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Research Article

Painted Plaster Fragments in the 'Public Building' At Migdal

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Abstract

Painted plaster fragments from the recently discovered Early Roman 'Public Building' at Migdal, Israel were noted to be of multiple colors common to the palette of this period: white, yellow, red, greenish-blue and black. At a contemporary nearby site, the Migdal synagogue, some pigments were imported, others were produced artificially; therefore, it seems necessary to analyze the pigments from the Public Building and compare them with those of the synagogue. We analyzed the chemical nature of the pigments used for the colors at the Public Building by using non-invasive diagnostics such as fiber optic reflectance spectroscopy (FORS) and X ray fluorescence (XRF), as well as minimal invasive methods of Fourier transform Infrared spectroscopy (FTIR). Analysis showed that the green pigment was imported whereas others were likely local (red and yellow). However, the plaster had been painted using the secco technique, unlike the nearby Migdal synagogue, which was painted with the more technically proficient fresco technique. Therefore, despite the simple workmanship of the painted plaster, the presence of celadon in the greenish-blue pigment indicates that the patrons who requested the paintings had the means to acquire long-distance trade items.

Keywords: Pigment; Plaster; Secco; Roman; Herodian; FORS; XRF; Import; Celadon; Terre verte; Synagogue

Introduction

Ancient Migdal (Magdala) lies on the western shore of the Kinneret, about four kilometers north of Tiberias and southeast of today's Migdal settlement, at the eastern foothills of Mount Arbel. The ancient settlement was established south of the floodplain of Wadi Hamam and dominates the southern convergence of the Ginosar Valley with the Sea of Galilee. The valley, which is a fertile ground for agriculture, can be seen from the density of plantations and agricultural fields today.

During recent excavations in Migdal [1], painted plaster fragments were found in the Public Building (W107; Permit No. A-9063) (Figure 1). These were painted in basic colors of a simple color palette with no brilliancy: dull shades of white, yellow, red, greenish-blue and black.

Figure 1: Location of Migdal.

Most of the fragments are small (maximum size is ca. 6 cm wide), with dirty incrustations and partially erased colors. They were discovered in the collapse of a wall (W107) next to a bench (L118) in Area 4 (Figure 3), indicating that the wall originally had colorful panels. The wall was composed of a combination of hewn and rectangular stones of basalt and chalk, as well as large and medium-sized fieldstones of basalt and chalk. The remains of the still-standing part of the wall show at least two building phases, with a bench attached to the wall in the last stage. The plaster on the still-standing wall is white.

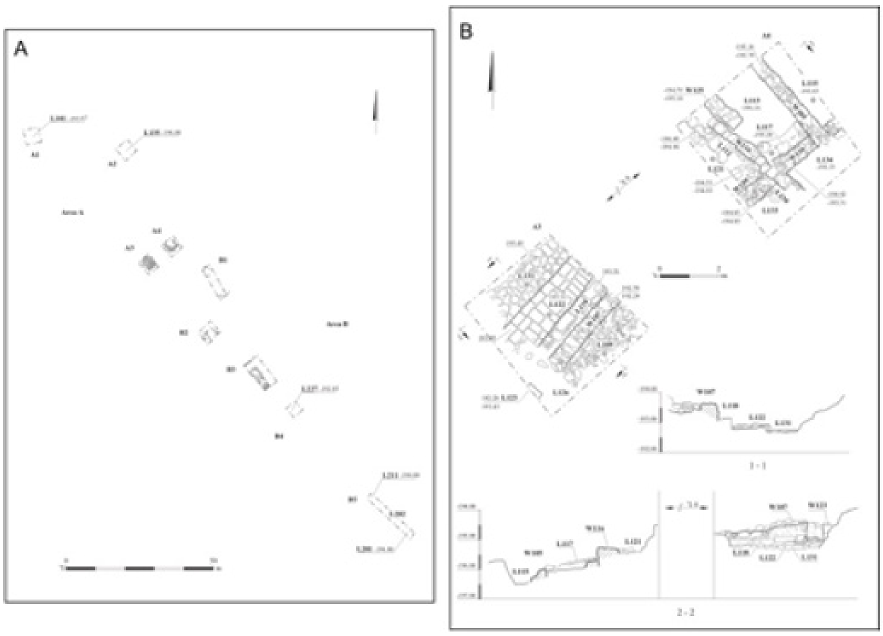

Figure 2: A. Areas of recent excavations at Migdal. B. Areas A3 and A4.

Figure 3: Wall 107, where the painted fragments were discovered.

The largest quantity of painted fragments found in the collapse of this wall (ca. 40 fragments) were red, probably used as a background color, probably for a panel decoration. There are many parallels to the red hues in Israel, where it seems also to have been the most frequent color for mural decoration in Herodian and Roman times [2]. Other colors include yellow (8 fragments), a few small greenish-blue fragments and one small fragment of black. Yellow could have been used as a background color, and black was probably used for outlines or dividing bands.

Similar pigments are known in the southern Levant from ancient times. The most common colors were red hematite and yellow goethite, which are iron-based minerals common throughout the region. Other colors, such as green, orange and pink, were imported from different countries, or prepared artificially [2], such as those used in the synagogue at Migdal. In order to identify the pigments, to establish if the materials were local or imported, and to compare them to those of the synagogue the painted plaster fragments discovered at the Public Building at Migdal (probably a second synagogue) underwent non-destructive analyses for pigment identification.

Minimal invasive methods including FTIR (Fourier Transform Infrared) spectroscopy were used to determine the plaster composition, while non-invasive methods including FORS (Fiber Optics Reflectance Spectra) and XRF (X-Ray Fluorescence) were used to identify the pigments. FTIR analysis was performed on four plaster samples, one with plain unpainted plaster and three from the red, yellow, and greenish-blue as representative samples. Every painted plaster fragment underwent FORS analysis. Further analysis of the blue fragment was done in order to confirm our interpretation of the FORS results.

Materials and Methods

Fourier Transform Infrared (FTIR) Spectroscopy

Four plaster samples underwent Fourier Transform Infrared (FTIR) spectroscopy. This analysis provides information on the different chemical phases of the material, both organic and inorganic. To generate infrared spectra, a one-gram sample is homogenized in an agate mortar. Approximately 0.2 mg is then ground to a fine powder and mixed with approximately 20 mg of KBr (FTIR-grade), and finally each sample is pressed into a 7-mm pellet using a hydraulic press (Specac). Infrared spectra were obtained using a Nicolet iS5 spectrometer at a 4 cm^{-1} resolution. Spectra were compared to the Kimmel Center for Archaeological Science Infrared Standards Library, Weizmann Institute of Science.

Fiber Optics Reflectance Spectroscopy (FORS)

Fiber Optics Reflectance Spectroscopy (FORS) was used to try to identify the pigments used. FORS measures visible and near-infrared wavelengths. The ratio between the intensity of reflected light and incident light is compared to a standard white reference. FORS is a non-invasive technique that has been established as a good tool for pigment identification [3]. The data collected was compared to the online database of United States Geological Study [4]. The device used was an ASD FieldSpec 4 Hi-Resolution Spectroradiometer with a small diameter reflectance probe, which has a field spot of 1 mm. Each color on each fragment was tested at three locations.

X-Ray Fluorescence (XRF) Spectrometry

X-ray Fluorescence (XRF) measurements were done on the greenish-blue painted fragment with a Bruker Tracer 5i portable XRF spectrometer. The greenish-blue plaster sample was analyzed on both sides-the unpainted as a control as well as the painted side. A wide aperture with a spot size of ~8 mm was used. The XRF can detect elements from Mg (magnesium) and to U (uranium) in the periodic table. The instrument is equipped with a Rh-anode, miniaturized X-ray tube and a Peltier-cooled high-resolution silicon drift detector (SDD). Each acquisition ran for 60 seconds at 15 kV for major elements (Mg to Ca) and additional 15 seconds at 40 kV with an Al-Ti filter for trace elements (Ti to U). An internal calibration by Bruker, 'Mudrock dual' was used to quantify elements expected in the pigment and plaster.

Results and Discussion

Visual observations of the fragments showed that the paint application technique was poor, with brushstrokes visible in many fragments (Figure 4). Only two layers of plaster of different thickness were discerned from the painted plaster fragments: a lower white coarse plaster forming the preparation layer, and an upper painted layer. The lower layers are ca. 1-3 cm thick, with an irregular and coarse texture of beige color, sometimes consisting of gravel, coarse sand, and even small rock fragments. The uppermost, painted layer (0.1 cm thick) is finer in texture, yet not completely smooth. The paint on the upper layer does not penetrate the plaster's surface, and it is easily erased indicating that it was applied when the plaster was dry, that is, the paintings were made in the secco[1] technique.

Mineralogical composition as determined by FTIR show the plaster samples contained mainly calcite with a small amount of quartz, indicating that the usual lime plaster common in the Roman world. All samples had a similar composition with slight variations in the amount of quartz in each sample, presumably used as an aggregate in the lime, although it is still a minor component in all the plaster samples analyzed. The calcite-based binder was identified by the IR peaks of calcite (713 cm^{-1}, 875 cm^{-1}, 1433 cm^{-1}) in all plaster samples. There is also presence of quartz in the samples as showed by the peaks at 1083 cm^{-1} and two small doublet peaks at 799 cm^{-1} and 780 cm^{-1} (Figure 5). Additional peaks were noted to be clay: in the red plaster at 1036 cm^{-1} and in the unpainted plaster at 1044 cm^{-1}.

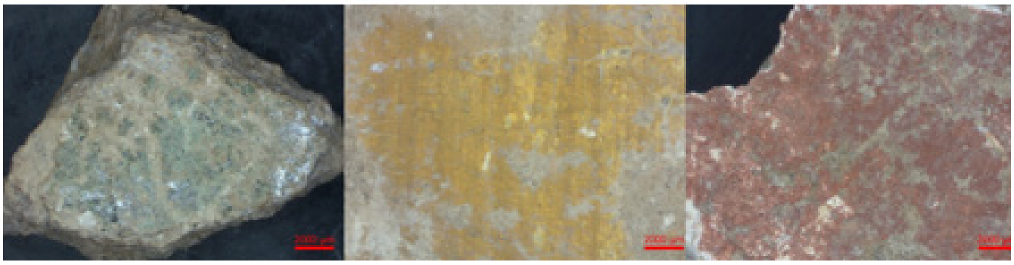

Figure 4: Painted fragments from the Public Building at Migdal Scale is 2 mm.

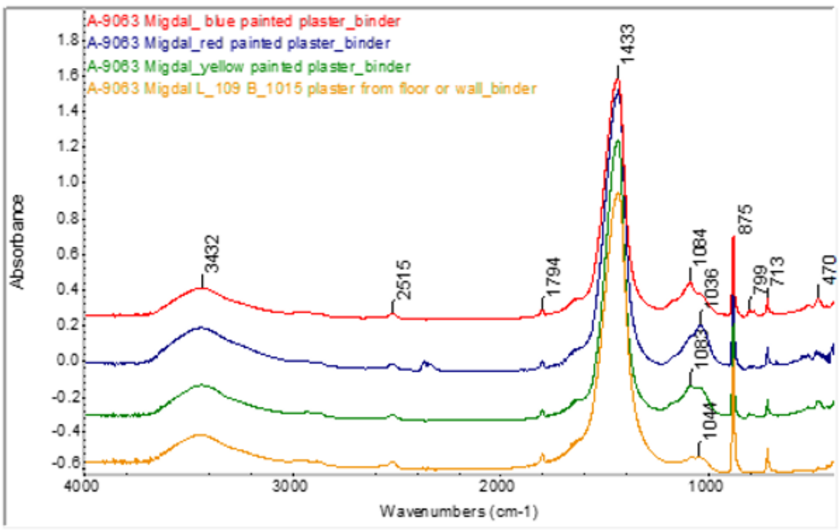

Figure 5: FTIR spectra of representative plaster samples.

[1] *Secco* involves mixing pigment with an organic binder which is applied to dry plaster.

Estimating the state of preservation and atomic order of the samples was done through a process using grinding curves [5, 6]. The normalized ν2 and ν4 values of calcite binder were plotted into the grinding curve graphs which shows atomic disorder between the curve of the modern plaster (marked in green in Figure 6) which is highly disordered calcite, and that of chalk or ash that have less disordered calcite (marked with blue and pink curves in Figure 6). This is an indication that the samples come from relatively well-preserved plasters, with minimal recrystallization via diagenesis, and perhaps some extent of geological limestone used as aggregates.

White appears as a background smooth color in a few fragments. It was also the color of a painted pilaster and of the benches in the Public Building. The color could have been Paraetonium, a natural colorant made from some form of calcium carbonate, usually obtained from dolomite or calcite, which was especially convenient because it also served as an agglutinating agent.

The analyses indicate hematite or red ocher as the principal pigment (Fe_2O_3), an iron oxide commonly used in antiquity. This was seen via its maximum absorbance around 550 and 880 nm (Figure 7). Hematite is one of the natural earth pigments, occurring in the Negev in Israel and in the Gilead area and west of Amman in Jordan. Different tonalities of hematite-based reds were also found in the Migdal synagogue [7, 8] in combination with yellow panels [21].

The yellow pigment was made from goethite (FeO (OH)), a hydroxide mineral common in antiquity. Its spectrum has absorbance peaks around 470, 650 and 900 nm (Figure 7). Goethite was a common component in wall paintings from the Hellenistic,[2] Herodian[3] and Early Roman examples. It was also the pigment for yellow in the near Migdal Synagogue [7, 8].

The pigments of a few small greenish-blue fragments seem to have been composed of green earth (*terre verte*) containing celadonite (K (Mg, Fe^{2}+) (Fe^{3}+, Al)[Si_4O_{10}]$(OH)_2$). The analyzed fragment was harder to identify with broad reflectance peak around 550 nm, as this reflectance peak can be compatible with blue and green pigments. Therefore, further information visual examination in ×50 and ×100 magnification was done using a Light Microscope Zeiss Discovery V12, and X-ray Fluorescence (XRF) measurements was done with a Bruker Tracer 5i portable XRF spectrometer. Close up microscopy shows the particles of the pigments are green, which goes well with the XRF and FORS observations (Figure 7-9).

XRF analysis characterizes the elemental composition of the pigment; therefore, this was done on the greenish-blue plaster fragment as well as the unpainted side of the greenish-blue fragment as a control. The pigment-covered side of the sample contains calcium as major element (mainly of the plaster), silicon, iron, aluminum and potassium as minor elements and phosphorus as a trace element (Figure 9). The pigment does not contain copper, chromium or cobalt, which eliminates most of the blue and green pigments used in antiquity [9, 10].

Creta Viridis, a green earth pigment containing glauconite (K, Na) (Fe, Al, Mg_2) (Si, $Al)_4O_{10}(OH)_2$) or celadonite, was, according to Vitruvius, utilized at many places [11, 12] and was a common pigment in the Roman world [13]. However, celadonite is a mineral which does not occur in in the Land of Israel. Celadon green was identified at Hellenistic Acco, attesting that the material was imported to the country already in Hellenistic times [14], and it continued to be used in the Herodian period as attested by the Jericho Herodian pigment bowls [15]. The pigment could have been imported from Cyprus, where ancient mines are known, or from Italy [15, 16, 17]. At the Migdal synagogue, the green pigments were composed of green earth (*terra verte*) also containing celadonite [7,8].

The black pigment was probably carbon-based, as the atramentum quoted in the ancient texts [11, 12].

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[2] At Hellenistic Acco the yellow color is also made from goethite or yellow ocher; see Segal and Porat 1997: table on p. 87. Goethite was also the pigment in the Hasmonean fragments from the Khirbet Umm el-'Umdan synagogue, see Rozenberg, Weksler-Bdolah, and Asscher, *forthcoming*.

[3] Dr. Porat identified goethite in the analyzed pigments from the bowls with pigments found in Jericho, Porat and Ilani 1998: 79, 82.

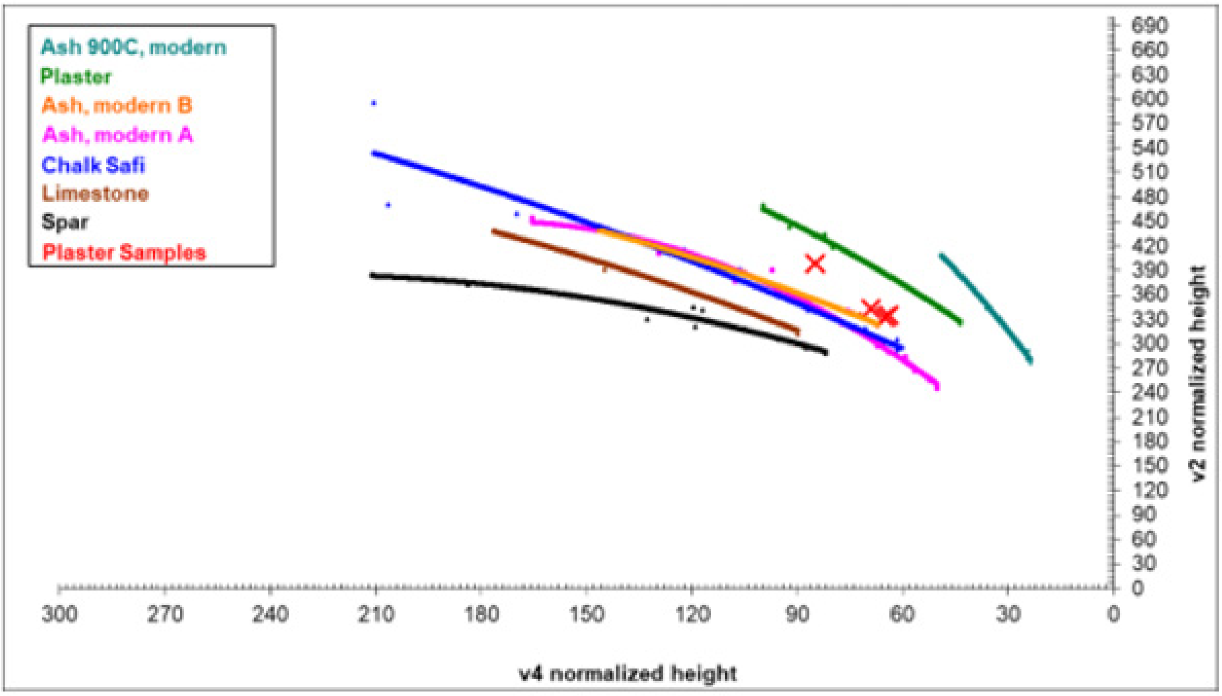

Figure 6: Calcite grinding curve with plaster samples from the Public Building at Migdal (following Regev et al. 2010).

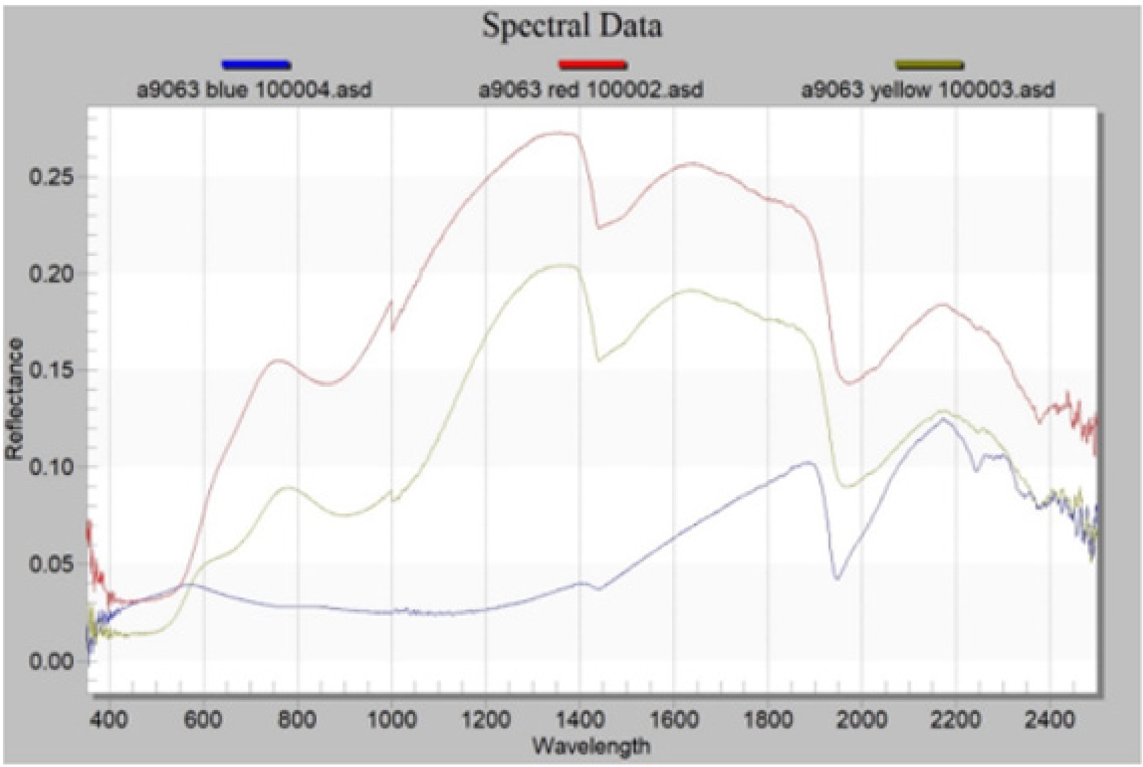

Figure 7: FORS spectra of painted plasters: red, yellow and greenish-blue.

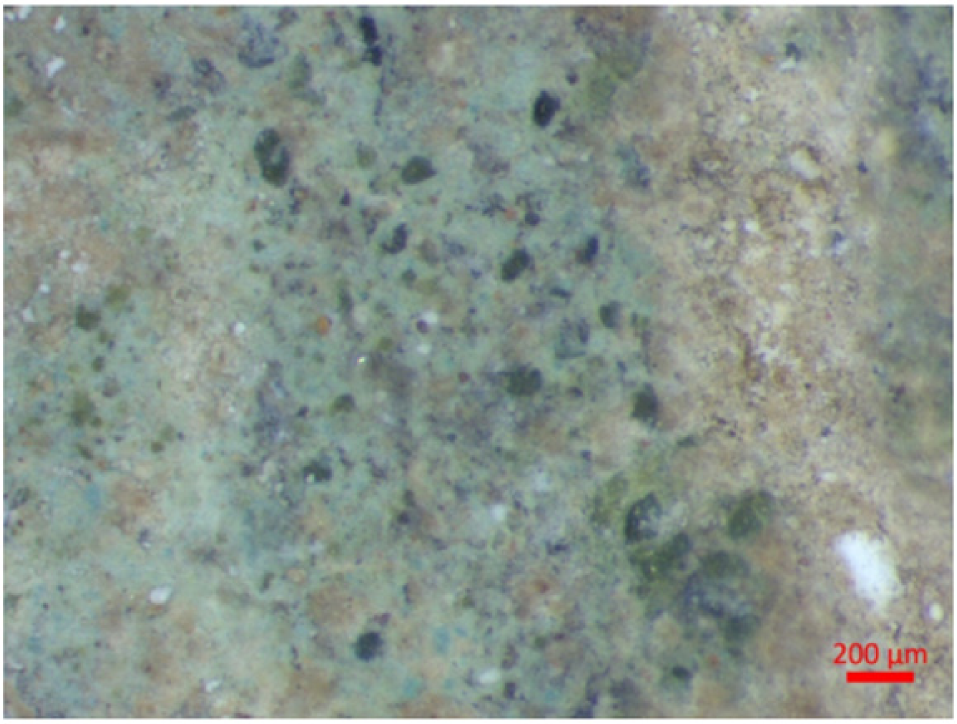

Figure 8: Painted plaster at ×50 magnification using a light microscope.

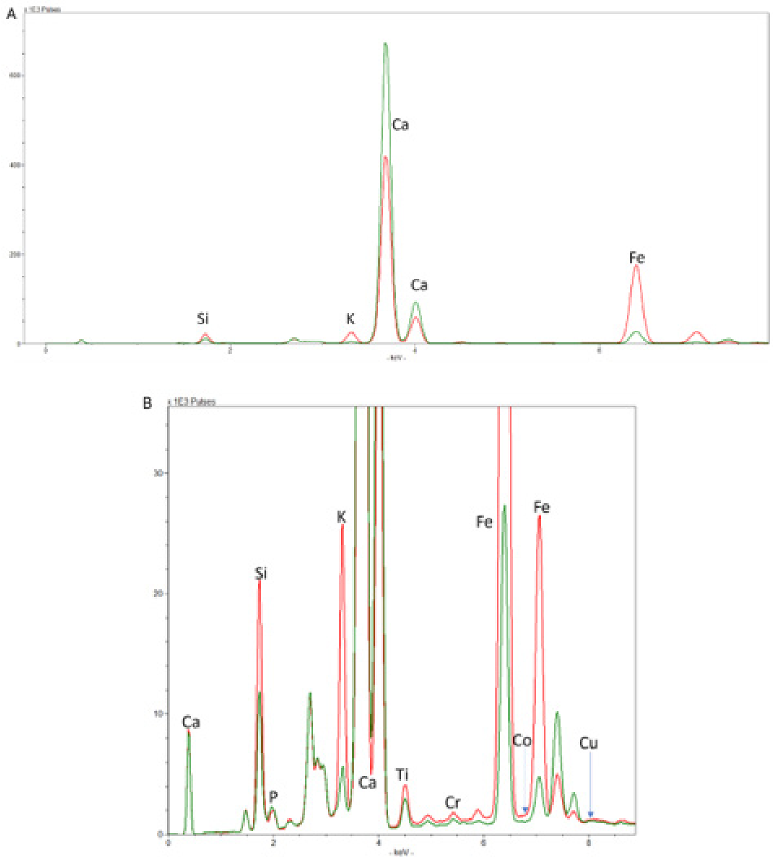

Figure 9: Chemical analysis for the green pigment and plaster (pigment – red spectra; plaster – green spectra). A. Major peaks. B. Minor and trace elements.

Conclusion

The plaster obtained from the Public Building at Migdal is a calcite-based binder with a minor component of quartz, with relatively good preservation. The greenish-blue pigment was an earth pigment that includes celadonite and glauconite, which was imported. The pigments used for red and yellow paint on the plaster were local iron oxides commonly used during this period (hematite and goethite).

The colors used in the Public Building at Migdal are consistent with pigments found elsewhere in the Roman Empire [2]. The palette at the Public Building is varied, but not extensive, and lacked the artificially produced colors (such as orange, pink, and blue) found in the murals of the nearby Migdal synagogue. The techniques utilized in the plaster fragments from the Public Building also differ from the Migdal synagogue where the standard of workmanship was better. In the synagogue, the paintings were executed in the fresco technique [21] with pigments ground in water and applied to wet plaster, whereas the fragments from the Public Building were executed in the secco technique. The most vibrant and longest-lasting frescoes tend to be from the fresco technique due to the pigment reacting with the plaster wall itself, whereby a compact and resistant layer of calcium carbonate forms on the pigment which becomes an integral part of the wall [18].

The fragments exhibit a mediocre standard of workmanship, likely due to being the product of a local workshop without the expertise known in this region during the Herodian and Early Roman period [2]. Although the fragments exhibited a relatively poor technique and a dullness of the colors in comparison to contemporary sites, including the mural at the nearby Migdal synagogue, the fragments from the Public Building show that long-distance trade items were utilized even for this less proficient work [19-22].

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Conflict of Interest

No conflict of interest.

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