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CREATING THE ILLUSION: THE MARBLE AND STONE-LIKE DECORATION OF THE MAIN ALTARPIECE OF ST. FRANCIS CHURCH, IN VISEU

Irina Crina Anca SANDU[1*], Elsa MURTA[2], Fátima EUSEBIO[3], Rita VEIGA[4], Lia JORGE[5], Vânia Solange MURALHA[6], Manuel Francisco COSTA PEREIRA[7], Tito BUSANI[8], Nuno LEAL[9], Sílvia FERREIRA[10]

[1] Evora University/HERCULES Laboratory/Palacio de Vimioso, Largo Marques de Marialva, 8, 7000-809 Evora, Portugal
[2] José Figueiredo Laboratory, Department of Museums, Conservation and Certification - General Directorate of the Cultural Heritage, Rua das Janelas Verdes, 1249-718 Lisbon, Portugal
[3] Diocesis of Viseu, Department of Cultural Heritage, Seminário Maior de Viseu, Rua de Santa Catarina, 3504-517, Viseu, Portugal
[4] Conservator-restorer/Oporto, Portugal
[5] Faculty of Sciences and Technology, NOVA University of Lisbon, 2829-516, Caparica, Portugal
[6] Research Unit VICARTE: Glass and Ceramic for Arts, Faculty of Sciences and Technology, NOVA University of Lisbon, 2829-516, Caparica, Portugal.
[7] CERENA, Technical Superior Institute, Technical University of Lisbon, Av. Rovisco Pais, 1049-001, Lisbon, Portugal.
[8] University of New Mexico, Electrical and Computer Engineering and Center for High Technology Materials, Albuquerque, NM, USA
[9] GeoBioTec, Departamento de Ciências da Terra (FCT/UNL), 2829-516 Caparica, Portugal.
[10] IHA/ FSCH/ UNL – Art History Institute, Faculty of Social and Human Sciences, NOVA University of Lisbon, Portugal.

Abstract

The paper presents an innovative interdisciplinary study focusing on the gilded/ polychrome decoration emulating stone-like surfaces of a Rococo Retable from Saint Francis Church in Viseu, Portugal. This study was undertaken within a 3-year research project, abbreviated Gilt-Teller (http://www.gilt-teller.pt). For the characterization of the altarpiece's polychromy a representative number of samples were analyzed using a multi-technique methodology: Optical Microscopy coupled with fluorescent staining tests, microFTIR/FTIR and microRaman spectroscopy, micro-computerized tomography, Scanning Electron Microscopy coupled with energy dispersive X-ray spectrometry. Preliminary results reveal the stratigraphical and compositional characteristics of the polychromy: ground layers made of gypsum, anhydrite, calcium carbonate and animal glue; bole layers of red ochre color (Hematite); Au/Cu/Ag metal leaf, coated with shellac; marble-like polychromy made with blue, white and red pigments (Prussian blue, Lead white, Hematite, Vermillion) and "golden particles" (Cu-Zn alloy ink-type) applied in the form of fine lines on their shaft or on the round-shaped base of the columns.

Keywords: *Marble-like decoration; altarpiece; interdisciplinary study; gilding materials; decorative techniques;*

Introduction

Built and decorated in the 18th century, the main retable of the Church of St. Francis (Igreja da Ordem dos Terceiros de São Francisco) (Figure 1) in Viseu, Portugal, presents decorative elements that can be classified according to Robert Smith's taxonomy [1], placing it

* Corresponding author: irinasandu@uevora.pt

within the context of the Rococo style, which was developed in Northern Portugal between 1735 and 1765 [2]. The altarpiece is a devotional retable dedicated to Saint Francis and displays also many decorative gilded elements in neoclassical style showing signs of scholarly conception.

In the Rococo period, altarpieces showed some transformations in terms of structure and decoration, particularly when compared to the Baroque style. The structure was more vertical, simple and classic, and the decoration had new gilded ornamental motifs and a tendency to reproduce stone colors and textures such as marble, jasper, alabaster, lapis-lazuli, in association with gilded areas.

The gilded and polychrome decoration of the altarpiece under study was made by a group of three *painter-gilders* as mentioned in the 18th century legal contract [2]. The contract made on the 12th of September of 1769 between the priest Serafim Garcia Dinis e Castro and the three *painter-gilders* (Leonardo José da Mota, Arcângelo de Almeida and Manuel de Almeida) was very specific regarding the materials and number of layers to be applied, the sequence of their application, and how and where each decoration technique (gilding and stone imitation) must be employed.

Fig. 1. Frontal view of the altarpiece (a) and details:
b) Tabernacle decoration; c) base of a column;
d) marble-like decoration imitating lapis-lazuli stone, with gilded accanth leaves

Some details about the materials and their application were provided - four layers of *gesso grosso* ("*quarto mãos de gesso grosso"*), and other four layers of *gesso matte (gesso fino)*; *Armenian bole* in the areas meant to be gilded; all had to be bound with white glue made out of pieces of white animal skin ("*temperado com cola de retalho branco*").

Regarding the gold, the contract stated it must be of high quality and burnished, with some matte areas ("*ouro subido, bom e brunido com o seu fosco necessario*"). All flat areas should imitate marble stone of different qualities, whereas the four columns should imitate lapis-lazuli stone ("*e serão todos os lisos fingidos de pedra mármore de várias qualidades, conforme pedir a Arte = As quatro colunas fingidas de pedra-lazúli"*). High quality paints ("*tintas finas*") had to be used, and all should be burnished or varnished with two layers of good oriental lacquer ("*brunidas ou envernizadas com duas mãos de verniza de charão bom*").

The contract also stated the presence of four angels that must be gilded or made to emulate jasper. The four angels can be found at the top of the altarpiece, presenting gilded and painted decoration, which clearly reveals an option made by the artists.

Two different things were stated about the colors: on one hand the artists had to use the same colors of the altarpiece of Lord of the Steps (Senhor dos Passos) from the cloister of Viseu Cathedral, in order to make it appear as though it was made by the same artist. On the other hand, the artist should not use purple paints or others that would not last long ("*fugindo das cores de tintas roxas e de outras que têm pouca duração*"), showing a concern with the visual aspect and durability of the altarpiece, and raising the question as to which pigments the contract refers to.

Finally, the contract mentioned the overall price for the work: 200.000 réis.

Other contracts from the same period are known to make reference to the imitation of stones, such as alabaster ("*alabasto*"), marble ("*pedra mármore"*), jasper, and expressions as "jasper varnished stone" ("*pedraria gaspiada e invernizada*"), "jasper polished with skins" ("*jaspe de polimento pulido com pelle*") [3-4].

Based on the text of the above-mentioned legal contract, the present study underlines the characteristics of polychrome/gilded materials and techniques and the relationship between the initial intention of the commissioner and the present decoration of the altarpiece.

The marble-like (*marmoreado*) polychrome decoration of the altarpiece was made with a technique of great acceptance since the middle of 18th century and largely used in elements of the wooden architectural composition and other decorative elements of Baroque and Rococo churches. Pigments and a binder were mixed to form the paint to be applied on the wooden support, which was properly prepared with ground layers. To give a marble appearance to the decoration, thus creating the illusion of stone surfaces, it should be buffed with oiled felt or beeswax that was also sometimes used [5-6].

For the purpose of the analytical study of the materials and techniques used in this decoration, several instrumental analyses were performed on 10 samples taken from the gilding and stone-like decoration of the altarpiece. Samples were collected from four different marble imitations zones, one dark blue, one light blue, and two reddish-pink. On the area presenting lapis-lazuli imitation, the surface has a sponge-like appearance with different shades of blue, and fine golden lines made with a fine brush in order to imitate the real lapis-lazuli stone, which has characteristic whitish and metallic veinlets of pyrite. The reddish/pink marble imitation has highly contrasting color areas, from light pink to a very dark shade.

The applied interdisciplinary, multi-technique protocol of investigation was designed with particular attention to materials and technique of gilding and polychromy, being developed during a specific task of the Gilt-Teller project [7-8]. This protocol made use of optical microscopy (OM) coupled with fluorescent staining tests on cross-sections, microFTIR/FTIR and microRaman spectroscopy, micro-computerized tomography (microCT), and scanning electron microscopy (SEM) coupled with energy dispersive X-ray spectrometry (EDX).

Table 1 presents the 10 samples, the description of the sampling positions and also the photographic documentation of the sampling areas.

Table 1. Samples, sampling positions and description of sampling areas

Sample ID	Description of each sample and sampling area	Photography of the sampling areas
PT-AM-SFVs_1	Gilded decoration frieze from the right side of the Tabernacle	
PT-AM-SFVs_2	Arch's gilded decoration above the central angels of the Tabernacle	
PT-AM-SFVs_3	Gilded decoration from the rounded base of the right side column, area of fissure	
PT-AM-SFVs_4	Blue color imitating lapis-lazuli stone from the base of the inner column, left side of the altar	
PT-AM-SFVs_5	Blue color imitating lapis-lazuli stone from the base of the inner column, left side of the altar	
PT-AM-SFVs_6	Gilded decoration from the decorative element (leaf) from the base of the inner column, left side of the altar	
PT-AM-SFVs_7	Gilded decoration with blue color from the outer column, left side of the altar	
PT-AM-SFVs_8	Red-pink decoration from the frontal upper part of the "predela"	
PT-AM-SFVs_9	Blue color from the base of the column of the left side of the altar	
PT-AM-SFVs_10	Red color and gold from the central area of the Tabernacle	

Materials and Methods

Optical Microscopy and cross-sections analysis

Cross-sections were obtained using a two components polyester embedding resin (Crystal, furnished by Dinis dos Santos: www.dinissantos.com, Portugal). After curing, the resin blocks were cut and polished in order to reveal the paint/ground composite in cross-section. The cross-sections were dry polished with a series of successive finer grades of Micro-mesh abrasive cloths (600, 800, 12000 mesh). A felt was used for the final polishing. Water or other aqueous-based liquids were avoided during polishing since they could dissolve the proteinaceous component in the samples [9-10].

The cross-sections were observed at different magnifications (from 50x to 500x) using an Axioplan Zeiss 2 imaging binocular microscope and the images were acquired using a Nikon DXM1200F digital camera, coupled to the microscope. The filter blocks used for observing the fluorescence were filter 8 (G 365, FT 395 and LP 420) and filter 6 (BP 450-490, FT 510 and LP 515). Visual light observations (illumination position for dark field observation, abbreviated as f2) were performed in reflection geometry.

A fluorescent stain, Sypro Ruby [11], was applied on some cross-sections for mapping the proteinaceous binders in the ground, bole layer and paint layers [12-13]. The procedure is easy to apply (1 drop is applied directly on the cross-section surface using a Pasteur pipette) and has a very good detection limit (ng order), being preferred to other stains commonly used in the conservation field for protein detection and mapping.

microRaman analysis on cross-sections

The equipment used was a Labram 300 JobinYvon spectrometer, equipped with a He-Ne laser of 17 mW power operating at 632.8 nm and a solid state laser operating at 532 nm. The laser beam was focused with a 50x or 100x Olympus objective lens. The laser energy was filtered up to 10% using a neutral density filter for all analyses. The attribution of the Raman spectra was made using databases of reference materials reported in literature [14-15].

Fourier Transformed Infrared Micro-spectroscopy

A Nicolet Nexus spectrophotometer interfaced with a Continuum microscope (15x objective), with a MCT-A detector cooled by liquid nitrogen was used. The spatial resolution was 100 μm, the spectra being obtained with a resolution of 4 cm^{-1} in transmittance mode and 256 scans, , in an interval between 4000 and 600 cm^{-1}, using a Thermo diamond anvil compression cell.

Fourier Transformed Infrared Spectroscopy

FT-IR analysis was performed using a Perkin Elmer Spectrometer (Spectrum 65 Model) in the 4000–400 cm^{-1} (2.5–25 μm wavelength) region, with 4cm^{-1} resolution in transmittance mode. Each spectrum is the average of 10 scans. A small amount of sample was diluted in KBr and pressed under 10 ton/cm^2 during 10 minutes, to obtain a pellet. ***X-ray micro-Computerized Tomography***

X-ray microtomography allowed a three-dimensional (3-D) observation of the samples without sample preparation or chemical fixation [16-17]. Digital radiographs were acquired with a microCT SkyScan 1172 instrument using an X-ray cone incident on a rotating specimen. The instrument included a 1.3 Megapixel camera, being able to reach spatial resolutions of 5 μm with a detail detectability of 2 μm. Due to variable size and composition of the samples, the experimental conditions were optimized for each specimen using a constant source power of 10W (69kV and 167 μA): highly opaque samples were investigated with source voltage and current of, respectively, 100kV and 100 μA, and using downstream 0.5 mm aluminum filtration increase beam penetration in the samples in order to prevent ”beam hardening", a nonlinear X-ray absorption effect; less opaque were inspected with lower source voltages, without the use of a filter. The pixel size was chosen according the size of the analyzed objects and the final magnification of the radiographic images (PT-AM-SFVs_5: 2.85 μm; PT-AM-SFVs_9: 4.45 μm).

The data set after acquisition consisted of transmission X-ray images saved as 16 bit TIFF files and presented in Hounsfield units (HU) or attenuation coefficient units (m^{-1}); the number of images acquired depended on the rotation step selected. The radiographs of gilded samples showed relatively high contrast due to the difference in X-ray absorption between layers. A modified Feldkamp cone-beam algorithm (http:\\skyscan.com) has been used to reconstruct 3-D representations of the internal microstructure with mitigation of beam hardening and ring artifacts. Two sets of vertical slices (coronal and sagittal) could be generated by default in 3-D reconstructions. Slice reconstructions were obtained with the NRecon 1.6.3 routine and volumetric visualization has been achieved with *DataView*, which integrates the instrument software packages.

Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy

A ZEISS Auriga working at 5 KeV at a working distance of 9 mm was used for the scanning electron images. The elemental mapping was obtained using an Oxford x-act detector operating at 10 KeV and at 5.5 mm working distance in order to map the Kα and the Lβ peak of the element of interest. The samples were coated with a thin layer of graphite to render the surface conductive to the electrons beam.

The Auriga CrossBeam Workstation combined both a low pressure scanning electron microscopy and a focus ion beam (SEM-FIB) to image the samples considered in this work. The FIB system can be used to remove surface charge without damaging the sample. The low pressure and low current of the SEM can be used to acquire high-resolution images and to compensate for the surface charge. Typically the acceleration voltage was 1 KeV, the filament current of 2.32 A, the working distance (WD) 4.5-9.6 mm, aperture size 30μm, and magnifications of 200x, 1000x and 3000x.

Sample 5 was also analyzed using a HITACHI S3700N scanning electron microscope interfaced with a QUANTAX EDS microanalysis system. The QUANTAX system was equipped with Bruker AXS 5010XFlash® Silicon Drift Detector (129 eV Spectral Resolution at FWHM/Mn Kα). Standardless PB/ZAF quantitative elemental analysis was performed using the Bruker ESPRIT software. The operating conditions for EDS analysis were as follows: backscattered electron mode (BSEM), 20 kV accelerating voltage, 10 mm working distance. The cross-section was previously coated with graphite.

Results and discussion

The stratigraphic observation under visible and fluorescent light microscopy and the chemical characterization of the constituents in the polychrome layers allowed identifying the inorganic and organic components on each layer of the polychromy. In Table 2 a summary of the results obtained with the different analytical techniques used is given.

The ground layers were made of gypsum, anhydrite and animal glue; the yellow-reddish bole layers contain silicon, aluminum and hematite and the colored layers from the marble-like decoration on the columns of the altarpiece were made with blue pigment (Prussian blue), white pigments (lead white), while red pigments (Vermillion and Hematite) were applied in the marble-like polychromy of the Tabernacle and front decoration of the Altarpiece. Figure 2 shows the SEM-EDS mapping on two areas of a cross-section (sample 5) and identifies the presence of gypsum (Ca, S, O) with an organic components (P) in the ground and of Cu/Zn-based layer together with lead white (Pb) and a blue pigment (identified as Prussian blue by microRaman) in the polychrome layer.

Table 2. Schematic description of the identified materials, from the bottom to the surface layers

Sample ID	**Stratigraphical description** (MO, Vis-UV and micro-CT)	**Elements for each layer** (SEM-EDX)	**Inorganic component** (FTIR, micro-FTIR, microRaman)	**Organic component** (micro-FTIR, fluorescent stain)
PT-AM-SFVs_1	Gold leaf	Au, Ag, Cu, (23 karats gold leaf)		-
	White ground layer	Ca, S Zn	Calcite Gypsum (calcium sulphate)	Proteinaceous component in the ground and bole layers (animal glue)
			Hematite	
	Yellow-reddish ochre bole layer	Si		
	“Gold” layers made of different overlapped thin leaves with an organic layer in between	Cu, Zn Mn (from the organic phase?)		-
	Organic coating (varnish) with orange-yellowish fluorescence	-		Shellac as varnish layer
PT-AM-SFVs_2	White ground layer	-	Gypsum Kaolinite	Proteinaceous component in the ground (animal glue)
	Yellow ochre thin bole layer	-	-	-
	“Gold” leaf	-	-	-
	Varnish layer with grayish fluorescence under UV	-	-	Shellac as varnish layer
PT-AM-SFVs_3	White ground layer	-	-	-
	Yellow ochre thin bole layer	-	-	-
	“Gold” leaf	-	-	-
	Varnish layer with grayish fluorescence under UV	-	-	-
PT-AM-SFVs_4	White ground layer	-	Gypsum	Proteinaceous component in the ground (animal glue)
	Light blue layer with dark blue inclusions	-	Prussian blue Lead white	Proteinaceous component in the colored layer (egg white?)
	Dark blue layer			
	Varnish layer with fluorescence	-	-	-
PT-AM-SFVs_5	White ground layer	Ca, (S), P, Al, Sr, Si	-	-
	Blue layer with dark blue inclusions	Pb, Al, Si, Fe, Mg, Sr	Prussian blue Lead white	-
	“Gold” layer	Pb, Cu, Zn, S	-	-
	Thin layer of varnish	Cl (?)	-	-
PT-AM-SFVs_6	White ground layer	Ca, S	-	-
	Yellow ochre thin bole layer	Fe, Al, Si, K	-	-
	“Gold” leaf	Au, Cu, Ag (22.5 karats gold leaf)	-	-
PT-AM-SFVs_7	“Gold” leaf	Au, Ag, Cu (23 karats gold leaf)	-	Proteinaceous component in the gilding layer (from bole?)
	Ground layer	Ca, S, Si, Al, K	-	Proteinaceous component in the ground
	“Gold” leaf”	Au, Ag, Cu (23,82 karat gold leaf)	-	-
PT-AM-SFVs_8	Ground layer	-	Gypsum	-
	White color layer	-	Lead white	-
	Red color layer	-	Vermillion, Lead white Gypsum	-
PT-AM-SFVs_9	Ground layer	-	Gypsum Anhydrite	Proteinaceous component in the ground
	White color layer	-	Gypsum Anhydrite Calcite	Proteinaceous component in the colored layers
	Green-bluish color layer	-	Prussian blue	
PT-AM-SFVs_10	Ground layer	-	Gypsum	Proteinaceous component in the ground (animal glue)
	White color layer	-	-	Proteinaceous component in the colored layers
	Light pink color layer	-	Hematite	
	Dark pink color layer	-		
	Varnish layer with orange fluorescence under UV	-	-	Shellac as varnish layer

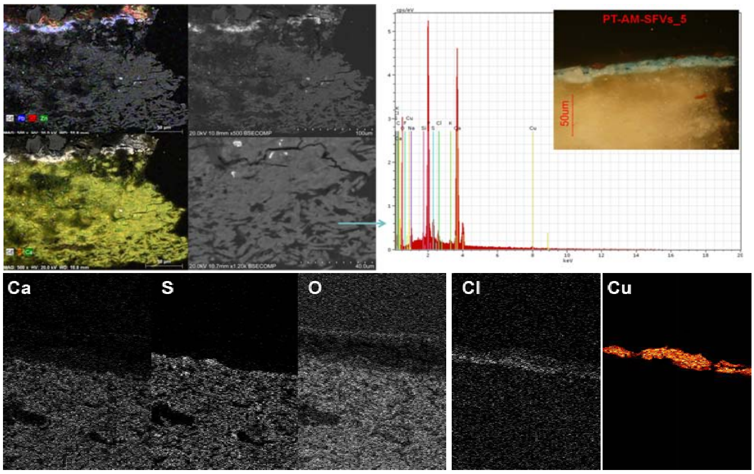
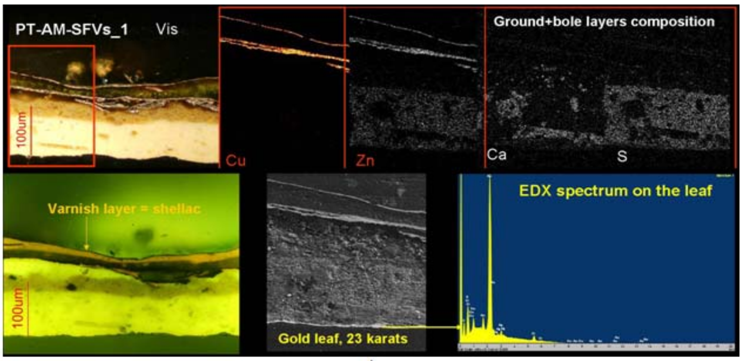
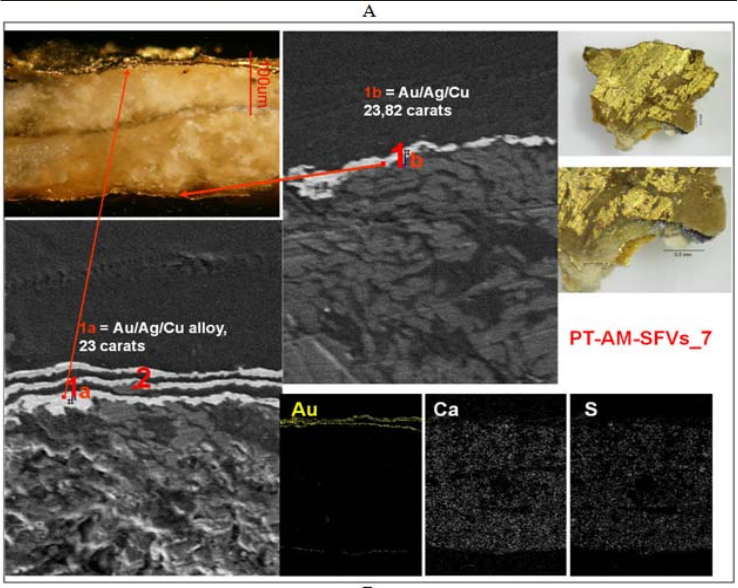


Fig. 2. SEM-EDS elemental analysis on sample 5



A



B

Fig. 3. Complementary microscopy investigation on two samples: A) Sample 1: visible and UV lamps (OM, Vis-f6) of part of the cross-section and SEM –EDX elemental mapping and identification of upper (Cu/Zn) and lower (Au-based leaf) gilding layers and of ground and bole layers; B) Sample 7: upper (1a) and lower gilding (1b) identified as gold leaf (Au/Ag/Cu) and gesso ground in between

Calcium carbonate (calcite) was detected by microRaman spectroscopy in the ground layer of sample 1 (Figures 3) and in the white layer of sample 9 (Figure 4). Its presence in the first sample is due to an intervention of restoration (based on the correlation of the visual observation of the altarpiece with the stratigraphic structure), while in the latter case the carbonate can be considered a white pigment belonging to the original layer of polychromy mixed with other components (gypsum and anhydrite as residues from the ground and grains of a blue pigment), as shown in Table 2 and Figure3.

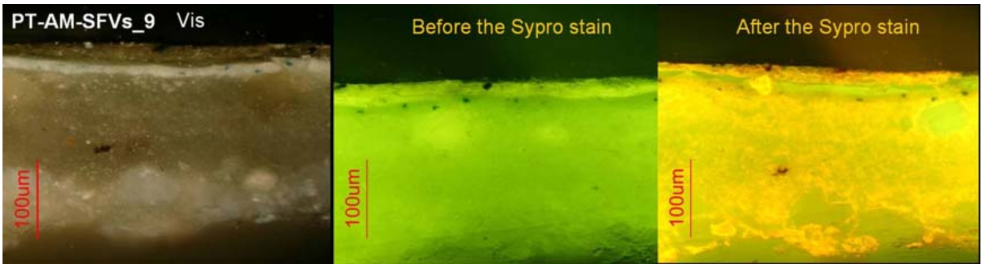


Fig. 4. OM-Vis observation and Sypro staining test for proteins on cross-section of sample 9

Regarding the construction of marble and stone-like appearance, different situations occur: presence of only one paint layer on top of the ground (samples 5 and 9); presence of two or three paint layers (samples 4, 8 and 10). In two cases (the imitations of red-pink marbles) a white layer was applied first on top of the ground, followed by the colored layers (light pink, and dark rose/pink, in sample number 10). Lighter tones seem to have been applied first, followed by the darker ones, and the paint seems to have been applied when the previous layer was already dry, although in some cases it is not completely clear.

Samples 4 and 5 were taken from different places from the column in which the surface layers imitate lapis-lazuli; in sample 4 there are two paint layers on top of the ground, one with a light color made essentially of lead white with some grains of blue; and a dark blue layer on top. On the other sample (5), only one paint layer was detected (of a light color), with a golden veinlet on top. The veinlet is made of a Cu-Zn-based alloy ink, already in use in late 18th century and was applied in the form of fine lines on the shaft of the blue columns (to emulate the veinlets of the lapis-lazuli).

The blue pigment present in samples 4, 5 and 9 was identified as Prussian blue (first produced around 1704) by microFTIR (Figure 5) and microRaman. This pigment was considered the most appropriate substitute for the original one made by grinding the lapis-lazuli stone, which was very expensiveat the time. Its synthetic version (ultramarine blue) would be discovered only later.

It was possible to conclude that the marble imitation in the decoration of the altarpiece was made using a simple technique, with one to three paint layers applied on top of the ground. Literature reports other more complex decorative techniques traditionally used to emulate stone, such as the "stucco-lustro", "stucco-marble" and "scagliola" [18], which do not apply to this case study.

The stone-like surfaces have a thick varnish that fluoresces stronglywith a whitish (under UV light, filter 8) or orange-yellowish color (green emission of fluorescence, Figure 6The original contract referred that the fake stones had to be burnished or varnished with two hands of good oriental varnish ("*brunidas ou envernizadas com duas mãos de verniz de charão bom*"). Nowadays, it is difficult to know if the varnish layers are all original or if something was later added. The fact is that the yellowing of the varnish and the deposition of superficial dirt has changed considerably the original color of the stone imitation areas. As Figure 6 shows the varnish layer in sample 10 acquired a strong orange fluorescent color. Correlating this with the identification of shellac by microFTIR in samples 1, 2 and 10 it can be assessed that shellac was largely used as coating layer in this altarpiece.

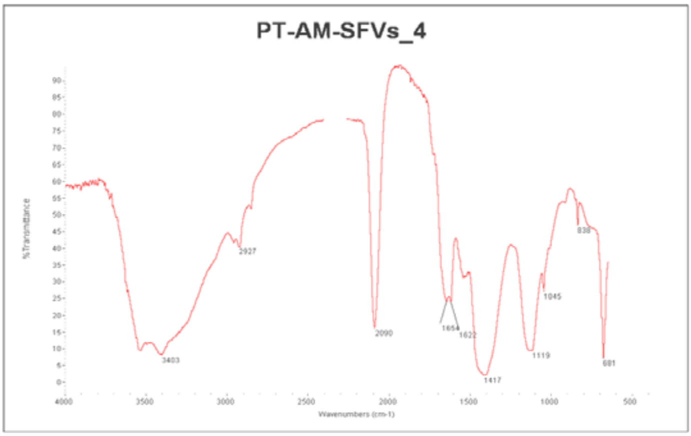


Fig. 5. microFTIR spectrum of sample 4 with the detection of Prussian Blue pigment in the paint decoration of the column

Apart from the shellac coating, the other organic materials identified in the samples were protein-based binding material (animal glue) in the ground and bole layers and probably a tempera component (egg white?) in the paint layers (sample 4). The microFTIR spectra identified characteristic bands for shellac (CH str at 2929/2930 and 2855/2857 cm^{-1}; 1713/1716 cm^{-1} for CO bending). The Sypro Ruby stain detected and mapped the presence of proteinaceous binders in the cross-sections (Figures 4 and 6), although it was not possible to specify which kind (absorption bands specific for proteins were detected at around 2844/2851 and 2924/2927 cm^{-1} for CH str, 1542 and 1654 cm^{-1} for NH_2 and CO Amide bands in samples 4 and 10). Further analysis should be performed to better assess the nature of the proteinaceous binder in the blue color polychromy.

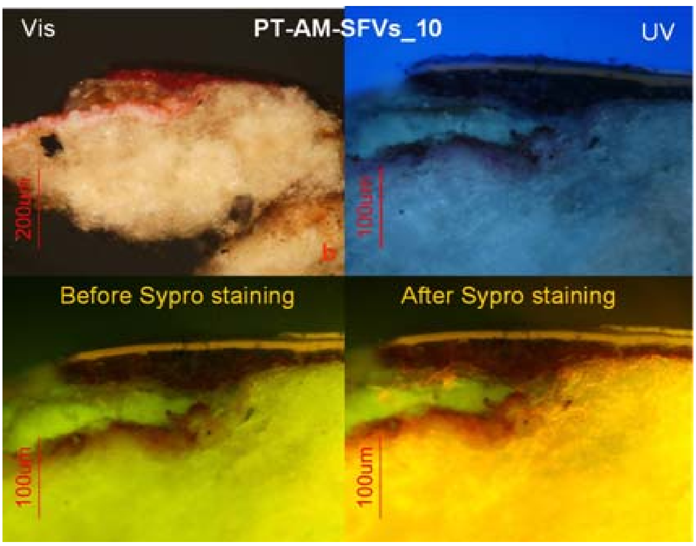


Fig. 6. OM (visible and UV lamps) observation and Sypro staining tests results on sample 10 from the red marble-like decoration

The observation by naked eye of the entire altarpiece decoration suggests that some of the areas have been restored and the gilding layers re-made. In sample 1, there are two gilding applications: one at the surface of the sample, made with a Cu-Zn-based alloy (probably an intervention of restoration) and covered by a fluorescent varnish (identified by microFTIR as being shellac); and another one at the bottom of the sample, made with a leaf composed of Au, Ag, Cu of 23 karats (Figure 3A). A similar situation of two gilding applications in the same sample stratigraphy was found in case of sample 7 ("gold" leaf decoration from the columns, Figure 3B). This sample is also an interesting case as it was collected in the boundary between gilded and blue marble imitation and the ground layers are present in the middle between the two gilding layers.

The bole layer is present only on the samples of the areas that were meant to be gilded (as the contractors asked: "*Armenian bole in the areas meant to be gilded"*). In sample 6, it presents a very light orange-yellow color and it is composed of a clay-based material (silicon, aluminum, potassium and iron were detected by SEM-EDX) with grains of pigments, seen by optical microscopy and stereomicroscopy (Figure 7).

Figure 8 gives the correlation between the SM, OM and microCT results on sample 5. The microCT reconstructed sections (Figure 8C) show the three main layers constituting the stratigraphy: coarse ground layer (*gesso grosso*), fine ground layer (*gesso mate*) and a "composite layer", including the paint layer of blue color (made of Prussian blue and lead white), the bole layer and the gilding made with a Cu-Zn ink to emulate veinlets of lapis-lazuli.

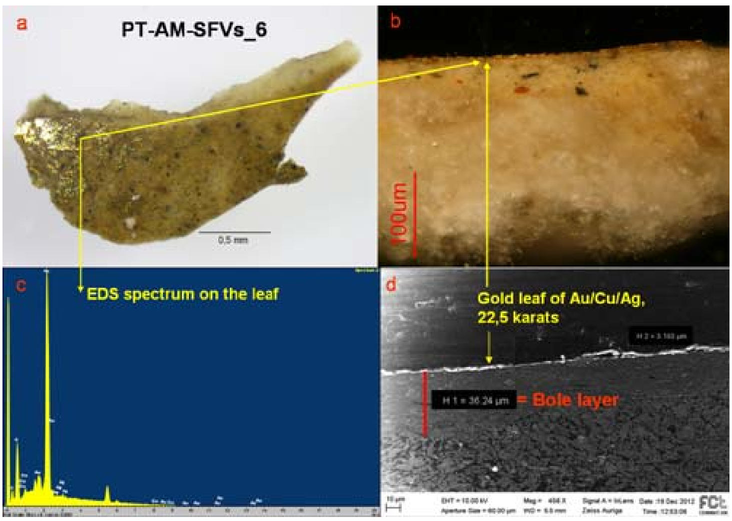


Fig. 7. SM, OM and SEM-EDS data for the sample 6: a) SM image of the sample (front side); b) OM-Vis image of the cross-section; c) SEM-EDS spectrum on the leaf; d) SEM image of the upper part of the cross-section showing the bole and gold leaf layers

The stratigraphic sequence and pattern observed by microCT for the "composite layer" has good correspondence with the OM stratigraphy. The first layers are presented in the microCT reconstructions with a purple color and the "composite layer" with very bright colors. The coarse ground layer and the interface between ground layers show high porosity. The interface pores are rounded, indicating that some organic binder was used. More refined layers can be also seen in the different ground layer, suggesting the repeated application of the technique, as indicated in the manufacture contract. Impurities (small bright features) and other physical heterogeneities are very frequent (Figure 8-d).

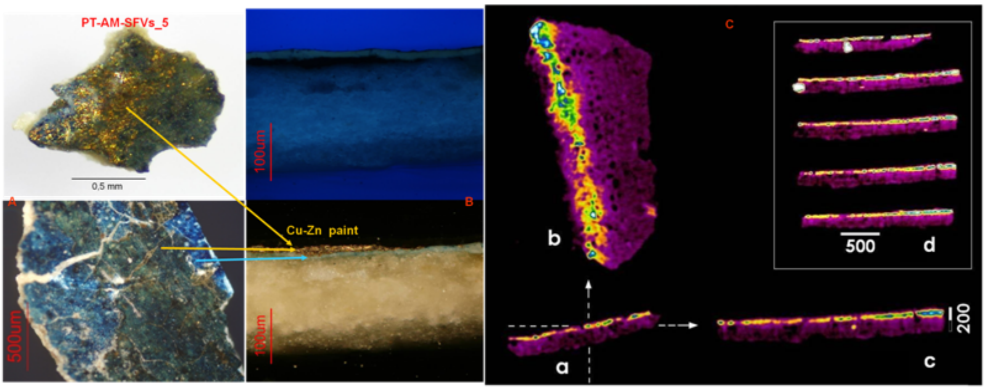


Fig. 8. SM (A), OM (B) and microCT (C) observations on sample 5 showing the different materials and layers present in the marble-like decoration of a column. MicroCT reconstructed sections in the lower half part of the figure: a - transaxial section; b - sagittal section; c - coronal section; d - set of coronal sections. Scan resolution 2.85 μm. Bar scales in μm

The SEM-EDX analysis of the gilding layers revealed also the presence of Cl in this sample, and this can be associated to corrosion processes of the Cu-Zn alloy that led to the formation of copper chlorides.

Conclusion

The decorative requirements stated in the legal contract, signed in 1769 between clericals and the three artists for the decoration of the main altarpiece of St. Francis church in Viseu, were fulfilled through the gilding and the polychrome marble-like stones of different qualities and colors - dark blue, light blue and reddish-pink.

The findings from the visual observation of the polychromy and from the integrated analytical protocol allowed us to conclude that in most cases, the technical and materials aspects were in accordance with the contract and the usual practices at the time. The use of ground layers made of anhydrite (*gesso grosso)* and gypsum (*gesso mate or gesso fino*), of Armenian bole to receive gold leaf of high quality (gold, silver and copper–based alloy leaf of 22 and 23 karats were identified), and varnishing of the marble-like areas with shellac were mentioned in the work contract and confirmed by analytical data. In some cases, as in areas of the Tabernacle, later restorations were detected and the chemical analysis confirmed the presence of gilding layers with different composition. Calcite was also identified in a sample (1) in the ground layers.

The marble-like decoration of the altarpiece was made with a simple technique, consisting in one to three paint layers applied on top of the ground. The paint layers contain pigments commonly used in the 18^{th} century, such as Vermillion, Hematite, Lead white and Prussian Blue.

The paint used in the marble-like decoration is not made of lapis-lazuli pigment (as stated in the 18^{th} century contract), but of Prussian blue. This pigment was considered the most appropriate substitute for the original one (lapis-lazuli), used to imitate the marble stones in ancient times but known to be very expensive. The "gold" lines imitating veinlets of the lapis-lazuli stone were made with a powder of Cu-Zn based-alloy and an organic binder, applied as liquid medium (ink) and not with powdered gold in Arabic gum binder, also known as shell gold.

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