



# Characterization of materials used in the execution of historic oil paintings by XRD, SEM-EDS, TGA and LIBS analysis

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## ABSTRACT

In this study, material characteristics of historic oil paintings in a 19th century church in Ayvalık/Turkey were investigated to propose the treatments to be used in their conservation and protection. For this purpose, physical, chemical and mineralogical compositions and the microstructure of the paintings were determined by X-ray Diffraction, Scanning Electron Microscope, Thermo Gravimetric Analyzer, Differential Scanning Calorimeter, Infrared Spectroscopy and Laser Induced Breakdown Spectroscopy. Analysis results showed that the paintings were composed of very thin binding and white priming layers on which the pigments were applied. Binding layers were composed of polymerized vegetable oil with Zinc Oxide. Priming layers were composed of anglesite mineral in polymerized vegetable oil. Pigments used in paintings were mainly green earth, red chrome and iron oxide.

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## 1. Introduction

Wall paintings have been the most important decorative pieces of historic buildings since ancient times. They can be classified as fresco or secco according to application technique of pigments on the plaster layer. Paintings executed in fresco technique, pigments are applied onto wet plaster and they are fixed during the carbonization of lime. In secco technique, pigments are applied on dry lime plaster with binding materials like gum, egg or oils. Secco technique is named to the used binding materials. If the binder is vegetable gum or animal glue, it is called tempera [1]. If the binder is egg, it is called egg tempera [1]. If the binder is vegetable oil it is called oil painting [1]. Walnut, poppy seed and linseed oils are the most common ones used as binding materials [2]. Vegetable oils are composed of mostly unsaturated fatty acids and solidify in the ambient conditions.

The first stage of the oil painting process is the coating of a fine plaster layer with boiled oil. At this stage, oil penetrates into plaster by capillarity and then solidifies. In the next step, the coated surface is covered with white priming materials

dispersed in oils [1,3]. The final step of the painting process is the application of pigments to the priming surface [1].

The most common inorganic pigments used in oil paintings are lead white, Naples yellow, azurite, vermilion, verdigris, malachite red, yellow ochre, zinc oxide, cobalt blue and ultramarine [2]. Organic pigments used in traditional oil paintings are indigo, Indian yellow, alizarin, madder, luteolin and quercetin [2,4]. Inorganic pigments are brighter and last longer than organic ones and hence they were used in paintings.

In the recent studies, raw material compositions of paintings and polymerization of vegetable oils have been determined by capillary electrophoresis (CE) [5], micro-Raman spectroscopy [6,7], differential scanning calorimetry (DSC) [8,9] gas chromatography [10] and Laser Induced Breakdown Spectroscopy (LIBS) [11–13].

In this study, the material used in the execution of wall paintings of Taxiarchis Church and the present state of the paintings were determined to decide the appropriate intervention methods and materials to be used in the conservation of the paintings.

Taxiarhis Church was built in the neoclassical style by Architect Emanuel Kounas as the main Church of Cunda/Ayvalık in 1873. It had the basic properties of Byzantine church architecture

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Fig. 1–Michael (a) and Gabriel (b) paintings from the Taxiarchis Church.

although it was built in late period. Taxiarchis Church is a valuable church due to its original wall paintings. Paintings are located on the walls of the main apse, arms of the cross, niches near by the main apse, drum of the central dome and over the doorway on

two sides of the narthex. Wall paintings show the events expressed in the Old Testament and Holy Bible (Fig. 1) [14]. Taxiarchis Church suffered structural failures by earthquakes, which occurred in 1942 and 1944. Cracks and the disintegration of

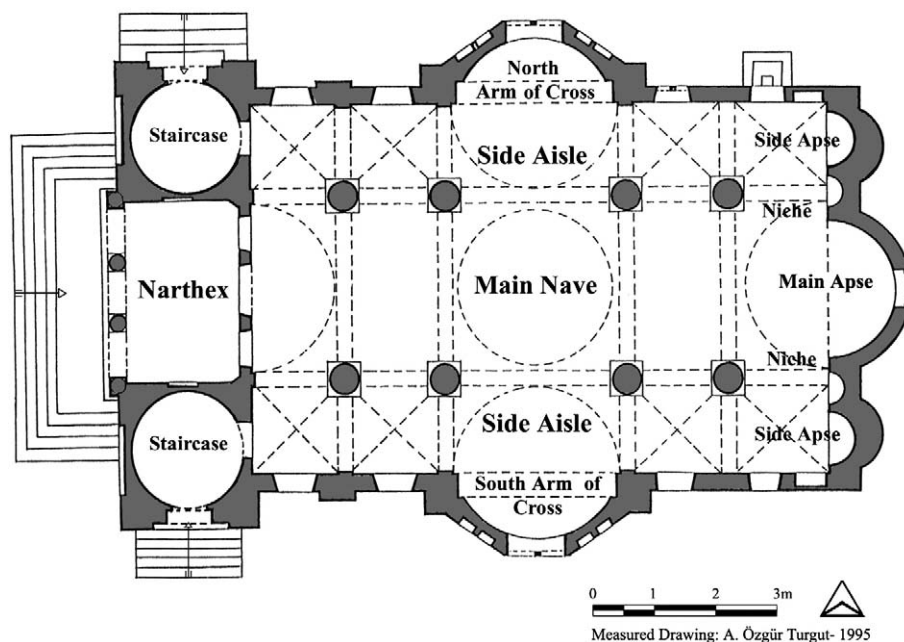


Fig. 2–Plan of Taxiarchis Church.

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