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Pigmet Identification of a Mural Painting in the Former Convent of Santo Domingo Tehuantepec, Oaxaca, Mexico

Ir a versión en español

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ABSTRACT

The following RESEARCH ARTICLE discusses the application of non-invasive and non-destructive analytical techniques to study the materials used in a mural painting from the first decorative stage at the former convent of Santo Domingo Tehuantepec, in Oaxaca, Mexico. This convent was built between 1544 and 1545 by Dominican friars, and the study is part of the restoration project for this heritage site and its ornamental finishes impacted by the earthquake of September 7th, 2017. The study focuses on characterizing the pictorial palette of the mural using X-ray fluorescence (XRF) and digital microscopy and colorimetry to record the colors of the newly revealed mural painting. The results indicated that very costly pigments with a high level of quality and durability (such as cinnabar or vermilion, orpiment, and bone

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black) had been used, which speaks to the historic and material importance of the decorations in the building.

KEY WORDS

mural painting; pigments; x-ray fluorescence; conservation; 16th century convent

INTRODUCTION

In recent years, one of the major tasks of restoration professionals in Mexico has consisted in dealing with the damage suffered by the country's cultural heritage due to natural phenomena like earthquakes. In this case, regions closest to epicenters sustain the greatest impacts, such as the ones caused by the earthquake that hit on September 7, 2017, with a magnitude of 8.2 on the Richter scale and epicenter located in the Gulf of Tehuantepec, which lies 133 km to the southwest of Pijijiapan, Chiapas (Servicio Sismológico Nacional [SSN], 2021). Major damage to cultural heritage sites occurred in the states of Chiapas, Oaxaca and —to a lesser degree— in the states of Veracruz, Tabasco, and Hidalgo (Prieto, 2018, p. 109). In Oaxaca, 130 historical buildings were damaged, 85 of them are temples, and 12, cultural venues and libraries (Instituto Nacional de Antropología e Historia [INAH], 2017). These damaged buildings include the former convent of Santo Domingo Tehuantepec, which suffered partial collapses, in addition to collapsed walls, vaults, and buttresses, not to mention cracks and detached architectural finishes.

The convent is located at the center of Santo Domingo Tehuantepec, a town in the state of Oaxaca. It is distinct from other more lavish edifices built by the Dominican order during the 16th century in its sober architecture and decor. The construction contains two levels built around a square central patio (Figure 1). The cloister on the ground level included common areas for the friars such as a refectory, anterefectory, and kitchen, as well as other rooms accessible through a corridor or ambulatory. The upper level is divided into private spaces, the cells.

The convent enjoyed religious relevance well up to the 18th century, since the town of Santo Domingo Tehuantepec was an essential stop on the way to the Soconusco region with the expansion of trade and evangelization routes towards the south (Mena, 2017). In the course of its history, the former convent has served various purposes. In 1859, the troops of General Porfirio Díaz were stationed in the town and it is inferred they occupied at least part of the religious buildings as barracks (Tello, 2015). Actually the site

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FIGURE 1. Image of the cloister of the former convent and aerial view (Photograph: Fernanda Martínez & Fidel Ugarte, 2019; courtesy: Centro INAH Oaxaca, Mexico).

may well have been used as barracks since the early part of the 1850s due to the armed battles between the inhabitants of Tehuantepec and the neighboring town of Juchitán, where old conflicts were now giving rise to a new tax on salt (Brasseur, 1981, p. 145). In later years, during the 20th century, the former convent served as a jail until 1974 saw the inauguration of the current Social Rehabilitation Center in the outskirts of town. After that, the site lay abandoned until the Casa de Cultura was established there in the 1990s which continues to this day. (G. Valderrama,[1] personal communication, September 15, 2019).

In light of the diferent uses given to this heritage site, it has been considered that religious scenes in the mural decorations remained hidden under several layers of whitewash until they were discovered —probably— during the works to adapt the site to become a cultural venue. At that time, these religious scenes underwent different restoration processes,[2] as corroborated by our identification of repairs, setting on the pictorial layer, and chromatic reintegration in various areas. Mural decorations vary according to the spaces. The ones in common areas, for example, reflect a different discourse from the ones in the more private areas. With time, these decorations changed. We identified several superimposed pictorial cycles that correspond with decorative adaptations, maintenance, and other uses given to the site during the 17th, 18th, 19th, and 20th centuries.

[1] Guillermo Valderrama Reyna is noteworthy not only for his research and retrieval of the traditions of Santo Domingo Tehuantepec but also for documenting the processes and changes undergone by the town.
[2] We have searched for documentation of this intervention both in the CNCPC and the Centro INAH Oaxaca, but have still failed to find any information to that effect.

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Since 2019, conservation and restoration work on mural paintings damaged in 2017 has produced many questions regarding, for example, the materials employed in the decorations at different times. Answers to such questions would make it possible to distinguish these decorations by superimposed layers, and to learn about the resources painters had available at any given time. In the course of the work performed during 2019, a pictorial layer was released in the lunette of the western ambulatory. This pictorial layer was partially exposed and in a state that would not allow accurate reading or appreciation (Figure 2a). The factor that determined moving ahead with the process was the amount of parts missing from the superimposed pictorial layer that revealed an underlying layer apparently in a good state of conservation. Besides, the upper layer showed deterioration in the form of scratches, tool marks and overall lack of maintenance to the building in addition to direct damage caused by the earthquake.

Consequently, we recovered a religious image from the same time period as the immediate lunette (on the northern wall), thereby retrieving the discursive reading of both spaces. In the image, we see a male character who is standing. The richly attired, bearded man is dressed in the manner of a Jewish priest: over a blue robe he wears a green tunic with pomegranates and yellow-gold bells along the border. Over the tunic, an ephod with phytomorphic motifs in red, blue and black. On his head he wears a miter. The character stands barefoot on a checkered floor (Figure 2b). His right hand holds a censer, and on the right side of his chest he wears a rectangular element, we assume to be a pectoral. The background of the image is light blue and to the sides, between the oblong canopies of trees, one can appreciate two buildings that look like castles or convents. The pictorial technique has been deemed tempera, due to color saturation and overlaying, the shine of the pictorial layer, and the lack of marks are indicative of successive plaster applications.

The conservation status of this painting and the fact that it had been uncovered only recently guaranteed its non-contamination with contemporary conservation materials, so we therefore decided to study it. Thus, the work team set out to analyze the constituent materials of the painting that would provide data to understand its historic, technical, and cultural value. Endowed with this information we could then contribute to decisions relative to selecting the processes and materials to be used in the preservation and restoration of this cultural heritage.

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FIGURE 2. Mural painting in the lunette of the western ambulatory, ground floor. *a)* Overlay before removal. *b)* Pictorial layer after removal of the overlay (Photograph: Roxana Flores y Carlos Vichido, 2019; courtesy: Grupo Tares/Fundación Alfredo Harp Helú Oaxaca, Mexico).

METHODOLOGY

The study of this mural painting involved interdisciplinary work with participating specialists in restoration, chemistry and materials science (Arciniega-Corona et al., 2020). We approached our investigation with the decision to study the colors in the chromatic palette via direct observation of the mural painting and digital microscopy. First, we identified the areas where these colors could be obtained in their purest and most saturated form (unmixed and undiluted). For the yellows, we examined the pomegranates and bells on the borders of the tunic (Figure 3d), the sleeves of the ephod and the pectoral (Figure 3a). We chose to study the green of the tunic (Figure 3a); the red on the ephod (Figure 3c); the blue of the robe (Figure 3a); the browns, in the character's hair and the castle in the background of the image (Figures 3a & 3b); the incarnadines of the face, feet, and hands (Figures 3a & 3b); and the black on the squares of the floor (Figure 3 a).

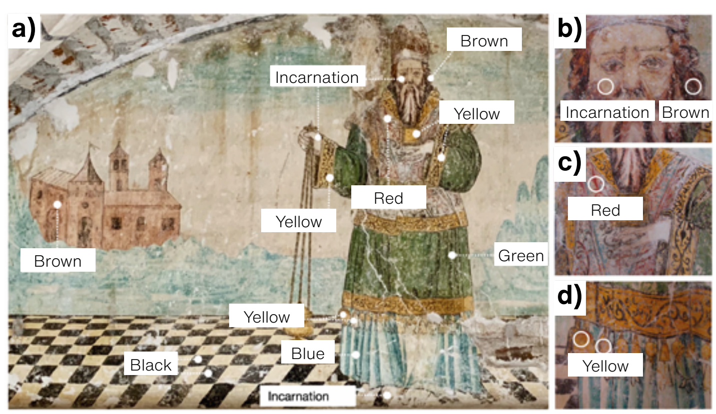

FIGURE 3. Areas analyzed according to the chromatic gamut of the painting (Schematic: Daniel Mélendez, Laboratorio CODICE-CNCPC).

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Digital microscopy was accomplished with a portable USB Zarbeco, MiScope® Megapixel 2 (MISC-MP2) microscope with a manual focus and LED lighting (white, UV and IR). Micrographs were acquired using ZephaVision, version 2.12.5 (4dv) Video ToolBox Pro PC software. The purpose of this technique was to observe pictorial layer homogeneity, overlays, *pentimenti*, foreign materials, and deterioration.

Afterwards, we registered the chromatic palette in the CIE L*a*b* color space, as defined by the Commission Internationale de L'éclairage (CIE) with coordinates L* (luminosity), a* (red/green), and b* (yellow/blue). This record was prepared in order to have the specific colors of the newly released mural painting for *a posteriori* comparisons and in this way, determine color changes relative to exposure.

Data were collected with a Konica Minolta, Model Spectrophotometer CM-2500d colorimeter, and SpectraMagic® NX Lite software. Chemicals and elements were identified with portable Bruker Tracer III-SD X-ray fluorescence (XRF) equipment. These data were acquired under the following measurement conditions: 40 kV, 12 μA y 30 s in air. We used Bruker Nano GmbH, Spectra Artax software to analyze spectra.

RESULTS AND DISCUSSION

The colorimetric study and micrographs we obtained appear in Figure 4 that shows values for coordinates L*, a*, and b* for every color analyzed. Deviations in the data are determined by the level of homogeneity in a given pictorial layer, layer superimpositions, color saturation and the presence of deterioration as well as light and shadow effects, both of which can be observed in the micrographs that accompany the data.

Figure 5 records the spectra associated with each color in the pictorial palette and the elements identified have been related to the presence of the pigments employed at the time (Trentelman *et. al.,* 2012). In general terms, calcium (Ca) is an element found in every measurement. It also constitutes the most dramatic peak, which may be explained by the presence of calcium carbonate ($CaCO_3$) in the preparation base coat as well as in the remnants of the lime layer removed during the release. For this reason, calcium cannot be considered an indicator element for pigment identification.

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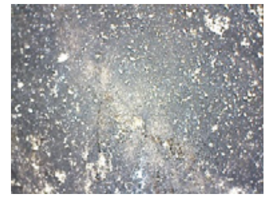
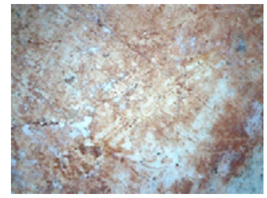
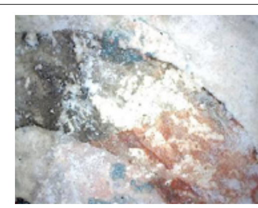
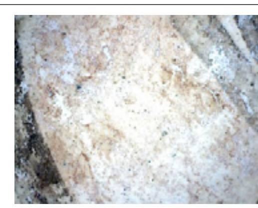
Color Range	*L	a*	b*	MOD
Black	13.45±8.93	1.72±0.32	7.63±1.09	
Brown	60.50±8.26	15.29±2.01	24.00±2.90	
Blue	63.60±4.61	11.38±1.26	2.53±2.71	
Yellow	69.03±1.62	16.51±1.36	46.34±3.81	
Green	49.28±1.59	-5.16±1.11	18.72±3.90	
Red	57.17±9.54	19.38±5.90	21.60±3.48	
Incarnadine	72.21±1.46	6.38±1.94	15.81±5.54	

FIGURE 4. Micrographs and values of CIE L*a*b* chromatic coordinates (Take: Perla Téllez and Daniel Meléndez, Laboratorio CODICE-CNCPC).

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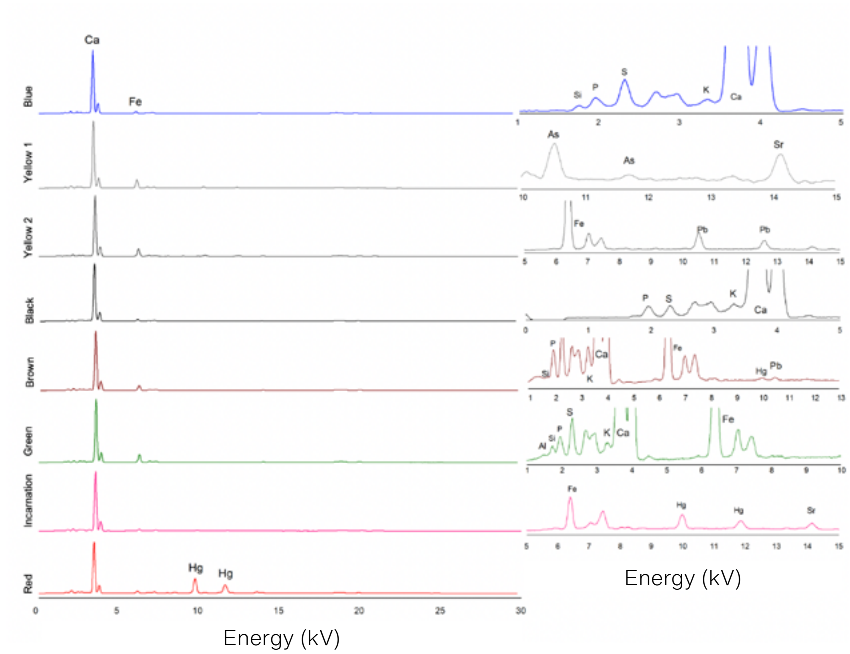
FIGURE 5. XRF spectra of the areas analyzed (Schematic: Armando Arciniega, Laboratorio CODICE-CNCPC).



A discussion about analytical techniques as a function of each color follows.

Blue

As observed in the chromatic coordinate analysis, the data show a not very significant deviation (<5 units) and thus the pictorial layer may be considered homogeneous. The difference occurs in the values of coordinate L* owing to specific effects, such as the folds of the robe where lighter areas are apparent. Likewise, in the visible light micrograph (Figure 4) remnants of the preparation base coat from a later pictorial stage are distinguishable. XRF no detect characteristic elements of blue pigments, like azurite (Cu) and blue enamel (Co, Al); also, iron (Fe) counts are too low to determine Prussian blue so the assumption is that it could be an organic blue compound. No aluminum was detected, therefore we ruled out clays as components of this color.

Yellow

In this color gamut there are no differences in the values of chromatic coordinates, even though we noticed changes in saturation and superimposed black outlines in certain areas. XRF identified two kinds of yellow. The first consists in arsenic (As) and sulphur (S), both characteristic elements of orpiment, a widely used pigment in the art of New Spain (Dupey, 2015; Miliani et al., 2012; Zetina

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et al., 2014). The second is an ochre yellow, which coincides with our identification of iron (Fe), a commonly used material in convent murals in México (Arroyo *et. al.,* 2019). This ochre yellow is associated with the *pentimenti* observed. Additionally, the presence of lead in measurements taken from the pectoral suggest the use of white lead to produce a white preparation base coat (Figure 6). We ruled out the use of other lead-based yellow pigments like lead-tin yellow or Naples yellow (Pb, Sb) because these elements were not detected.

FIGURE 6. Detail of the pentimento under the left hand of the main character. (Photograph: Roxana Flores y Carlos Vichido, 2019; courtesy: Grupo Tares/Fundación Alfredo Harp Helú Oaxaca, México).

Green

In this case, data from CIE Lab chromatic coordinates did not show high dispersions such as the ones observed in the blue color gamut; it was thus considered a homogeneous pictorial layer. Nevertheless, values in coordinate a* (green-red) approach to the achromatic point, while in b* (blue-yellow) values are between 15 and 25 units located towards the space of the color yellow (Figure 7). This is due to an underlying yellow pictorial layer, evident in the visible light micrograph in Figure 4.

The presence of iron (Fe), aluminum (Al), potassium (K) and silicon (Si) has been identified with XRF. All of these elements are associated with green earth (celadonite/glauconite). Also detected were arsenic (As) and sulphur (S), associated with orpiment found in the underlying layer (Trentelman *et. al.,* 2012).

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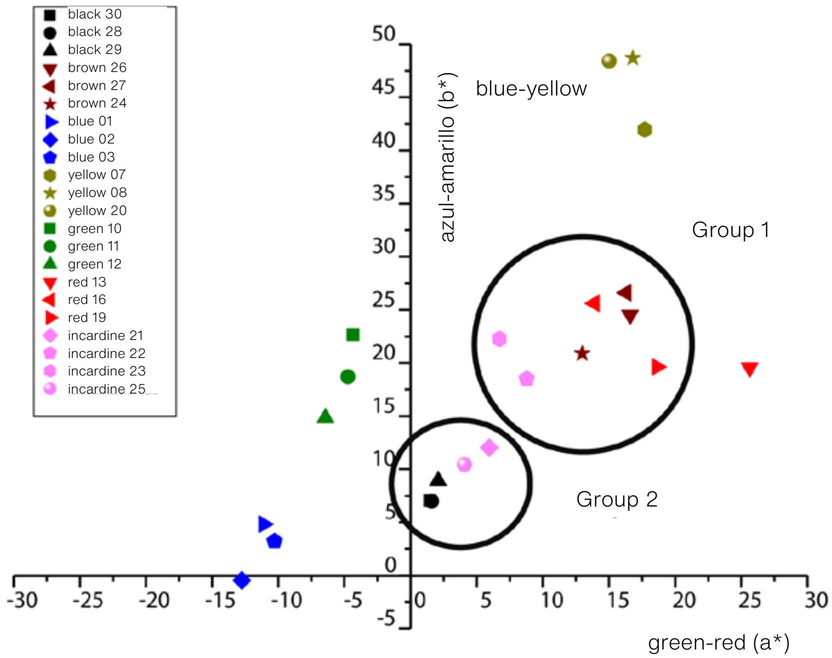

FIGURE 7. General view of the chromatic palette in the bidimensional CIE L*a*b* color space (Schematic: Daniel Meléndez, Laboratorio CODICE-CNCPC).

Black

A dispersion in the values of coordinate L* (>5 units) exists in the black color mainly owing to lost pictorial layer and exposed preparation base coat. Also, remnants of the lime layer that once covered the painting have affected measurements. XRF analysis has determined the presence of phosphorus (P), which evidences the use of bone black, a pigment used since antiquity (Ortega, 2003; Vázquez de Ágredos, 2007).

Red

Reds were mainly used for the finer lines on the decorations of the ephod, which exhibits superimposed layers of black and blue over the red (Figure 4). This causes greater dispersion in the values of coordinates L* and a*; in other words, certain areas are more luminous than others as the values of coordinate a* depart from the component in red (Figure 7). XRF identified mercury (Hg) as part of the element mix. This proves the use of cinnabar or vermillion,[3] a pictorial material widely used in different prehispanic and Colonial artistic expressions (Vázquez de Ágredos et al., 2019; Argote et al., 2020; Rigon et al., 2020; Vandenabeele et al., 2005; Camacho & Mederos, 2011; Zavala, 2013; Zetina et al., 2014).

[3] From this point onwards we will use the term *cinnabar*.

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Brown

XRF results have shown the presence of mercury (Hg), phosphorus (P), and iron (Fe) in the areas analyzed for brown tones indicating that preparations of this color contain a combination of the following pigments: *1)* burnt umber composed of iron oxide-hydroxide responsible for browns; *2)* cinnabar as the red constituent in the mix, and *3)* bone black used for shadows. This composition takes the values of coordinates a* and b* to the first group shown in Figure 7, which includes tones of red.

Incarnadines

Intense mercury (Hg) counts indicate a higher concentration of cinnabar in skin colors (Figure 5). Use of this pigment in incarnadine was a common practice in the mural paintings of various convents in Mexico (Flores, 2020). In this case, the combination of cinnabar and burnt umber is reflected in the values of coordinates a* and b* in group 1 of Figure 7.

Outlines and shadows on the face, hands, and feet were made using bone black pigment (XRF identified phosphorus [P]). The result of this combination of pigments is that some values of coordinates a* and b* in Figure 7 approach the achromatic point in group 2.

Pentimenti

A few areas with pentimenti are patent even in plain sight. Among these we should highlight the base of the censer, the left side of the border on the sleeve of the ephod, the left hand over the pectoral, and the pomegranates and bells around the tunic (Figure 8). This indicates that a few mistakes were made in the proportion and perspective of the image, which the artist tried to correct as he painted or closely thereafter. XRF identified the use of white lead in the pectoral area. We believe, therefore, that this pigment was used as a covering layer to make way for the change in the paint.

CONCLUSIONS

The results from our analysis of the mural painting located in the lunette of the west ambulatory, have made it possible to identify most of the pigments utilized in its chromatic palette. Thus, we can establish that cinnabar, bone black, and burnt umber were essential in the composition of the painting since they can be found in

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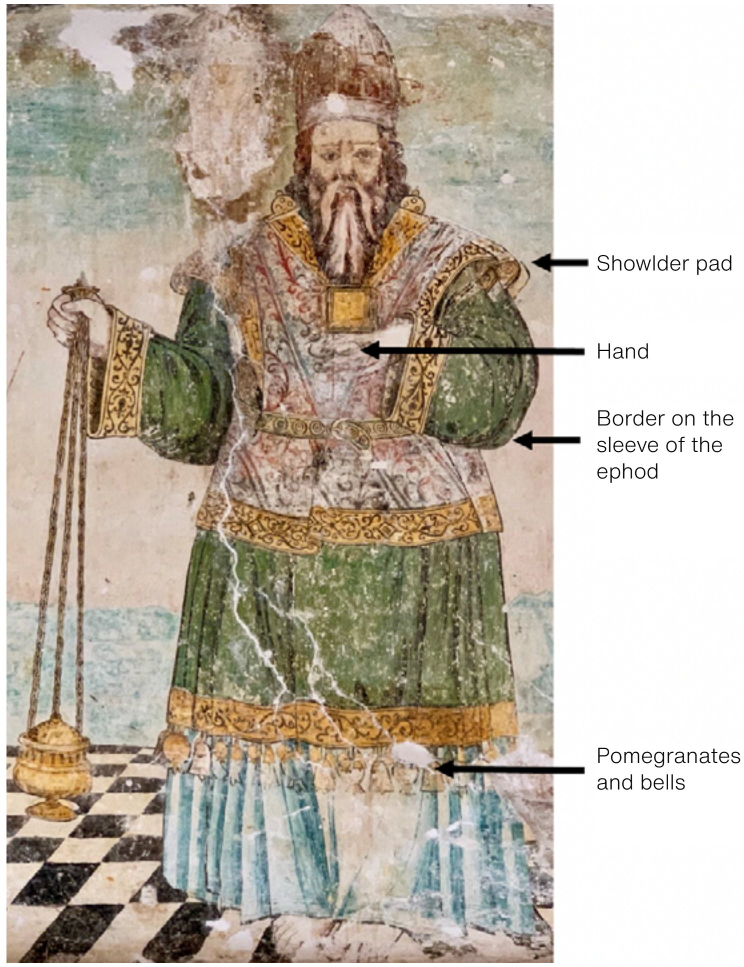

FIGURE 8. Location of the pentimenti under the main character (Schematic: Armando Arciniega, Laboratorio CODICE-CNCPC).

its reds, browns, shadows, outlines, and incarnadines. Other pigments, like orpiment and green earth, have been used individually on the tunic and border decorations. These materials speak about the importance assigned to creating mural paintings in common areas that manifested a religious discourse and symbolic meaning that could lead to contemplation and spiritual development. Cinnabar, bone black, and orpiment were quite costly materials in the 16th century (Sánchez & Quiñones, 2009), and already in the 14th century such pigments were being selected because of their recognized quality, color, and durability on murals (Cennini, 2009).

Our techniques have not allowed us to identify the color blue, because FRX only characterizes chemical-element compositions, so organic molecules in matter cannot be determined. Because we could not find an element characteristic of blue pigments, we inferred that an organic material (colorant) was employed for that color gamut. Since Colonial times, indigo production has been important in the Tehuantepec Isthmus, where the material is widely available, so we cannot rule out its use in mural paintings of this

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kind (García, 2010). In the parts of the mural showing *pentimenti*, we determined the use of ochre and white lead, particularly in the pectoral.

The color register completed in this study will constitute a tool to monitor color changes in the pictorial layer with the passage of time and assess potential conservation treatments.

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