

Hidden colours of Albania: Fresco pigments study from an isolated church in Leshnicë, 18th-19th century.

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Abstract. In the 18th-19th centuries, Balkan fresco painting developed under political change, religious continuity, and cultural exchange. Despite Ottoman rule, Orthodox traditions remained strong, blending with local and folk elements to form a distinct artistic language. The frescoes served as both religious symbols and affirmations of cultural identity, anticipating modern art movements. Artists mainly relied on natural pigments such as lead white, calcite, and ochre for their durability and accessibility. Costly pigments like azurite and lapis lazuli were rare, while newer synthetic colours such as Prussian blue and chrome yellow, common elsewhere in Europe, saw limited use reflecting Byzantine influence and regional traditions. Frescoes in the Monastery of the Presentation of Christ (Ipapandia) in Leshnicë e Sipërme were analysed in-situ with portable micro-XRF across 34 points. Results suggest different painters worked at different times. Elemental profiles link pigments to their colours: Fe-rich ochres and Cu-based greens were most common, while elevated Pb, Hg, and Sb indicate the possible use of cinnabar, stibnite, or minium. High antimony in red and black tones points to intentional use of Sb-rich materials. Overall, the findings highlight complex pigment mixtures shaped by local sources and historical techniques. **Keywords.** pigments, frescoes, painters, monastery, 18th-19th century, Albania.

1 Introduction

The 18th and 19th centuries in Europe were marked by significant artistic evolution, with fresco painting styles shifting from the dynamic intensity of Baroque to the ornate playfulness of Rococo, and later to the ordered forms of Neoclassicism and the emotional depth of Romanticism. In contrast, the Balkan region during the same period demonstrated a strong continuity of Orthodox Christian artistic traditions. Despite being under Ottoman rule, these areas preserved a distinct iconographic style rooted in Byzantine influences, while selectively

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incorporating local, folk, and occasional Western European elements. This artistic persistence served not only religious purposes but also as an affirmation of cultural identity. Such examples include Serbian monasteries of Studenica and Žiča; Greek monasteries, especially on Mount Athos; Bulgarian churches like Rila Monastery; Romanian frescoes in Voroneț Monastery; etc. Albanian religious art, in particular, developed a unique character within this Balkan context, maintaining medieval techniques and a palette based on durable, often locally-sourced, earth pigments. Between the 18th and 19th centuries, Balkan fresco painters consistently favoured traditional mineral pigments. Their work relied on accessible and stable materials like iron oxide-based ochres and calcium-containing whites (calcite and lead carbonates). Expensive blues, derived from copper (azurite) or containing cobalt (lapis lazuli), were reserved for sacred figures. Although new synthetic compounds like Prussian blue (iron hexacyanoferrate) became available, their integration was slow. The palette included mercury sulphide (cinnabar) for reds and copper-based greens like malachite (copper carbonate) or the less stable verdigris (copper acetate), which often degraded. Blacks were typically carbon-based or from iron manganese oxides. This steadfast use of ancestral materials was a deliberate choice, preserving an artistic tradition deeply woven into the region's cultural and spiritual identity. [1-6, 23, 24]

The specific material practices of Albanian fresco painters from this era remain insufficiently studied. This research aims to address this gap by presenting an elemental analysis of the pigments used in the frescoes of the Monastery of the Presentation of Christ (Ipapandia) in Leshnicë e Sipërme, Albania, thereby contributing to a deeper understanding of the region's artistic and cultural history.

2 Materials and Methods

The Monastery of the Presentation of Christ (Ipapandia) in Leshnicë e Sipërme (fig. 1) consists only of a naos. The authorship remains unclear due to the absence of an inscription at the entrance, and there is reason to believe that multiple painters may have worked on the frescoes at different periods. [23, 24]



Fig. 1. Monastery of the Presentation of Christ (Ipapandia) in Leshnicë e Sipërme.

The fresco pigments in this church were analysed in situ using non-destructive methods to identify their metal composition and trace their origins. This study employed the Explorer 5000, a portable X-ray fluorescence (XRF) device capable of rapid, accurate elemental analysis (fig. 2, the analytical conditions were 45 kV voltage, 30 μ A current, and a 20 s acquisition time). This portable XRF offers valuable, non-destructive insights into fresco composition, but its results are semi-quantitative due to several limitations including matrix effects, surface irregularities, the shallow penetration depth (10-100 μ m) and elemental overlaps. These factors can all affect accuracy by only capturing surface layers and missing

deeper pigments or restorations. Nevertheless, through this method the maximum amount of information was obtained under the conditions in which sampling was not permitted.

The XRF technique employed in this study is widely regarded as non-destructive for cultural heritage materials when used under controlled conditions. In our analyses, the X-ray tube operated at relatively low power (45 kV, 30 μ A) with a short acquisition time (20 s), resulting in a low radiation dose delivered to the surface. The interaction volume of X-rays in wall paintings is shallow, typically limited to the upper tens of micrometres, and does not induce measurable heating, ablation, or mechanical stress. Unlike electron- or ion-beam techniques, XRF does not require vacuum conditions, sample coating, or physical contact beyond positioning the instrument close to the surface. Numerous conservation and heritage studies have demonstrated that such operating parameters do not produce visible, chemical, or structural alterations in pigments or binders, even after repeated measurements. Therefore, under the conditions applied here, XRF allows in situ elemental characterization of fresco pigments without sampling and without causing observable damage, fully justifying its classification as a non-destructive analytical technique. [7-9]



Fig. 2. Portable X-ray fluorescence (XRF) Explorer 5000 device.

3 Results and Discussions

For the Monastery of the Presentation of Christ (Ipapandia) in Leshnicë e Sipërme (34 analysed points in total, fig. 3), there is doubt regarding the painters of the frescoes, whether they were created by the same painters during the same period. From the photos, it appears that different painters worked at different times.



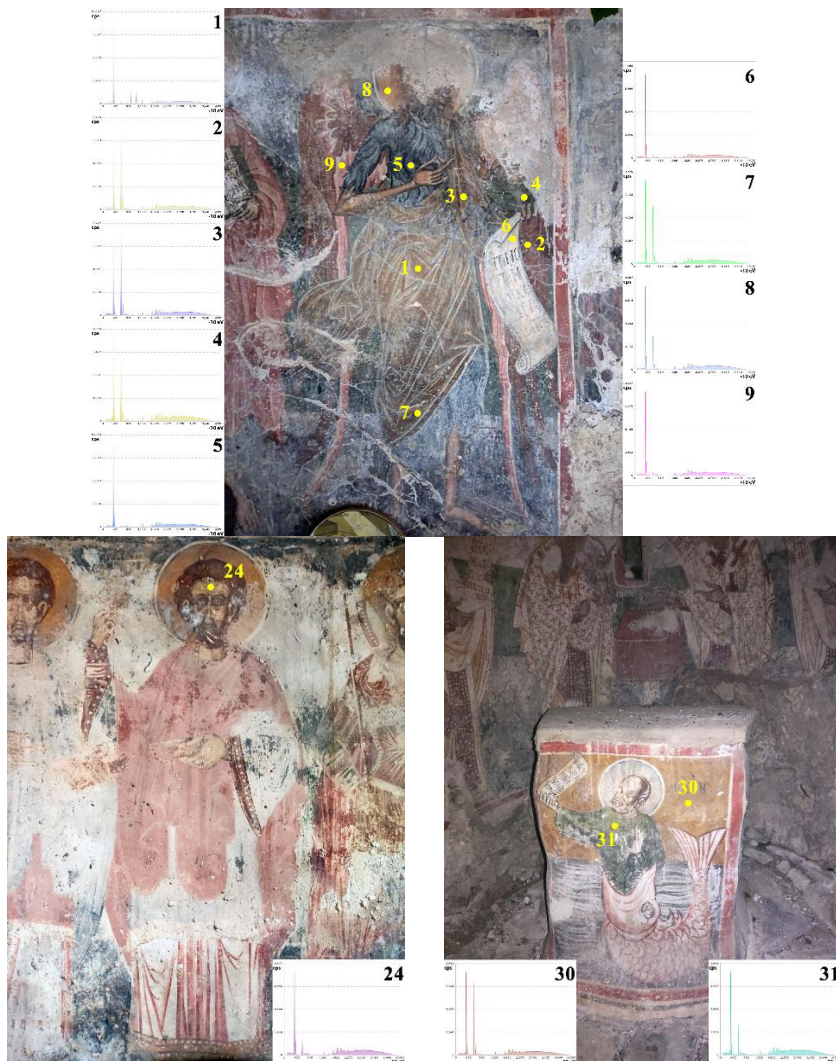


Fig. 3. The analysed points on the frescos of Presentation of Christ Monastery (Ipapandia) in Leshnicë e Sipërme, along with the corresponding spectra; images were processed with Adobe Photoshop and Adobe Fireworks

The detected elements across all analysis points in the church allowed for the identification of the likely pigments used (see table 1).

Table 1: Detected elements across all analysed points and the possibly identified pigments.

Pigment	Dominant element	Phase	Secondary element
Ochre (yellow, red, dark)	Fe is the primary component (61%-87%), consistent with natural ochres	Goethite $\text{FeO} \cdot (\text{OH})$ Hematite Fe_2O_3	Sb (up to 10% in point no 12) likely due to impurities or intentional additives; elevated Pb (up to 5.4% in point no 20) and Hg (up to 1.6% in

			point no 33), suggesting possible use of lead-based or mercury-based compounds (e.g., minimum Pb ₃ O ₄ or cinnabar HgS mixtures)
Green	Fe remains high (62%-83%), but with notable Cu (up to 4.4%)	Verdigris Cu(CH ₃ CO ₂) ₂ ·(H ₂ O) Malachite Cu ₂ (CO ₃)·(OH) ₂ Terre verte K[(Al,Fe ₃₊),(Fe ₂₊ ,Mg)] (AlSi ₃ ,Si ₄)O ₁₀ (OH) ₂	Zn (up to 2.2%), Pb (up to 1.9%) possible contaminations or impurities; Sb (up to 9.8% in point no 32) unusually high, possibly from stibnite (Sb ₂ S ₃)
White	Fe is present (65%-83%), but with lower heavy metals	Lead-white 2PbCO ₃ ·Pb(OH) ₂ Fe-rich clays or lime might be present	Hg (up to 3.8%) possible contamination from adjacent cinnabar (HgS) use; Sb and Pb (less than 1%) trace amounts possibly from processing tools
Black	High Fe (64%) and elevated Sb (10.3% in point no 5)	Stibnite (Sb ₂ S ₃)	Sn (up to 7%) may indicate cassiterite (SnO ₂)

Elemental analysis of the frescoes reveals a complex material history, defined by the use of iron-rich base pigments and the strategic incorporation of distinctive, sometimes toxic, minerals. The palette is overwhelmingly dominated by iron-based ochres, with concentrations from 61% to 87% across yellow, red, and dark hues. However, significant deviations from this iron-rich baseline point to specific artistic choices. Certain red and dark ochres contain elevated levels of mercury (up to 1.6%) and lead (up to 5.4%), signalling an intentional and possible mix with cinnabar or minium to modify shade or intensity. [10-15] A particularly notable finding is the recurrent presence of antimony, which reaches approximately 10% in a red ochre point and 10.3% in a black pigment. This suggests the deliberate use of a mineral like stibnite, an uncommon practice that may reflect local sourcing or specialized knowledge. Similarly, green pigments, while iron-rich, also contain copper and zinc, indicative of copper-based greens like verdigris. The white pigments are atypical, lacking the expected high lead content and instead being primarily composed of iron, pointing to the use of calcite or clay-based materials. [16-22]

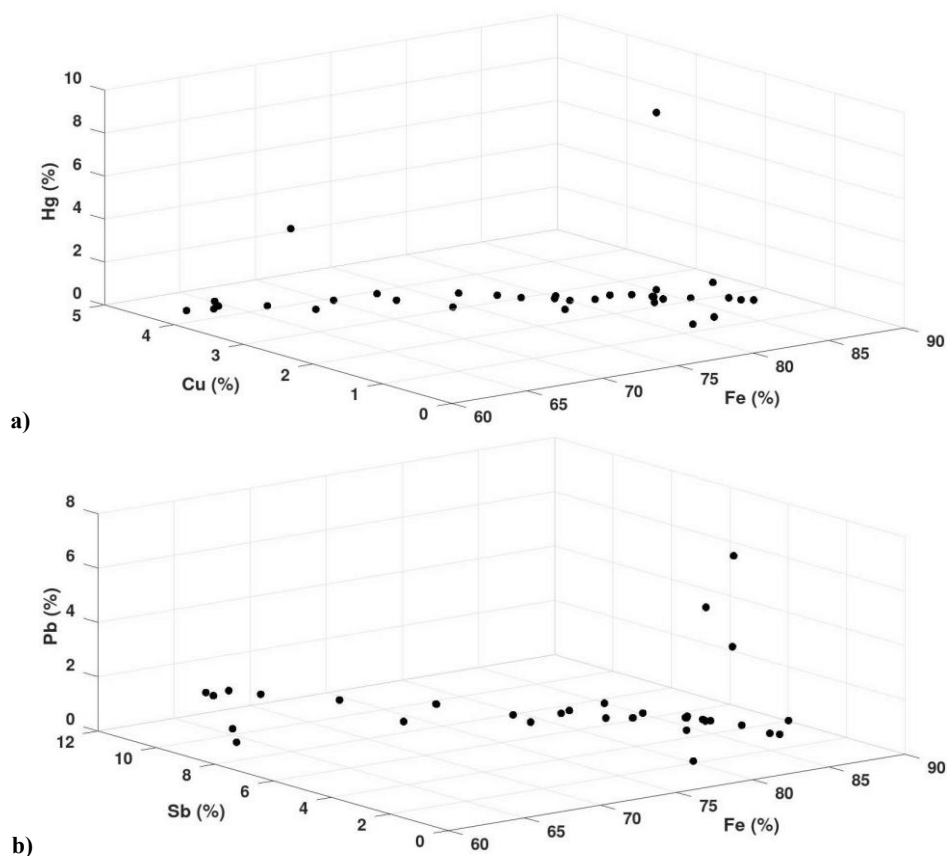


Fig. 4. Plots of the relationships between a) Fe-Cu-Hg and b) Fe-Sb-Pb concentrations across the analysed points. GNU Octave was used for the plots.

Spectral mapping (Figure 4) illustrates these compositional relationships. Most data points form a tight cluster of high iron/low impurity samples, while distinct outliers exhibit elevated mercury or antimony. These outliers might represent the deliberate introduction of specific compounds rather than background contamination. This chemical diversity aligns with visual evidence of multiple artistic campaigns at the site. The frescoes display a mixture of traditional post-Byzantine iconography and sections with more expressive, detailed brushwork and a broader pigment repertoire. The correlation between distinct chemical signatures, such as the possible presence of cinnabar or stibnite in some areas but not others and specific stylistic features strongly supports the involvement of different artists or workshops over time. Consequently, the church serves as a significant repository of layered artistic activity, where chemical evidence modestly helps decode a history of contributions from various hands, each employing their own materials and techniques.

This study is intended as a focused case study of the frescoes from the Monastery of the Presentation of Christ (Ipapandia) in Leshnicë e Sipërme, an isolated but well-preserved example of 18th-19th century Albanian Orthodox mural painting. The results are therefore directly representative of this specific monument, rather than of all mural paintings in Albania. However, the materials and painting practices identified, particularly the reliance on traditional mineral pigments, are consistent with those reported in previous studies from other regions of the country. In this sense, the present work contributes comparative reference data and supports a broader understanding of Albanian post-Byzantine fresco traditions. [23, 24]

4 Conclusions

This study provides the first elemental characterization of the fresco pigments at the Monastery of the Presentation of Christ in Leshnicë e Sipërme. The results confirm a primary reliance on iron-based earth pigments but also uncover a more complex material practice than anticipated. The presence of significant levels of antimony (Sb), lead (Pb), and mercury (Hg) in specific areas suggests the use of minerals like stibnite, minium, or cinnabar, either as intentional colorants or as part of unique mixtures. These findings, coupled with observed stylistic variations, strongly support the hypothesis that the frescoes are the work of multiple artists or workshops from different periods, each potentially employing distinct material sources and techniques. This research underscores the value of scientific analysis in uncovering the layered history of cultural heritage objects and provides a foundational dataset for future comparative studies of post-Byzantine art in Albania.

Acknowledgments

The authors would like to express their sincere gratitude to the University of Tirana for sponsoring this study through the “Research, Excellence, and Innovation” program, and to the Albanian-American Development Foundation (AADF) together with the National Agency for Scientific Research and Innovation (AKKSHI) for supporting the spectral analysis process through the Research Expertise from the Academic Diaspora (READ) program funding. Special thanks are also extended to the National Institute of Cultural Heritage, under the Ministry of Economy, Culture, and Innovation, for facilitating the study of these cultural monuments.

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