

# Beyond Iconography

MATERIALS, METHODS, AND MEANING  
IN ANCIENT SURFACE DECORATION

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# MAYA MURAL ART AS COLLABORATION: VERIFYING ARTISTS HANDS AT SAN BARTOLO, GUATEMALA THROUGH PIGMENT AND PLASTER COMPOSITION

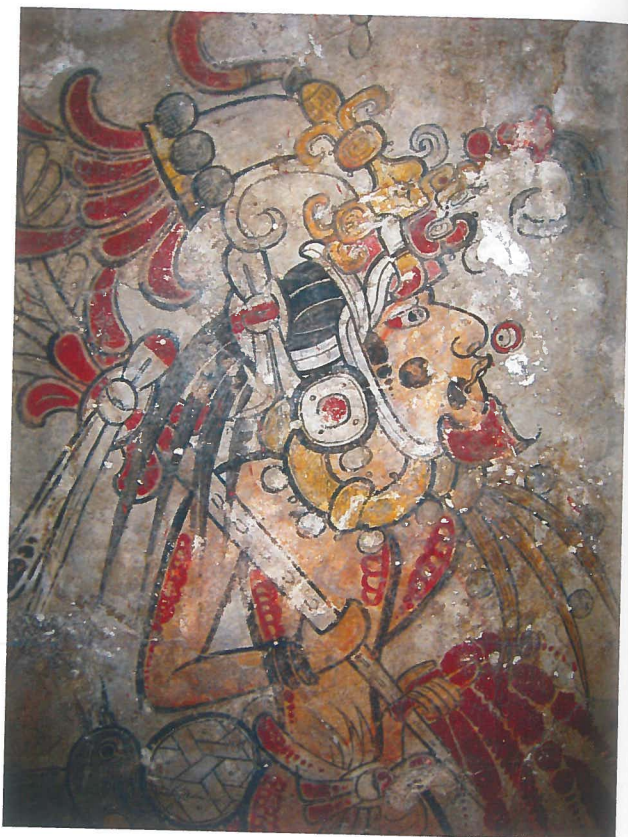
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## Abstract

*This chapter reports on the investigation and interpretation of wall paintings recovered from the Late Preclassic period (300 B.C.E–300 C.E.) Maya site of San Bartolo in Guatemala, as well as provides insights into artistic attribution and understanding of workshop practices in the archaeological past. Through both stylistic and compositional analysis of the murals, multiple artistic hands are identified and confirmed. This integrated analysis characterizes the painting technique and the development of figural features, examines wall preparation through the application and finishing of plaster, and studies the spatial distribution of specific colorant hue compositional groups. Reliance on multiple lines of evidence enables a comprehensive reconstruction of collaborative workshop practice and understanding of artistic identity, while at the same time informs future conservation of the in situ murals.*

SMOOTH, COOL, LUSTROUS WHITE PLASTER WALLS ARE THE muralists' canvas. The recipe of the plaster, the techniques used to prepare its surface, the manipulation of pigments into a range of hues, and finally, the integration of vibrant color and line to create images are all part of the artists' practice of mural painting. The study of how an artwork was produced can reveal an artist's participation in shared, regional traditions as well as aspects of individual identity. Mural artists' practice is highly visible in the chemistry, selection, and refinement of raw materials, the prepared surfaces, and the iconographic content of the wall painting; moreover, the site-specific nature of mural painting further contextualizes these data. In this study, stylistic and materials analysis are reported within the framework of characterizing pigments and plasters used to create mural paintings preserved in situ at the archae-

Fig. 1. Mural scene detail depicting young lord, west wall, Sub-1A, San Bartolo, Guatemala, (photograph by H. Hurst 2005).



ological site of San Bartolo, Guatemala (fig. 1). Our focus has been to describe the activities surrounding the creation of a mural painting from Late Preclassic Maya civilization (300 B.C.E.–300 C.E.). As will be shown through data regarding production and practice, we have identified three individuals who worked collaboratively to paint the San Bartolo mural chamber denoted Sub-1A (ca. 100 B.C.E.). This specific characterization of artists' practice in Maya mural art leads to new assessment of the conditions under which painters and scribes worked and speaks to their social organization.

Research into artists' hands and/or artists' practice is not new to the disciplines of art history, technical art history, materials science, and archaeology. However, each discipline generally addresses these topics within limited datasets. For example, the practice of attribution in art history relies on the identification of specific artistic hands based on a corpus of signed works, historical documents, or a well-documented stylistic "school,"<sup>1</sup> whereas archaeological data that

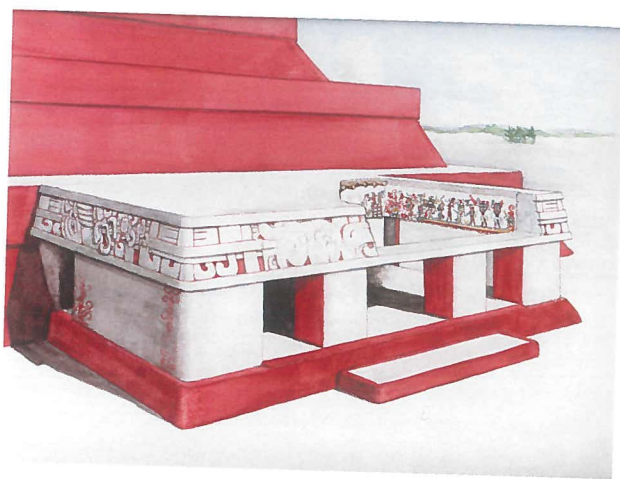
rely on material remains generally favor inquiry at a larger scale than individual artisans. Archaeology has developed techniques for studying craft production from ancient time periods, with recent contributions in studying agency and social meaning.<sup>2</sup> Due to challenging preservation conditions and material deterioration of ancient artworks, advanced methods using a number of datasets to develop multiple lines of evidence is very useful. An approach that draws from art history, materials science, and archaeology provides an opportunity to expand investigation to address new types of research questions. Our study investigates mural painting using a variety of data—stylistic, material, chemical, and contextual—paired with a relatively new analytical technology to reveal detail on artists' painting practice that would otherwise be overlooked.

### History of Investigations

In comparison to Old World mural traditions, ancient Mesoamerican wall paintings are sparse in their preservation and have an abbreviated technological history following the discovery and manipulation of lime plaster as a building material in the Oaxaca Valley ca. 1400 B.C.E.<sup>3</sup> Since their discovery in 2001, the San Bartolo murals have shed new light on the development of early Maya civilization in the Late Preclassic period (300 B.C.E.–300 C.E.). The murals' expressive calligraphic line and color creates rich imagery of humans, animals, deities, and landscape that are the most elaborate artistic program devoted to mythology and largest corpus of hieroglyphic texts from the first centuries B.C.E. documented to date.<sup>4</sup> Isolated in dense lowland jungle, the murals were partially exposed (less than 1 m<sup>2</sup>) through looter activity in the late 1990s. In the following thirteen years since their discovery, extensive excavation and research have focused on understanding, interpreting and characterizing the murals.

The largest corpus of polychrome wall paintings at San Bartolo is concentrated within a chamber denoted Sub-1A, located in the Las Pinturas architectural complex (fig. 2). Constructed ca. 100 B.C.E., Sub-1A is a single-room structure (4.1 m × 9.5 m) with mural painting preserved on an interior frieze, as well as limited exterior areas (these extant paintings are excluded from this study). All wall surfaces were prepared with a layer of coarse plaster overlaid

Fig. 2. Architectural reconstruction of Structure Sub-1A, Las Pinturas architectural complex (drawing by H. Hurst 2004).



with fine plaster and artists painted on a semidry to dry lime plaster surface using a limited range of pigment colors.<sup>5</sup> Only the north and west walls are preserved in situ in the Sub-1A structure. The majority of the east and south walls were ritually destroyed to construct later phases of the pyramid complex and are preserved as fragments (numbering ca. 3200). Deliberately tossed into construction fill by the ancient Maya, the fragments were excavated from secure contexts and can be definitively used to reconstruct the east and south walls.

The San Bartolo mural iconography includes images of the interface between humans, supernaturals, and sacred places that are the foundation of Late Preclassic period Maya cosmological, religious, and ideological beliefs.<sup>6</sup> The in situ Sub-1A murals depict images of sacrifice by four young lords; a sequence of offerings made to four directions and the world tree; the Maya maize god; the enthronement of a king receiving the crown of rulership; and a scene of ancestral emergence from a sacred cave. The foundational themes and symbolism used in the San Bartolo mural narrative have been employed for thousands of years. For example, images of Maya origin mythology in the San Bartolo paintings are related to iconography from the colonial period Popol Vuh manuscript, ritual offerings depicted in the 13th century Dresden codex, and 6th to 8th-century stela carvings of coronation ceremonies.<sup>7</sup> The occurrence of this imagery in the San Bartolo mural paintings demonstrate that iconographic traditions were well-defined at an earlier period than previously recognized.

## Placing the Data on the Wall: Summary of Stylistic and Material Investigations

Stylistic<sup>8</sup> and chemical<sup>9</sup> characterization of the Sub-1A murals has revealed significant information regarding the materials and method of manufacture used in their construction. When viewed within the context of associated archaeological evidence, this research provides multiple lines of evidence towards understanding the development of artistic practices within a workshop setting in the Maya world.

Ancient Maya artists are best known through portraiture on vases and descriptive titles, such as “scribe” and “carver,” attached to personal names in hieroglyphic inscriptions. Maya artists and their families who produced artworks for the royal court were often of high status themselves. They lived and worked in residences near the ceremonial center of sites; produced objects using a variety of media including codex, vase, and mural painting, stela carving, bone and shell carving, and textile fabrication; and held numerous roles in court administration that relied on their proficient knowledge of Maya writing, symbolism and calendrics.<sup>10</sup> Although archaeological evidence demonstrates that artists often produced a diversity of artworks, the role of artist as both a painter and creator of texts is most celebrated; for instance, the identity of “artist-scribe” is held by several kings who included inkpots among their burial goods.<sup>11</sup> In the Late Classic period (sixth through eighth centuries C.E.), artist-scribes and a number of associated supernatural creators are shown making art and writing upon screen-fold books in palace-like locations or in the otherworld of deities (e.g., Kerr Maya Database images #511, #1185, #1225).<sup>12</sup> In the seventh century, not only did artist-scribe iconographic traditions become more common, but individuals also began to sign their work.<sup>13</sup> Furthermore, recent scholarship utilizes multiple lines of evidence to understand that the elite office of scribe was transferred patrilineally.<sup>14</sup>

Much less is known about the role and identity of artists during the time period when the San Bartolo murals were painted. Although artists are frequently portrayed in eighth century polychrome vase paintings, their portraits are rare in the first century. This situation is due to a number of factors, including the fact that in the Preclassic period sculpted artworks, such as large stucco architectural friezes and masks, are a more prevalent art form compared to vase painting.<sup>15</sup>



Contributing to this lacuna is the lack of archaeological investigation of similar residential sites from this period; and, as yet, the sparse and undeciphered epigraphic data of titles and roles during this period. The Preclassic is of critical interest due to the fact that it is a dynamic period of social change when many communities in the Maya lowlands are first settled and then rapidly grow to establish the foundations of dynastic kingship. During this period, major city-states including Tikal, Xultun, and Calakmul developed and played important sociopolitical roles in subsequent millennia.<sup>16</sup> Archaeological, epigraphic, and iconographic evidence demonstrates that Maya artist-scribes held prominent positions in sociopolitical activity in later periods. Better defining artist-scribe roles and working practice within the first royal kingdoms therefore will provide insight into nonroyal elite lives and the construction of power.

Mural painting was once ubiquitous at Maya sites, however it is rarely well preserved in the fluctuating heat and humidity of the tropics. Perhaps the best-known murals from the Maya area are those of Bonampak (Chiapas, Mexico), which date from the late eighth century C.E. and represent the Usumacinta valley tradition.<sup>17</sup> Scholarship of Maya painting process and materials is largely based on studies of these late murals located in the western and northern regions of the Maya area.<sup>18</sup> Newly discovered murals from the eastern Maya region that date to earlier centuries have only recently been incorporated in the scholarship of painting process.<sup>19</sup> These new contexts and temporal periods of mural painting expand our understanding of the range of materials used for pigments and plasters, as well as add to the corpus of mural iconography.

### 1. Summary of Stylistic Analysis

Mural creation of large-scale images is generally a collaborative production due to the labor required to prepare the wall and apply plaster. However, documenting individual roles is often difficult, even when a large corpus is preserved.<sup>20</sup> In the modern period, for instance, detailed records illuminate the relationship between Siquieros and Renau in creating the mural for the Mexican Electricians' Syndicate in Mexico City (1939–1940).<sup>21</sup> Yet it is unclear if the nature of their partnership, and ultimately Renau's lead authorship, would be recoverable without historic documents. Similar to well-

known studies of ancient Roman wall painting or authorship of Greek vases,<sup>22</sup> an art-historical approach has been used to examine artists' hand in Maya mural painting with particular attention to investigating the development of underpainting and calligraphic outlines.<sup>23</sup> Researchers have examined figure painting using the Morellian technique, where distinctive features such as hands, faces, and feet are considered diagnostic and reveal tell-tale conventions of the hand of the painter.<sup>24</sup> At Bonampak, for example, the hands of master artists and less-experienced painters who worked together were identified using stylistic analysis leading to the observation that their relationship was structured as master-apprentice.<sup>25</sup> At San Bartolo, in contrast, the initial stylistic analysis of artists' hands was a secondary outcome of the documentation process during excavation and this early identification included macroscopic evaluation of materials in addition to painting style.

After several years of recording the murals through detailed field drawings and watercolor renderings, observed patterns in the way figures were rendered have led to the recognition of stylistic variations that could be attributed to different artists. Additionally, evidence suggests the entire chamber was painted at once, over a period of several weeks.<sup>26</sup> The stylistic observations and iconographic evidence outlined here lay the groundwork for further investigations into painting materials. The results of materials analysis in the following pages better define individual artists' processes and evaluate our hypothesis of multiple artists working in collaboration at San Bartolo.

Through extensive visual assessment, Hurst identified three artists who painted the Sub-1A interior murals using stylistic analysis of mural painting techniques.<sup>27</sup> Each of the artists prepared the wall with a prepainting in red-line, and all share a common color palette, use a common vocabulary of iconographic symbols, and applied color using the same technique to create the volutes and margin of space between color field and body outline that are distinctive. However, a degree of variation in the details of each figure is also present within the mural chamber. Fingers, eye shape, noses, and feet form the most diagnostic features, enabling the identification of various different artist hands. Based on consistency in prepainting, calligraphic line, and application of color, she determined that individual figures in the San Bartolo mural were painted in entirety by only one artist, with the exception of the northwest corner.



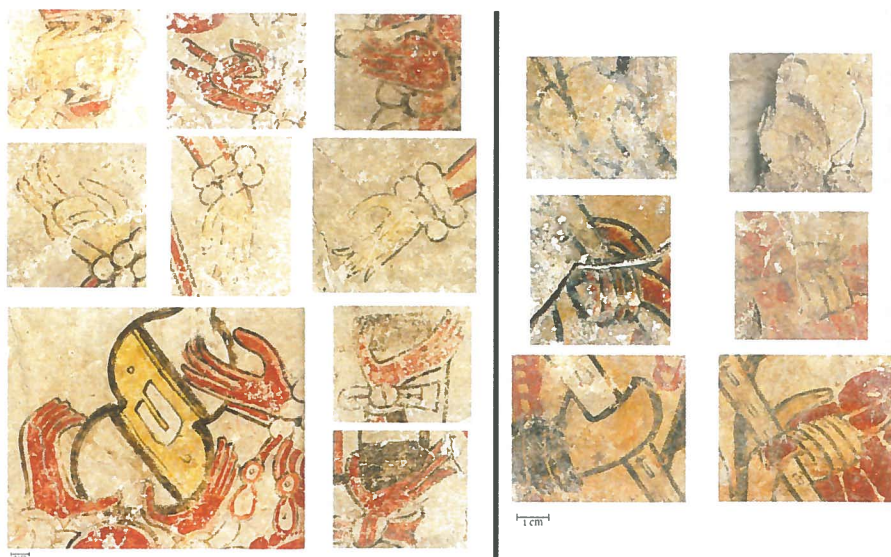


Fig. 3. Comparison of finger rendering, Painter 1 and Painter 2.

Painter 1, associated with the north wall, renders hands with tapering fingers that terminate in points, while Painter 2, identified on the southern half of the west wall, generally avoids rendering individual fingers, or renders them as fleshy and round with clear lobed joints and fingernails (fig. 3). Painter 1 depicts rounded noses with no nostrils, while Painter 2 draws the bottom of the nose in a flattened line followed by the addition of the nostril in a second stroke (fig. 4). Stylistic differences were clearly divided by wall, except in the northwest corner of the room. On the northern extent of the west wall, both Painter 1 and Painter 2 hands' were present in the final painting. A small detail of underpainting demonstrated that the prepainting sketch of the mural program in this area was outlined by Painter 1, but the final painting was completed by Painter 2. This unusual detail of shared execution within a single figure is restricted to this corner of the room. When assessing the *in situ* murals with respect to the application of paint to produce fingers and facial features, it is clear that Painter 1 and Painter 2 collaborated in the execution of the northern half of the west wall (fig. 5). Finally, a third painter has also been identified and is associated with portions of the now broken east wall; the hand of Painter 3 is best described as more immediate, or casual, in the quality of calligraphy (see fig. 5).

The finishing of plaster on wall surfaces also provides evi-



Fig. 4. Comparison of faces and noses, Painter 1 and Painter 2.

dence regarding the identification of multiple artists working together to prepare and paint the Sub-1A chamber. While the variability of overall plaster thickness is due to an uneven masonry substrate, the underlying coarse- and upper fine-plaster layers are well-bound to one another suggesting that fine plaster was added while the lower surface was still wet.<sup>28</sup> In contrast, the degree of finishing of the fine-plaster surface exhibits significant variation including polishing, burnishing, and the presence of striations. Polished surfaces are associated with areas of the north wall and the northeast corner of the room; while surface striations are visible on the upper portions of the southern half of the west wall and various reconstructed fragments likely from the east wall. Burnishing is associated with border fragments, particularly visible near two scenes—an architectural component and a large serpent. These observations regarding surface treatment further confirm the attribution of distinct artistic hands, working together to produce the Sub-1A murals.

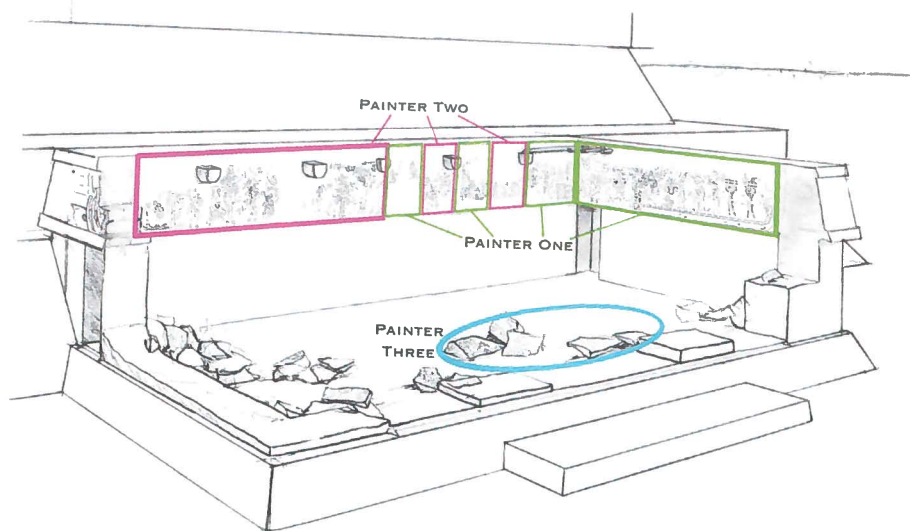


Fig. 5. Architectural reconstruction identifying location of artists' hands (drawing by H. Hurst 2009).

## 2. Summary of Chemical Analyses

Pigments and the production of paint used in mural painting of ancient Mesoamerica have been widely researched.<sup>29</sup> In general, these data inform studies of ancient technology, trade and economics, and symbolism, or are applied in conservation science. At San Bartolo, chemical analysis of Sub-1A murals was conducted in order to understand the materials and methods of manufacture used in their construction. Analysis has focused on identification of pigments used to produce paint colorants, as well as the fine- and coarse-plaster layers and masonry support, where possible. Designed to confirm observations made regarding the presence of individual artists' hands, this study collected data from multiple sampling sites within each colorant hue. This unique research design assesses the range and variation in composition in order to understand material homogeneity with respect to the spatial distribution of mural materials. This study moves beyond a baseline of paint identification to capture a nuanced range of data that relates individual artistic identity and practice including selection of raw material procurement and its preparation for manufacture. Compositional uniformity within a single artwork may support highly unified production methods, while heterogeneity suggests variable preparation and manufacturing methods. Both destructive analytical techniques,<sup>30</sup> which required samples to be removed from the

murals, and nondestructive methods, enabling analysis to be conducted directly on the mural surface, were used. The relative stability and condition of the painted surface played a role in sampling site selection, and, when possible, data collection was optimized through site selection.

#### *Individual compositional identifications*

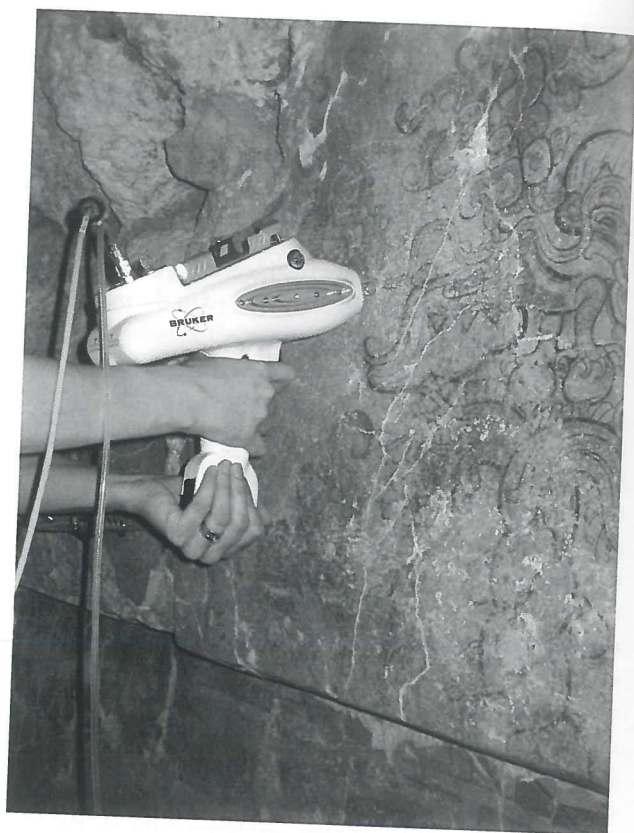
Chemical analysis has focused on identifying compositional components of pigments and plasters used in the production of the Sub-1A murals.<sup>31</sup> Initial analysis, following discovery of the murals, focused on materials analysis of eight stratigraphic samples (pigment, plaster substrate) removed from the north wall of the mural.<sup>32</sup> Prepared samples, analyzed by Magaloni (2003) and Rainer and Heginbotham (2006) using reflected light microscopy, indicate the presence of a multilayered structure consisting of a finely ground pigment applied to a fine lime-plaster layer, which overlays a preparatory plaster layer with large aggregate. When analyzed in cross section, the upper plaster layers appear well-bound to the lower layers.<sup>33</sup> Additionally, varying degrees of surface compaction are visible analyzed samples.<sup>34</sup> In some cases, multiple layers of distinct pigment layers are visible.<sup>35</sup> X-ray diffraction analysis identified the presence of hematite ( $\text{Fe}_2\text{O}_3$ ) (red), maghemite ( $\gamma\text{-Fe}_2\text{O}_3$ ) (lighter red), goethite ( $\alpha\text{-FeO(OH)}$ ) (yellow/orange), and carbon (black) in pigment layers.<sup>36</sup> Barite ( $\text{BaSO}_4$ ), a barium sulfate mineral, was identified as aggregate in both the fine plaster and preparatory layers, which is unusual for the Maya lowlands.<sup>37</sup> Finally, some samples tested positive for the presence of an organic binder, which could not be specifically identified.<sup>38</sup>

Additional nondestructive analysis using a portable X-ray fluorescence (pXRF) instrument (fig. 6) was conducted in order to complement the work of Magaloni (2003) and Rainer and Heginbotham (2006), as well as understand the spatial distribution of artist materials with respect to paint and plaster composition.<sup>39</sup> Spectral data was collected from over 230 locations along the north, west, and east walls of structure Sub-1A (fig. 7). This was completed in order to characterize the range and variation of composition within specific color hues (background [unpainted], white, black, gray, light gray, red, pink, peach, and yellow) and represent the complete range of color used in the mural painting.<sup>40</sup>

Compositional trends in observed pigment spectral com-



Fig. 6. Collecting spectral data using the pXRF instrument in situ, Sub-1A, (photograph by C. O'Grady 2009).



positions are unsurprising and confirm the preliminary results reported by Magaloni.<sup>41</sup> Paint colorants are generally iron-rich, reflecting the use of readily available natural resources, while the absence of iron in black, gray, and light gray paints suggests the presence of organic pigments (possibly carbon-based) and have been reported previously.<sup>42</sup> This nondestructive analysis also expanded the recognized color palette used to produce the Sub-1A murals. Results from the pXRF compositional survey identified a deliberately prepared and applied white paint,<sup>43</sup> as well as the presence of compositionally distinct dark red (Fe- and Mn-minerals) and black (Mn-mineral) paint colorants.<sup>44</sup>

Compositional trends associated with specific iconographic features and artist hands suggest the specific preparation of pigments and fine plaster layers by individual artists. Preliminary material identification and assessment of painted layers by Magaloni (2003) and Rainer and Heginbotham (2006), as well as our work suggest the use of locally available minerals

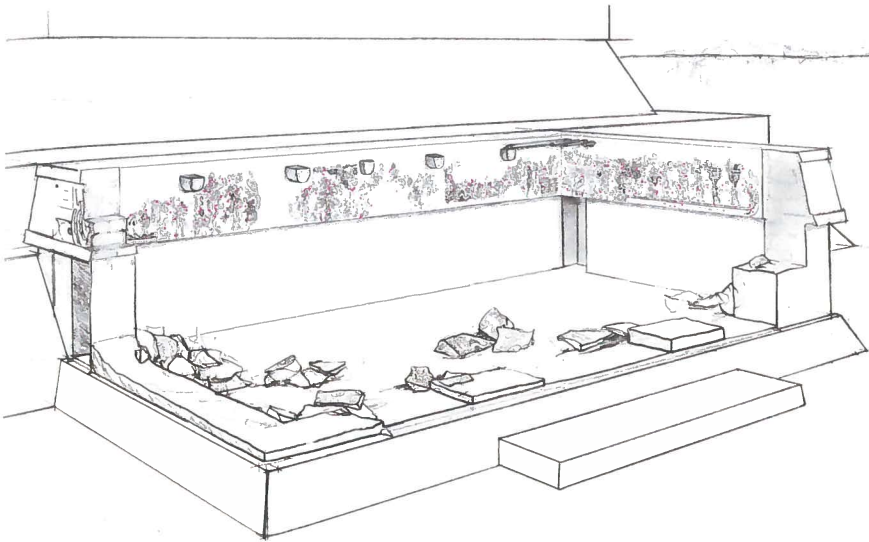


Fig. 7. Locations of pXRF sample locations situated on architectural drawing of Sub-1A (drawing by H. Hurst 2009).

to make finely ground pigments. These results are consistent with Classic period (300–900 C.E.) Maya mural technology<sup>45</sup> and imply the existence of an established artistic tradition nearly 500 years earlier than previous thought.

#### *Synthesis of materials composition and spatial distribution*

Variations in raw materials or pigment preparation method could be expected to produce compositional variations within hues over the entire mural corpus. When sampled widely, clusters of compositional variation within the limited color palette are observed in pXRF spectra. This suggests that the Sub-1A artists may have prepared the mural surface differently, and that they used a variety of paint compositions to generate a single hue. Generally, the presence of barium is spatially distributed in a number of locations on the west and north walls. In particular, the most concentrated readings are associated with the turtle figure and white paints, which are located on the west wall.<sup>46</sup> While the chemical contribution of a specific paint or plaster matrix layer to the overall barium content cannot be determined using pXRF, its identification in white paint and background samples suggests the presence of barite ( $\text{BaSO}_4$ ) in the plaster substrate or paint medium.<sup>47</sup> This confirms previous observations,<sup>48</sup> but must be recognized as unique in the Maya area, and, likely, a result of the limestone procured from local resources used during mural production.<sup>49</sup> Localization of barium in spectra from



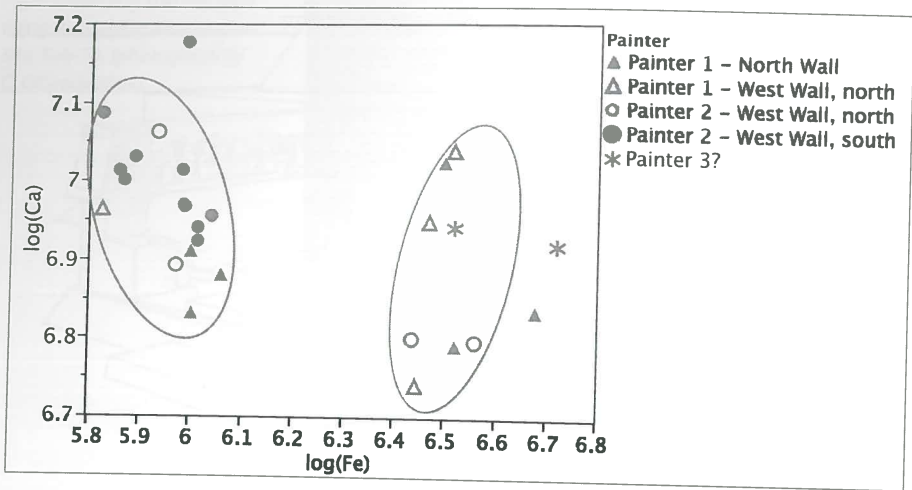


Fig. 8. Comparison of red colorant hue compositional groups; Group A is visible on the right and Group C is on the left.

the north wall and northern half of the west wall suggests differential surface preparation and corresponds to previously identified artists' hands.<sup>50</sup>

When combined with stylistic evidence, observed compositional patterns collected from the in situ Sub-1A murals provide insight into San Bartolo raw-material procurement and mural manufacture. Assessment of spectral data suggests the presence of a number of statistically valid compositional clusters associated with colorant hues, which are distinguished by relative elemental ratios identified by pXRF.<sup>51</sup> These distributions, while not immediately clear and unambiguous, provide insight into San Bartolo raw material preparation and mural manufacture when combined with stylistic evidence. Two distinct compositional groups are associated with red pigments. When assessed within the context of stylistic evidence, the identified compositional groups suggest Painter 1, working on the north and west walls, used different pigment mixtures from Painter 2 who was working on the west wall (fig. 8).<sup>52</sup> Additionally, a number of yellow pigment compositional groups have also been identified and can be associated with specific painters.<sup>53</sup> When viewed within the context of accompanying stylistic evidence, these patterns provide insight into the preparation and manufacture of the San Bartolo murals—highlighting the great utility of this new methodology, which enables the study of the mural painting process in the archaeological past. Furthermore, identified compositional groups may provide an



additional method for reconstructing the existing corpus of preserved broken mural fragments.

### The Chemistry of Collaboration: Seeking the Individual Hand in a Shared Artwork

In conclusion, the presented stylistic and compositional analyses provide critical data regarding the Sub-1A murals at San Bartolo (fig. 9). Compositional variation with little visual differentiation is present within some hues and background plaster substrates and is localized in spatial clusters. Data regarding compositional spatial clusters align with localized stylistic recognition of distinct artists' hands. In this study, multiple lines of evidence point toward a group of ancient Maya artists collaborating to paint a single artwork. These artists worked closely to create a visually unified mural, yet they probably prepared their own paints and adjusted their own recipes. The individual artists shared training in iconography and painting technique, and in one area worked to finish each other's sketched figures. This characterization of similar technical training and collaborative production methods suggests

*Fig. 9. Mural scene detail depicting sacrificial offering, west wall, Sub-1A, San Bartolo, Guatemala, (drawing by H. Hurst overlaying digital image of mural by W. Saturno 2005).*

shared artistic practice best described as a school of mural painting. This represents the earliest evidence for a "school" of painting in the Maya area, a type of social organization among artists that has previously been documented for the Classic period Maya nearly 600 years later. While further analysis is needed to identify specific minerals and binders of various paint recipes, this study advances our understanding of artist practice and internal organization, which suggests a formally organized group of artist-scribes.

Efforts to understand the role of individual artists in Late Preclassic Maya mural production is a complicated process that requires present-day collaborative research and multiple lines of evidence that can be integrated towards a meaningful conclusion. New evidence of differential artist preparation was suggested by pigment spectra collected from colorant hues preserved *in situ*. The strength of this argument is augmented by Hurst's previous work, which recognized the presence of three artistic hands on the north, west, and east wall murals of San Bartolo Sub-1A. It is only through this synergistic collaboration that we have been able to really characterize the role of the individual artist. Our research relies on the integration of multiple analytical methods that have their foundation in the disciplines of art history, archaeology and materials science. This is accomplished by characterizing stylistic and compositional analysis, which is spatially distributed within the *in situ* murals. As a result, we have been able better to define the role of the Preclassic artist within the very first Maya royal kingdoms through this study of the San Bartolo murals.

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## Notes

<sup>1</sup> ABV.

<sup>2</sup> Hruby and Flad 2007.

<sup>3</sup> Marcus and Flannery 1996.

<sup>4</sup> Saturno et al. 2005; Taube et al. 2010.

<sup>5</sup> Hurst 2009, 109–17; Bass Rivera et al. 2005.

<sup>6</sup> Saturno et al. 2005; Hurst 2009; Taube et al. 2010.

<sup>7</sup> Taube et al. 2010.

<sup>8</sup> Hurst 2005, 2009.

<sup>9</sup> Magaloni 2003; O'Grady and Hurst 2011.

<sup>10</sup> See Webster 1989; Coe and Kerr 1998; Inomata et al. 2001.

<sup>11</sup> See Coe 1977 and Reents-Budet 1994 for discussion of artists' roles and titles. Although many inkpots in museum collections are unprovenienced, examples from archaeologically excavated elite tombs (e.g., Fash 1994, 104–11) show that these items belonged to elites with noble titles, even kings.

<sup>12</sup> Kerr 2014.

<sup>13</sup> Stuart 1989.

<sup>14</sup> Fash 1994, 120.

<sup>15</sup> Miller 1999.

<sup>16</sup> Martin and Grube 2008.

<sup>17</sup> Miller 1986.

<sup>18</sup> The western and northern areas of the Maya lowlands are located in present-day southern Mexico and the Yucatan peninsula. See Littmann 1975; Kamal et al. 1999; de la Fuente and Staines Cicero 2001; Sánchez del Río et al. 2004.

<sup>19</sup> These include: Carrasco Vargas and Cordero Baquero 2012; Estrada-Belli and Hurst 2011; O'Grady and Hurst 2011; and Saturno et al. forthcoming.

<sup>20</sup> See Richardson 2000.

<sup>21</sup> Jolly 2008.

<sup>22</sup> See Richardson 2000; Boardman 1975.

<sup>23</sup> See Miller 1997.

<sup>24</sup> Morelli 1892–93.

<sup>25</sup> Senchyshyn 2000; Miller and Brittenham 2013.

<sup>26</sup> Hurst 2009, 198–206.

<sup>27</sup> Hurst 2005, 2009. See Hurst 2009, 117, 199–204 for detailed analysis of stylistic evidence summarized in this section.

<sup>28</sup> Hurst 2009, 117.

<sup>29</sup> See Littmann 1958; Magaloni 1996; Sánchez del Río et al. 2004; Houston et al. 2009.

<sup>30</sup> Destructive analyses require a sample to be removed from the original. In addition, sample preparation irrevocably modifies the sample in order to prepare it for analysis. For example, sample preparation for light microscopy requires embedding in adhesive and polishing prior to analysis.

<sup>31</sup> Magaloni 2003; O'Grady and Hurst 2011.

<sup>32</sup> Magaloni 2003.

<sup>33</sup> Rainer and Higenbotham 2006, 5, 25, 33.

<sup>34</sup> Magaloni 2003, 5, 7; Rainer and Heginbotham 2006, 44.

<sup>35</sup> Rainer and Heginbotham 2006, 8, 17–20, 37–39.

<sup>36</sup> Magaloni 2003.

<sup>37</sup> Magaloni 2003.

<sup>38</sup> Magaloni 2003, 11.

<sup>39</sup> O'Grady and Hurst 2011.

<sup>40</sup> Sampling sites for analysis were selected based on a number

of interrelated factors in order to test hypotheses regarding the relationships between identified artists and pigment and wall preparation. More information regarding this process is reported in O'Grady and Hurst 2011.

<sup>41</sup> Magaloni 2003; Rainer and Heginbotham 2006.

<sup>42</sup> O'Grady and Hurst 2011.

<sup>43</sup> O'Grady and Hurst 2011, 7–8.

<sup>44</sup> Further XRD analysis is needed to confirm the presence of specific minerals in the west wall mural and investigate variations observed in pXRF data.

<sup>45</sup> Magaloni 1996, 2001.

<sup>46</sup> O'Grady and Hurst 2011, 7–8.

<sup>47</sup> Barite is more probable, given its previous identification in fine-plaster layers from the north wall (Magaloni 2003, 3).

<sup>48</sup> Magaloni 2003, 3.

<sup>49</sup> There is no published evidence for the use of barite as a Maya pigment (Littmann 1975, 350; Magaloni 2001, 173) suggesting its presence in the San Bartolo murals is associated with limestone raw material resources used during mural production. In the Maya area, quartz and sascab are typical aggregates in Late Classic plaster production (Littmann 1958), but substitutions for specific lime-plaster formulations are documented as early as 400–300 B.C.E. Further investigation is needed to identify and understand its contribution to Maya mural manufacture and technology.

<sup>50</sup> Hurst 2006, 2009.

<sup>51</sup> O'Grady and Hurst 2011, 8.

<sup>52</sup> Compositional Group A red pigments, found on the north and west walls, are associated with Painter 1, while Group C pigments, found on the west wall, are associated with Painter 2 (O'Grady and Hurst 2011, 8–9).

<sup>53</sup> Two yellow pigment mixtures are associated with Painter 1 including low and high Fe/Ca groups, while only low Fe/Ca ratios are associated with Painter 2 working on the southern half of the west wall (O'Grady and Hurst 2011, 8).

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