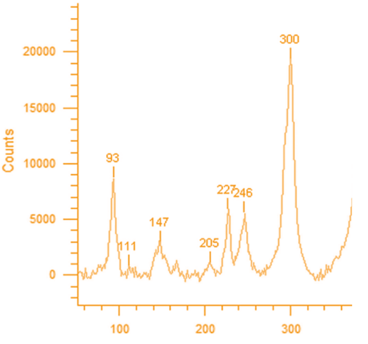
The technique and technology of wall paintings from the Villa of Theseus in Nea Paphos (Cyprus)



Abstract: This article presents the results of research conducted on the material structure of preserved fragments of Late Roman wall paintings from the Villa of Theseus at the archaeological site of Nea Paphos in Cyprus. Microchemical tests, instrumental methods, petrographic analysis, and optical microscopy were employed. The analysis of collected plaster samples revealed a mineral binder and carbonate-based filler, along with a lime binder in the painting layers, natural pigments, and Egyptian blue. The stratigraphy of the technological layers was established, which, in most cases, consists of two types of plasters differentiated by the filler material. The arrangement of the technological layers includes the lower plasters (arriccio) resting on the stone surface of the walls, the top layer of plaster (intonaco), on which pigments dispersed in water were applied, and impasto paints — where pigments were mixed with limewash. The results of the analyses and the findings regarding the painting techniques largely align with previous studies of ancient wall paintings in Cyprus.

Keywords: Nea Paphos archaeological site, Villa of Theseus, Roman wall paintings, technique and technology, pigments, plasters, analytical techniques, SEM-EDS, Raman spectroscopy

Anna Tomkowska[1]
Elżbieta Jeżewska[1]
Krzysztof Chmielewski[1]
Magdalena Skarżyńska[2]

[1] Academy of Fine Arts in Warsaw
[2] University of Warsaw, Polish Centre of Mediterranean Archaeology

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INTRODUCTION

The inspiration for conducting extended research on the techniques and technology of the preserved fragments of wall paintings in the Villa of Theseus at the archaeological site of Nea Paphos stemmed from conservation work carried out in 2023. The few but valuable decorations preserved on the villa's walls required urgent strengthening and safeguarding.[1] Since many fragments of polychrome plaster that had fallen from the walls are stored in the archaeological park's warehouses in Paphos —having been collected during previous excavation work— it was decided to analyze some of these fragments as well. For comparative purposes, fragments were included not only from the villa but also from earlier structures, such as the so-called Hellenistic House[2] [*Fig. 1*].

Numerous studies have been conducted on the technology and techniques of ancient wall paintings in Cyprus.[3] The work of Vasiliki Lysandrou and Demetrios Michaelides (2021) stands out, focusing on Hellenistic and Roman tombs in the Paphos region. Their research includes both wall paintings preserved *in situ* and fragments housed in the Paphos Museum. The authors also created a catalog of tombs and iconographic motifs. Ioanna Kakoulli (1997) studied paintings from Paphos and Kourion, analyzing samples from houses, tombs, and buildings in the Nea Paphos area, including the House of Orpheus, the House of Aion, and the Villa of Theseus. Furthermore, Roxanne Radpour, Christian Fischer, and Ioanna Kakoulli (2019) investigated Hellenistic and Roman wall paintings from tombs and residential buildings in Nea Paphos. Their study analyzed material from five villas, including the Villa of Theseus and the so-called Hellenistic House, as well as from various tombs and necropolises. Diana Wood Conroy (2004: 275–293) conducted analyses of painted decorations in the Paphos theater, which was built in the 3rd century BC and underwent multiple reconstructions until the 4th century CE. The chemical analyses of painting samples from the theater were described in detail by Josephine Atkinson in an appendix to Wood Conroy's article (2004: 294–300). A research team consisting of Catherine Vieillescazes, Céline Joliot, and Matthieu Ménager (2016) studied the techniques

1 The polychrome plasters exposed to the open air are continuously subjected to harmful atmospheric conditions, particularly sunlight and rainwater. Although they had been conserved in the past, new damage has occurred —including the detachment of plaster from the stone substrate and salt crystallization on the surface of the decorations— necessitating further conservation. The work involved professors, students, and graduates of the Faculty of Conservation and Restoration of Works of Art at the Academy of Fine Arts in Warsaw, as well as Magdalena Skarżyńska, a conservator from the Polish Centre of Mediterranean Archaeology, University of Warsaw.

2 For more on the structures that preceded the villa's construction, see: Daszewski and Sztetyłło 1988; Młynarczyk 1990: 160–177. On the so-called Hellenistic House, see most recently: Brzozowska-Jawornicka 2019; 2021.

3 It should be noted that pigment analyses are currently being conducted at the portico of the Agora in Nea Paphos. For more information on research and conservation efforts in this area, see: Papuci-Władyka et al. 2020.

used in painted decorations in buildings on Fabrika Hill. They analyzed samples from the northern and southeastern parts of the hill, comparing techniques used in a Roman villa with a cistern from the Roman period. Claire Balandier and her team (Balandier et al. 2017) continued research in this area, expanding the chemical and technological analyses of wall paintings in a Roman residential building. Their results made it possible to identify chronological changes in decorative techniques and date the building to the 1st century CE.

The dating of the preserved fragments of wall paintings from the Villa of Theseus can only be inferred from the architectural context of the rooms they once decorated. Given that the villa was in use from the end of the 2nd/beginning of the 3rd century to the second half of the 5th century (Papuci-Władyka and Miszk 2020: 95–96), a broad date range should be assumed for the wall decorations themselves.

The aim of the research was to identify the material composition of the individual technological layers (plasters and

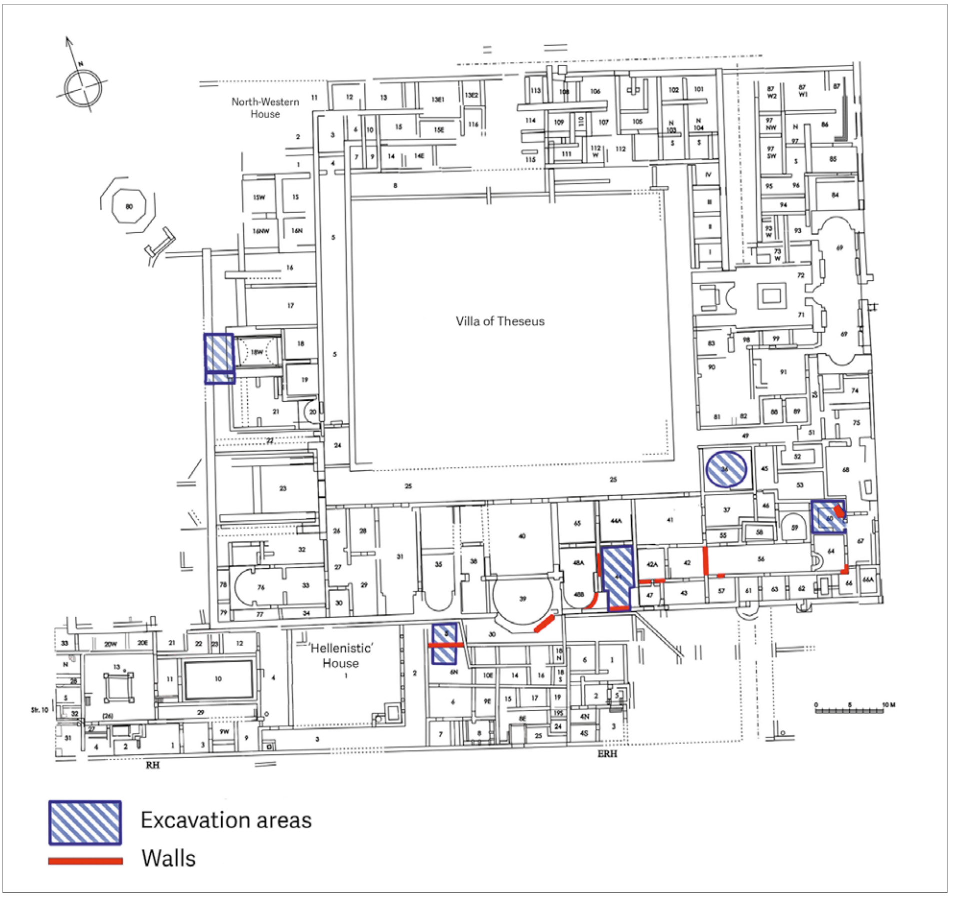

Fig. 1. A 2011 plan of the Villa of Theseus, with sampling locations marked (PCMA UW)

paint layers), establish their stratigraphic arrangement, and determine their most important physical characteristics. By combining the results of the sample analyses with microscopic and visual observations of the paintings, an attempt was made to synthesize a description of the painting technique. The research employed optical microscopy, microchemical analysis methods, SEM-EDS analysis, Raman spectroscopy, and petrographic analysis.[4]

VILLA OF THESEUS IN NEA PAPHOS

Archaeological research has shown that the Villa of Theseus was built on the remains of earlier city structures.[5] Various layers of settlement at the site date from the 4th century BC to the second half of the 2nd century CE (Daszewski and Sztetyłło 1988). The villa was the largest ancient residence in Cyprus, and its construction occurred in at least two phases (Medeksza 1992: 26). In the first phase, which took place from the late 2nd century to the early 3rd century (Papuci-Władyka and Miszk 2020: 95–96), the villa featured a peristyle plan with side risalites. In the second phase, it was transformed into a peristyle layout (Medek-

4 Microscopic *in situ* analysis was conducted by Prof. Krzysztof Chmielewski (Faculty of Conservation and Restoration of Works of Art, Academy of Fine Arts in Warsaw), Dr. Anna Tomkowska (Faculty of Conservation and Restoration of Works of Art and Inter-Academy Institute of Conservation, Academy of Fine Arts in Warsaw), and Magdalena Skarżyńska (Polish Centre of Mediterranean Archaeology, University of Warsaw); Paint layer cross-sections, pigment identification, microchemical tests for paint layers and mortars were carried out by Dr. Eng. Elżbieta Jeżewska (Faculty of Conservation and Restoration of Works of Art, Academy of Fine Arts in Warsaw); Microraman spectroscopy was conducted by MSc. Aleksandra Wesołowska (Inter-Academy Institute of Conservation, Academy of Fine Arts in Warsaw); petrographic analysis by Dr. Eng. Wojciech Bartz (Institute of Geological Sciences, University of Wrocław); SEM-EDX analysis by Dr. Eng. Jakub Kotowski (Faculty of Geology, University of Warsaw).

5 Research on painted decorations at the Nea Paphos site is closely linked to archaeological discoveries in the area. The beginnings of archaeological work in ancient Paphos date back to the early 20th century, when I.K. Peristianis conducted studies (Papuci-Władyka and Miszk 2020: 93). In 1942, shortly after the establishment of the Department of Antiquities, researchers associated with the institution discovered mosaics depicting Heracles and the Nemean lion at what is now known as the House of Orpheus (Papuci-Władyka and Miszk 2020: 93). From 1950 to 1951, the Kouklia Expedition, led by the University of St. Andrews and the Liverpool Museum, conducted test excavations in Nea Paphos (Młynarczyk 1990: 59). In 1962, mosaics were accidentally uncovered in a Roman villa known today as the House of Dionysus, marking the beginning of intensive research led by the Department of Antiquities under K. Nicolaou until 1969 (Młynarczyk 1990: 59). Since 1965, Polish archaeological missions have been conducting excavations in the Maloutena area, initially led by Prof. K. Michałowski (1965–1970) (Młynarczyk 1990: 62), followed by W.A. Daszewski (1971–2007) (Papuci-Władyka and Miszk 2020: 94), and since 2008 by H. Meyza. Currently, since 2019, research has been continued by a joint mission from the Institute of Archaeology, Jagiellonian University, and the Polish Centre of Mediterranean Archaeology UW, in collaboration with the Warsaw University of Technology. The project is led by E. Papuci-Władyka (https://pcma.uw.edu.pl/en/2019/02/15/nea-paphos/).

sza 1998: 26). Remains uncovered in the northwest corner of the villa suggest that the construction of the peristyle in that area could not have occurred before the 4th century (Medeksza 1998: 26). This second phase of expansion was divided into three stages. In the first stage, the width of the western and eastern wings was determined by the depth of room No. R.23. The western wing was progressively filled with additional rooms. These renovations followed a series of earthquakes that affected Cyprus until the third quarter of the 4th century, after which the second stage of modifications was carried out. These included the expansion of the southern wing and the construction of baths in the southeastern part of the villa (Medeksza 1998: 34). Changes to the northern wing of the villa transformed the peristyle from a square to a rectangular shape, with new rooms added centripetally to the northern wing. In the third stage of expansion, a monumental entrance was constructed in the eastern wing.

In its final form, the villa had over 100 rooms arranged within a rectangular plan measuring 120 m × 80 m (Medeksza 1998: 25). The gradual decline of the residence began in the second half of the 5th century, and by the second half of the 6th century, the villa was likely inhabited by occupants who significantly contributed to the deterioration of its décor (Medeksza 1992: 42).

Fig. 2. Painted imitation of *marmor carystium* (*cipollino*) preserved in room No. R.44 VT (Photo A. Tomkowska)

DECORATIVE MOTIFS OF THE PRESERVED WALL PAINTINGS FROM THE VILLA OF THESEUS

Because the wall paintings in the Villa of Theseus have survived only in fragments and are severely damaged, any detailed investigation of their motifs and types of representations must, by necessity, be limited to a few very general observations. Based on the preserved wall fragments and small pieces collected during several seasons of archaeological excavations, we can conclude that the motifs fall into three categories of decoration. The first category is painted imitations of marble slabs, the best example being a large fragment with green streaks, known as *cipollino* (*marmor carystium*), preserved in room No. R.44. Additionally, on several small, broken fragments, we can identify the imitations of stone with irregular red veining on either a yellow (*giallo antico*) or white background [*Figs 2, 3*].

Fig. 3. Painted imitation of *giallo antico*. Left: fragment from context VT1. 1986 B. Right: fragment from context VT 1973 R.60 (Photo A. Tomkowska)

The second and largest group of motifs consists of fragments of geometric decoration that originally covered the walls of the villa's rooms. These were composed of sequences of long black and red lines of varying widths, along with wider and narrower bands of solid colors running alongside them. These lines intersected at right angles, forming the main fields of the composition against a white background. These fields were likely filled

Fig. 4. Composition of fragments from context VT 1977 R.44 (Photo A. Tomkowska)

Fig. 5. Composition of thin black lines in the corner of room No. R.56 in the baths of the villa (Photo A. Tomkowska)

Fig. 6. Painted imitation of stone cladding in the apse of room No. R.48B VT (Photo A. Tomkowska)

with simple, colorful geometric shapes imitating marble slabs. Fragments of thin black compositional lines have also survived in the lower part of one of the walls in the baths and in the lower section of the apse in room No. R.48B, one of the villa's representative chambers [*Figs 4–6*].

The third category consists of several fragments of floral decoration, including vine elements and red flowers. Additionally, on one of the pillars in the baths in room No. R.56, the damaged outline of a running panther has been preserved, while on one of the loose fragments, there is a shape resembling an animal paw [*Figs 7, 8*].

The remains of the preserved paintings from the villa suggest a decoration style characteristic of the late Empire, in which walls were divided by rhythms of simple lines and colored planes, adorned with imitations of marble cladding and

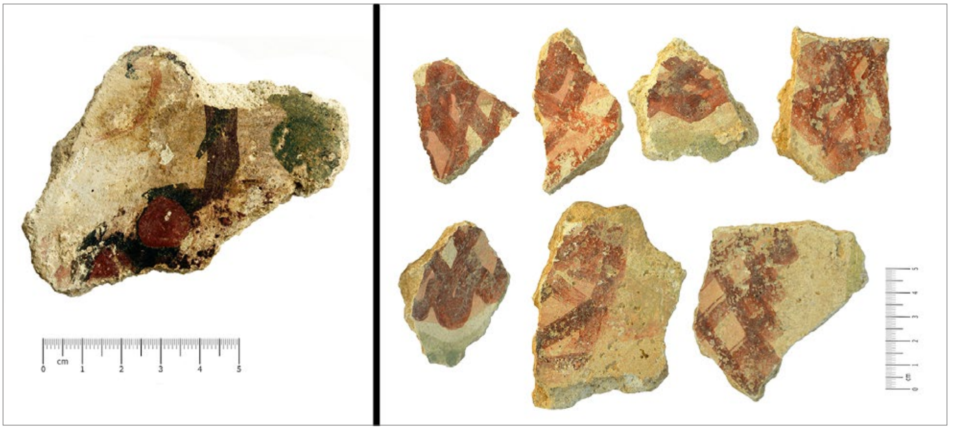

Fig. 7. Floral motifs. Left: depiction of vines. Right: motif of red flowers from fragments in context VT 1973 R.60 (Photos A. Tomkowska)

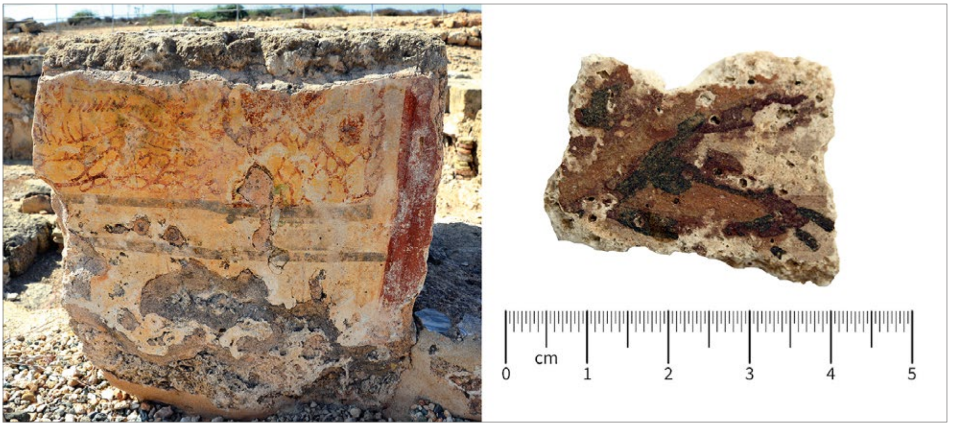

Fig. 8. Left: painted depiction of a running panther on the southern wall of room No. R.56 VT. Right: fragment from context VT 1973 R.60 featuring an animal's paw (Photos A. Tomkowska)

repeating small figurative motifs.[6] It is unclear whether other motifs, such as human figures, were also painted on the walls in addition to the plant elements, or what the proportions were between the various registers and the recurring decorative elements.

MATERIAL ANALYZED THROUGH CHEMICAL AND PHYSICAL TESTS

All samples identified as *in situ* were collected during the assessment of the condition of painted decorations at the Villa of Theseus in 2023 and 2024. The remaining samples were taken from fragments permanently stored in the warehouses of the Archaeological Park in Paphos [*Table 1*].

Table 1. Overview of samples with context

Sample No.	Location within the Villa of Theseus	Proposed dating of painted decorations based on previous research (CE)[7]	Sample origin	Additional information
VT 1977 R.44	R.44 – southern wing of the palace (representative area)	Late 2nd/early 3rd–mid-5th century	No data available. Fragments were discovered during excavations in 1977.	–
R.44/2023	R.44 – southern wing of the palace (representative area)	Late 2nd/early 3rd–mid-5th century	Southern wall	–
R.42/2024	R.42 – eastern part of the southern wing	No earlier than the 3rd quarter of the 4th century	Eastern wall	In its early phase, the room likely contained baths; its function may have changed later.
R.56/2023	R.56 – southeastern part of the villa – baths (frigidarium)	After the 4th quarter of the 4th century	Bench in the eastern part of the room	The bench from which the sample was taken was positioned on a mosaic dated to the 4th quarter of the 4th century.

6 Fragments of the remaining paintings from the Villa of Theseus bear similarities to wall decorations preserved to a much greater extent in the Villa of Leukaktios in ancient Ptolemais, Cyrenaica: Żelazowski 2012; Chmielewski and Żelazowski 2014. For information on wall paintings from the Late Roman period, see: Ling 2012: 186–197; Baldassarre et al. 2006: 346–383.

7 Dating based on previous research: Daszewski 1976; 1994; Medeksza 1992: 23–45; Młynarczyk 1990: 160–177; Brzozowska-Jawornicka 2019: 87; 2021: 109.

Table 1. Overview of samples with context (continued)

Sample No.	Location within the Villa of Theseus	Proposed dating of painted decorations based on previous research (CE)	Sample origin	Additional information
R.64/2024	R.64 – southeastern part of the villa – baths (apodyterium)	4th quarter of the 4th century	Southeastern corner	The painted decorations are obscured by a ceramic pipe, suggesting they may date to the bath's initial construction phase.
VT 1973 R.60	R.60 – southeastern part of the villa (latrine)	4th quarter of the 4th century–2nd half of the 5th century	No data available. Fragments were discovered during excavations in 1973.	Small fragments with floral and geometric motifs were found in the drainage channel among rubble.
VT R.36 TP 3 93 2x3	R.36 – southern wing of the palace (representative area)	Late 2nd/early 3rd–mid-5th century–end of the 3rd/beginning of the 4th century	Fragments from beneath the Theseus mosaic, discovered in 1993	The defining date is the installation of the mosaic, beneath which fragments of painted plaster were discovered.
HH R.5	The so-called Hellenistic House	End of the 1st–2nd half of the 2nd century	Southern wall	The sample does not originate from the Villa of Theseus.
VT 1. 1986 B	The so-called Hellenistic House – HH R.5(?)	End of the 1st century–2nd half of the 2nd century	No data available. Fragments were discovered during excavations in 1986.	In 1986, excavations south of the villa's southern wall (at the level of room R.39) yielded this material, labeled VT 1B. Later, this area was identified as room HH R.5, part of the so-called Hellenistic House.
VT 1985 S.4	Excavations along the western wall of the western wing of the villa	1st half or beginning of the 2nd half of the 2nd century	No data available. Fragments were discovered during excavations in 1985.	Excavation 4/85 was located directly west of room 18W.
VT1985 S. 6/85 and S. 4/85	Excavations along the western wall of the western wing of the villa	1st half or beginning of the 2nd half of the 2nd century	No data available. Fragments were discovered during excavations in 1985.	To the west of room 18W.

METHODOLOGY OF THE CHEMICAL AND PHYSICAL ANALYSES

MICROSCOPIC OBSERVATION

Fragments of mortars, plasters, and pigments were initially examined under a stereomicroscope (Delta Optical SZ-430B). Photographic documentation in reflected light was captured using a MicroQ microscope camera (3.1 MP, Aptina CMOS sensor). In subsequent stages, detailed analysis was conducted using optical microscopes: a Nikon Eclipse 50i, a Nikon Eclipse Ci polarizing microscope, and a Zeiss polarizing microscope equipped with a Canon G2 camera.

PAINT LAYER STRATIGRAPHY (VISIBLE/ ULTRAVIOLET LIGHT OBSERVATIONS)

Samples were obtained from polychromed fragments of wall decoration by sawing off pieces containing all paint layers along with as much underlying plaster as possible. They were then embedded, in a specific orientation, in a transparent acrylic resin (Meliodent Rapid Repair, Heraeus Kulzer), and subsequently ground and polished using sandpaper. These samples were used for analysis with a Nikon Eclipse 50i (EPI illumination, flexible fiber optic illuminator) and for observation of UV-induced visible fluorescence (Nikon Eclipse 50i, EPI illumination fluorescence: excitation 365 nm with filter block of EX 377/50 H, DM 400 LP, BF 425 LP). A Canon Eos 77D camera, attached to the microscope, was used to record visible light and ultraviolet-induced fluorescence images of samples (hereafter referred to as VIS/UV).

MORTAR AND PLASTER IDENTIFICATION

Visual examination of mortar and plaster samples was carried out using a PZO MSt 130 stereomicroscope. In addition, specific microchemical tests were performed to detect certain cations and anions.

Thin sections for optical microscopy in polarized light were prepared. Samples were cut in two using a diamond circular saw in a way that exposed the sequential layers of plaster and preparation grounds. The cut samples were mounted on microscope slides using an epoxy resin with a refractive index of 1.54, then polished with polishing powder to a thickness of approximately 35 μm. After polishing, the thin sections were covered with a glass slip and glued using Canada balsam. The sections were examined under a Zeiss polarizing microscope equipped with a Canon G2 camera, which was used for thin-section photography.

Modal analysis was performed using the point-counting technique in JMicroVision software (v 1.2.7), with at least 200 randomly selected points analyzed for each sample.

PAINT LAYER IDENTIFICATION

Pigment identification was carried out using reflected light microscopy (PZO MSt 130 stereomicroscope) and transmitted light microscopy (Nikon Eclipse E50i). Water smears were prepared using a small amount of the paint layer sample. The use of water facilitates easy substitution with reagents, as described in the following paragraph. Particle size, shape, and surface morphology were analyzed in this way. Some smears were also examined in polarized light (using both parallel and crossed polarizers, Nikon Eclipse Ci polarization microscope). The latter proved particularly helpful for identifying minium, known for its strong pleochroism.

Subsequently, a series of microchemical tests were performed, including reactions to acids (concentrated HNO_3 and diluted 3M HCl), alkalis (4M NaOH), and tests for specific cations and anions.

Selected samples were further analyzed using Raman microspectroscopy to determine the mineral composition of pigments. Tests were carried out using a Renishaw inVia Qontor confocal Raman spectrometer, equipped with two excitation lasers (wavelengths: 532 and 785 nm; laser power: 1–5%; collection times: 1–20 s).

In addition, selected samples were subjected to elemental analysis using scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDX), conducted on a Carl Zeiss Sigma scanning electron microscope. Uncoated samples were analyzed in low-vacuum mode.

MORTARS AND PLASTERS IDENTIFICATION

Each of the analyzed mortar samples exhibited a multilayer structure composed of two to three distinct layers.

BASE PLASTER LAYERS (ARRICCIO I AND ARRICCIO II[8])

Microscopic examination under both transmitted and polarized light revealed that the binder in both layers is microcrystalline, brown in color, and slightly translucent. It consists of microcrystalline calcium carbonate formed as micrite. The binder is heterogeneous and contains distinct micritic clusters.

Among the filler grains, carbonate rocks predominate —primarily biogenic limestones— with some individual bioclasts, such as foraminifera and mollusk shells. Some of these fragments may originally have constituted limestone. In addition to the limestones, fragments of crystalline rocks are present, including both plutonic rocks (e.g. gabbro) and volcanic rocks (resembling basalt). Fine grains of siliceous rocks (such as chalcedony) and possible acidic volcanic rocks (e.g. rhyolite or trachyte), as well as gypsum rocks, were also identified. Less commonly, grains of metamorphic rocks —such as serpentinites containing chlorites and possibly chlorite schists or greenschists— are present. Quartz and feldspar appear sporadically as accessory components, along with rare crystals of pyroxenes and opaque minerals. In both the arriccio II and arriccio I layers, black particles with tabular or needle-like shapes —likely charcoal— were observed. The differences between the two layers are minimal; however, in the arriccio I layer, gypsum fragments are visible. Although less numerous than limestone, they are consistently present in every sample.

8 In some publications on ancient wall painting techniques, the terms "arriccio" (referring to the base layers of plaster) and "intonaco" (the final plaster layer directly painted on) are commonly used. Although these are modern terms, they are employed in this article to facilitate comparison with the corresponding layers described in other works. Here, "arriccio I" refers to the plaster applied directly to the stone wall, while "arriccio II" denotes the layer onto which the intonaco was applied.

TOP PLASTER LAYER (INTONACO)

The binder of the intonaco layer is microcrystalline and composed of submicroscopic crystals of calcium carbonate, formed as micrite. It creates a light brown, slightly translucent mass that, under crossed polarizers, exhibits high-order interference colors — though these are masked by optical effects seen under a single polarizer.

The filler grains of the intonaco layer primarily consist of carbonate fragments, including pieces of biogenic limestone and bioclasts. The bioclasts may represent either organic carbonate structures isolated from larger carbonate grains or individual skeletal elements (e.g. single shells) that have not yet been cemented into a diagenetic sedimentary rock. These grains can reach up to approximately 1.5 mm in size, though most measure around 1.0 mm. Very small grains, ranging from 0.1 to 0.2 mm, are also commonly observed. The grains show minimal rounding. They are accompanied by very rare opaque mineral grains, which occur only as accessory components [*Table 2, Fig. 9*].

Table 2. Results of mortar and plasters analyses based on petrographic thin sections

Sample No.	Layer	Traces of organic fillers (straw)	Bioclasts (microfossils)	Biogenic limestones	Siliceous sedimentary rocks (e.g. chalcedonite)	Gypsum rocks	Crystalline rocks (quartz, feldspars)	Crystalline volcanic rocks similar to basalts	Crystalline plutonic rocks similar to gabbro	Opaque minerals	Metamorphic rocks (chlorite schists, serpentinites)	Charcoal	Lime binder	Binder percentage (%)
Pr 1 VT R.42 A	Arriccio I	(+++)	(++)	(+++)	(+)	(+)	(+)	(++)	(++)	(+)	(+)	(+)	(+++)	54.5
	Arriccio II	(+++)	(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	55.0
	Intonaco		(+++)	(+++)						(+)			(+++)	52.5
Pr 1 VT R.42	Arriccio		(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	50.5
	Intonaco		(+++)	(+++)						(+)			(+++)	54.0
Pr 1 VT R.64	Arriccio I	(+++)	(++)	(+++)	(+)	(+)	(+)	(++)	(++)	(+)	(+)	(+)	(+++)	37.5
	Arriccio II	(+++)	(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	46.5
	Intonaco		(+++)	(+++)									(+++)	44.5
Pr 3 1977 R.44	Arriccio	(+)	(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	53.5
	Intonaco		(+++)	(+++)						(+)			(+++)	55.0
Pr 5 VT1/1986/B	Arriccio	(+++)	(++)	(+++)	(+)	(+)	(+)	(++)	(++)	(+)	(+)	(+)	(+++)	60.0
	Intonaco		(+++)	(+++)						(+)			(+++)	57.5

Table 2. Results of mortar and plasters analyses based on petrographic thin sections (continued)

Sample No.	Layer	Traces of organic fillers (straw)	Bioclasts (microfossils)	Biogenic limestones	Siliceous sedimentary rocks (e.g. chalcedonite)	Gypsum rocks	Crystalline rocks (quartz, feldspars)	Crystalline volcanic rocks similar to basalts	Crystalline plutonic rocks similar to gabbro	Opaque minerals	Metamorphic rocks (chlorite schists, serpentinites)	Charcoal	Lime binder	Binder percentage (%)
Pr 1 HH5	Arriccio	(+?) possible	(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	40.5
	Intonaco		(+++)	(+++)						(+)			(+++)	46.0
Pr 1 VT R.36 TP 3 93	Arriccio I	(+++)	(++)	(+++)	(+)	(+)	(+)	(++)	(++)	(+)	(+)	(+)	(+++)	49.5
	Arriccio II	(+++)	(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	54.4
	Intonaco		(+++)	(+++)						(+)			(+++)	52.5
Pr 3 VT R.56	Arriccio I	(+++)	(++)	(+++)	(+)	(+)	(+)	(++)	(++)	(+)	(+)	(+)	(+++)	43.0
	Arriccio II	(+++)	(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	40.5
	Intonaco		(+++)	(+++)						(+)			(+++)	57.5
Pr 3 1973 R.60	Arriccio I	(+++)	(++)	(+++)	(+)	(+)	(+)	(++)	(++)	(+)	(+)	(+)	(+++)	54.5
	Arriccio II	(+++)	(++)	(+++)	(+)		(+)	(++)	(++)	(+)	(+)	(+)	(+++)	43.0
	Intonaco		(+++)	(+++)						(+)			(+++)	53.0

(+++) – high occurrence

(++) – moderate occurrence

(+) – low occurrence

(+?) – possible presence

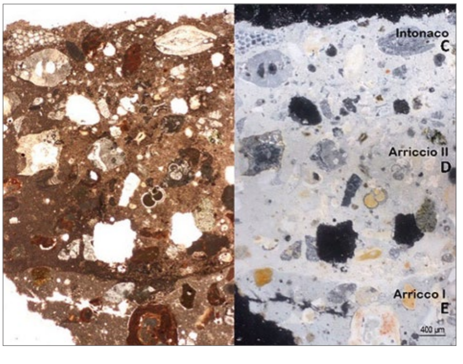

Fig. 9. Microphotograph of a thin section made from sample Pr 1 VT R.64 under plane-polarized light (left) and reflected light (right) (Photos E. Jeżewska)

PIGMENT IDENTIFICATION

REDS

Most of the samples covered with a red paint layer exhibited a dark, dull hue identified as oxides and oxide-hydroxides of naturally derived iron minerals. A typical microscopic appearance included translucent, red-orange-brown particles with an extremely wide size and shape distribution. The presence of frequent impurities typical of this pigment (e.g. quartz) and positive microchemical tests showing iron, calcium, and soluble silicates indicated the use of natural red iron oxide.

In two samples, red iron oxide was identified along with an admixture of minium (Pb_3O_4). Unlike natural red iron oxides, minium particles displayed strong pleochroism and readily dissolved in diluted hydrochloric acid. Hematite (Fe_2O_3) was also identified in ochre-painted areas via Raman spectroscopy, indicating its intentional use to achieve a desired ochre shade.

YELLOWS

In most of the yellow-painted samples, natural yellow iron compounds were detected. These were indicated by the presence of translucent yellow crystals with a broad particle size distribution and natural impurities and confirmed

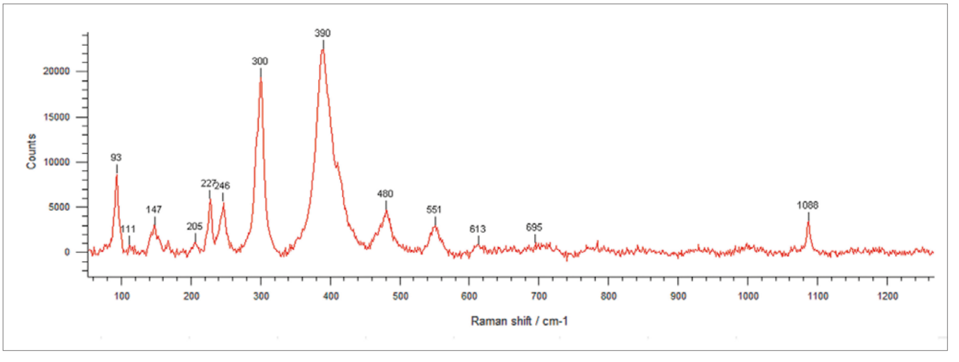

Fig. 10. Micro-Raman spectrum of sample Pr 8 VT 1973 R.60. Characteristic bands for goethite, hematite, and calcite are visible (A. Wesołowska)

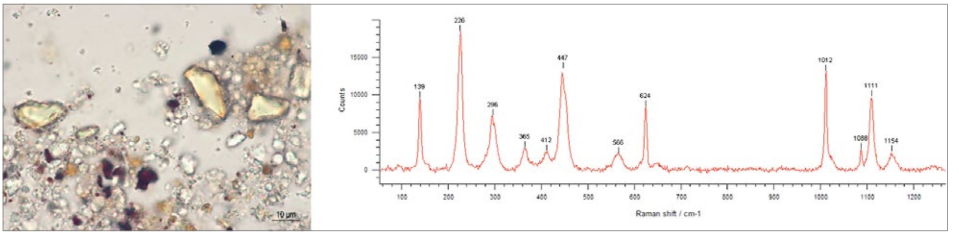

Fig. 11. Left: crushed, pale yellow crystals of natrojarosite along with hematite in sample No. Pr 8 VT 1973 R.60. Right: micro-Raman spectrum showing characteristic bands of natrojarosite (E. Jeżewska (left), A. Wesołowska (right))

by microchemical tests showing iron and calcium, as well as small amounts of soluble silicates. Raman spectroscopy identified goethite (FeO(OH)), the primary constituent of yellow ochre. Under plane-polarized light, translucent red, rounded particles were also observed. Along with Raman spectroscopy identification of hematite (Fe_2O_3), this suggests that red iron oxide pigment may have been added [*Fig. 10*].

However, one unique sample (Pr 8 VT 1973 R.60) showed a distinct microscopic appearance. In addition to red and yellow natural iron compounds, it exhibited euhedral, hexagonal plates of pale yellow color. A variety of similarly colored forms, including subhedral and anhedral plates, were also present. Raman spectroscopy revealed the presence of natrojarosite, a sodium iron sulfate hydroxide mineral with the composition $NaFe_3(SO_4)_2(OH)_6$ [*Fig. 11*].

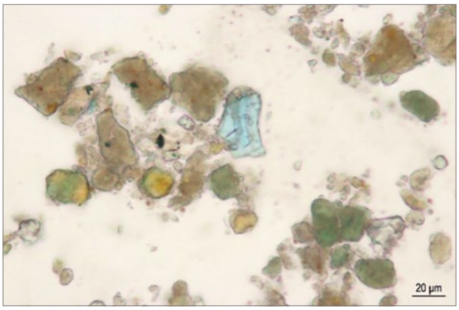

Fig. 12. Sample No. Pr 3 VT 1985 S4 in transmitted light. Coarse, translucent blue grain of Egyptian blue and oval, weakly translucent green and yellow-green particles, possibly celadonite (green earth pigment) (Photo E. Jeżewska)

GREENS

In all green paint layers, the pigment green earth was identified. Microscopic observations under plane-polarized light revealed translucent to weakly translucent particles, pale green to yellowish-green in color, with variable shapes (up to 10 μm in size). Typically rounded, occasionally fibrous or lamellar forms were noted, often with rough particle surfaces. Microchemical tests confirmed the presence of both Fe^{3+} and Fe^{2+} ions, as well as some soluble silicates. Raman spectroscopy identified celadonite ($K(Mg,Fe^{2+})(Fe^{3+},Al)Si_4O_{10}(OH)$) and, in one sample, calcite [*Fig. 12*].

BLUES

As with green earths used for green paint, only a single pigment was identified in all blue paint layers: Egyptian blue, a synthetic analogue of the mineral

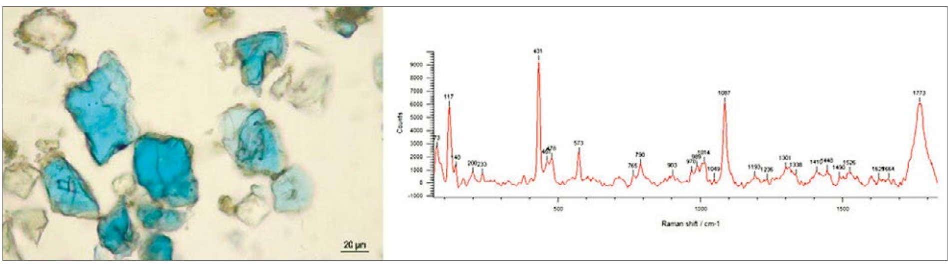

Fig. 13. Left: water smear of blue layer containing Egyptian blue in transmitted light (sample No. Pr 1, VT 1. 1986 B). Right: micro-Raman spectrum showing characteristic bands of Egyptian blue — a calcium copper tetrasilicate (E. Jeżewska (left), A. Wesołowska (right))

cuprorivaite ($CaCuSi_4O_{10}$). Raman spectroscopy confirmed the presence of this mineral along with calcite, which likely originated from the binder. Coarse blue pigment grains were easily distinguished in reflected light, as well as under plane-polarized light, where blue particles with smooth textures and highly variable shapes were noted. Perfectly tabular crystals appeared alongside angular and irregular grains with a pitted surface texture. Microchemical tests confirmed the pigment's insolubility in acids and the presence of calcium.

Occasionally, a green-blue layer was observed, in which Egyptian blue was mixed with green earth [*Fig. 13*].

BLACKS

The greatest variety of pigments was found in the black paint layers. Charcoal particles were identified under transmitted light microscopy by their characteristic angular and elongated shapes, typically opaque but occasionally exhibiting brown, translucent zones. In other samples, very fine-grained black particles with a narrow size distribution suggested the use of lamp black. Regardless of the specific pigment used, it should be noted that these layers were often extremely thin and the painted decoration was minimal. Therefore, the possibility that the black coloration resulted from fume deposits (i.e. soot from a light source) should also be considered.

Two different black pigments were identified in two different sample sets. In sample Pr 7, taken from the group 1973 R.60, todorokite ($(Na, Ca, K)_2(Mn^{4+}, Mn^{3+})_6O_{12} \cdot 3\text{-}4, 5H_2O$) and hausmannite ($Mn_3O_4$) were identified in a black layer. Optical microscopy under transmitted light revealed black and opaque (rarely weakly translucent), anhedral to subangular particles. SEM-EDX analysis confirmed that the pigment was predominantly composed of manganese [*Fig. 14*].

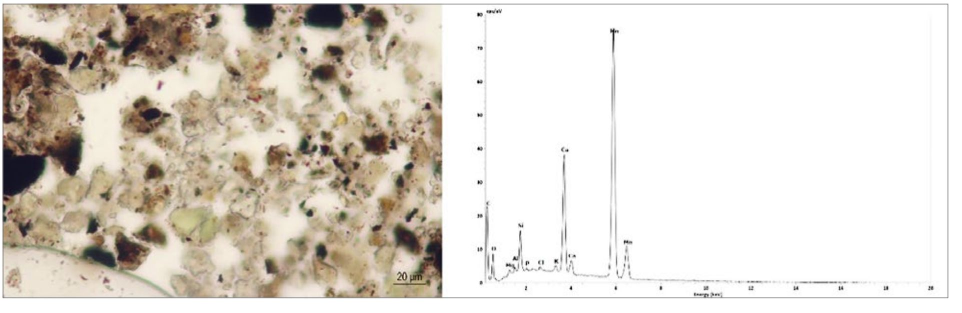

Fig. 14. Left: water smear of a black layer (covered with a green one) in transmitted light. Right: EDS spectrum of a black grain from sample Pr 7 VT 1973 R.60 (E. Jeżewska (left), A. Wesołowska (right))

INTERPRETATION OF RESULTS IN THE CONTEXT OF TECHNIQUES AND TECHNOLOGIES

WALL CONSTRUCTION MATERIALS

The primary building material used in the construction of the walls of the Villa of Theseus was stone blocks made of calcarenite (Dzwoniarek-Konieczna 2020: 84). Calcarenite is a type of limestone composed of more than 50% sand-sized carbonate grains (Neuendorf, Mehl, and Jackson 2005: 91). The stone was most likely quarried from Fabrika Hill in Paphos or from rocky terraces along the coast (Młynarczyk 1990: 215). Additionally, materials were reclaimed from earlier structures and rubble (Medeksza 1998: 25). The southern wing of the villa —the representative section— was constructed with large, regular stone blocks joined using gypsum-lime mortar (Medeksza 1998: 24).

Calcarenite is characterized by a partially porous structure, which makes it relatively weak and prone to water absorption through its pores. It is also considered less aesthetically pleasing. However, its rough and porous surface provides an excellent base for the application of plaster, eliminating the need for additional surface preparation [*Fig. 15*].

BASE PLASTER LAYERS (ARRICCIO I AND ARRICCIO II)

The dominant components of the fillers in the lower plaster layers are primarily fragments of carbonate rocks (biogenic

Fig. 15. Regular blocks of calcarenite used in constructing the apse of room No. R.39 VT (Photo A. Tomkowska)

Fig. 16. Traces of organic fillers (fragments of straw) visible in the plaster on the eastern wall of room No. R.60 VT (Photo A. Tomkowska)

Fig. 17. Preparation of the base plaster for the upper layers: distinctive herringbone incisions on the western wall of room No. R.20 VT (Photo A. Tomkowska)

limestones), embedded within a lime binder (calcium carbonate).[9] In the arriccio II and arriccio I layers, occasional bioclasts (microfossils) are also present. Additionally, opaque black particles —up to 0.4 mm in size— were observed, most likely representing charcoal. The minimal quantity —just a few dozen particles in the lower plaster layers— raises doubts as to whether these were intentionally added (possibly to slow the drying process of the mortar) or are the result of accidental contamination during lime processing.[10]

Most of the analyzed samples from the lower plaster layers also revealed traces of organic fillers — specifically, straw fragments [*Fig. 16*].

The lower plaster layers served to level the stone wall surfaces and acted as an immediate base for the final top intonaco layer with painted decoration. On some room walls (e.g. Nos R.20, R.48A, R.44, and R.60), distinctive herringbone incisions have been preserved[11] [*Fig. 17*].

Petrographic analysis using polarized light microscopy revealed two distinct layers within the lower plaster: arriccio II and arriccio I. The boundary between these coarse layers is easily identifiable. The clear separation suggests that the lower layer had dried before the subsequent one was applied. Since calcarenite is an extremely porous material, it is highly likely that the arriccio I layer functioned as a smoothing layer [*Fig. 18*].

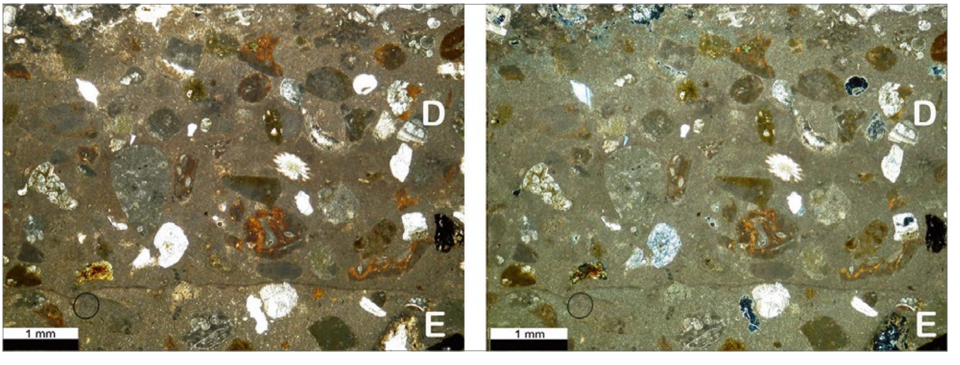

Fig. 18. Microphotograph of a thin section made from sample No. Pr 1 VT R.42A under plane-polarized light (left) and two crossed polarizers (right). The boundary between arriccio II (D) and arriccio I (E) is visible (Photos W. Bartz)

9 Findings regarding the fillers in the plasters are consistent with the research of Ioanna Kakoulli (1997: 132) and Claire Balandier and her team (Balandier et al. 2017: 334). These studies demonstrated that in the Paphos area, the most common fillers in mortars were limestone aggregate and rock fragments.

10 In studies of painted decorations in tombs, Lysandrou and Michaelides (2021: 230) also noted the presence of carbon particles in plaster samples, which may result from the lime processing.

11 This was a method commonly used, even in antiquity, to enhance the adhesion of the subsequent plaster layer. Incisions or impressions were made with a masonry tool in still-wet plaster (Ling 2012: 198). In Nea Paphos, such preparation of underlying layers has been documented by Claire Balandier in the Roman house on Fabrika Hill (Balandier et al. 2017: 334), and by Roxanne Radpour in the House of Orpheus (Radpour, Fischer, and Kakoulli 2019: 9).


Fig. 19. Traces of a tool used to smooth the surface of the upper plaster layer. Fragment from context VT 1973 R.60 (Photo A. Tomkowska)

TOP PLASTER LAYERS (INTONACO)

The main components of the filler grains in all examined samples of the top plaster layers are carbonate fragments (biogenic limestones) and bioclasts (microfossils).[12] Additionally, accessory materials in the form of opaque mineral grains were identified in the intonaco layers.[13]

On both fragments of murals preserved *in situ* and on detached pieces stored in warehouses, a smooth outer surface of the top plaster can be observed. This is also clearly visible in microscopic photographs of stratigraphic cross-sections [see below, *Fig. 21*]. The wet plaster was smoothed using wide wooden floats (Ling 2012: 200). On one of the fragments, traces of a small trowel can be seen, which was likely used to correct surface irregularities[14] [*Fig. 19*].

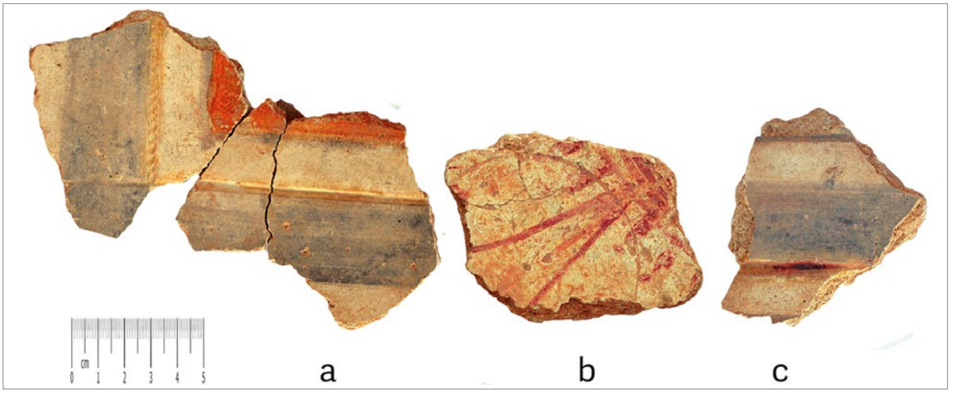

Fig. 20. From left: imprint of a cord (fragment from context VT 1. 1986 B); trace of a compass (fragment from context VT 1985 S4); line marked with a tool in wet plaster (fragment from context VT 1. 1986 B) (Photo A. Tomkowska)

12 The presence of microfossils in plaster samples from Paphos was also noted in the research of Ioanna Kakoulli (1997: 132). The researcher observed that to the northeast of Paphos lies the Kathikas Melange, where deposits of microfossil-rich chalk from the Lefkara Formation were mined.

13 The presence of individual, red-stained grains with ceramic characteristics was noted only in sample No. Pr 7 VT R.44, within the upper plaster layer. This additive was sufficiently rare that its contribution to enhancing the hydraulic properties of the mortars appears questionable. Further studies and petrographic analyses excluded the use of hydraulic additives.

14 Similar types of treatment involving the smoothing of the upper plaster layer were also observed in the research conducted by Ioanna Kakoulli (1997: 140).

In the wet top plaster, simple tools such as compasses or string were often used to mark or imprint the main compositional lines (Ling 2012: 203–204). This method was typically employed to aid in drawing parallel lines and circles in geometric decorations. In the analyzed mural fragments, traces of imprinted string, compass-drawn lines, and a concave mark left by moving the tip of a tool (such as a stick or brush handle) through the wet plaster were observed [*Fig. 20*].

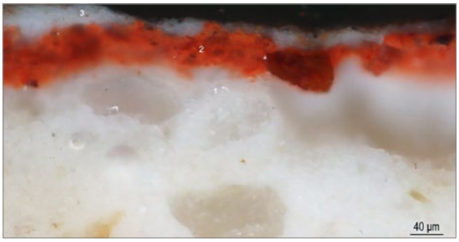

Fig. 21. Cross-section of red paint layer and intonaco, showing good adhesion in sample Pr 9 VT 1985 S4 (Photo E. Jeżewska)

PAINT LAYERS

In samples taken from the painted layers, the following pigments were identified: Egyptian blue, celadonite-rich green earth, natural iron red, minium, natural iron yellows (goethite and natrojarosite), plant black, soot, and calcium carbonate. All of these were commonly used in ancient painting (Colombo 2003: 71–106; Ling 2012: 207–209)[15] and have also been identified in previous studies of wall paintings in Cyprus. Additionally, in the black paint layers, two manganese-containing black minerals —todorokite and hausmannite— were identified. These have not been previously reported in the literature on the subject. In the samples containing painted layers, a mineral binder in the form of calcium carbonate was also confirmed. This indicates that all the studied fragments, whether preserved *in situ* or stored in archaeological mission warehouses, originate from paintings executed using lime-based

Fig. 22. Overlapping paint layers (left) and paint applied with the impasto technique under side lighting (right). Both fragments are from context VT 1973 R.60. Details like flower petals were painted with pigment mixed with a thicker binder —limewash— as indicated by the impasto (Photos A. Tomkowska)

15 For information on the properties and applications of the mentioned pigments in historical periods, see also: Feller 1986.

techniques. The paintings were created using dry pigments mixed with water and applied to the surface of still-damp plaster.[16] As the lime plaster dried and hardened, a chemical reaction occurred that permanently bonded the pigments to the plaster.[17] In microscopic photographs of cross-sections from the top plaster layers, the pigment layer can be seen adhering well to the plaster surface while also penetrating its structure [*Fig. 21*].

The first layers of colored underpainting for the decoration were created using the "wet-on-wet" painting technique.

Table 3. Pigment identification results by various research teams

Color	Pigment identification and research team[18]						
	A. Tomkowska, K. Chmielewski, E. Jeżewska	R. Radpour, C. Fischer, I. Kakoulli	D. Wood Conroy, J. Atkinson	I. Kakoulli	V. Lysandrou, D. Michaelides	C. Vieillescazes, C. Joliot, M. Ménager	C. Balandier, C Joliot, M. Ménager, F. Vouve, C. Vieillescazes
White	Calcite	Calcium carbonate	–	Calcite	Calcite	Calcite	Calcium carbonate
Black	Todorokite Hausmannite Romanechite Lamp black(?)	Iron oxide Manganese oxide Carbon black(?)	Carbon black(?)	Carbon black Pyrolusite	Magnetite Hausmannite Vernedite Amorphous organic carbon	Iron oxide	Iron oxide
Red	Hematite Red lead	Hematite Cinnabar Red lead	Hematite Cinnabar Red lead(?) Chalcopyrite(?)	Hematite Cinnabar	Hematite	Hematite	Iron oxide
Yellow	Goethite Natrojarosite	Goethite	Goethite Carphosiderite(?) Chalcopyrite(?)	Goethite	Goethite	Goethite	Iron oxide
Green	Celadonite	Celadonite	Celadonite Glauconite	Celadonite Stellerite Gmelinite	Celadonite	–	–
Blue	Cuprorivaite (Egyptian blue)	Cuprorivaite (Egyptian blue)	Cuprorivaite (Egyptian blue) Glaucophane (?)	Egyptian blue	Cuprorivaite (Egyptian blue)	–	Egyptian blue

16 The same technique of painting on wet plaster was also noted in the research by Ioanna Kakoulli (1997: 140), Claire Balandier (Balandier et al. 2017: 334), Roxanne Radpour (Radpour, Fischer, and Kakoulli 2019: 9), and Vasiliki Lysandrou (Lysandrou and Michaelides 2021: 224).

17 This is a chemical reaction in which the calcium hydroxide present in wet mortar reacts with carbon dioxide in the air, resulting in the formation of calcium carbonate (Mora, Mora, and Philippot 2001: 63–64). The technique of painting on wet plaster was known in antiquity and was described by Vitruvius (Ling 2012: 201–204). In Roman wall painting, it was the most widely used technique, later referred to as fresco during the Renaissance.

18 The way pigment names are recorded in the table reflects the methods used for their identification.

Fig. 23. Left: fragment from context VT 1977 R.44, showing red compositional lines painted with a single pigment. Right: fragment from context VT 1973 R.60, where colors were achieved by mixing various pigments (Photos A. Tomkowska)

Fig. 24. Contrast between areas painted with red pigment (red ochre) and blue (Egyptian blue) on a fragment from context VT 1985 S4 (Photo A. Tomkowska)

Subsequent paint layers were likely applied to the still-damp plaster using brushes of varying widths, as evidenced by marks visible in the microscopic photographs of the surfaces of the paintings. In many fragments, the upper paint layer merges with the lower one. Impastos were created using pigments mixed with limewash [*Figs 22, 23*].

Different sections of the decoration were painted either using a single pigment type (e.g., compositional lines) or with mixtures of two pigments. In some areas, two or three layers of different colors overlap, most clearly observed in fragments featuring painted flowers [see *Fig. 23*].

In fragments imitating *giallo antico* marble [see *Fig. 3*], the first layer of underpainting —yellow or white— shows structural variation created with red paint, partly achieved using impressions from a paint-soaked sponge.[19]

The surface of the paintings reveals physical differences between the pigments used. Yellow and red earth pigments (clays) are easily crushed and mix well with water or a thin lime binder, allowing them to penetrate the structure of the damp plaster. In contrast, Egyptian blue is hard and must be ground before use. It does not dissolve readily in water and leaves no distinct brush marks during application, though its rough texture is still noticeable [*Fig. 24*].

Some color patches are outlined with a black contour, as seen in a small fragment resembling an animal's paw [see *Fig. 7*]. Traces of contour drawing can also be observed on a damaged fragment depicting a panther running along the pillar in the thermal rooms [see *Fig. 7*].[20] Due to the fragmentary state of preservation, it is difficult to assess the artistic quality in full. Nonetheless, the broad color fields, precisely drawn lines, and representations of plants and animals suggest a skilled hand —or hands— familiar with both artistic principles and the technical means to achieve specific artistic effects.

CONCLUSION

The analysis of wall decoration fragments from the Villa of Theseus and earlier structures largely aligns with previous research on ancient wall painting techniques in Cyprus. This applies to both the plaster and paint layers [*Table 3*].

Two main types of plaster were identified on the walls of the Villa of Theseus, differing in both composition and appearance: the underlying plaster and the top layer, which served as the surface for the painted decorations. The underlying plaster was applied with masonry trowels directly onto the stone walls, sometimes in two successive layers of the same mortar. The boundaries between these layers are visible in the stratigraphic sections of the analyzed samples [see *Fig. 9*]. The decorative layers rest on the top plaster, which differs in both thickness and composition from the underlying layers. In some rooms, multiple plaster layers

19 A very similar technique was used to imitate two-tone marble in the paintings at Ptolemais in Libya (Chmielewski 2012: 231).

20 This fragment is currently very damaged, with only remnants of brown lines visible. It is possible that these are remnants of an initial compositional sketch.

were identified, likely reflecting successive alterations and repairs to the interior decoration.

The surviving fragments of the underlying plaster (arriccio) in the villa suggest a thickness of around 1 cm. In contrast, the top plaster (intonaco) in most rooms ranges from 0.5 to 0.2 cm in thickness. An exception is the southern wall of room No. R.44, where the combined thickness of the plasters is approximately 4 cm. The presence of later protective mortar bands around the edges of the original plasters made it difficult to determine the exact number and thickness of individual layers. However, the overall thickness suggests that new plaster layers were added over older ones, indicating potential changes in the interior decor. In room No. R.42, signs of mortar keying were observed on the eastern wall, likely indicating preparation for the application of new plaster and painted decorations [*Fig. 25*].

It is important to note the varied artistic quality of the painted decorations in both the villa and the earlier buildings beneath it. Particularly noteworthy are the high-quality decorations from earlier structures, as well as those from the villa associated with context VT 1973 R.60, which feature plant motifs [see *Figs 22* and *23*]. These decorations were applied to well-prepared plaster surfaces, using a diverse color palette and various painting techniques involving brushes of different widths. Additionally, the guiding lines impressed into the plaster on fragments from context VT 1. 1986 B allowed for the precise execution of patterns. In contrast, fragments from context VT 1973 R.60 that depict imitations of *giallo antico* marble

Fig. 25. Eastern wall of room No. R.42, showing clear signs of mortar keying on the plaster surface (Photo A. Tomkowska)

cladding were executed carelessly, with little attention to their aesthetic quality. The painted decorations from the Villa of Theseus span a broad chronological range, from the late 2nd/early 3rd century to the mid-5th century. This long temporal span likely contributed to the significant stylistic variation and differences in execution quality, reflecting the differing skills of the painting workshops. Additionally, the general decline in technological quality observed during Late Antiquity appears to be another important factor in this variation [*Fig. 26*].

The research conducted on the painted decorations from the Villa of Theseus and the earlier construction phases offers valuable insights into the wall painting techniques used in Cyprus. While the findings fit within the broader framework established by previous research, some minor differences —such as the absence of polished, thick pigment layers observed in earlier Cypriot paintings (Radpour, Fischer, and Kakoulli 2019: 10)— may be attributed to the limited quantity of preserved material. Moreover, the poor condition of the decorative fragments from the Villa of Theseus complicates a full assessment of their original execution techniques, leaving some aspects open to speculation.

Despite these limitations, the analyses conducted contribute significantly to our understanding of painting techniques from the period. Mineral pigments such as natrojarosite, todorokite, and romanechite were identified — materials that had previously been anticipated (Radpour, Fischer, and Kakoulli 2019: 25) but had not yet been confirmed in studies of the Paphos area.

Finally, it is important to emphasize that technological studies of wall painting at the Nea Paphos site hold great potential for deepening our knowledge of regional artistic practices, particularly during the Hellenistic and Roman periods. Each newly discovered decorative fragment offers valuable information about the materials, tools, and methods used by painters. Unfortunately, most scholarly publications on Paphos painting focus predominantly on pigment analyses, leaving plasters and mortars comparatively understudied. Continued research that thoroughly examines these foundational aspects of wall painting techniques is therefore essential.

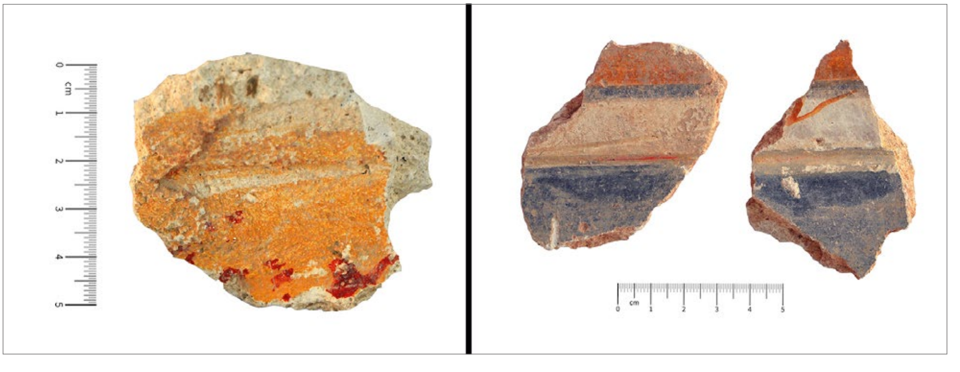

Fig. 26. Left: fragment from context VT 1. 1986 B. Right: fragment from context VT 1973 R.60. The fragments demonstrate different technological and artistic levels (Photos A. Tomkowska)

Dr. Anna Tomkowska
https://orcid.org/0009-0006-8021-9505
Academy of Fine Arts in Warsaw
anna.tomkowska@asp.waw.pl

Dr. Eng. Elżbieta Jeżewska
https://orcid.org/0009-0004-7438-6724
Academy of Fine Arts in Warsaw
elzbieta.jezewska@cybis.asp.waw.pl

Prof. Krzysztof Chmielewski
Academy of Fine Arts in Warsaw
krzysztof.chmielewski@cybis.asp.waw.pl

Magdalena Skarżyńska
https://orcid.org/0009-0009-3441-9647
University of Warsaw
Polish Centre of Mediterranean Archaeology
magdalena.skarzynska@uw.edu.pl

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