

Assessment of chemical and antimicrobial components of artworks attributed to the Costa Rican painter Fausto Pacheco

M.C. Rivera-Romero^{1,2,3}, B.E. Varela-Mejía⁴, L. Ugalde-Campos⁴, D. Jaikel-Viquez^{4,5,6}, P. Calderón-Mesén^{6,7}, R. Marín-Delgado^{1,6}, K. Ureña-Alvarado⁸, A.M Rojas-González⁹, R. Urcuyo^{2,10}, M. Cubero-Campos^{1,3}, M. Redondo-Solano^{4,5,6,11}, and O.A. Herrera-Sancho^{1,3,6,7,*}

¹Escuela de Física, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

²Escuela de Química, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

³Centro de Investigación en Ciencias Atómicas Nucleares y Moleculares, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

⁴Facultad de Microbiología, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

⁵Centro de Investigación en Enfermedades Tropicales, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

⁶Instituto de Investigaciones en Arte, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

⁷Centro de Investigación en Estructuras Microscópicas, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

⁸Diseño Gráfico, Sede de Occidente, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

⁹Escuela de Ingeniería de Biosistemas, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

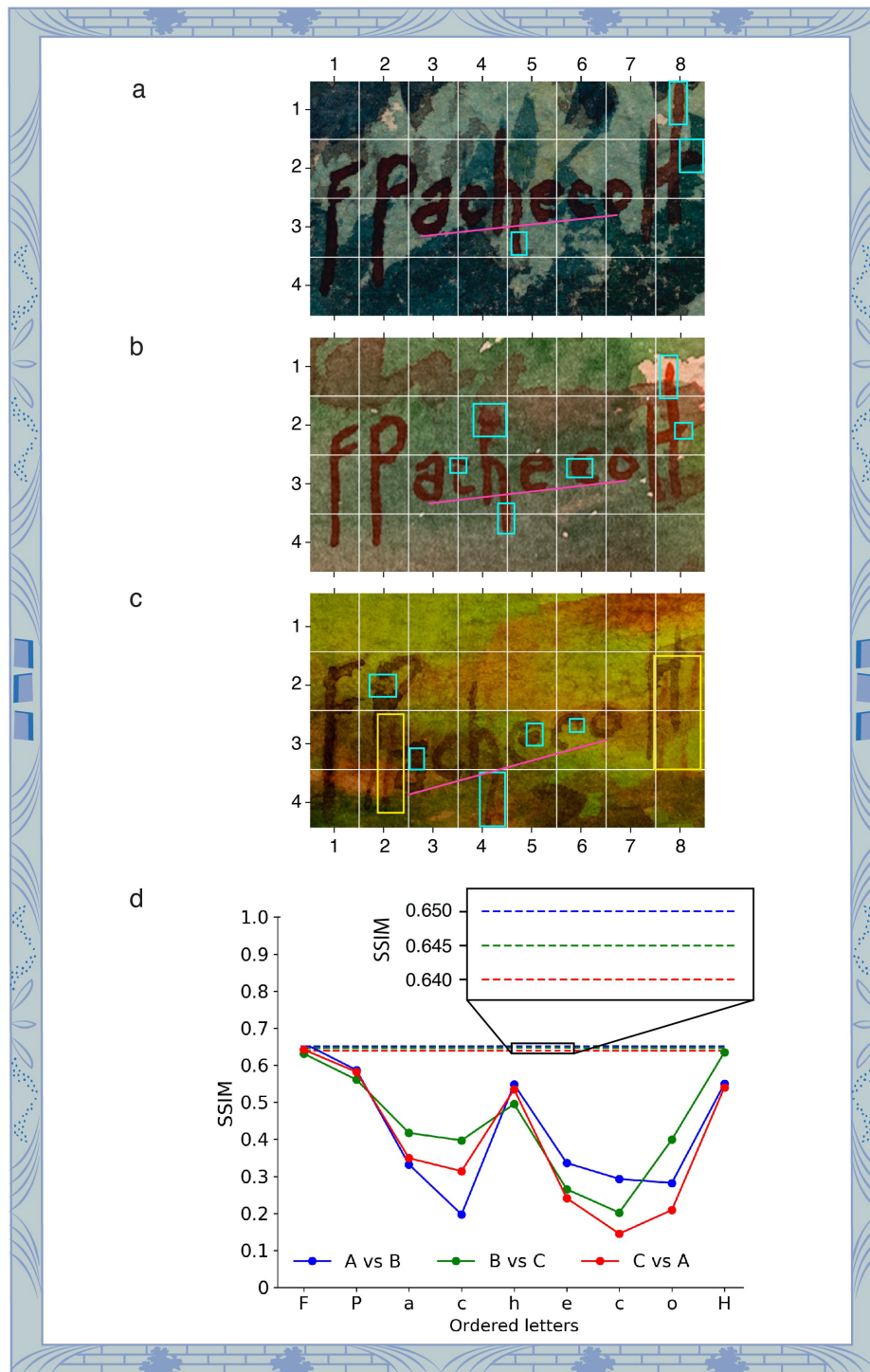
¹⁰Centro de Investigación en Electroquímica Y Energía Química, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica

¹¹Laboratorio de Investigación y Entrenamiento en Microbiología de Alimentos y Aguas, Universidad de Costa Rica, Costa Rica, 2060 San Pedro, San José, Costa Rica

*oscar.herrerasancho@ucr.ac.cr

Artistic design in the figures and decorative frame representation

The purpose of this section is to define the artistic design used in the figures and to describe the representation of the decorative frame. All the figures were prepared with information from all the authors of the different methodologies used and finally using the following computer tools that belong to the University of Costa Rica: Adobe illustrator, version number 27.1 (<https://www.adobe.com/la/products/illustrator.html>) and Adobe Photoshop, version number 23.3.2 (<https://www.adobe.com/la/products/photoshop.html>) and free access: BioRender (<https://www.biorender.com>). The color palette, the outline of the shapes and the technique of the digital manual were applied and designed by Keilyn Ureña Alvarado. All the figures have the same digital intervention in their design. A color was determined for each painting according to Fig. 2. For this reason, the other figures that refer to a specific artwork include the already established color palette. Also, to create a visual unity, a light blue frame was added to all the figures. In the case of Figs. 2, 3, 4, 5, 6 and 7, they were digitally assembled with the information -photographs and graphics- provided by the researchers. These figures illustrate the research process and the main results. Fig. 1 was made by hand, designed by the graphical designer using watercolors and color pencils and corresponds to a representation of our research, applied techniques and main result. On the other hand, the design of the frame was carried out taking into consideration some characteristic elements of each of the artworks, such as the windows and walls of *Paisaje con casa campesina*, as well as the unique vegetation of the three paintings. in study. Finally, a light blue color was applied to reflect the frame of the paintings.

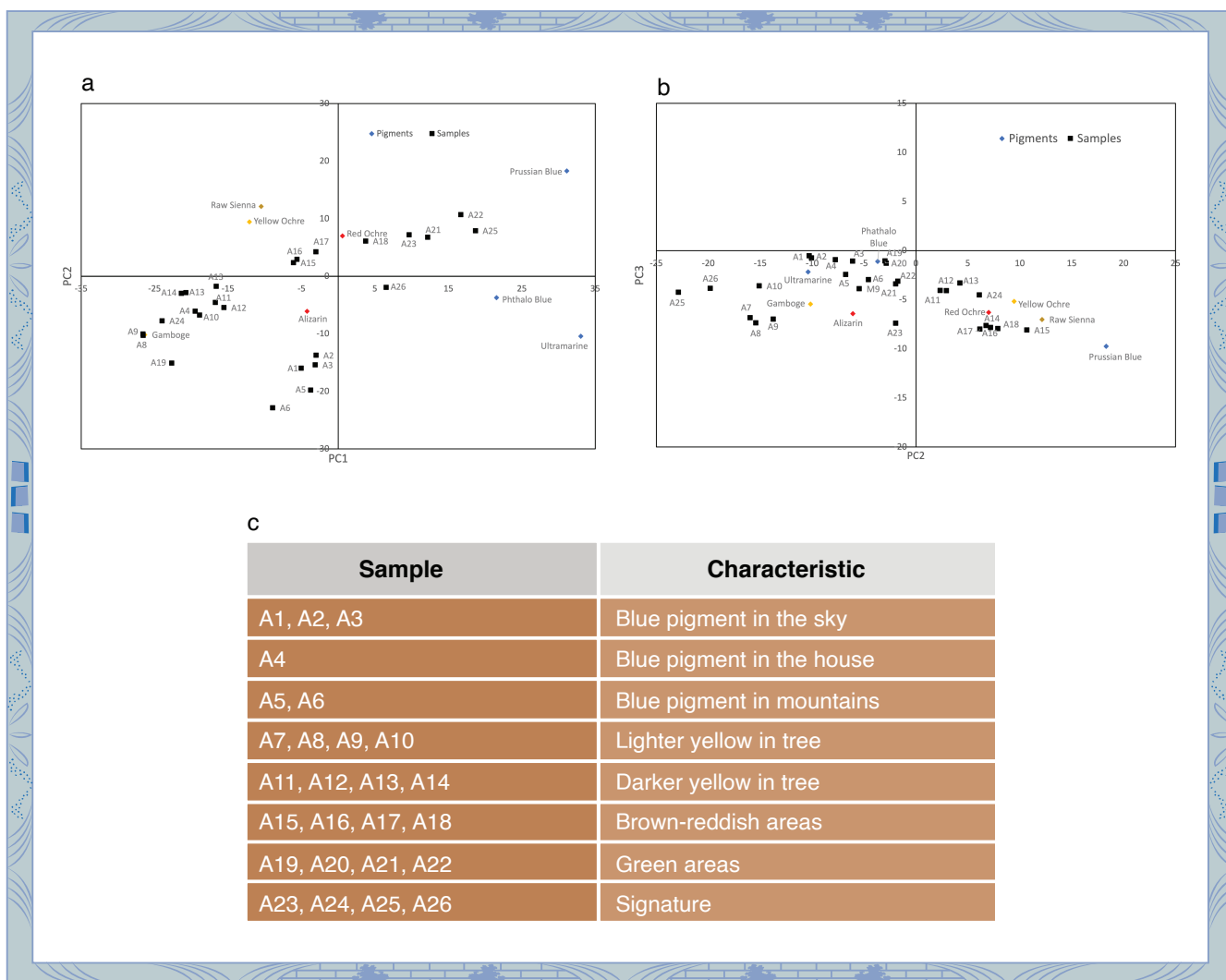


Supplementary Figure S1. Signature review of (a) *Paisaje con árbol* (baseline angle corresponds to 6.6°), (b) *Paisaje con casa campesina* (baseline angle corresponds to 6.1°), (c) *El puente* (baseline angle corresponds to 15.5°) and (d) SSIM values comparing similarities of each letter, horizontal lines correspond to the values of the whole signature.

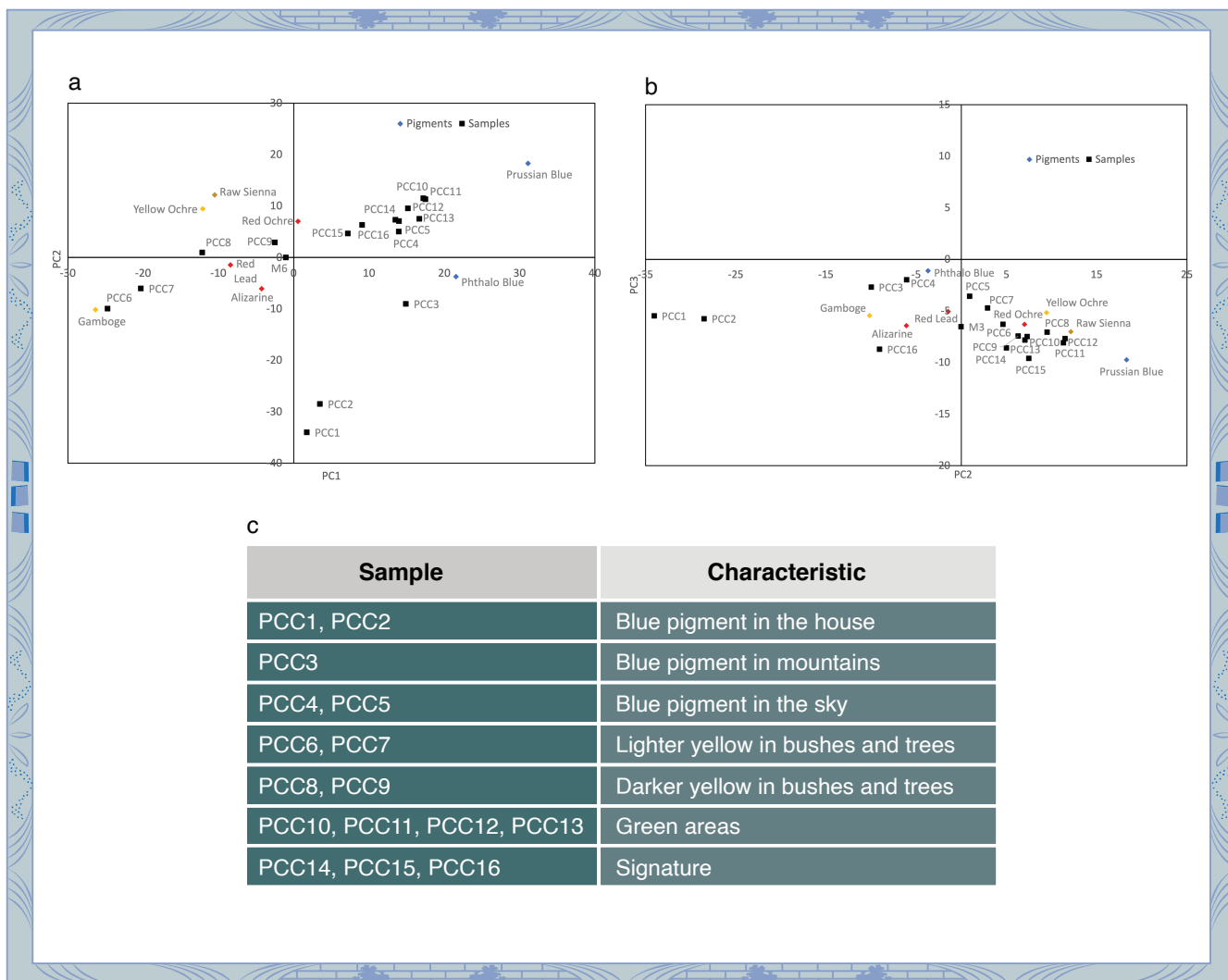
Fiber Optics Reflectance Spectroscopy (FORS)



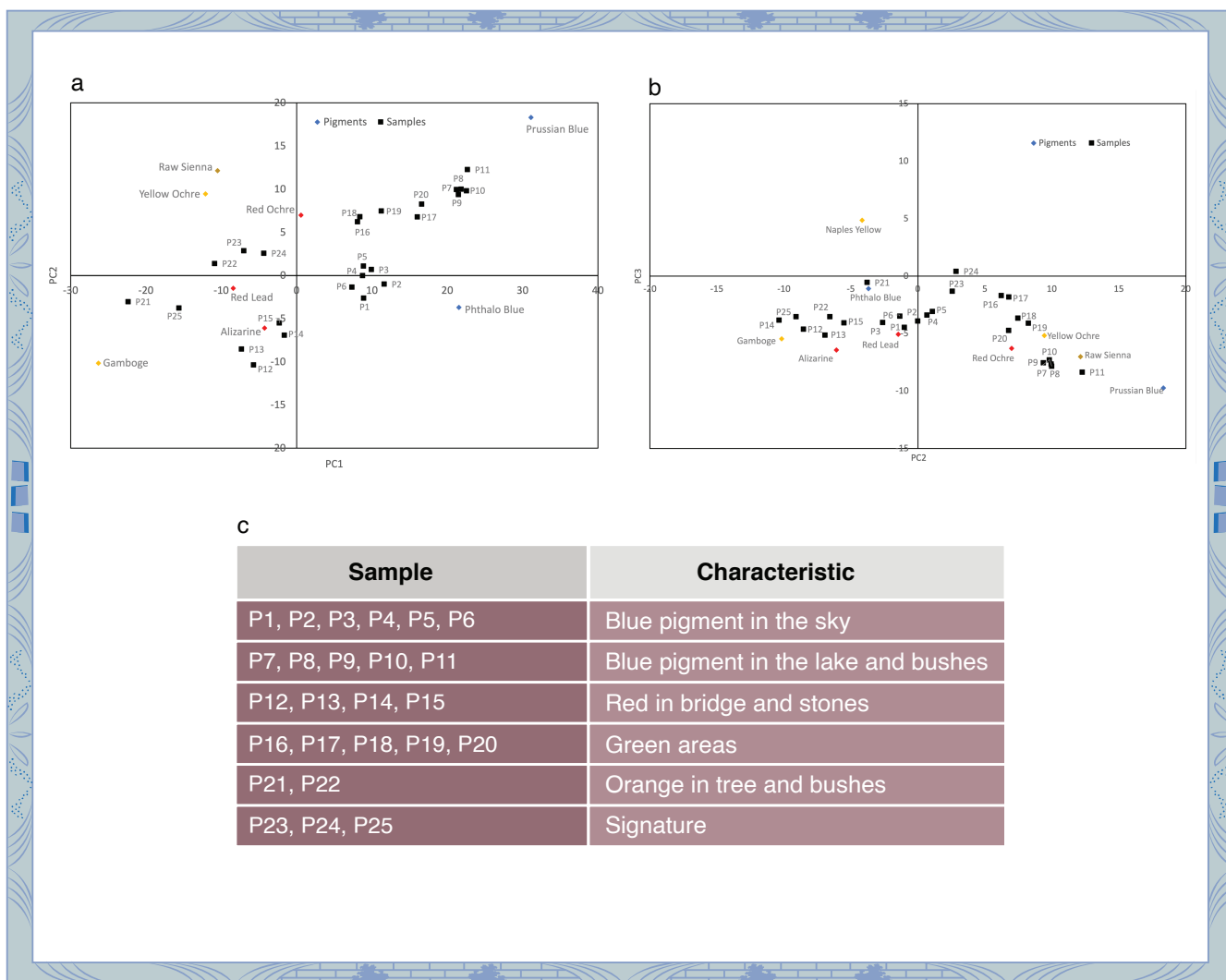
Supplementary Figure S2. Areas of interest sampled with FORS of (a) *Paisaje con árbol*, (b) *Paisaje con casa campesina* and (c) *El puente*.



Supplementary Figure S3. Groups of the paint colors revealed by the dependence of the principal components (a) PC2 vs. PC1, (b) PC2 vs. PC3 of the PCA data obtained for the FORS spectra collection of *Paisaje con árbol*. (c) sample characterization.

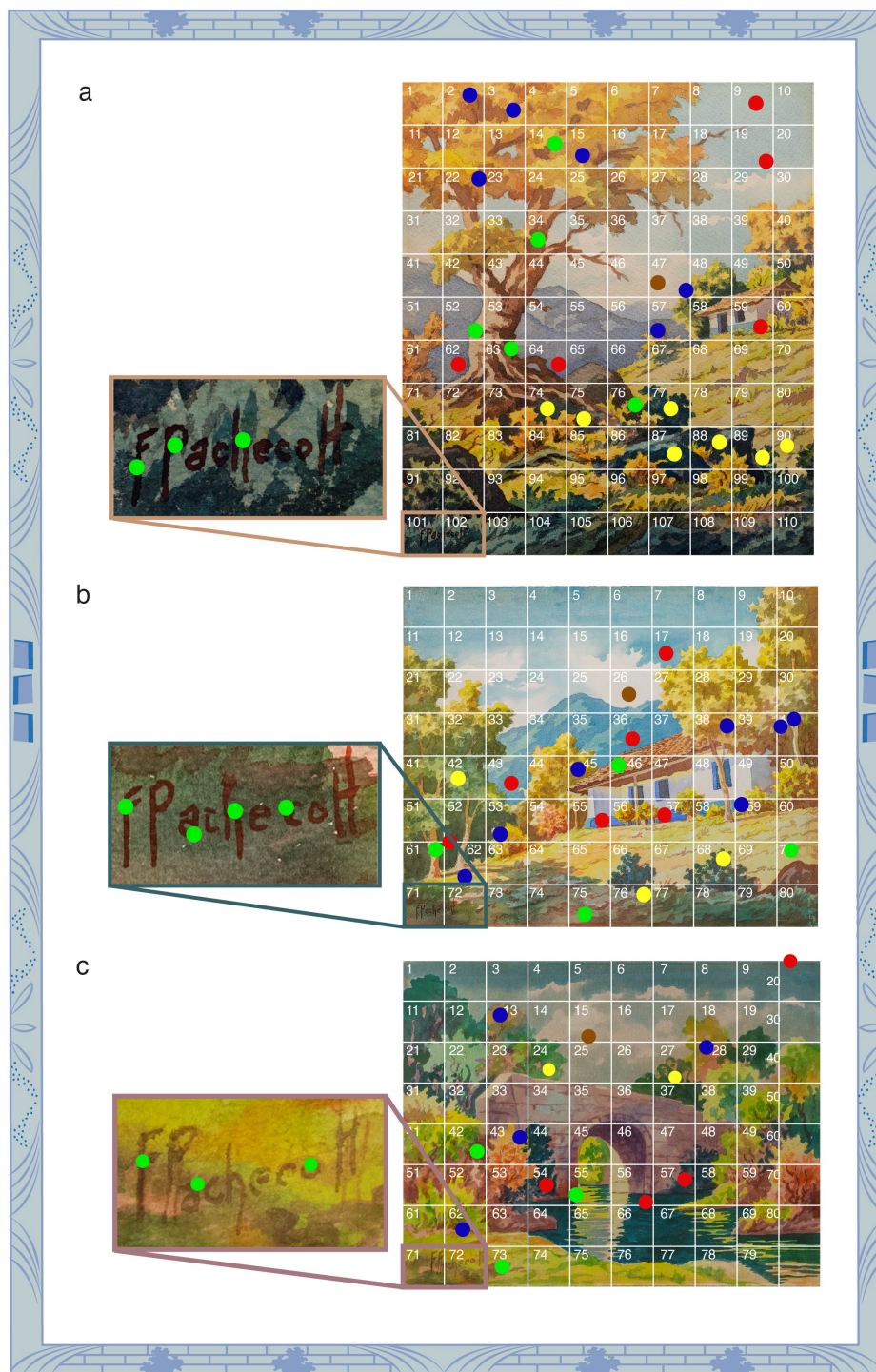


Supplementary Figure S4. Groups of the paint colors revealed by the dependence of the principal components (a) PC2 vs. PC1, (b) PC2 vs. PC3 of the PCA data obtained for the FORS spectra collection of *Paisaje con casa campesina*. (c) sample characterization.

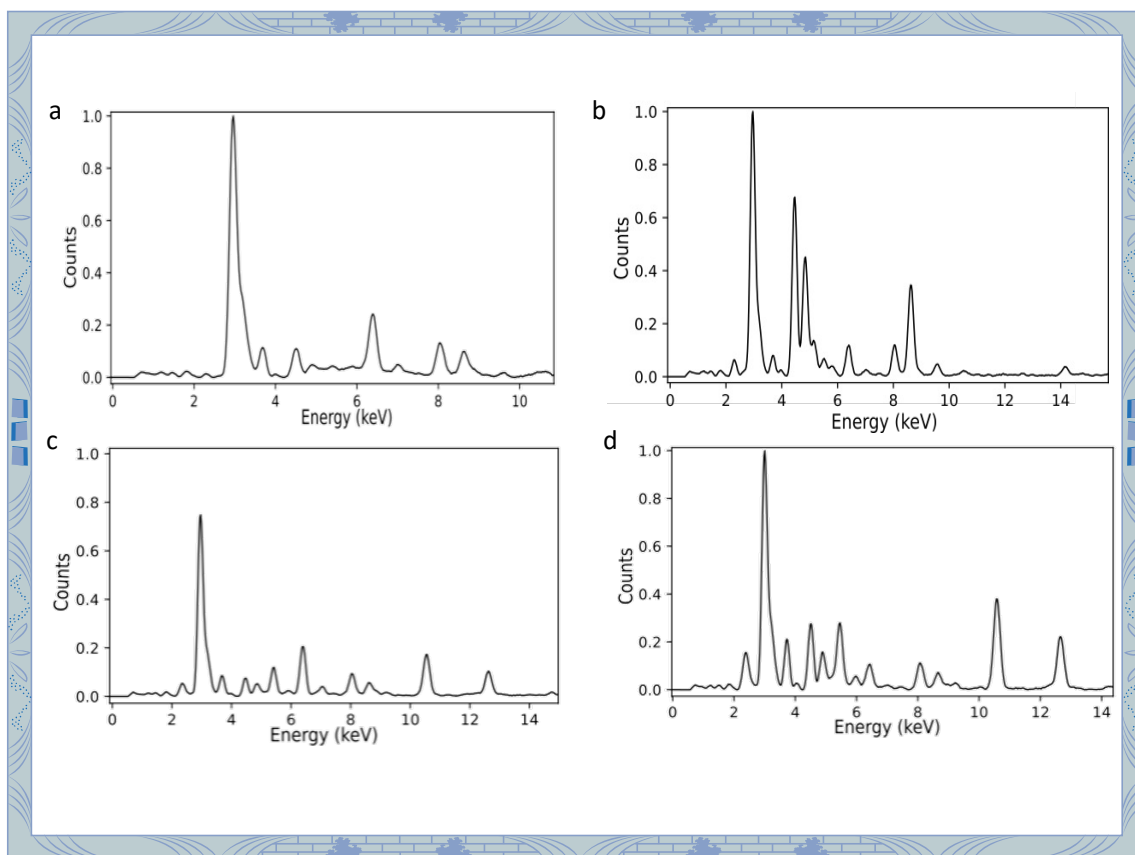


Supplementary Figure S5. Groups of the paint colors revealed by the dependence of the principal components (a) PC2 vs. PC1, (b) PC3 vs. PC2 of the PCA data obtained for the FORS spectra collection of *El puente*. (c) sample characterization.

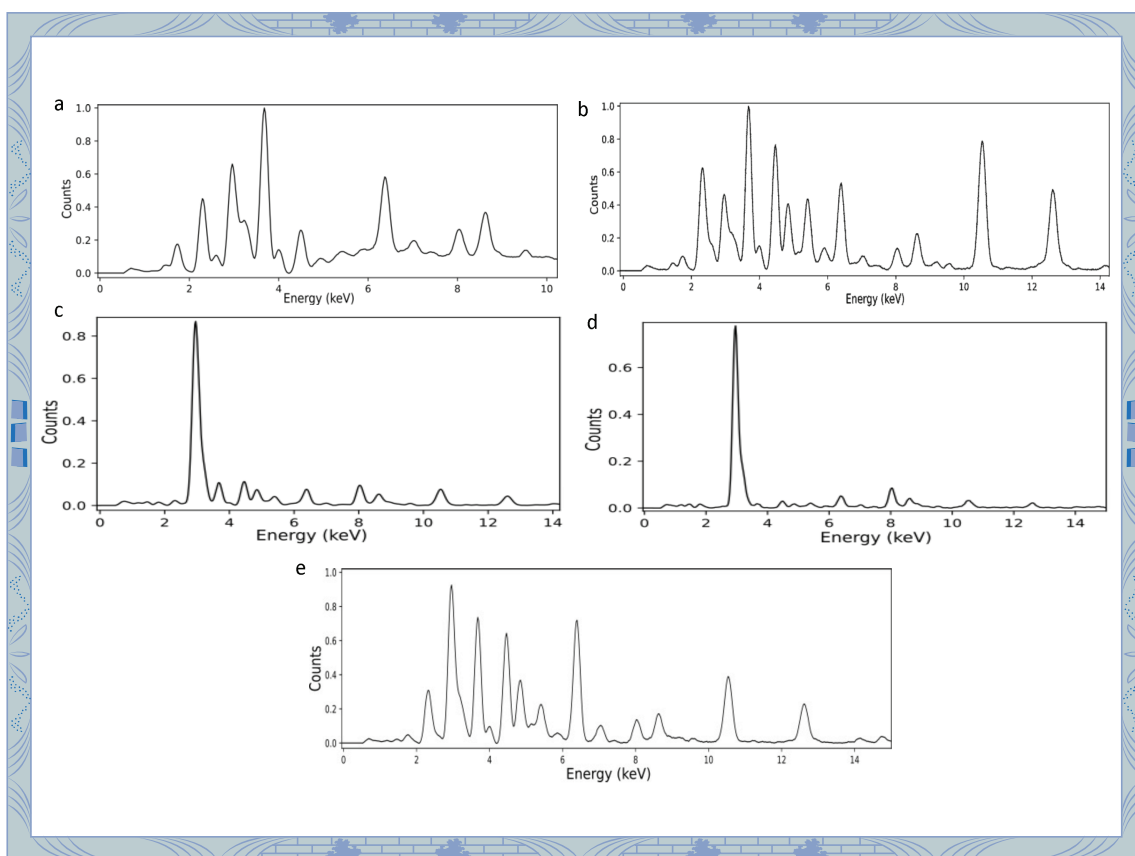
X-Ray Fluorescence Spectroscopy (XRF)



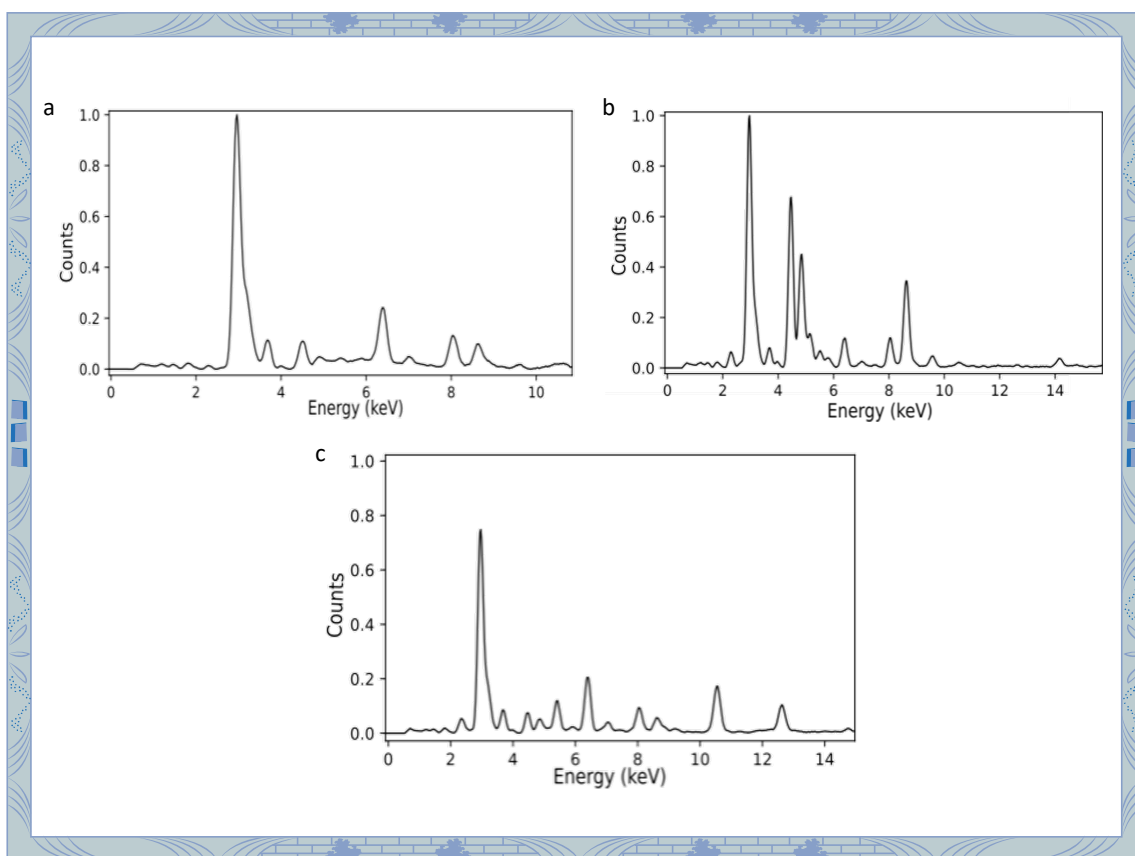
Supplementary Figure S6. Areas of interest sampled with XRF of (a) *Paisaje con árbol*, (b) *Paisaje con casa campesina* and (c) *El puente*.



Supplementary Figure S7. XRF spectra of *Paisaje con árbol*. Pigments identified correspond to (a) ultramarine, (b) yellow ochre, (c) raw sienna and (d) red ochre



Supplementary Figure S8. XRF spectra of *Paisaje con casa campesina*. Pigments identified correspond to (a) ultramarine, (b) naples yellow, (c) realgar, (d) raw sienna and (e) chrome oxide green



Supplementary Figure S9. XRF spectra of *El puente*. Pigments identified correspond to (a) ultramarine, (b) chrome yellow and yellow ochre, (c) raw sienna and lead red

Supplementary Table 1. Summary of pigments identified with spectroscopic techniques of the three works studied.

Pigment	Painting		
	<i>Paisaje con árbol</i>	<i>Paisaje con casa campesina</i>	<i>El puente</i>
Blue	Ultramarine Prussian Blue Phthalo Blue	Ultramarine Prussian Blue Phthalo Blue	Ultramarine Prussian Blue Phthalo Blue
Yellow	Yellow Ochre Gamboge	Yellow Ochre Naples Yellow Gamboge	Yellow Ochre Naples Yellow Gamboge Chrome Yellow
Brown	Raw Sienna	Raw Sienna	Raw Sienna
Red	Red Ochre Alizarin	Red Lead Red Ochre Alizarin	Red Lead Red Ochre Alizarin
Green	Mixture of blue and yellow pigments	Mixture of blue and yellow pigments	Chrome Oxide Green

Analysis of biological factors

Supplementary Table 2. Bacterial and fungal isolates obtained from the microbiological sampling of the paintings *Paisaje con casa campesina* and *El Puente*

Painting	Section of the painting (Sample code)	Details of the zone of interest	Microorganism
<i>Paisaje con casa campesina</i>	68 and 69 (M3C)	Interventions on the painting	<i>Dermacoccus nishinomiyaensis</i> Hialine non-sporulated fungi
	57 (M4C)	Interventions on the painting	Demateaceus non-sporulated fungi
	14,15 (M10)	Zone of decoloration in the sky	<i>Diaporthe</i> sp.
<i>El puente</i>	15 (M1P)	Upper side of the painting, cloud	<i>Bacillus cereus</i>
	91 and 92 (M5P.1 and M5P.2)	Signature of the artist	<i>Aspergillus</i> section <i>Versicolores</i>
	33 back side (A1P)	Stain on the back side of the painting	<i>Cladosporium tenuissimum</i>
	14, 15, 16, 24, 25 and 26 back side (A2P)	Writing in the back of the painting	Demateaceus non-sporulated fungi