in the panels presents various phenomena of deterioration. The elements appear completely opaque because degradation layers of varied thicknesses are present; they are porous and exhibit a whitish mother-of-pearl aspect (Fig. 2). These layers of altered glass (probably hydrated silica resulting from dealkalization) tended to disintegrate from numerous large cracks and microcracks that, in some instances, spread toward the nucleus of the still undamaged glass. On many of the glass inlays, surface flaking was visible, and the flakes tended to become detached. The tesserae, which were heated and pulled, had also become totally opaque. This pattern of decay coincided with the direction in which the molten glass was worked and stretched to obtain the bars.

The opaque layers of alteration covering the surface have made the color of most of the tesserae hardly recognizable. For this reason, and in order to form an idea of how the sectilia appeared in their original state, a graphic representation that attempts to reproduce the lost color scheme of Panel 1 has been composed (Fig. 3).

In many of the gold tesserae, the gold leaf had been lost, although this was often hard to recognize because of the deterioration of the glass and thick encrustations. On the other side, the marble crustae were in better condition, except for the breccia corallina, where differential decay was evident after cleaning.

Apart from the deterioration of the materials, there are structural problems due to the loss of adhesion between the tessellatum and the preparatory layers. In fact, many areas have become detached, and voids exist between the inlays and their bedding layers. The many lacunae in the preparatory layers had resulted in the deformation, principally of the opus sectile in Panel 1. The interstice mortar, most of which is missing, was compensated by accumulations of soil.

The condition of the sectilia has been further compromised by the flooding that occurred in the cenatio following a heavy storm in June 2007. Urgent intervention was necessary to remove the damp layer of mud deposited on the surfaces (Fig. 4), but a large quantity of water had penetrated below the surfaces and infiltrated the preparatory layers. The water then tended to migrate to the surface, evaporating through the more permeable zones. Soluble salts, consisting mainly of sulfates and calcium carbonates, subsequently appeared along the edges of the glass elements. With the changes in the thermohygrometric conditions, these salts have undergone variations in volume, becoming crystallized or soluble. In this way, they...
exert increasing pressure on the porous silica layers, causing their progressive disintegration (Fig. 5). This physical-chemical process is the main cause of the deterioration in the glass elements at Faragola. In fact, several recent climatic events that occurred before the site was definitely sheltered have rapidly increased the loss of cohesion of the glass surfaces, which partly disintegrated into flakes.

In order to reduce further deterioration of the sectilia, it was necessary to proceed with a systematic restoration treatment of the panels, and then to establish a program to monitor their condition.

Restoration Treatment
The restoration of the sectilia was carried out between October and December 2007. A meticulous graphic and photographic campaign was conducted before, during, and after the restoration work for documentation.5

First, the loose deposits and soluble salts were mechanically removed, using small brushes and aspirators. The presence of more coherent deposits necessitated the use of scalpels. This preliminary dry cleaning was followed by a further cleaning with swabs soaked in pure ethanol and deionized water (1:1), which facilitated the removal of the soil that was still present. This cleaning was carried out carefully in order to avoid affecting the layer of hydrated silica on the glass, which is part of the original material.

The cleaning operation was accompanied by the consolidation of the cracked and disintegrated glass. The adhesion of the flakes and the detached fragments of glass was achieved with a polyvinyl butyral (PVB) resin (Mowital B60 HH) in 15% ethanol (w/v). The same resin, in lower concentrations (2%–10% w/v), was also applied to the porous surface of the altered glass. PVB resins have good properties of adhesion to glass, which is confirmed by the fact that they have been used since the 1930s as the intermediate layer for security glass. They are also widely employed in the restoration of cultural properties, being described as reversible and resistant to aging (Sidoti 2002).6 Furthermore, the glass transition temperature of PVB is 65°C, while that of Paraloid B-72, an acrylic resin that is often used for the consolidation of glass, is only 40°C. For this reason, Paraloid B-72 is not really suitable for use on an excavation site, where summer temperatures can easily approach 40°C. A further advantage of the PVB resin, as compared with Paraloid B-72, is its excellent solubility in alcohol, which is nontoxic for the user.

The structural consolidation to readhere the tessellatum to its underlying layer was carried out using a liquid hydraulic mortar (Ledan TB 1)7 injected into the interstices and into the voids below.

Some crustae that had become detached from their original bedding layer were removed and correctly repositioned on a bed of repair mortar.8

The interstices were filled with a mortar consisting of slaked lime, yellow cocciopesto, and gray pozzolana. The restoration treatment was concluded by filling the lacunae

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5. The graphic documentation was carried out using AutoCAD software.
6. PVB resins maintain their mechanical properties of color and reversibility. Compared with the Paraloids, the PVBs seem more resistant after ultraviolet aging but less resistant to high temperatures (above 100°C).
7. This mortar consists of chemically stable hydraulic binders with a low content of soluble salts, siliceous aggregates, slate, aerated pozzolana, and fluidifying additives.
8. This mortar is made up of slaked lime and gray pozzolana (1:2).
with mortar ⁹ and by reinforcing the edges of the panels with an edging repair.

When the restoration work was completed, it was decided not to apply any protective resin to the surface, so as to facilitate the evaporation of water and transpiration through the natural porosity of the materials.

On-Site Preservation

The restoration work on the *opus sectile* panels was concluded in December 2007. During the autumn of 2008, the temporary protective shelter that covered the area of the *cenatio* was replaced with a permanent structure (Fig. 6). This architectural shelter was closed along its sides by vertical wood-frame panels coated with Gore Tenara VG0181 in order to protect the *cenatio* from dust and wind. Gore Tenara is a fluoropolymer-coated fabric woven from polytetrafluoroethylene, which is used in architectural contexts such as tensile structures. It is a highly resistant fabric that is both waterproof and permeable by water vapor.

The level of the archaeological excavation surrounding the *cenatio* has been lowered by about one meter below the level of the pavement, permitting the dampness that is still trapped below the *sectilia* to find a lateral exit. Moreover, a rainwater drainage system has been created in order to limit further infiltration of water. The surface of the *opus sectile* panels is currently covered by layers of different materials for the seasonal reburial. There is a layer of geotextile fabric—the nonwoven polyester textile Reemay 2033—on which sacks of the same textile full of expanded pearlite (Igloperlite T3/8) have been placed (Fig. 7). Pearlite is an extrusive silicified volcanic rock that is able to expand up to 20 times its original volume when brought to high temperatures. Pearlite has an extraordinary insulation capacity; it is thermal but allows water vapor to permeate it.

This device is designed to slow the evaporation of residual moisture from below the pavement and thereby to decrease the deterioration of the glass, avoiding the continuous physical exchange of humidity. In fact, below the *cenatio* pavement, a residual water content of about 20% was measured in the soil. The reburial device is intended to reduce the stress of the panels caused by daily/seasonal evaporation cycles of the soil moisture.

When the restoration treatments were completed, a program to monitor the conservation condition of the *opus sectile* panels was set up to (1) carefully observe and photographically document the surfaces monthly, and (2)

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⁹ This mortar consists of hydraulic lime Saint Astier NHL 3.5, local gray sand, yellow cocciopesto, and fine-grained stone dust.
monitor the temperature, relative humidity, and airflows on the surfaces in contact with the panels, below the covering roof, and externally. The data collected reveal that the thermohygrometric conditions of the sectilia have stabilized: the daily temperature oscillations have strongly decreased, and the relative humidity values on the surface have settled close to 100% (Laurenti and others 2010). Despite this, the evaporation of water trapped below the sectilia continues, very slowly, to transport the soluble salts to the surface, where they remain deposited. In December 2009, a cleaning campaign was required to remove the salts and, in certain areas, to reconsolidate the leached glass.

**Conclusion**

While waiting to make a final decision on the conservation of these mosaic panels, we continue our program of environmental monitoring and periodic checks on their conservation condition. Although the new shelter improves the thermohygrometric conditions of the environment, the values of relative humidity are not yet ideal for the conservation of the glass, even under the protective device. However, we believe that it is preferable to maintain this state to avoid extreme changes in temperature and relative humidity, given that the latter could result in the rapid alteration of the glass inlays even in the short term. Our objective is to reduce the causes of deterioration of the crustae, opting for their in situ conservation, despite the fact that this obliges us to carry out frequent inspections and maintenance operations. On the other hand, if the condition of the panels is going to deteriorate further, we will be faced with the difficult choice of having to detach the mosaics, despite the potential risk of damaging the underlying mosaic and the nearby marble slabs, heavily modifying the image of the archaeological site.

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*ISC R working group:*

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Petrographic and mineral analysis of stone and mortars: L. Conti and M. Mariottini (laboratory for testing materials)
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*Materials*

Mowital B60 HH (Kuraray)
Paraloid B-72 (Rohm & Haas)
Ledan TB 1 (Tecno Edile Toscana S.r.l.)
Saint Astier NHL 3.5 (TCS S.r.l.)
Gore Tenara VG0181 (W. L. Gore & Associates GmbH)
Reemay Filtration Grade Spunbonded Polyester 2033 (Reemay Inc.)
Igroperlite T3/8 (Perlite Italiana)

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Laurenti and others 2008


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Melucco Vaccaro 2003


Michaelides 2001


Santagostino Barbone and others 2008


Sidoti 2002


Theophilus 2000


Turchiano 2008


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