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DETAILED DOCUMENTATION AND IN SITU CONSERVATION ACCORDING TO MORTAR CHARACTERISATION OF OPUS SECTILE UNCOVERED IN THE SAINT PHILIP CHURCH OF HIERAPOLIS (PAMUKKALE-TURKEY)

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ABSTRACT

During the archaeological excavations carried out in the ancient city of Hierapolis (Pamukkale-Turkey) in 2011-2012, a colourful opus sectile (ancient stone-art) dating back to the Middle Byzantine Period was revealed at the pavement of the Saint Philip Church. As the opus sectile was badly damaged, it was decided to preserve the opus sectile with the minimum of intervention. Before in situ conservation activities were initiated, a sample was taken from bedding mortar of the opus sectile and the following analyses were carried out: loss on ignition, deal with acid and particle size distribution analysis, petrographic analysis (thin and thick sections, Stereo and Polarizing Microscope observations), as well as Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy (SEM-EDX). According to results of the analyses, a mortar closely resembling the original mortar was produced and applied to a total of 14 opus sectile panels.

The conservation treatments carried out during the 2012-2014 seasons included documentation of the opus sectile by detailed photography, drawings in the scales of 1:1 and 1:20 with the Auto-CAD program and 3D documentation with the Agisoft program, as well as aerial photos at the end of activities. Conservation treatments included mechanical and chemical cleaning, reinforcing the opus sectile panels and edges, filling the missing parts with lime mortar according to the results of the analyses, and finally the reburial of the opus sectile with Geotextile and a mixture of clay/sand/gravel (treated with herbicide to prevent plant intrusion) in different aggregate sizes.

The inter-disciplinary collaboration on this excavation enabled us to determine that all the materials used in the creation of the opus sectile pavement were derived from local materials. In addition, we succeeded in providing a detailed documentation from the beginning of the project to the end, including the materials used and all the interventions carried out. As a result, the detailed documented data that was gathered will also be used in monitoring the condition and state of preservation of the opus sectile for future conservation projects.

KEYWORDS: Byzantine Period, Active Conservation, Documentation, Restoration, Lime Mortar, Analysis, Pamukkale, Chamber, Burial.

1. INTRODUCTION

Hierapolis (Holy City) was founded in the 3rd century BC by Greek-Macedonian colonists of the Seleucid Reign and was an important city of the Roman and Byzantine Empires. At the same time it was famous for the presence respectively of an oracular sanctuary of Apollo and the Ploutonion (one of the accesses to Hades identified in antiquity) and the tomb of the Apostle Philip (one of the most relevant pilgrimage destinations in Asia Minor during the Medieval age). Hierapolis is located on the ancient *Lykos* Valley where the *Çürüksu* River (one of the tributaries of the *Menderes-Maeander* River) flows. The *Lykos* Valley is situated between two high mountains, the volcanic *Honaz-Kadmos* Mountain on the southeast and the *Baba-Salbakos* Mountain on the south. Hierapolis and its territory were on the northern side of the *Lykos* Valley, corresponding with the modern Denizli basin. This region, where ancient roads intersect, connects the plains of Central Anatolia with the Aegean world. In ancient times it was located on a branch of the royal road that connected the land of the Persians to the Mediterranean (D'Andria, 2003).

The site of Hierapolis sits on a limestone platform at some 350 meters above sea level, on the western edge of the Anatolian plateau, and overlooking the eminently fertile *Lykos* River valley, in western Asia Minor. In extent, its ruins cover almost 800,000 square metres and they must always have formed a prominent landmark (Arthur, 2012). The urban area of Hierapolis was abandoned in the 13th–14th centuries AD during the wars between the Byzantines and Seljuk Turks for control of the Anatolian peninsula. The earlier Byzantine emperors (about 5-6 centuries AD) constructed two religious' buildings in the eastern part of the city, the Saint Philip Church in the high side of a mountain where the tomb was located and the Martyrion (octagonal basilica) that was built at the place of execution of the Apostle Philip (Figure 1). Saint Philip is one of the twelve apostles of Christ and was crucified on the cross in the 1st century AD not far from the "hill of victims" located in east part of the ancient city of Hierapolis. Immediately after his death, Saint Philip was buried in the tomb which is hardly distinguishable from the other tombs on the eastern necropolis of Hierapolis. The site of Hierapolis was inscribed on the UNESCO World Heritage List in 1988.

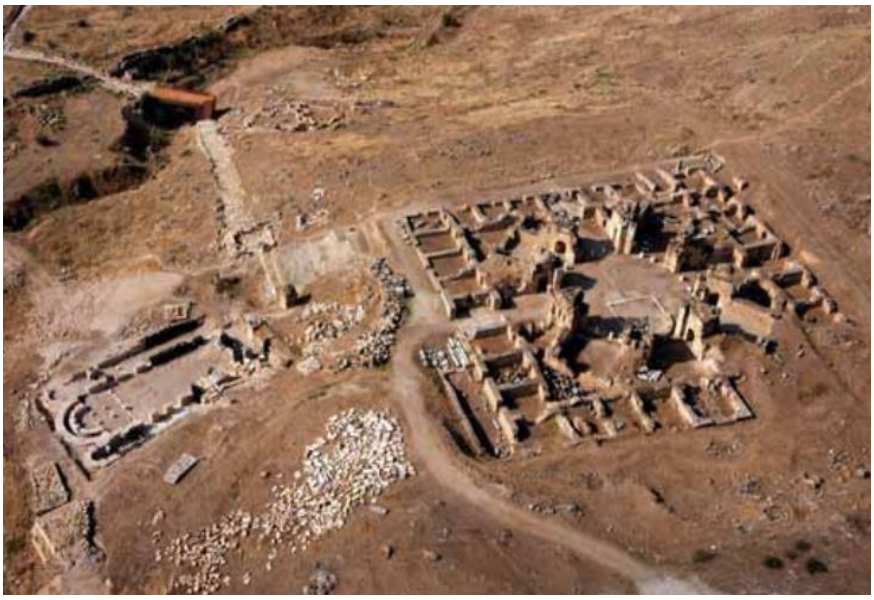

Figure 1. The Martyrion and Saint Philip Church (D'Andria, 2018).

In the 9th century the church of Saint Philip underwent extensive refurbishment, with changes in the functions of its various parts. Specifically, in the central nave the baths were closed, the level of the flooring was raised, and the *solea* and *ambon* were constructed. On this occasion a new pavement in opus sectile (the one currently visible) was installed (Caggia, 2016). The tomb of Saint Philip and the remains of the Church were uncovered during the 2011-2012 excavation seasons. The opus sectile was shattered and ruptured due to seismic events and earthquakes in the 10th century AD. The middle part of the church, which remained partially standing after the earthquake, was used extensively during the Seljuk Period and became a shelter for people living among the ruins (D'Andria, 2018). In later periods, after the church was completely abandoned, great damage occurred due to human activities and environmental factors (El Sayed, 2021).

The excavations in the 2011-2012 seasons revealed an opus sectile that dated back to Middle Byzantine period, consisting of coloured slabs of different types of stone unearthed at the base of the Saint Philip Church. The opus sectile was unfortunately badly damaged due to environmental factors, earthquakes, and human activities (Figure 2). So, the pavement required urgent action and it was decided to carry out conservation treatments and save the opus sectile pavement from further damages.

During the first season in 2012 a joint decision was made to conserve the opus sectile pavement with the minimum of intervention. Before in situ conservation activities were initiated, a sample was taken from bedding mortar (Arinat, 2020) of the opus sectile and the following analyses were carried out: loss on ignition, deal with acid and particle size distribution analysis, petrographic analysis (thin and thick sections, Stereo and Polarizing Microscope observations), as well as Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy (SEM-EDX). According to results of the analyses, a mortar closely resembling the original mortar was produced and applied to a total of 14 opus sectile panels. In this manner, only four panels of opus sectile located right in front of the burial chamber of the Saint Philip Church were selected for in situ conservation. We preferred the method of conserving by "freezing" them in place with a suitable mortar according to the results of the analyses and to follow up on the results. At the beginning of the 2013 excavation season, the restored panels were uncovered to reveal a highly successful result. So, it was decided to apply same method to all the remaining panels (10 panels) in the nave of church. At the end of the project (2014) in situ conservation of 14 opus sectile panels (made with cut stones) in two rows (7 panels each) on the left side of the entrance of the Church nave in front of the burial chamber and the borders (slabs in white marble) between them were conducted.

In this manner, the first step was documentation which was initiated by assigning numbers to the panels starting from one. Documentation began in 1:1 scale drawing on polyethylene sheets with permanent pen (Faber-Castel) and shoot a series of detailed photographs with using a digital camera (Nikon-EOS 60 D). At the same time digital 1:20 scale drawings of panels were also made with the Auto-CAD program. In 2013 and 2014 the same steps were carried out for the documentation of other panels (remaining 10 panels). Each panel was drawn separately and finally all the drawings were put together. During this phase, 3D documentation with the Agisoft program was also initiated. At the end of the 2014 season the aerial photos were taken, and the documentation activities were finished.

After drawings were completed, the active conservation phase was initiated. The first step was dry and wet cleaning. After cleaning, reinforcing the edges and filling the gaps and missing parts (*lacunae)* with lime mortar (according to the results of the analyses) was the next phase of conservation treatments. The final step was the reburial of the opus sectile with Geotextile and a mixture of different aggregates sizes for protecting the pavement from environmental factors. Some earlier or current holistic interdisciplinary projects for restoration purposes of building materials in churches and masonries have been reported (Psalti et al., 2022; Ali et al., 2022; El-Sayed, 2021; Sherif Omar 2022; Montana et al., 2018).

Our goal in this study was to carry out conservation and restoration tasks by using a range of scientific methods. Detailed and careful analysis was used to determine the constitution of the historical mortar and prepare the conservation mortar according to these scientific guidelines. In a sense, we implemented modern science to define the materials used in the historical mortar to gain insight on ancient science and technology.

The principal aim of the in-situ conservation of these unique opus sectile works was to preserve them as they were, because the Church is a unique holy place with great importance from a variety of aspects. In addition, this historic place would eventually be accessible to the public as an open-air museum after all the excavation and restoration activities were completed. Taking all these factors into consideration, the approach of minimum intervention was deemed the best way for conservation. At the same time, this less implementation method of in situ conservation would help the visitors to better understand the history of events that happened over time in the church, and they would be able to visualize the effects of earthquakes and later activities in the Islamic Period as moments in time. In accordance with this approach, the standard method of lifting and straightening the panels one by one and reassembling them again was excluded because such applications require a great deal of intervention and may potentially lead to a loss of authenticity and cultural values.

Figure 2. Tomb of Saint Philip and damaged opus sectile.

2. EXPERIMENTAL STUDY

For the in situ conservation of the opus sectile masterpieces, two different options were discussed with the excavation director and other conservator colleagues. The first one was to preserve and "freeze" the opus sectile with lime mortar (according to analysis results) as they were placed; and the other option was to lift the panels, attach the broken pieces of stones with epoxy resin, and level them by putting the panels in place one by one. This method was discarded since it is time-consuming, pushes budgets higher and requires large-scale intervention and effort. Furthermore, our collective experience has shown that chemical materials (specially in out-door) such as epoxy resin that would be used for attaching, deteriorates (Horie, 2010) over the years (yellowing, expansion…) resulting in different types of damage to the stones and thus negatively impacting the integrity of the panels. Consequently, the first method was preferred as it would require the least intervention with results that stand up to the test of climate conditions and time. In parallel, we also took into consideration that the damages caused by earthquakes which occurred over time must be acknowledged as a part of the history of the Church and that these traces should be preserved for future generations. Since the top of the church will be completely covered with a protective roof, it was decided to only lift the collapsed parts of panels and level them in order to prevent water accumulation on the floor, thereby protecting the panels with minimum intervention. As part of the excavation project, the types of stones used in the panels were also specified and documented with the help of geologists on the excavation team (Scardozzi, 2019). As part of the Marmora Phrygiae Project, provenance of the White and grey marbles used inside the church with the specific attention to the decorative schemes, materials and technical characteristics of opus sectile flooring were studied by archaeologists (Caggia, 2016)

2.1. *Methods*

The identification of the contents of archaeological materials by various methods of analysis is of great importance as far as active and passive conservation applications are concerned. Simple chemical tests besides petrographic and archaeometrical analyses provide valuable data regarding the content of ancient materials and technological processes applied during the production of these materials. Overall, the conservation of these kinds of architectural decorations requires detailed knowledge concerning the construction techniques, properties of the materials used, as well as the deterioration factors.

A sample from bedding mortar was taken before any conservation treatments and the following analyses were carried out: loss on ignition, deal with acid and particle size distribution, petrographic analysis (thin and thick sections, Stereo and Polarizing Microscope observations) and SEM-EDX (Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy) analysis (Gulec et al., 1998). During the sampling, sterile latex gloves were worn.

First, we decided to start with simple chemical tests and petrographic analyses. For this reason, loss on ignition, deal with acid and particle size distribution were conducted. Loss on ignition analysis was carried out to determine the amount of moisture, organic materials and amount of carbonate and silicate materials of the sample.

For the loss on ignition analysis, a finely ground sample of approximately 500 mg was placed in a porcelain crucible and weighed (± 0,10 mg, Mettler H20). The sample was heated in an oven (Heraeus) at 105 ± 5 °C ±, 550 ± 5°C and 1050 ± 5°C for 24 hours at each heat setting. After each heating the sample was cooled in a desiccator and then weighed. From the weight differences, the percent of moisture absorption (at 105°C), the amount of organic materials (at 550°C) and calcium carbonate content (at 1050°C) of the sample was calculated.

Deal with acid and then sieve analyses were carried out to determine the total content of the binding medium (carbonated material) and siliceous aggregates and other insoluble materials (organic materials) with acid were separated and the size grading of the siliceous aggregates was evaluated by sieve analysis. For the deal with acid and sieve analysis, a dried sample (50 gr) was treated with HCl (10%) to dissolve the binding medium. Then the acid insoluble residue was filtered, washed and dried at 105 ± 5 °C. For the size grading, the acid insoluble residue made up of siliceous aggregates was sieved through different mesh sizes of -<63, 63, 125, 250, 500 and 1000 microns, as well as 2.5mm and 5mm. The types, shapes, colours, and inclusions of material, as well as the approximate ratios of the different types of the aggregates were identified by means of a stereo microscope (Nikon SMZ 800 model) and sieve analysis.

Petrographic analysis, thick and thin sections, Stereo and Polarizing Microscope observations were carried out with the aim of determining the mineralogical compounds of the samples and the substances within them in their approximate quantities. Thick section observations were carried out with a Nikon SMZ 800 model stereo microscope. Thin section studies were carried out using a Nikon Eclipse CI-POL model polarizing microscope to identify the minerals. All photographs were taken with an Olympus OM-1 camera. For the petrographic analysis, sample moulded in epoxy resin (Araldite AY103+HY 956) was cut with a low-speed saw (Buehler Isomet) to obtain thick and thin sections. The sample sections were attached to petrographic slides and thickened first up to 1-2 mm and then down to 30 microns by using various sizes of silicon carbide powders (Buehler). The minerals were identified by a polarizing microscope (Nikon Eclipse CI-POL model) with transmitted light. All photographs were taken with an Olympus OM-1 camera.

Petrographic investigations and SEM were conducted for studying the morphological characteristics of the sample. Parallel to petrographic investigations EDX analysis helped us to determine the chemical composition of bedding mortar. A Carl Zeiss EVO LS 10 MODEL scanning electron microscopy equipped with a BRUKER and QUANTAX 200 EDX spectrometer was used to investigate the micro structural and micro chemical properties of the bedding mortar. The analyses were carried out on fresh-fractured sample, operates at 13 kV voltage, and current of 4 µA filament, 80 Pascal air vacuum, 225 magnification, and 11.8 mm working distance. EDX was employed on the selected areas of SEM images (with the scales changing in the range of 50-100µm) belonging to bedding mortar. EDX data were in the form of elemental concentration, and they were transformed into oxides as wt. % which is conventionally used. For the SEM-EDX (Scanning Electron Microscopy-Energy Dispersive X-ray Spectroscopy) analysis, sample moulded in epoxy resin (Araldite AY103+HY 956) was cut with a low-speed saw (Buehler Isomet) and polished with 3, 1 and 0.25 micron-sized diamond polishing compound. After polishing with silicon carbide powders, the polished surfaces were covered with gold and the samples were analysed both in Scanning Electron Microscopy (Carl Zeiss EVO LS 10 MODEL) and Energy Dispersive X-ray Spectroscopy (BRUKER and QUANTAX 200- Program; Espirit 1.8.5.).

After studying the results of the bedding mortar analyses, the chemical content of the materials used in the mortar, the type/ratio of the binder, the amount of moisture in the sample, the particle size distribution/amount of the silicious aggregates, the type/ratio of the additives and filling materials in the mortar were determined. In line with these results, a conservation mortar similar to the properties of the ancient mortar was consequently prepared and applied during the active conservation treatment of the panels.

2.2. Condition of the Opus Sectile

The opus sectile stone-art covering the middle nave of the Saint Philip church is made of cut stones panels, delimited by slabs in white marble with different geometric motifs arranged side by side (Fig. 3). The revealed panels are made of octagonal (22×22 cm and 31×31 cm), hexagonal (27×16 cm), square (12×12 cm and 9×9 cm) and triangular (8×6 cm, 12×6 cm and 14×8 cm) cut stones in various colours. Panel sizes are different from each other, with a width of between about 80-100 cm and a length of between 140-160 cm. The width of the borders between the panels range between 30 and 35 cm and the borders between the panels are laid with single pieces of marble blocks. Stones are generally in three different forms with different colours in each panel. Although some of these panels consist of similar motifs, but the dimensions of the panels are not the same. Also, the dimensions and colours of stones used in these panels are different from each other. The stones used in the opus sectile consist mainly of white marble, both white and grey (*marmo bianco, marmo grigio*) veined marble, red marble (*marmo rosso*), black marble (*marmo nero*), travertine, calcite alabaster, and polychromatic breccia. These stones are widely available in the territory around the city, where they were extensively quarried in antiquity (Scardozzi, 2019).

Figure 3. Partially preserved 14 panels right in front of the tomb.

As mentioned above, the floor of the Church was severely damaged and only 14 partially preserved panels were found side-by-side placed in situ position right in front of the burial chamber (tomb). In some parts of the church, the panels were completely disintegrated, in other parts panels they were completely destroyed, and large gaps had formed at the base of the nave. Some depressions in different forms presented in some panels which may have been due to the general weakness of the foundation layers or a result of loading or collapse of heavy objects over the panels (see below Fig. 12), signifying great destruction brought on by earthquakes. In some parts of the panels, the attachment between the stones and bedding mortar was also lost due to collapses and human activities. None of the panels and borders were in good condition and approximately 90% of the stones were broken. Furthermore, the panels were also affected by different forms of bulges caused by plant growth and plant roots which cut the connection between the stones and the bedding mortar. Another aspect of negative impact, especially near the main entrance (North Wall of Nave) of the church, was damage from the use of an oven dating back to the Seljuk Period (D'Andria, 2018). The smoke and heat emanating from the oven over a period of time produced a sticky thick black layer of oil and ash that covered the surface of the panels (Fig. 4), and it was observed that the stones were also affected with cracks and sugaring effect (Sassoni et al., 2016) due to the high temperature in the areas of closer proximity.

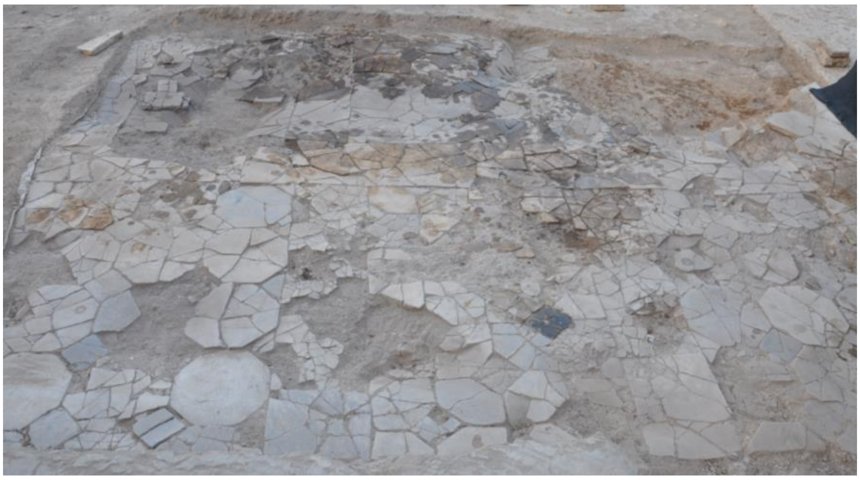

Figure 4. Layer of oil and ash at the top of the picture.

However, despite all the deterioration, what was uncovered is a fine example of a high quality and beautiful opus sectile due to the workmanship, different geometric patterns and the colour and variety of the stones utilized in the work. Due to the importance of this magnificent discovery, it was decided to start immediately on the in situ conservation of the opus sectile and get it the under protection. Thus, conservation studies began by laying out a sustainable plan which was carried out in phases of the analysis of bedding mortar, detailed documentation, cleaning, conservation activities and protecting the pavement with reburial. At the end of each season the panels were covered with geotextile, as well as a mixture of sand and gravel.

3. RESULTS AND CONSERVATION TREATMENTS

3.1. Results of Analyses

According to visual observations, it was determined that the mortar has a solid structure with a light pinkish color. In general calcite and dolomite aggregates in the 3-4 mm sizes were present, while 4-5 mm sized brick fragments were also found. The aggregates are angular shaped and of terrestrial origin. The bedding mortar was comprised of two layers, consisting of a very thin (*nucleus*) layer and a thick mortar (*rodus*) layer sitting on the palm-sized brick and stone blocks (*statumen*). The thin nucleus layer measured approximately between 0,2-0,3 cm, apparently only for attaching the stones to the *rodus* layer. The bedding mortar measured approximately between 5-6 cm thickness.

As a result of simple chemical analysis, it was determined that the moisture content in the sample was 1.23%, loss at 550°C (organic materials) was 3.37% and the $CaCO_3$ (1100° C) content was 46.81% (Table 1). According to the acid treatment results, eliminated materials amounted to 58.47% and the retained was comprised of 41.53% silicate aggregates that do not react with acid (Table 1). These were separated into sizes by sieve analysis and their visible properties were examined under a stereo microscope.

Table 1. Loss on ignition, acid deal and sieve analysis results.

Sample	Loss on Ignition (%)			Acid deal (%)		Sieve (%)							
Bedd. Mortar	105 °C	550 °C	1100°C	Lost	Left	5000 µ	2500 µ	1000 µ	500 µ	250 µ	125 µ	63 µ	<63 µ
	1,23	3,37	46,81	58,47	41,53	6,91	17,44	25,71	9,40	12,57	11,66	9,27	7,02

According to the mortar evaluation of the thick and thin sections (Figs 5, 6), and microscope observations showed aggregates of black slag powder and quartz smaller than 125 µm, with the rest comprising of brick dust and clay sized material. Aggregates between 125-500 µm contained black slag dust and mica as well as a small amount of quartz, around 10% were volcanic rock fragments, 25-30% were constituted from undispersed masses containing feldspars and quartz, and the remainder was brick dust. It was also determined that aggregates larger than 500 µm were feldspars and quartz, 3-5% were brick dust, 20% of the undispersed masses were volcanic rock fragments and the remainder consisted of brick fragments. Aggregates were generally in 4-6 mm sizes, with some (3-4%) reaching 8 mm in size.

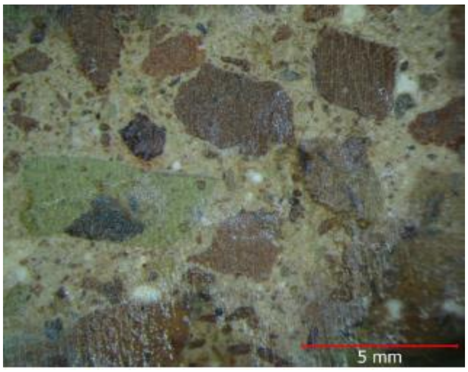

Figure 5. Thick section displaying the binder and aggregates.

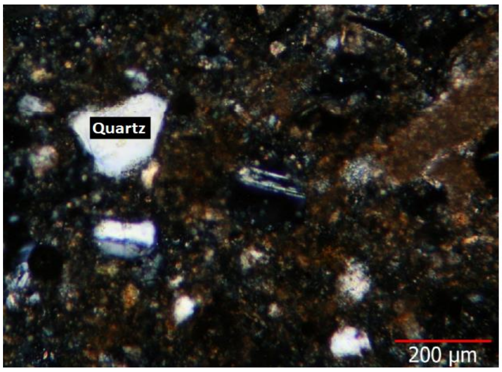

Figure 6. Quartz and brick pieces in thin section.

The results showed the ratio of binder (slacked lime) was 30%, up to 30-35% were brick fragments (crushed and dust), approximately 5% were volcanic materials, and the rest (20-25%) consisted of travertine and marble fragments in different sizes.

The SEM (Scanning Electron Microscope) picture highlights the micro cracks inside the mortar body (Fig. 7). According to the EDX (Energy Dispersive X-Ray Spectroscopy) results (Fig. 8) by percentage of weight (Table 2), the sample contained CaO (79.78%), SiO_2 (11.20%), Al_2O_3 (3.62%), MgO (1.32%), FeO (1.57%), K_2O (0.98%), SO_3 (0.90%), P_2O_5 (0.00), Cl^- (0.13), TiO_2 (0.00) and Na_2O (0.50%). By studying the results of the EDX analysis, it was determined that high amounts of calcium were found in the sample, along with respectively diminishing amounts of silicon, aluminum, iron, magnesium, potassium, sulfur, sodium and chlorine. The X-ray diffraction results of the mortar sample in the church are published (Caggia, 2016).

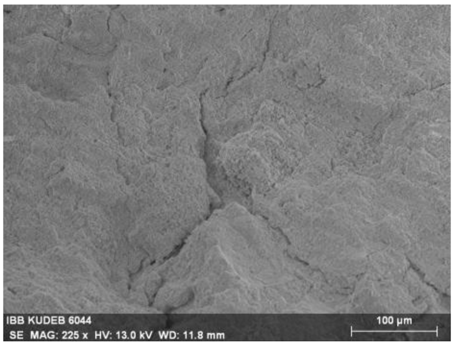

Figure 7. SEM images of micro cracks in the mortar body.

According to these results a mortar was prepared containing 30% of slaked lime as a binder, 30% travertine and marble (crushed and dust sizes), 5% local river sand, 35-40% of brick (crushed and dust) as a filler, according to loss in ignition (on 550 °C), 3% (v/v) concentration of Primal AC 33 acrylic resin in water were used as additives. About 3-5% of the aggregates used in the thick mortar (*rodus*) were 8 mm in size and the rest were 6 mm and 3 mm sifted through respective sieves.

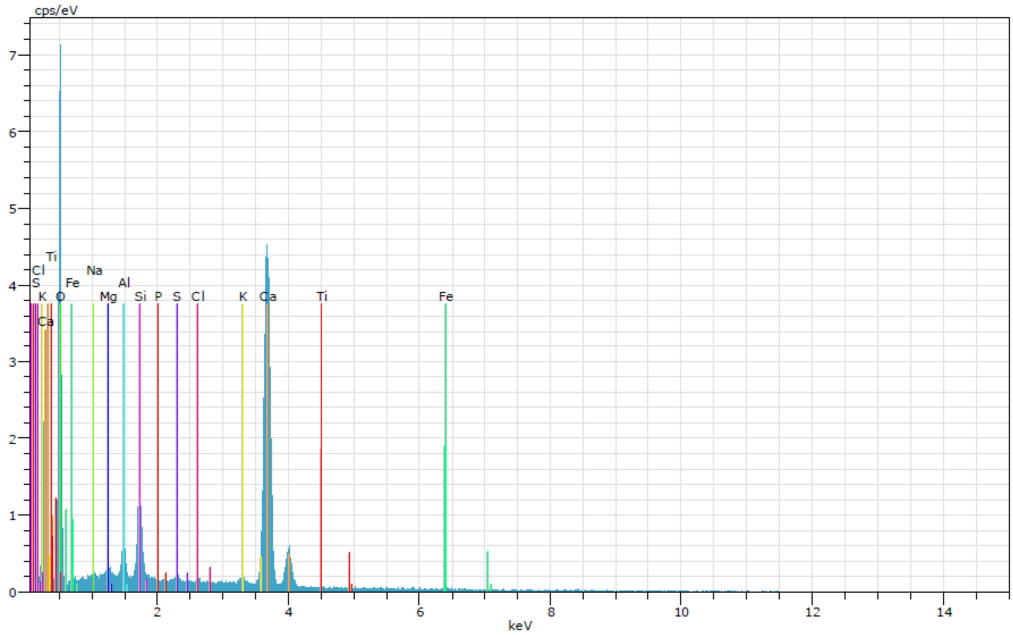

Figure 8. EDX spectrum.

Table 2. EDX results.

Element	Norm. C (Wt.%)	Atom. C (At. %)	Compound norm.	Comp. C (Wt. %)
Oxygen	32.14	52.93		0.00
Magnesium	0.80	0.86	MgO	1.32
Aluminium	1.91	1.87	Al_2O_3	3.62
Silicon	5.24	4.91	SiO_2	11.20
Potassium	0.81	0.55	K_2O	0.98
Calcium	57.02	37.48	CaO	79.78
Iron	1.22	0.58	FeO	1.57
Phosphorus	0.00	0.00	P_2O_5	0.00
Sulphur	0.36	0.30	SO_3	0.90
Chlorine	0.13	0.10		0.13
Sodium	0.37	0.42	Na_2O	0.50
Titanium	0.00	0.00	TiO_2	0.00
Total:	100.00	100.00		

3.2. *Detailed Documentation*

In 2012, ancient art-work opus sectile panels were uncovered right in front of the burial chamber of the Saint Philip Church and four were selected for in situ conservation. The layer of geotextile and sand that was laid the year before for protection was removed from the panels in front of the burial chamber, and documentation was started by assigning numbers to the panels from one. Work began with the careful cleaning of dirt and soil. After cleaning the residue and soil accumulated on the surface, documentation began in 1:1 scale drawing (Fig. 9) on polyethylene sheets with permanent pen (Faber-Castel) and shoot a series of detailed photographs with using a digital camera (Nikon-EOS 60 D) by placing measurement points at intervals of approximately 50 cm according to size of panels. During this time 1:20 scale drawings were also made with the Auto-CAD program. Each panel was drawn separately and finally all the drawings were assembled into a complete image (Fig. 10).

Figure 9. 1:1 Documentation on polyethylene sheets.

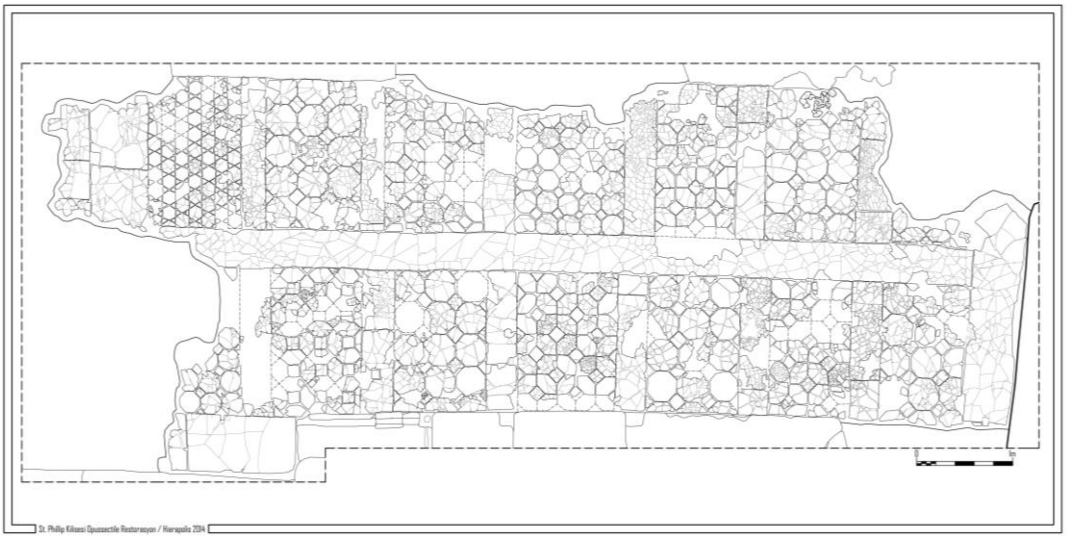

Figure 10. 1:20 Drawing with Auto-CAD program.

In 2013 and 2014 the same steps were carried out for the documentation of the other panels. During this phase, 3D documentation with the Agisoft program was also initiated. This was done in very short intervals of approximately 25-30 cm by taking over one hundred photographs (Nikon-EOS 60 D) from different angles around the panels. All the photographs were transferred and processed on a computer with the Agisoft program and finally detailed 3D documentation was rendered (Fig. 11). At the end of the 2014 season after finishing the in-situ conservation treatments of the panels, the aerial photos were taken, and the documentation activities were finished (Fig. 12). As a result, the detailed documented data that was gathered will also be used in monitoring the condition and state of preservation of the opus sectile for future conservation projects and seasons.

Figure 11. 3D image shows collapse of heavy objects over the panels.

Figure 12. Aerial photo of Saint Philip Church.

3.3. Dry and Wet Cleaning

Before the work was started, a temporary and portable canopy system was installed over the area in order to prevent the mortars from cracking due to loss of water, and also to protect the area from visitors who were entering the Church. In order to fill the cracks between the broken parts and joints with mortar, it was necessary to clean the spaces between the cracks and joints of broken pieces to remove deteriorated bedding layers and accumulated soil. After drawings were completed, the detailed dry-cleaning phase was initiated. The soil and dirt accumulated on the surface and between the gaps was cleaned with the use of different types of brushes and bulb pipettes. For the final phase a vacuum cleaner was used for detailed cleaning. The cleaned panels were immediately covered with a layer of geotextile, so that dust and sand would not get in the way again (Figure 13). The roots that had spread among the joints and cracks were already dry and withered, so they were carefully cut and the remains were completely cleared.

Figure 13. Detail cleaning with a vacuum cleaner.

Because the tap water in the Pamukkale region contains a lot of minerals and salts (Akşehirli, 1966), distilled water was used in all treatments throughout the entire conservation. Wet cleaning and a final cleaning with the use of a vacuum cleaner was carried out just before the mortars were applied. The areas were dampened with a nozzle spray and all the surfaces were cleaned gently with soft brushes and clean sponges (Arinat, 2014). As previously mentioned, an oily black layer covered the surface in some parts. The layer of soot in these parts was cleaned with a 3% (v/v) concentration of non-ionic detergent in distilled water and alcohol solution at a ratio of 1:1. Immediately after the removal of the dirt, the surface was washed with water and plastic brushes, followed by the application of clean sponges to absorb excess water.

3.4. Conservation Treatments

At the beginning of the 2013 excavation season, the restored panels were uncovered to reveal a highly successful result. So, it was decided to apply same method ("freeze" the opus sectile with lime mortar according to analysis results as they were placed) to all the remaining panels (10 panels) in the nave of church. Finally, according to analysis results a lime mortar was prepared and applied to fill the missing parts (*lacunea*), as well as the joints and cracks between the broken pieces. To produce the mortar, a slacked lime was used as binder which was kept for 5 years. Thus, a traditional lime mortar was produced according to the analysis results. By this way the conservation mortar is similar to original mortar as could as possible.

Each of the panels was evaluated separately and implementations were carried out according to the situation that they were in. On the left side of the entrance door of the tomb chamber, the old repairs made with ancient mortar were found in two places on panel number 3 and the border, so these parts were preserved as they were and consolidated (Mora, 1984) with 5% (v/v) concentration of Primal AC 33 acrylic resin in water by brushing (Figure 14).

Figure 14. Old repairs made with ancient mortar.

If there was no collapse, only the joints were cleaned, and lime mortar was applied between them. Before applying the mortars, the surfaces were well dampened with sprayed water (Ashurt, 1988). If there were collapses, the stones were removed and mortar was placed under them, then the level was corrected and fixed back in place. A mortar of fine 500 μ (micron) aggregates of the same mixture was applied for filling the micro cracks and joints.

The large gaps (*lacunea*) were later filled with mortar, the shapes that should be on the panel were drawn (etched) on the mortar surface to provide visual integrity and motifs were created (Fig. 15). During the excavation activities (2011-2012), a few pieces of geometrical stones belonging to the floor were found and were put in storage. Later on, the sizes of these stones were compared with the measurements on the panels, their places were determined, and they were reintegrated by specifying in the drawing sheets.

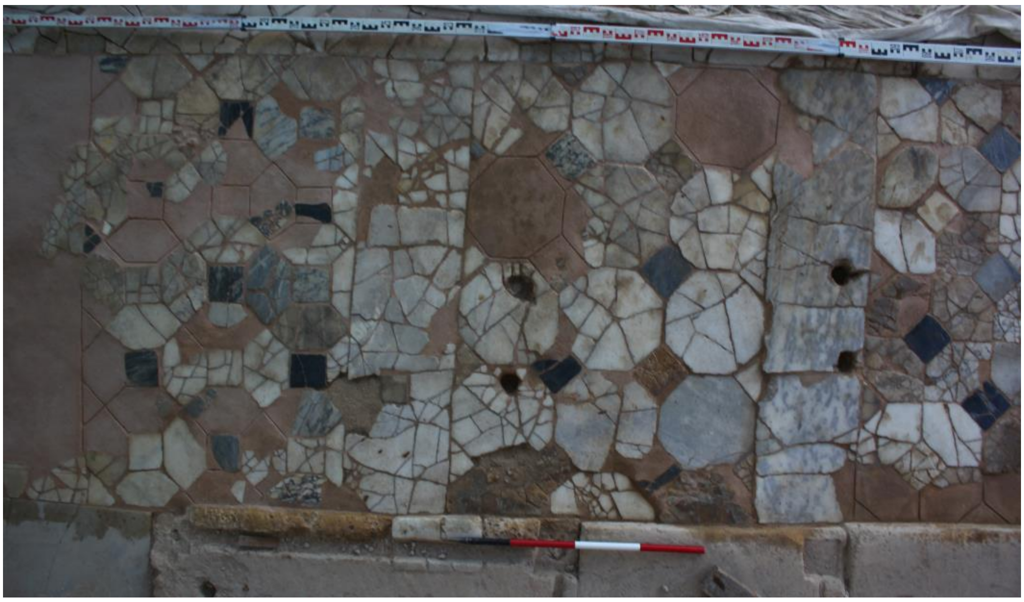

Figure 15. Patterns etched on the missing parts.

A large layer of ash was detected on three panels opposite the room (chapel) next to the tomb. In the middle of this area, there was an oily layer covering a panel and plant roots at the bottom. Plant roots under the panels were completely cleaned during these applications. A “sugaring” effect was detected on the marbles of the panels, a type of deterioration usually caused by high temperature and soluble salts. To consolidate these marbles, 10% (v/v) concentration of Primal AC 33 acrylic resin in water was applied by spraying. All the information and details obtained during the conservation of the opus sectile were noted and were shown on the drawing sheets (Fig. 16). The whole restoration work was carried out over 3 excavation seasons in total. Thus, 14 panels in two rows (7 panels each) on the left side of the entrance of the Church nave in front of the burial chamber (Fig. 17) and the borders between them were conserved in situ (Fig.18).

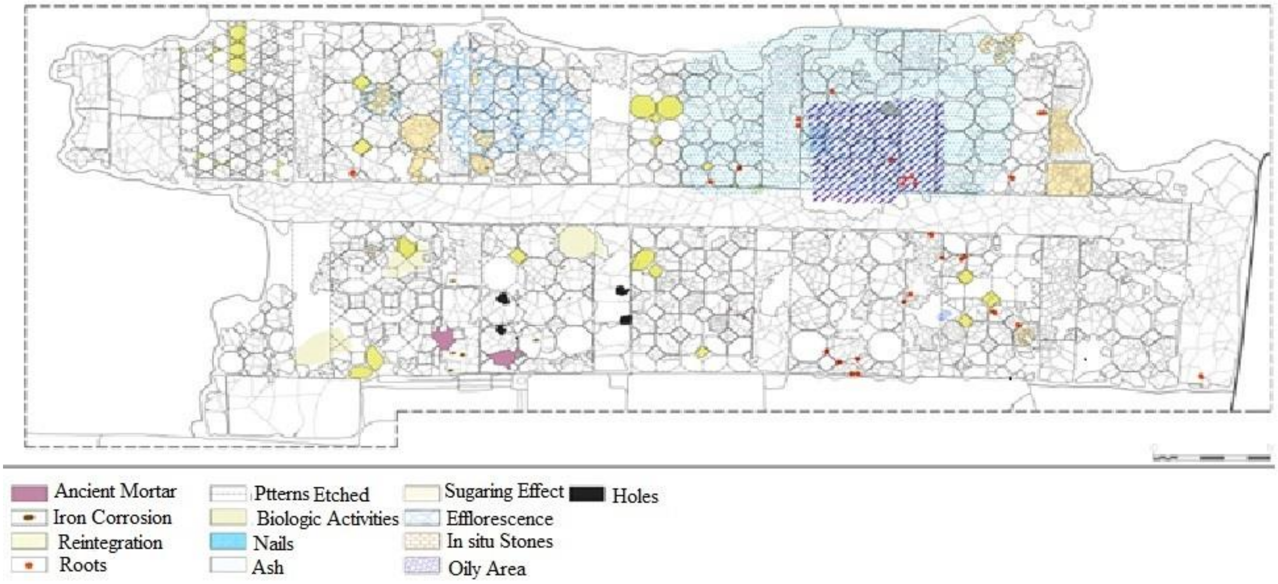

Figure 16. Detailed documentation of condition and deteriorations.

Figure 17. Tomb of Saint Philip and opus sectile after conservation.

Figure 18. 3D image of all panels at the end of the Project.

As reburial is one of the best passive conservation treatment methods for pavements on archaeological sites (Theodorakeas et al., 2010), at the end of the 2014 season the panels first were covered with a *Gore-Tex* geotextile layer (Fig. 19) and then a mixture of local clay, sand and gravel size aggregates in thickness about 30 cm in different layers (Fig. 20).

Figure 19. Panels were covered with Gore-Tex geotextile.

Figure 20. Reburial of pavement.

4. CONCLUSIONS

In situ conservation of architectural elements and decorations revealed during archaeological excavations is a subject that requires interdisciplinary knowledge and teamwork. For site conservators it is advisable to get opinions of experienced archaeologists and conservator architects about the practices and methods in the field. Individual experiences pooled into a working knowledge base on the excavation site, provides a great basis for attaining optimum results. With the advancements in technology, conservators have further access to a fount of global knowledge and detailed information about the contents and production techniques of archaeological materials. Consequently, the conservation and restoration of historical monuments has reached a very high level of scientific accuracy.

All architectural elements revealed during archaeological excavations should be protected and exhibited in their original places as much as possible, and interventions must be kept at a minimum. During these kinds of conservation activities, the aesthetic, authentic and historical values of the archaeological materials should be preserved. While the materials used for the restoration should not cause damage in any way, the interventions should conversely protect without harming the originality and aesthetics of the historical artifact.

In this manner, the conservation mortars should be as similar as possible to the ancient mortars in terms of chemical content and should thus have similar physical properties. In addition, it is recommended that conservation mortars should be softer than ancient mortars. In this way, the mortars will not press on the original parts as a result of expansion or contraction due to changing atmospheric conditions (relative humidity and temperature changes) and should not cause of any type of deterioration to the original parts. Thus, detailed analyses should be carried out on the ancient mortars and conservation mortars should be produced in line with the results. In recent years, there are a lot of scientific research about the analysis of ancient mortars. However, in these studies, a mortar similar to the original mortars was not produced and only the characterization of the mortars was studied. In this study, the contents of the ancient mortars were determined in detail and a traditional mortar was produced in accordance with the ancient mortar. During this project, to produce the traditional mortar, a slacked lime was used as binder which was kept for 5 years. We did not want to use industrial hydraulic lime (Lafarge Blanc). Thus, according to the analysis results a traditional lime mortar was produced. By this way the conservation mortar is so similar to original mortar as could as possible. Archaeometric analysis alone is not enough for this purpose and it is also necessary to carry out analyses that can determine the physical properties, the type/amount of binding materials and the aggregates of the ancient mortars.

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