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XVI CENTURY COLONIAL PANEL PAINTINGS FROM NEW SPAIN: MATERIAL REFERENCE STANDARDS AND NON-DESTRUCTIVE ANALYSIS OF MEXICAN RETABLOS

Elsa Arroyo[1], Sandra Zetina[1], Eumelia Hernández[1], Tatiana Falcón[1],
José Luis Ruvalcaba[2], Laura Mancilla[3], Alfredo Nieto[3]
[1]Laboratorio de Diagnóstico de Obras de Arte, Instituto de Investigaciones Estéticas, Universidad Nacional Autónoma de México
Circuito Mario de La Cueva, s/n. C.U., México DF, 04510, México
[2]Instituto de Física, Universidad Nacional Autónoma de México
[3]Escuela Nacional de Artes Plásticas, Universidad Nacional Autónoma de México

ABSTRACT

Most of the examples of XVI century panel paintings preserved in Mexico, are located in Retablos (altar pieces) of Dominican and Franciscan convents situated in rural areas. The study of these paintings implies the impossibility to remove the paintings from their original support. In situ analysis is required, non-destructive studies are preferred in order to have a global comprehension of the object, as well as to carry out a limited sampling and to avoid further damage of the paintings.

In order to establish a non-destructive methodology for material analysis our project has reproduced XVI century paintings following recipes from treatises and documentation of Italian, Spanish, and Flemish Schools. The reproductions considered: 1) Preparation of pigments, binders, grounds, and supports; 2) Fabrication of oil colours with the prepared pigments and binders; 3) Creation of material reference standards (with fills and one colour, i.e. reds: minium, hematite, kermes lake, etc.); 4) Recreation of paintings (using designs, and colour combinations as expected in an original work of art); 5) Creation of data bases with the analytical results of the analyzed standards (IR reflectography, UV imaging and UV-VIS-IR, X-ray Fluorescence, FT-IR and Raman spectroscopies). 6) Comparative analysis of the reference standards with original panel paintings from museum collections to evaluate the sensitivity and performance of our methodology. In this work, the main results of our first year of research are presented. This research is supported by PAPIIT –UNAM research grant IN-40200 and partially by CONACyT grant U49839-R..

INTRODUCTION

A few exceptional *retablos* (altarpieces) have survived in the territory that once pertained to the domains of New Spain. They exemplify the artistic production of late Renaissance period, on the last third of the sixteenth century in New Spain. Some, like the one from the Franciscan church at the convent of Huejotzingo, Puebla, maintain their original form and placement. Unfortunately, most of them are fragmented and the panel paintings that once where part of their composition, are now isolated in temples, museums, or private collections. The study of this kind of objects implies the necessity to establish relationships between paintings in order to propose reconstructive hypothesis that may help to build up the puzzle of the *retablo* production of the first century of the viceroyalty, and thus be able to contribute on the understanding of their overall meaning.

The present study is centred in *retablo* and panel painting production of two artists: Andrés de Concha and Simón Pereyns. Examples of their work may be seen today in the states of Puebla and Oaxaca, and in Mexico City. The Flemish Simón Pereyns arrived to America in 1566 as part of viceroy Gastón de Peralta retinue. Andrés de Concha arrived to New Spain in 1568 from Sevilla, and was contracted to build the *retablo* from the church of Yanhuitlán, in Oaxaca. These painters associated to create at least three different *retablos*. The legal contract for the construction of the mentioned altar of Huejotzingo states the conditions of the construction and elaboration of the paintings, a literal quote from the document says that,

"…it is condition for this contract that the paintings from the whole *retablo* are done by the hand of the said Simón Pereyns or Andrés de Concha, and no other, even if they want to…"[1]. The patrons were willing to pay for the masters' ability; they appreciated the quality of their creations, and the effects that the finished objects attained. This certainty, the altar being accomplished by either Simón Pereyns or Andrés de Concha, has been taken as a point of departure to analyse the craft involved on the construction of panel paintings from a material and technical point of view.

But, what implications are behind a contract that demand's the execution of an altarpiece by a specific artist? Is this a point that may be analyzed through the scientific analysis of the materials, and their interaction within the body of painting? We want to know to what exactly is the concept of *ability* referring to: is it the representation of forms on a surface; to the design as drawing and composition; or, to the election and combination of colours on the palette –the variations of the binder, and the superposition of paint films to create specific plastic effects? [2] To what point does XVI century painting allow us to recognize the skill of one master and differentiate it from the dexterity of another? Which are the distinctive signs of the hand of a talented craftsman, the code that the patrons of Huejotzingo demanded, and on which the prestige of the whole creation was founded?

Our hypothesis proposes that on the production of early colonial paintings the European tradition was permeated by a social, geographic and economic reality particular to New Spain. In that sense, artistic requirements were resolved in alternative ways. This meant for instance the substitution on the use of specific materials: the availability of gypsum mines of high quality is reported by fray Toribio Benavente de Motolinía in 1536; the exploitation of Mexican cochineal and indigo also starts very early, Hernán Cortés is reporting about it on his second letter to Charles V. Yet, the process of adaptation and use of the new findings was progressive, so the study of the early examples of viceregal painting will allow us to find those structures – material and technical – that pertain to the European tradition, from those that are invented or adapted in New Spain.

RESEARCH PROJECT

The study is based on a comparative approximation between the technical analysis of original paintings and the scientific creation and study of reference standards. The project has an interdisciplinary character, and comprehends aspects that involve diverse areas of knowledge: conservation, history, art history, chemistry, physics, visual arts, and photography.

The creation of standards includes material selection, construction of wood panels and, application of four characteristic strata of a painting: ground, priming, pictorial layer, and varnish. It demands a constant process of experimentation to obtain the quality and consistency required in the combination of materials, because of this, the participation of visual artists' is fundamental.

The point of departure for the experimentation with reference standards is based on historical and bibliographical research of European art treatises written between 1400 and 1700 [3], archival documents such as contracts (altar piece commissions), *ordenanzas* or royal regulations for the painters' guild, and documents related to the commerce of local and ultramarine materials between the Metropolis and New Spain (trade lists of painting materials). We've also incorporated the data collected from the technical and material analysis of three original panel paintings: one signed by Simón Pereyns, and two attributed to Andrés de Concha [4]. These have helped us define and select construction techniques of the panels, and the material combination for the elaboration of grounds, primings, and colour mixtures. The paintings are:

- Simón Pereyns, *María Magdalena*, 60 x 168, oil on panel, Huejotzingo, Puebla, México.
- Andrés de Concha, *La Sagrada Familia con San Juan niño,* 131.5 x 92.2, oil on panel, Private coleccion, Mexico. (Fig. 1)
- Andrés de Concha, *El Martirio de San Lorenzo*, 225 x 166, oil on panel, Museo Nacional de Arte, Mexico. (Fig. 2)

Figure 1. La Sagrada Familia con San Juan Niño, 131 x 92 cm. oil on panel, Private collection, Mexico.

Figure 2. El martirio de San Lorenzo, 223 x 165 cm. oil on panel, Museo Nacional de Arte, Mexico.

Variations Considered on the Creation of Standards

<u>Panel preparation</u>

Sixteen panels of 50 x 50 cm were constructed using pinewood, in accordance to the structure commonly found on New Spaniard paintings.

<u>Ground layer</u>

We used two variables for the application of grounds: 1) calcium carbonate, and 2) calcium sulphate (anhidrite). The difference on the ground material has proven to be characteristic of specific painting schools and regions during the XVI century [5].

<u>Priming or imprimatura</u>

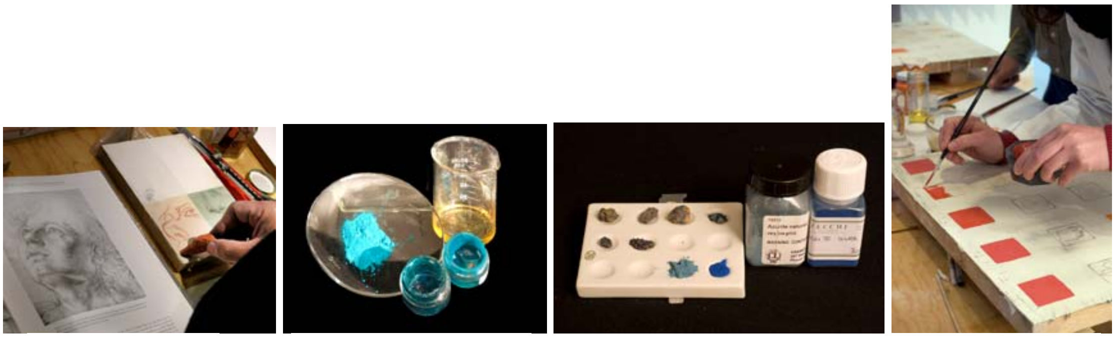
The use of a green coloured priming composed of lead white, green earth, azurite, ochre, and black, has been identified in our studies of XVI c. panel paintings. Its' function is to create a material compatible strata for the pictorial layer and to confer a cold tonality to the general atmosphere of the finished painting.

<u>Underdrawing</u>

The reference standard experiment has used five variations for the application of preliminary drawings in order to understand the behaviour of colour mixtures, and that of the camera's sensibility, at the same time. The variables are: Transferred lines. Carbon pencil. Pouncing with lamp black. Pouncing with iron oxide. Carbon ink applied with brush. It is important to mention that until today, we have not been able to identify explicit underdrawings on New Hispanic canvases, only isolated applications of contour lines with the aid of inks.

Pictorial layer: Pigments

To produce standard reference samples we used two different material sources: laboratory prepared pigments, lakes and binders, and high quality commercially prepared materials.



Preliminary drawing | *Preparation of copper resinate.* | *Azurite. Mexican mineral and commercial brands used for the reference samples.* | *Application of reference pigments.*

Figure 3. Preparation procedures of pigments

A selection of 25 pigments of mineral nature and lakes prepared from organic dyes were chosen (Table I). Special attention was paid to the election of material references. Priority was given to minerals with known geological identification and geographical precedence. Minerals exploited on Mexican ground were best. Some colours, such as copper acetate, lead basic carbonate, and lapis-lazuli were grinded and purified on laboratory, following traditional recipes.

Pictorial layer: Binders

Five different vehicles were used: bleached linseed oil, nut oil, egg yolk, egg yolk with boiled linseed oil, rabbit glue, and sandarac resin with boiled linseed oil.

Methodology for the Characterisation of XVI c. Paintings

The methodology involves the non destructive examination and recording by imaging techniques as well as non destructive characterization by analytical techniques.

The non destructive examination involves to assess the effectiveness of the methodology of scientific approach used in the panel painting examination, and to carry out the photographic register under controlled conditions in order to define parameters in the use and response of the digital cameras, lighting, filters and software used during the investigation. The examination was performed by visible light, infrared (IR) reflectography and ultraviolet (UV) imaging and recorded by digital photography.

Table I. Selection of pigments of mineral nature and lakes prepared from organic dyes.

Pigment	Source or preparation as standard reference	Painting treatises in which it is mentioned:	Found in 16th century New Spain paintings	Pigments used in pre-Columbian art in Mesoamerica
Lead white	*Kremer pigmente®* 463000 and laboratory preparation	Cennini, Palomino, Pacheco, Vasari	X	
Gypsum	Cosmopolita®001721	Cennini, Vasari, Pacheco	X	X
Calcium carbonate	Serra®	Cennini, Carducho, Palomino, Pacheco, Vasari		X
Yellow lead oxide/plumbous oxide, litharge	Laboratory preparation (SnO2 + PbO)	Palomino, Pacheco		
Lead Tin Yellow Type II	*Kremer pigmente®*10120	Cennini, Pacheco	X	
Orpiment	Laboratory preparation from Asian mineral	Cennini, Pacheco	X	possibly
Weld dye	*Senelier®* y *Zecchi®* 1122N	Cennini, Palomino, Pacheco		
Cinnabar, vermilion	Laboratory preparation from Mexican mineral (Queretaro)	Cennini, Pablo de Céspedes, Palomino, Pacheco	X	X
Red iron oxide	Laboratory preparation from Mexican mineral (Queretaro)	Plinio, Cennini, Palomino, Pacheco, Vasari	X	X
Minium, red lead	*Kremer pigmente®* 42500	Cennini, Pacheco	X	
Red lake, cochineal, Kermes, madder lake	*Lac dye Kremer pigmente®* 36020, madder lake *Kremer pigmente®* 372142 Mexican cochineal *Nochestli*	Cennini, Pacheco, Palomino	X	cochineal
Rejalgar	Laboratory preparation from European mineral	Cennini, Pacheco		
Azurite	*Zecchi®*, *Kremer pigmente®* 10210 and laboratory preparation from Mexican mineral	Cennini, Pacheco	X	X
Ultramarine blue	Laboratory preparation from Afghan mineral	Cennini, Pacheco		
Indigo	Mexican dye, Niltepec, Oaxaca and *Kremer pigmente®*36000	Carducho, Pacheco		X
Verdigris	Laboratory preparation cupper + CH_3COOH	Pacheco	X	
Malachite	Laboratory preparation from African and Mexican mineral	Cennini, Pacheco	X	X
Green earth	*Kremer pigmente®*11000	Cennini, Vasari	X	X
Raw sienna, dark brown earth and yellow ochre	*Kremer pigmente®* 40430, 40241,40310	Pacheco, Vasari	X	X
Asphalt	*Sennelier®*	Pacheco, Palomino		
Lampblack (Negro de humo)	*Kremer pigmente®*47010	Cennini, Palomino	X	X
Carbon black (Negro de carbon)	*Serra®*	Cennini, Pacheco, Palomino		X

On the other hand, the analytical approach considers the use of non invasive in situ techniques such as X-ray fluorescence (XRF), Raman and FT-IR spectroscopies by portable equipments. After this step, and using the examination and analytical data, representative and minimum sampling may be done for cross sections preparation. Since X-ray fluorescence (XRF) allows the study of a higher depth into the paintings, this was one of the main techniques for this research. Raman and FTIR will be used afterwards for surface layers characterization (e.g. pigments and binders).

Because this work is still in process, on the following pages we report the most relevant data derived from registration in UV and IR lighting, IR reflectography, and portable X-ray fluorescence spectrometry (XRF). A relation of results from original panel painting analysis and standards is presented.

RESULTS

Preparation of Standards

To facilitate the exposition of results of the comparative study between standards and original panel paintings, we have selected a table of references that contain a sample of each of the 25 colours that integrate the XVI c. palette (Table I). Colours were applied over a green priming.

The pigments were mixed with boiled linseed oil, and special attention was given to the final consistency of the coatings.

Each pigment required a specific preparation treatment that influenced on the general behaviour and final material characterisation. In this sense, it is important to mention that proportional relations between pigment and medium (oil) vary greatly due to the nature of each colour: for instance, pigments such as earths have a very high covering power, and only two coats were needed in order to cover the underdrawing. In contrast, mineral pigments such as azurite and malachite required between four and five coats of painting, and lakes were not able to cover the charcoal traces after six applications.

Photographic Register with Visible, UV Light and IR Reflectography

In order to guarantee the reproducibility of the photographic measurements, a selection and control of the equipment and conditions were established. Cameras, filters, luminaries, computers, and software were characterized. Illumination types and conditions highly secured and registered each time. The photographic parameters were defined after testing the equipment's efficiency (camera CCD's sensitivity to IR and UV and lenses luminosity) as well as that of the luminaries, and filters used by measuring all of these with a UV-IR spectrophotometer. The best results were attained with a Nikon D80, lens 18-50mm 4.5-5.6f (f22 for visible and IR, ISO100, and f5.6 for UV, with time variation of 2sec. for long wave, and 8sec. for short wave), in manual program and RAW format. For colour control we used Kodak Q14 colour scale and Greta Macbeth colour chart. No colour correction was applied to UV or IR photos.

The main results are presented in Table II. Nine pigments present a characteristic fluorescence under UV: these are all red lakes, lead tin yellow, smalt, malachite, and asphalt (bitumen). We've chosen the comparative register of the red lakes to show variations of florescence of the pigments.

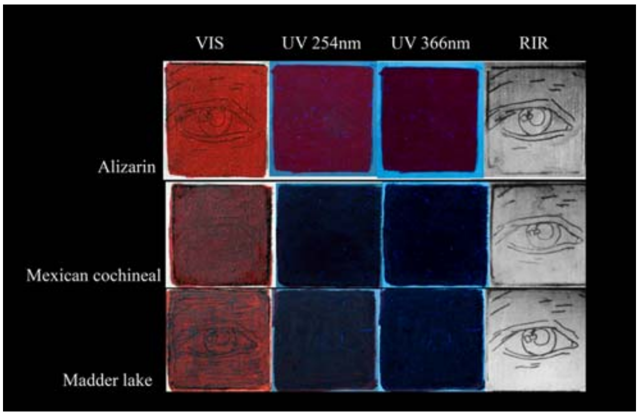
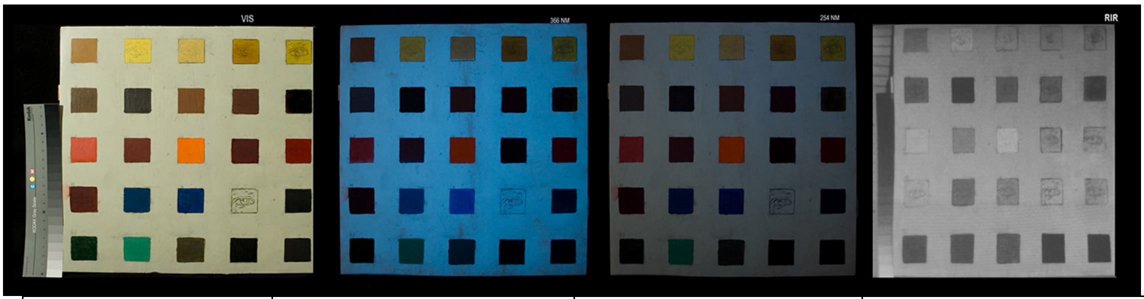


Figure 4. Characteristic optical properties and fluorescence for different red lakes under visible light and UV and IR lighting

Table II. UV and IR imaging of standards of pigments and lakes.



Pigment	UV 254 NM	UV 366 NM [a]	Infrared Reflectography [b]
Yellow Ochre	Non florescence	Non fluroresence	Transparent
Orpiment	Non florescence	UV Absorbent	Transparent
Lead Tin Yellow Type II	Low florescence- orange	UV Absorbent	Transparent
Weld dye, Reseda Luteola	Non florescence	Non florescence	Transparent
Raw umber	UV Absorbent	UV Absorbent	Transparent but brushstrokes marks remain visible
Burnt umber	UV Absorbent	UV Absorbent	Transparent
Raw sienna	UV Absorbent	UV Absorbent	Transparent but brushstrokes marks remain visible
Burnt raw sienna	UV Absorbent	UV Absorbent	Transparent but brushstrokes marks remain visible
Asphalt	Medium florescence-white	Low florescence-white	Semi transparent
Cinnabar, vermilion	High florescence-pink	Low florescence-pink	Transparent
Red iron oxide	UV Absorbent	UV Absorbent	Semi transparent
Minium, red lead	High florescence-cherry	High florescence-cherry	Semi transparent
Cochineal	Low florescence- red	Low florescence- red	Transparent
Alizarin	High florescence-pink	Low florescence-pink	Transparent
Madder lake	Low florescence- red	Non florescence	Transparent
Azurite	UV Absorbent	UV Absorbent	Semi transparent
Smalt	Low florescence-purple	High florescence-purple	Transparent
Indigo	UV Absorbent	UV Absorbent	Transparent
Verdigris	UV Absorbent	UV Absorbent	Opaque
Malachite	Low florescence-yellow	Non florescence	Opaque
Green earth	Non florescence	UV Absorbent	Opaque
Lampblack	UV Absorbent	UV Absorbent	Opaque
Carbon black	UV Absorbent	UV Absorbent	Opaque

[a] For UV light register we used a multiband lamp: Entela ® model UVGL-58, of 15 V~ 6º Hz. Short wave at 254 nm and long wave at 366 nm.

[b] IR reflectography by a lead sulfide Hammamatsu Vidicon tube camera, model C2471, range 400 to 1800 nm with 940 nm led lighting. Illumination quartz lamps Lowell® model Omni Tota - 750 watts. Photography directly from a B&W monitor. Digital images are treated using Photoshop® program and digital colorimeter. Colour control is made using Kodak Q14 colour scale.

The relationship between the reference standards and the original panel paintings let's us interpret the behaviour of some of the pigments present on the original canvases. For instance: cinnabar on Magdalene's lips, and asphalt on the landscape of the background on a panel from Huejotzingo (Figure 5), or the red lakes on the Virgin's dress on *La Sagrada Familia* (Figure 1).

Figure 5. Comparative images with UV and visible illumination. Magdalene, Huejotzingo, Mexico.

X-ray Fluorescence Analysis

X ray fluorescence has proven to be of invaluable help for *in situ* analysis of paintings because it allows a first general analysis and to establish a relationship between areas of colour and material composition, it is also very useful for the final selection of sampling areas. Portable X-ray fluorescence (XRF) was performed with an equipment (SANDRA) developed at IF-UNAM. Measurements can be carried out by two different X-ray detectors (CZT and Si-Pin) with a 75 W Mo X-ray tube. CZT detector is more suitable for pigments analysis with heavy elements while the Si-Pin detector may detect lighter elements. Measuring time was 60 s at 45 kV and 20 mA with a X-ray spot of 1 mm dia. For the references the Si-Pin detector was used.

Through the XRF analysis of the reference standards we have determined the instrument's effectiveness and sensibility to detect elements beneath known pictorial layers, such as priming and ground. We have also evaluated its sensibility depending on the paint film's nature and thickness. The left graph of figure 6 on the left shows the signal for hematite (Fe_2O_3), over two different grounds: calcium carbonate and calcium sulphate. This pigment allows us to infer the composition of the base (Ca or Ca and S) including Si. In fact, the S signal is very low by comparison to Ca peaks. This effect is due to the nature of excitation phenomena of XRF. In the graph on the right we observe that the presence of Pb due to a pigment (such as minium or even Hg from cinnabar) gives rise to strong interferences between the S and the Pb-M lines and a high absorption of Ca X-rays. Then, we may expect that usually it is not possible to determine directly the ground composition for a painting with ground, Pb priming and pigments layers, unless the ground is not covered. From the use of the reference it is established this limitation that is very important to determine the technical painting schools of XVI century from ground identification (calcite or gypsum). Besides other interferences may be verified, it is still possible to provide reliable information from priming and painting layers by systematic analysis of the paintings when analyzing lakes and pigments composed of lighter elements than Pb. References allows us to determine the experimental conditions for a suitable materials identification through the identification of specific elements (Figure 7). For instance it is interesting to observe the specific presence of K for the weld dyes and most of the elements of the green priming. This is due to a low absorption of the X-rays that can be verified from Pb-M/Pb-L ratios from the Pb in the priming. Similar behaviour is observed for other lakes.

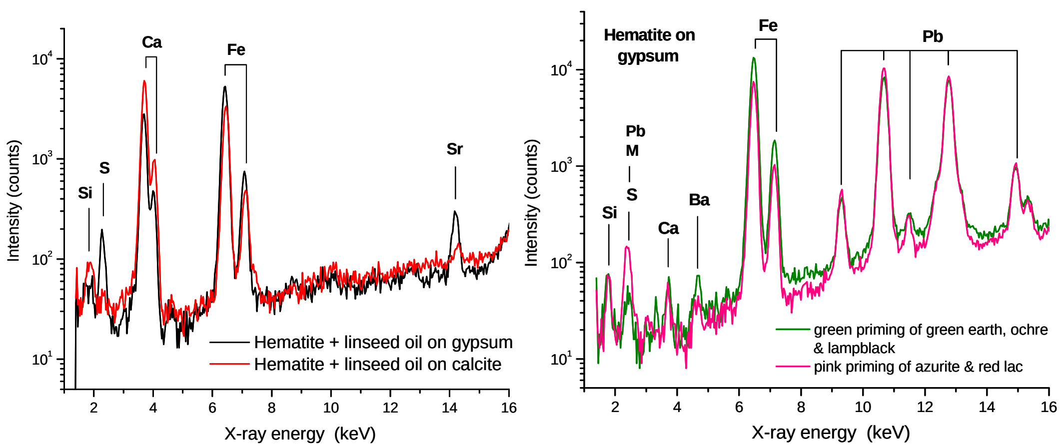


Figure 6. XRF spectra of hematite on gypsum and calcite grounds and various primings.

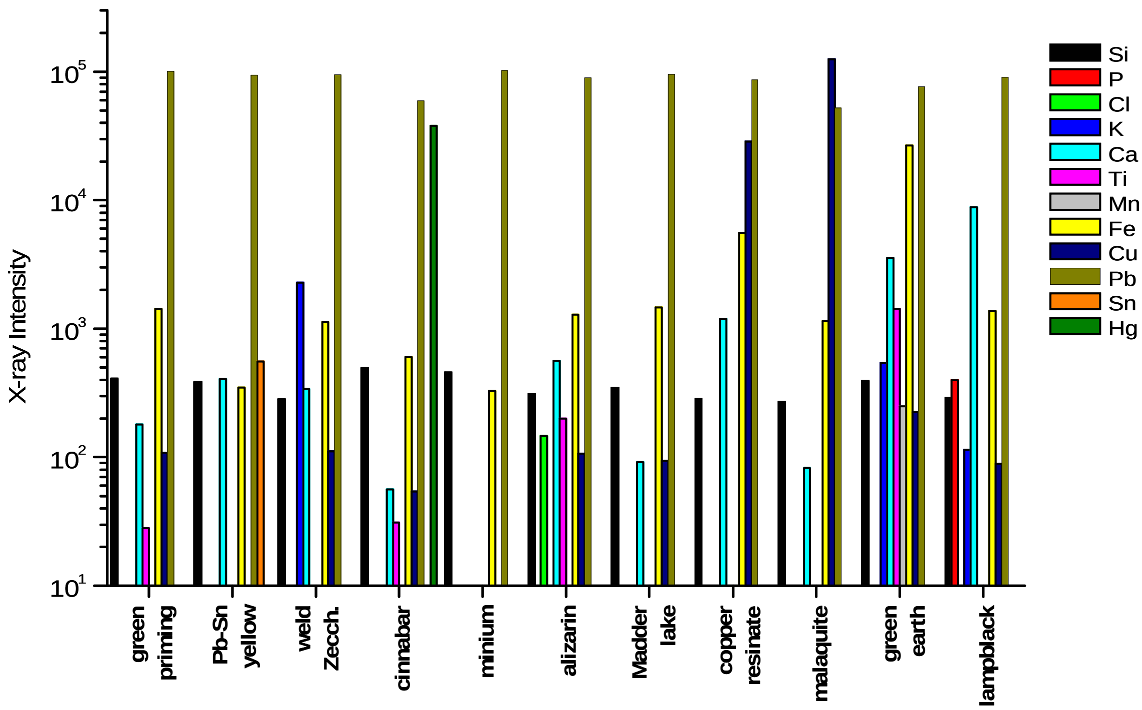


Figure 7. X-rays intensities detected for the pigments and lakes on the green priming (Table II).

Reliable information has been gathered when comparing the XRF spectra from blue pigments on our reference standards with the original paintings. The specific analysis of blue colours on original panels shows mainly the signals of the heavier elements, such as Pb, Cu, and Fe. Our experience painting the reference standards made us understand that azurite may be a very difficult pigment because of its particle size and poor covering power, thus, painters always mixed it with white Pb, and a huge quantity of medium. When analyzing the azurite references a similar response to that of the original paintings was obtained; that is, Pb, Cu, and Fe on the highest intensity signal are clearly seen. The presence of iron of the reference belongs to the green earth of the priming, the presence of iron on XVI c. samples also comes from an under coat. In this case, the information was confirmed after doing cross section analysis. Moreover, the behaviour of azurite on both, the original panels and reference standards correlates perfectly under UV and IR lighting.

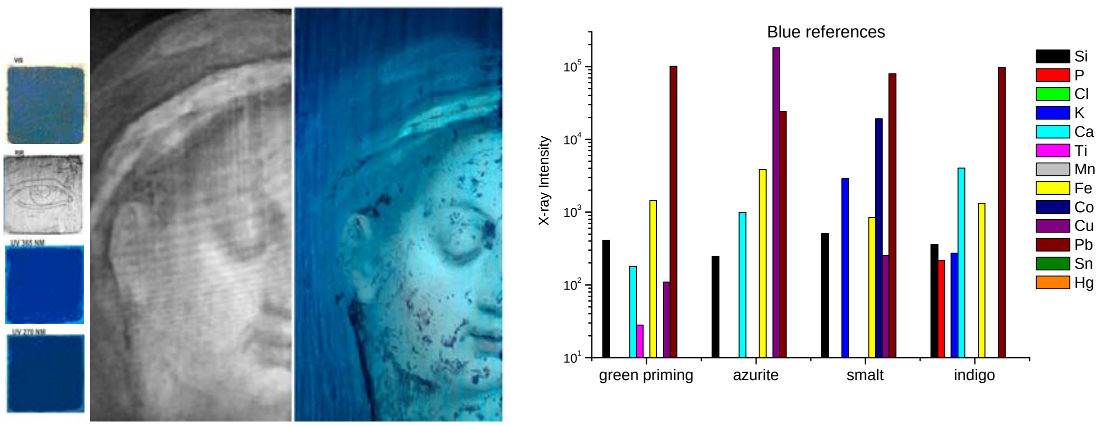


Figure 8. Comparative images of IR, UV and visible illumination, XRF of blue colors of the reference.

CONCLUSIONS

In the case of the study of XVI c. panel paintings history of art has constructed the History of the painter's guild through the search and interpretation of historical documents, such as contracts, edicts, commercial trade, artists' genealogies, not to mention the work of art itself. The stadium of knowledge about this period now requires the integration of new perspectives and questions that science can afford.

The scientific approach and all it's technology included, let's us today ask questions that go from the material reality: that is, from raw material, to it's modification by human hands, in order to arrive and understand material culture: technologies, expressions, solutions. In this sense, some of our results may seem simple, yet, to us are invaluable since they represent the foundations of a more complex and profound understanding of a historical period. We have developed a punctual methodology that puts emphasis in non destructive analysis. The creation of reference standards enabled us to know the particular behaviour of each pigment in relation to five different binders used during the XVI century, and the colour properties when the mixtures are applied on different grounds and primings. Besides the higher inherent complexity, this information opens the field of interpretation when viewing the original paintings.

Through the systematic registration of the reference standards with UV and IR lighting, infrared reflectography, and XRF we have collected information about the properties and characteristics of each material. The conjunction of this data with further analysis of three original XVI century panel paintings and other analytical data from organic materials using complementary techniques (Raman, FI-IR spectroscopies), will led us to construct a database that will integrate a platform for posterior case studies.

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