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Technology and materials of Early Christian Cypriot wall mosaics

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ABSTRACT

Production technology of Early Christian (5th–7th centuries AD) wall mosaics, in the eastern Mediterranean and particularly in Cyprus has only recently attracted scholarly attention. Despite the numerous fragments and detached tesserae found in many sites in Cyprus with churches dated to the Early Christian period, it was only now that a more holistic technological study of the materials used for the production of these wall mosaics was initiated. Five sites were chosen for this first study: the seaside basilica of Kourion, the basilica on the acropolis of Amathous, the basilica of area EF2 at Polis-Chrysochous, the basilica of Yeroskipou — Ayioi Pente, and the two basilicas of areas II and V of Kalavasos-Kopetra. Both the glass tesserae and the plasters of the preparatory layers are discussed in this article in order to get a first insight into the technology of Early Christian Cypriot wall mosaics. XRD, DTA-TGA and mercury intrusion porosimetry were employed for the technological and compositional study of the plaster fragments. They were found to be of different compositions depending on the sites of their recovery, and may be made from local materials. Glass tesserae were compositionally characterised with the use of SEM-EDS, Raman spectroscopy, and UV–vis spectrometry. They were found to be made from different raw glass compositions compatible with the early Byzantine period, and opacified with lead stannates and tin oxide. Furthermore, some blue tesserae were found to have been opacified with calcium phosphate, probably coming from bone ash, in accordance with other, recent studies on other early Byzantine glass tesserae. The existence of colour-specific secondary workshops, hypothesised by other studies, seems to be confirmed by the results of this study.

1. Introduction

Cyprus is well known for its magnificent floor mosaics such as the ones at the site of Nea Paphos (UNESCO, 2014; Michaelides, 1987). The most famous pavements date to the Roman Imperial period (2nd and 3rd centuries AD) but mosaics from the Hellenistic (late 4th–1st centuries BC) to the early Byzantine (5th–7th centuries AD) periods have been found on the island. Early Christian churches in Cyprus, as in other parts of the eastern Mediterranean, used to be elaborately decorated with such costly floor pavements and wall mosaics. However, due probably to the fact that fewer examples of wall mosaics have survived in a good state of preservation, in comparison to the floor mosaics, they have received until recently less attention than their floor counterparts. Indeed, with the exception of a few examples (such as the one in the apse of Panagia Angeloktistos at Kiti), most of what remains is mainly in the form of loose tesserae and detached fragments left unstudied after their excavation.

The relative neglect of the Early Christian wall mosaics in Cyprus has resulted in our limited understanding of the technology of their production. In fact, our understanding of the technology of glass mosaics from the early Byzantine time in general is very limited (James, 2006). A few studies have been made on mortars from Early Christian floor mosaics, including in Cyprus (Charalambous, 2012), but plasters from Early Christian wall mosaics have been mostly overlooked so far. A few recent publications however investigated the composition of glass tesserae. A compositional study of early Byzantine glass tesserae from various sites in Italy and the Middle East (Jordan and Syria) evidenced differences in compositions between the two regions, with Middle Eastern tesserae apparently close to Levantine I production and Italian tesserae more closely matched with Roman and HIMT compositions (Vandini et al., 2006; Silvestri et al., 2012). More recently, a study of sixth-century glass mosaics from the site of Sagalassos in Turkey seems to evidence the existence of several specialised workshops related to the colours of the glass tesserae (Schibille et al., 2012). The case of Cyprus, an island located between East and West, is particularly interesting in this emerging discussion about the technology of production and the networks of distribution of ancient glass in the Mediterranean. The prominent role of Cyprus in the eastern Mediterranean, as a stepping stone between the various regions of the Mediterranean basin is reflected on the island's cultural, religious and political history. The Cypriot Church, for example, was part of the patriarchate of Antioch and all the East until 431 when it gained its independence, while the

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island had been a Roman province since 58 BC (Michaelides, 1998). It is anticipated that this first large-scale, technological study of glass tesserae of Early Christian wall mosaics from Cyprus, will contribute to our knowledge regarding wall mosaic technology and production during that period on the island, but also in the eastern Mediterranean, considering the broader cultural and historical milieu.

2. Materials, sampling, analytical methods, and research objectives:

Five sites dispersed along the island of Cyprus have been selected; these are the Early Christian basilica of Ayioi Pente at Yeroskipou, the basilica of area EF2 at Polis Chrysochous, the basilicas of areas II and V at Kalavasos Kopetra, the basilica of the acropolis of Amathous, and of the seaside basilica at Kourion (Fig. 1). For all these sites, no wall mosaic is in situ anymore, and the preserved material includes only fragments of plaster (with or without tesserae) and detached tesserae. For each site, a number of samples were selected for analysis, carefully selected with the aim to represent in the overall sample the range of different textures, colours and techniques at each site and between sites. Imaging and sample preparation, for both the tesserae and the plaster samples, were performed with the help of a Leica E24 stereoscopic microscope owned by the Department of Civil Engineering of the University of Cyprus.

2.1. Plaster analysis

For all the 33 plaster fragments collected, fragments of about 1 g were taken and crushed to powder for further analysis. When the sample was big enough and several layers were visible, one such fragment was taken for each layer, otherwise, only one fragment was taken. In order to get their mineral composition, these fragments were analysed with a Bruker D8 advance powder XRD from the Department of Civil Engineering of the University of Cyprus, with Cu ka radiation. Data collection was performed in the following conditions: two theta angular range = 5–70°, step size = 0.038°, step time = 3 s. XRD data collected were exported to Eva software for the identification of minerals with the built-in as well as with the RRUFF (http://rruff.info) database. For the quantification of the different mineral phases identified, the Rietveld refinement method (described in Kniess et al., 2012) with the Topas software was used. In order to check XRD results and evaluate the presence of organic material, thermal analysis was conducted on around 50 mg of the powder for a selection of samples with a Shimadzu DTA-TG 60 from the Department of Civil Engineering of the University of Cyprus. Data collection was performed in the following conditions: starting temperature = 35 °C, temperature rate = 5 °C/min, hold temperature = 1200 °C, hold time = 1 min. Finally, when enough material was available, another small fragment about 3–4 g was collected and analysed by MIP with a Micrometrics Autopore IV MIP from the Department of Civil Engineering of the University of Cyprus. Data collection was performed in two steps for low pressure and high pressure, in the following conditions:

- Low pressure step: evacuation pressure = 50 μm Hg, evacuation time = 5 min, mercury filling pressure = 1.01 psia, equilibration rate = 0.010 μL/g/s, maximum intrusion volume = 0.005 mL/g.
- High pressure step: equilibration rate: 0.005 μL/g/s, maximum intrusion volume: 0.005 mL/g.

Porosimetry on sample KKf1 was calculated by the water absorption method, similar to what is described in standard ASTM C830-00(2011), 2011.

2.2. Glass tesserae analysis

The glass tesserae samples under study consist of a selection of the detached tesserae which were found on the sites. Contrary to the plaster fragments, the number of detached tesserae is usually high and for this reason getting such samples is easier.

From these tesserae, a fragment (about a third of the tessera) was embedded in acrylic resin, ground and polished to 1 μm grade. 80 samples were prepared in this way, embedded in eight resin blocks of diameter 2 cm, each resin block containing ten samples. Before SEM-EDS analysis, the samples were coated with a thin conductive carbon layer. In order to get the oxide composition of the samples, and to identify microstructures in the glass matrix, SEM-EDS analysis was conducted with a JEOL JSM-6400 SEM with EDX detector provided from the Vrije Universiteit Brussel. Data collection was performed in the following conditions: 20 kV voltage, 100 s live time recording of X-rays, 2–5 different square areas per sample. Absorbed current on pure metallic copper was measured in order to check the stability of the current. In order to assess the reliability of the measurements, reference standards Corning A, B and D from the Corning Museum of Glass were analysed under the same conditions. Results on the standards are given in Table 4. In addition to SEM-EDS analysis, colour analysis was performed with an AvaSpec 3648/Avantes portable UV–

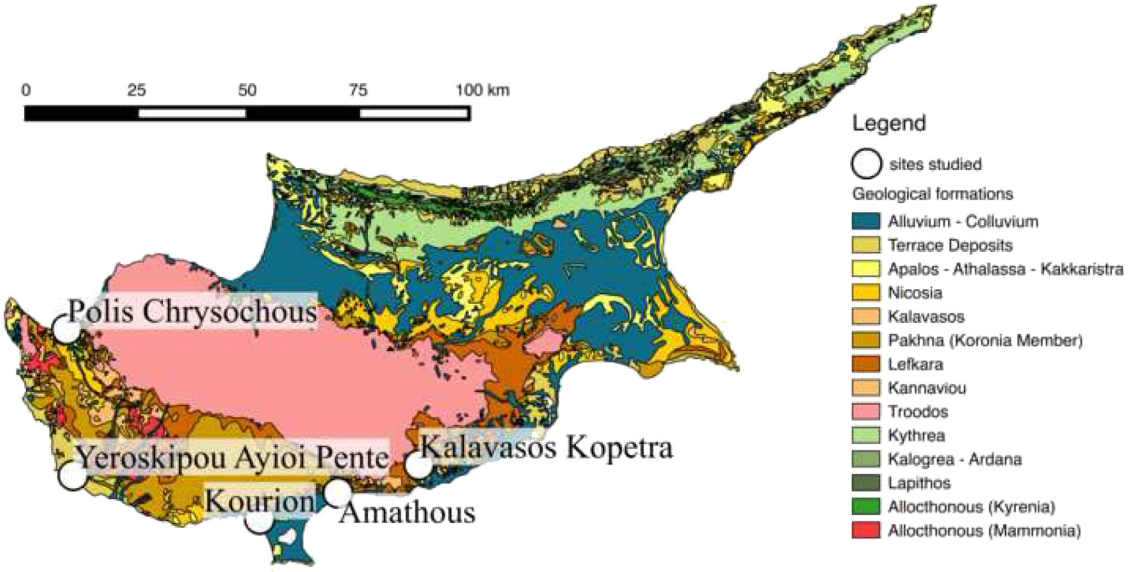

Fig. 1. Geological map of Cyprus with the provenance of the samples studied (geological data from Geological Survey Department of Cyprus, 1995).

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