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IN SITU MOSAIC CONSERVATION: A CASE STUDY FROM KHIRBET YAJUZ, JORDAN

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ABSTRACT

The methodology for the conservation of the mosaic floor of the byzantine bath in Khirbet Yajuz in Jordan is presented. The mosaic was discovered in 1998, and needed urgent protection measures. Both optical investigation and analytical examination of mosaic samples were carried out by stereo optical microscopy and XRD, and both revealed that the tessellatum (Mosaic surface) was subjected to intensive deterioration aspects such as deposited encrustation, salt efflorescence, cracking, surface pitting, discoloration and biological growth.

The performed conservation activities included documenting the mosaic by photographs and drawings in scale 1:1; reinforcing the mosaic edges and the preparatory layers with lime mortar; mechanical and chemical cleaning; filling the small lacunae; surface coating using Paraloid B72 ; reburial of the mosaic by sand to avoid the environmental factors, and herbicide application to prevent plants intrusion.

KEYWORDS: Khirbet Yajuz, Mosaic, Conservation, Consolidation, Lime-mortar, Tesserae, Reburial.

1. INTRODUCTION

Khirbet Yajuz located about 11 kilometers northwest of the capital Amman (Fig.1). Excavations started on the site in 1994 by the Jordan Department of Antiquities. (Suleiman, 1996). Further excavations were carried out yearly since this year and continued until the summer of 2011 by the Jordan Department of Antiquities and the University of Jordan.

Figure 1 Map of Jordan showing the location of Khirbet Yajuz

However, excavations indicated that this site has been settled during Roman, Byzantine and Islamic periods. The site was built in the late roman period on the Roman road between Amman (Philadelphia) and Jerash (Jerasa), the site was flourished in the Byzantine period, and it was extended to the Umayyad and Abbasid periods. Important architectural structures such as churches, wine presses, public building, tombs and other features were discovered in the site. Furthermore, a great number of mosaic floors of different typology and function have been uncovered together with numerous types of pottery, glass and coins (Khalil and Al-Nammari, 2000).

The Byzantine Bath was discovered during the excavation work carried out in 1998 in the south-eastern area of the site (Fig. 2) (Suleiman, 1999).

Figure 2 General View of the Byzantine Bath

Unfortunately not enough information was available about the bath and the mosaic; there is no records of the excavation of 1998. The only documentation available some photographs done about this mosaic.

Figure 3 General View of the Mosaic Floor

The mosaic floor located at the middle room of the bath and is not particularly large, measuring approximately 4m.W x 5m.L. The room paved with mosaic floor of plain white tesserae. The southern side of the room and in front of the entrance is decorated with a rectangular polychrome mosaic.

The polychrome mosaic subdivided into squares and rec tangular panels and surrounded by a braided guilloche. The panels contain a variety of geometric patterns. The middle of the mosaic has two amphora on a high pedestals with a vine pomegranate and grapes between them. Also, the area in front of the entrance of the room is decorated with a pair of sandals (Fig.3).

After its discovery in 1998, the mosaic was covered by plastic sheets and sand layer by the archaeologists and kept in this condition until the year 2013 without any interventions. So, this paper describes the remedial and preventive conservation treatment of this important mosaic floor in situ. This work was done 15 years after the discovery of the mosaic. The conservation process included state of conservation, documentation, cleaning, consolidation, lacunae treatment and reburial.

In the past, strategies for mosaic conservation were very limited, detachment was the primary option available, materials used were exclusively cement, gypsum and glues, as well as documentation was lacking (de Guichen and Nardi, 2005).

Several studies performed on mosaic conservation confirmed the importance of conserving the mosaic in its original context in order to better preserve the integrity of their cultural values and authenticity for the future. In addition, the International Committee for the Conservation of Mosaics (ICCM) organized a series of regular conferences, whose themes were focusing on the importance of in situ mosaic conservation.

Applied studies carried out by Ferragni et al (1983), Cobau and Nardi (1996) and Roby (1996) affirmed that the mosaics which suffer from detachment between its support layers can be treated by injection techniques without detaching and lifting.

According to research done by the Italian Conservation Scientist Giorgio Torracca suggests the replacement of the cement with one of the oldest construction materials known, lime-based- mortar in the conservation of mosaic (de Guichen and Nardi, 2005).

Both conservators and archaeologists have always recognized the fundamental importance of documentation. Cordfield (1996) reported that all the elements of documentation such as iconography, materials, condition and treatments should be brought together into a single integrated archive.

According to Nardi (1996) the process of in situ mosaic conservation consists of several steps namely documentation and study; actual treatment and other steps taking for protection. Last, the good practice for conservation of mosaics was followed as recommended elsewhere: (e.g.http://www.getty.edu/conservation/our_ projects/field_projects/mosaics/mosaics com. Ponent 1htm1).

2. EXPERIMENTAL PROCEDURES

2.1 Mosaic samples

Five mosaic tesserae of different colors (red, yellow, black, white and orange) were collected together with block of mortar from bedding layer and prepared for chemical and microscopic examination. Table 1 summarized the description of these samples.

2.2 Analytical techniques

The mineralogical composition of the tesserae samples was determined by X Pert MPD-Philips X-ray powder diffractometer (XRD) with Cu Kα radiation (1.543 A°) operating at reflection mode, which also used to determine the mineralogical composition of encrustation and deposits on the mosaic surfaces addition to the mortar used. Furthermore, optical assessment using stereo optical microscopy was carried out before conservation process.

2.3 Chemical analysis identification

The identification of the components of mosaic tesserae was important in order to identify the nature of its constituent materials, as well as to study their condition. To identify the composition of the components of the mosaic floor, five tesserae samples of different colors (black, white, yellow, orange and red) were analyzed using XRD. The results of the tesserae samples selected and shown in Table 2 indicate that they are mainly composed of the famous mineral "Micrite" which mineralogicaly named as microcrystalline calcite ($CaCO_3$) or pure calcite. However, the colour hue of all tesserae is due to the very trace presence of iron oxide FeO, so all samples of different colors were chemically similar which contained calcium carbonate($CaCO_3$) basically, and differ only in color , this is an indication to the purity of the limestone used (Marchese and Garzillo, 1984).

On the other hand, calcite ($CaCO_3$) and quartz (SiO_2) are the major and minor component of mosaic mortar respectively, and this means that the mortar used in the construction of the floor is a localized Lime mortar (Stewart, 2004; Abd-Allah, 2010; Khswneh et al., 2011).

2.4 Microscopic examination observation

Additions to the visual examination of tesserae and mortar in the site, sufficient samples were investigated by stereo microscopy at 2.5-10 X. It was observed that the tesserae are regularly shaped and nearly similar in sizes. Whereas other aspects of fractured surface and highly fissured nature of decayed surfaces were observed on the red and yellow samples. Furthermore, examination was carried out on cross-sections of the same samples to examine the structure morphology of inner core of every tesserae to show how the inner body relatively differs from the outer surfaces.

Salt crystallization or efflorescence was simply observed on the surface of all samples but differ in their dispersion and effect. Addition to that thin calcareous deposits and encrustations were also observed.

3. INTERVENTION TREATMENT

3.1 Removal of the backfill

There were stones collapsed and grassy plants over the sand backfill. The plants were passed through the plastic layers and reached to the mosaic preparatory layers (Fig. 4).

The sand layer was removed manually and by brushing. The action has to be carried out with special attention to avoid disturbing the plastic layers, and then the plastic layers were removed only after they had been allowed to dry out gradually to prevent salt crystallization on the mosaic surface. Under the plastic sheets, plants and small roots were also existed (Fig. 4). There were removed by using hand tools during the removal of the plastic sheets.

Figure 4 The mosaic before backfill removed

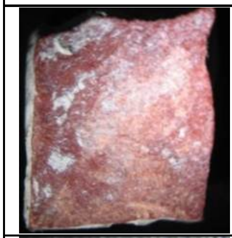
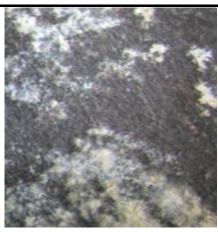
Figure 5 The mosaic after backfill removed

3.2 The state of conservation

The plants and roots under the plastic sheets were evident and caused significant mechanical damage on the tessellatum (Fig. 6). This means that the plastic sheets not work well against vegetation by preventing their growth. It is well known that the plastic sheet stop any liquid-water-vapor transport, then the water trapped under the plastic sheet will foster vegetation growth (GCI, 2011), as well as, the sand backfill was found inadequate to allow the ground water to evaporate completely. In addition, some dark colored residues caused by roots and plants and many spots of microorganisms were evident on the tessellatum (Fig. 7). However some of them were easily removable by hand tools, brushes and water, the others were needed a chemical cleaning.

Approximately the mosaic was in complete form, with the exception of a few parts which some of them were already lost before was discovered, and the others were lost after was discovered (probably due to vandalism).

Table 1 The description of selected samples

Photo	OM.	Sample No.	Material	Color	Deterioration Form
		1	Stone	yellow	Incrustation, Salt efflorescence, Fracture
		2	Stone	Red	Salt efflorescence, Fracture
		3	Stone	Black	Thin deposits
		4	Stone	Orange	Salt efflorescence
		5	Stone	White	Incrustation, Salt efflorescence

'**Table 2 Mineralogical composition of mosaic tesserae and mortar samples obtained by XRD analysis**

Samples	Minerals	Formula	Card No.
(1) Yellow tesserae	Calcite	Calcium carbonate ($CaCO_3$)	5-586
(2) Red tesserae	Calcite	Calcium carbonate ($CaCO_3$)	5-586
(3) Black tesserae	Calcite	Calcium carbonate ($CaCO_3$)	5-586
(4) Orange tesserae	Calcite	Calcium carbonate ($CaCO_3$)	5-586
(5) White tesserae	Calcite	Calcium carbonate ($CaCO_3$)	5-586
Mortar	Calcite	Calcium carbonate ($CaCO_3$) major	5-586
	Quartz	Silicone oxide (SiO_2) trace	46-1045

Figure 6 Plants have grown over tessellatum

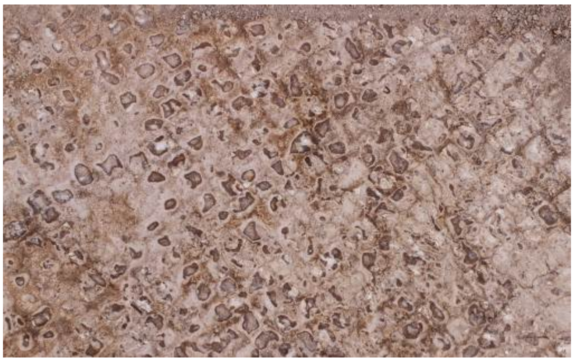


Figure 7 Plants residues and microorganism

After brushing the soil, the mosaic showed a number of lacunae (Fig.5) and disintegrated tesserae (see below Fig.10). Several tesserae were detached from the bedding layer, which were under the risk of disintegration.

Generally, the mosaic layers are still intact, but there is some of areas of the mosaic affected by different level of detachment between its layers, which required grout injections. Some depressions in different forms were presented in some areas of the mosaic floor, which may be due to the general weakness of the foundation layers or was result of loading or collapse of heavy objects over the mosaic floor (Fig.8). The mosaic also affected by different forms of bulges caused by plants growth (Fig.9).

The mosaic had also some fragmented and deteriorated tesserae, especially the black ones, because the structure of the black tesserae is weak and subject to mechanical alteration. Moreover, some deposits were found on the surface of the tesserae in the form of dirt, soil, and other hard deposits (Fig.11).

Figure 8 Depression of Tessellatum

Figure 9 Bulge caused by plants

Figure 10 Disintegrated tesserae

Figure 11 Incrustations

3.3 Documentation

Documentation was implemented in the form of drawings and photographs, in both traditional and digital formats. The mosaic was photographed using digital camera by placing measurement points at intervals of approximately 70cm.

These photos were then used as the basis for developing base map in Auto CAD. Also, all the mosaic was recorded in scale 1:1 on polyethylene sheets. These methods of documentation were used for documenting the state of conservation of the mosaic as well as the phases of mosaic interventions (Fig. 12). After all interventions on the mosaic, a general view of the mosaic was taken by using a digital camera.

3.4 Consolidation

The aim of mosaic consolidation is to improve the mechanical endurance of the degraded materials as well as to increase its chemical resistance (Mora, 1986).

Figure 12 Documentation of the mosaic by scale 1:1

Consolidation treatments were carried out in three phases:

I. Reinforce the tessellatum edges;
II. Filling interstices between tesserae and cracks;
III. Grouting voids located between preparatory layers of the mosaic.

A mortar composed of hydraulic lime, limestone powder and marble powder in ratio of (1:1:1) were used for reinforcing the edges and filling between tesserae and cracks.

Before the use of mortar, a number of mortar samples in different ratio were prepared in order to select the appropriate one.

Before the edges were reinforced with repair mortar, the areas that would be in contact with fresh mortar were cleaned and wetted using a nozzle spray to reduce their water absorption from fresh mortar, then the mortars were protected from direct sunlight to prevent rapid drying, and wetted by water early in the morning for a few days.

In order to fill between tesserae, it was necessary to clean the spaces between tesserae from deteriorated bedding layers and soil accumulated using brushes, small hand tools and blower. The areas were wetted using a nozzle spray, and then a fluid mortar were applied by brushing and lifted to dry. This operation aimed to improve the compactness of the tessellatum and the adhesion between tesserae. A wet sponge was used to clean the tessellatum from the excess mortars. Similar applications were also used for the treatment of cracks.

Injection grouts were used in a few cases, this process was applied to the sections of mosaic which showed lack of cohesion. Fluid mortars made of hydraulic lime, limestone powder and marble powder in 1:1:1 proportions were used for this treatment.

Before proceeding with the application of the injection, the areas of detachments were detected and marked, then several access points to the areas of detachment were created by removing some tesserae. The tesserae were cleaned, numbered and placed on a sand tray in the same position as found to facilitate putting them back in their original place. Then a small hole was made by digging. After cleaning the hole by blower and removing the deteriorated mortar, the hole was wetted by injection of distilled water to prevent the absorption of water from the repair mortar.

Fluid mortars were made and injected gradually in the hole using a suitable syringe. Finally the removal tesserae were put back to their original location.

To insure that the area being treated is completely saturated by the new consolidant, the area was checked by hand. If not, more fluid mortar is injected.

3.5 Cleaning

This operation is carried out using mechanical and chemical methods. The mosaic surface was cleaned from dirt and dust accumulated by using water, plastic brushes and sponge (Fig. 13).

Figure 13 Wet cleaning

In addition, Cellulose fiber (Paper pulp) saturated with AB57 solution was applied for four hours. Before proceeding with the application, the tessellatum was wetted in order to reduce the penetration of the chemical, and then the poultice was laid in the mosaic surface, covered with plastic film to prevent drying out. Immediately after the removal of the poultices, the surface was washed with water and plastic brushes. Furthermore, scalpels and small chisels were used to remove the solidified deposits such as hard crust (Fig. 14).

Figure 14 Manual mechanical cleaning

In order to remove the soluble salts, the mosaic surface was covered by compress of paper pulp wetted by water. This operation was repeated several times. To remove the microorganisms such as algae and moss, biological treatment was carried out by using a solution of diluted ammonium (25% concentration). Application was followed by washing and brushing the tessellatum, and then dried to avoid any remaining of chemical residues over the mosaic surface.

3.6 Treatment of lacunae

The treatment of lacunae was important. This facilitate to preserving the aesthetic values of the mosaic, while maintaining its historic integrity in the presence of larger lacunae (Nardi, 1996).

Two methods of treatment were implemented according to lacunae size and shape. In the case of small lacunae, tesserae of the same size and color were placed to fill the lacunae with lime mortar. To point out the new integrations in the ancient mosaic, the tesserae were placed under level.

These interventions were carried out with the help of old slides and photos, which had been taken in 1998 showed the mosaic in fairly good state of conservation. In addition, a great numbers of original tesserae were collected in situ and its original positions are unknown, the decision was taken to utilize these tesserae to fill in the lacunae. In case of large lacunae, it was enough to fix the internal edges of the lacunae by lime mortar.

3.7 Surface coating

For more protection, a Paraloid B72 3% solution in acetone was used to form a protective layer. Paraloid is an acrylic resin used more than many years in conservation field because it is a good- all-purpose consolidant. Brushing with a soft brush was used in a regular direction of application (Bani-Hani et al., 2012; Abd-Allah, 2013).

3.8 Reburial

The mosaic was reburied with the layer of sand about 50cm thick, and then the sand was treated with the herbicide Thymol (3% spray solution in water) and sprayed on the sand backfill in order to prevent plant intrusion and fungal growth (Fig.16).

Fig 15 The mosaic after conservation

Fig 16 Mosaic reburial

4. CONCLUSION

Over all, this study investigated the conservation of the mosaic floor of the byzantine bath in Khirbet Yajuz in Jordan.

The results indicate the importance of the in situ mosaic conservation in order to preserve it in its original context. However, the conservation of mosaic in situ is achievable and the mosaic can be preserved in situ without detachment. In addition, the materials and techniques used are approximately compatible with the original structure of the mosaic and are obtainable and not costly.

The reburial was carried out using local sand in order to protect the mosaic from the environmental factors. The sand was used without plastic layer which have proved to be dangerous to the stability of the mosaic floor.

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