

# A COMPARATIVE MULTI-ANALYTICAL STUDY OF THE POLYCHROMY AND GILDING IN TWO BAROQUE ALTARPIECES OF EVORA, PORTUGAL

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## Abstract

A dispute among the best five painters-gilders of Evora, for two of the most important contracts regarding the gilding of the altarpieces, gave rise to an extensive and detailed documentation on the technique, materials and prices used in 1729. The rivalry between the master Filipe de Santiago, responsible for the gilding of the whole set of the Church of Mercy (*Igreja da Misericórdia de Évora*), and the team led by Manuel da Maia, responsible for gilding the main altar of the Convent Church of Scala Coeli's (*Igreja do Convento de Scala Coeli, Cartuxa*), forced the commissioners to redraft contracts with unusual rigor since both did not accept the possibility to be examined by the opponent. Physical-chemical characterization of the gilding and polychrome layers of samples from both altarpieces, performed within the GILT-Teller project ([www.gilt-teller.uevora.pt](http://www.gilt-teller.uevora.pt)), led to a comprehensive approach of the pictorial culture of this period. As it is reported in contracts, the gilded woodcarving was enriched with flesh-coloured tones, "estofado" and "regraxos". These techniques were both used in the Church of Mercy and in the Church of the Convent of Scala Coeli, of the Carthusian monks of Evora. The documentation and the results of the physical-chemical analyses presented in this paper confirm the existence of a common and poorly differentiated artistic culture between the main workshops of Evora.

## Keywords

Portuguese gilded woodcarving, gilding and polychrome techniques, physical-chemical characterization of polychromy, 18th century.

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**ANÁLISE COMPARATIVA DO DOURAMENTO E POLICROMIA DE DOIS  
RETÁBULOS DE ÉVORA, PORTUGAL**

**Resumo**

Uma disputa entre cinco dos melhores pintores douradores de Évora deu origem à realização de uma extensa documentação sobre a técnica, os materiais e os preços em vigor em Évora, no ano de 1729. A rivalidade entre o mestre Filipe de Santiago, responsável pelo douramento do conjunto de talha da Igreja da Misericórdia, e a equipa liderada por Manuel da Maia que executou o douramento do retábulo da capela-mor da Igreja da Cartuxa, obrigou os comitentes a redigirem os contratos com um rigor inusual, já que ambos os mestres não aceitavam a possibilidade de serem examinados pelo oponente. A caracterização físico-química do douramento e das camadas de policromia de ambos os altares, realizada no âmbito do projecto GILT-Teller ([www.gilt-teller.uevora.pt](http://www.gilt-teller.uevora.pt)), permite-nos uma aproximação à cultura pictórica do período. Como é reportado nos contratos, o douramento da talha dourada foi enriquecido com carnações, estofado e "regraxos". Estas técnicas foram utilizadas de maneira muito semelhante em ambos os conjuntos da Igreja da Misericórdia e no Convento de Scala Coeli dos monges cartuxos de Évora. Os resultados documentais e analíticos dessa investigação confirmam a existência de uma cultura comum e pouco diferenciada entre as principais oficinas de Évora.

**Palavras-chave**

Talha dourada em Portugal, materiais e técnicas de douramento, caracterização físico-química da policromia, século XVIII.

**ANÁLISIS COMPARATIVO DEL DORADO Y POLICROMÍA DE DOS ALTARES  
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**Resumen**

Una disputa entre cinco de los mejores pintores doradores de Évora condujo a la realización de una amplia documentación sobre la técnica, los materiales y los precios vigentes en Évora, en el año 1729. La rivalidad entre el maestro Filipe de Santiago, responsable pela ejecución del dorado del retablo de la Iglesia de la Misericórdia de Évora, y el equipo dirigido por Manuel da Maia que realizó el dorado del retablo de la capilla principal de la iglesia de la Cartuja, obliga los comitentes a redactaren contratos con un rigor inusual, ya que ambos los maestros no aceptaron la posibilidad de ser examinados por el oponente. La caracterización físico-química del dorado y policromía de los dos altares, que se realizó en el ámbito del proyecto Gilt-Teller ([www.gilt-teller.uevora.pt](http://www.gilt-teller.uevora.pt)), permite acercarnos a la cultura pictórica de la época. Como se informó en los contratos, el dorado se ha enriquecido con tonos de

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carnacion, estofado y „regraxos“. Estas técnicas se utilizan de la misma manera tanto en la Iglesia de la Misericordia y en la iglesia de Scala Coeli del convento de los monjes cartujos de Évora. La documentación y los resultados de los análisis químicos presentados en este documento confirman la existencia de una cultura artística común y poco diferenciada entre los principales talleres de Évora.

### Palabras clave

Retablo dorado en Portugal, materiales y técnicas de dorado, caracterización físico-química de la policromía, siglo XVIII.

### INTRODUCTION

Since the beginning of the sixteenth century, there is a certain social stratification among the “óleo” (oil) painters and the “têmpera” (distemper) painters. Besides, this social differentiation turns out to be the result of the struggle’s process for the social recognition of the painters, as evidenced by the lawsuit moved by Lisbon decorative painters (têmpera) in order to achieve the same benefits granted to the “oil” painters (SERRÃO, 1982). Generally speaking, this specialization occurs after a common training, taking place due to a professional strategy, and marks the painter’s career in artistic terms.

Another important factor of distinction between the painters is their belonging to the learned circles of Lisbon, where new artistic ideas are accepted and discussed and where the best professionals are appreciated and rewarded social and economically. Évora, in the late 15th century and throughout the 16th century, benefiting from long court stays, was able to sustain a vibrant and independent art scene. In the seventeenth century, with the establishment of the court in Lisbon, it becomes even more evident the importance of the archbishops patronage action, as sponsors throughout all the archbishoprics (SERRÃO, 2015).

After the long and difficult process of restoration of the Portuguese independence, the year 1729 is one of great optimism. The gold and precious stones from Brazil, in constant flux since the last decades of the seventeenth century, allow the King João V compete with other European monarchs and develop an artistic patronage in the magnificent shape of a great Maecenas. The double marriage between the monarchs of Spain and Portugal, or as it will become known, “the exchange of the princesses”, is like a return to political normality, reinforcing the peace agreements reached in Lisbon, in 1668.

This year (1729) of celebrations imposes many artistic interventions in the way of the magnificent bridal peregrination that drove the Spanish princess from Caia to Lisbon. It is due to several royal donations that ended the gilding work of the alterpiece of the Church of Scala Coeli probably carried out three decades ago (LAMEIRA, 2005) (Figure 1) <sup>1</sup>. It is also in

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<sup>1</sup> “*El Rei D. João V, que Deus tenha em glória, deu por uma consulta cinco mil cruzados que se cobraram no Almojarifado de Évoramonte e no ano de 1729 deu outros cinco mil cruzados na ocasião das passagens das Princesas para Portugal e Castela que todos se aplicaram às obras da igreja, dourados e pintura e como ainda*

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1729 that are finally completed the gilding works of the Church of Mercy of Évora, covering with gold the master carver's work of Francisco da Silva (MANGUCCI, 2008) accomplished between the years 1710 and 1714 (Figure 2).



**Figure 1** – General view of the main altarpiece of the Church of Scala Coeli, atr. Francisco Machado, c. 1700.



**Figure 2** – General view of the main altarpiece of the Church of Mercy, Évora. Francisco da Silva, 1710-1714.

These two decorative campaigns, for most years the bulkiest held in the Archbishopric of Évora, was a strong incentive for a fierce competition among Évora gilders-painters. On the one hand, the team led by Manuel da Maia and, on the other, the painter Filipe de Santiago. The distrust between the two sides, who denied the possibility of a final evaluation of the work by a master of the city, forced the drafting of quite detailed contracts that give us a complete information of the various techniques associated with the gilt.

The comparative study of these two campaigns, with the completion of physical and chemical analyses performed on samples taken from polychromy and gilding, contributed to the knowledge of a variety of plastic resources used by gilders-painters, particularly in the context of Évora's artistic world in the eighteenth century. It also allows us to know the social life of these regional painters who established client networks with the major religious institutions in the city.

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*faltava o dourado dos retábulos, o Nosso Padre Prior fez súplica ao mesmo Senhor D. João V, que logo segundo a sua costumada piedade e grandeza deu outros dois mil cruzados com que se acabou o douramento*<sup>n</sup> [Lameira, 2014].

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### HISTORICAL BACKGROUND

The study of gilded carved wood in Évora offers a good opportunity to understand the development of the decorative arts in the regional context. Unlike the painting of tiles in Lisbon, the execution of gilded woodcarving requires the establishment of regional workshops, and Évora was a radiating centre for the Alentejo, in the seventeenth and eighteenth centuries. On the other hand, there is still a “dependence” from Lisbon, with the renewal of generations and the start of new art ideas, made by the out coming of new masters from the capital (MANGUCCI, 2010).

In Évora, there are examples of recognized painters who, attracted by a good economic return, perform or supervised the gilt of altarpieces. This is the case of painter Francisco Nunes Varela (1621-1699) responsible for the gilding of the chapel of Our Lady of the Rosary’s altarpiece, in the church of the extinct Convent of St. *Domingos*, for the sum of 250 000 reis, in 1667 (BORGES, 2014).

In this particular case of Filipe de Santiago and Manuel da Maia, we are dealing with regional artists with a weak individual recognition and their pictorial productions extend from a wide range of contributions of small interventions of restoration, conducting pictorial campaigns on fresco and oil paintings. We could say that they are considered painters in the most technical mean of the word.

The painter Filipe de Santiago, over which we have more data, was the author of the fresco painting of the church of Safara, in Moura (SERRÃO e CAETANO, 1999) in 1722. The painter has established relationships with various Churches of Mercy in Alentejo, and in spite of constant complaints, he accumulated enough money to send two daughters to the village’s convent.

Manuel da Maia was “brother” of the Mercy of Évora, having participated in the important Lord’s burial processions, dressed like a prophet. He was responsible for carrying out several interventions of sculptures and small restorations. In 1702, with other painters, he gilded the altarpiece of the Dead Christ Chapel in the church of the brotherhood.

The agreement<sup>2</sup> for the gilding work, which was signed on July 24, 1728, between the Mercy and Manuel da Maia, Bernardo Luis, Francisco Ferreira and José Correia, lists a number of technical recommendations related to the intended pictorial results, making it possible that behind the writing of the contract there is a strong artistic culture, which was unusual:

*“primeiramente se obri/garção a dourar toda a obra de madeyra que es/tiver no frontespicio da igreja com o ouro/ mais corado que ouver e alguns vãos que tiver o en/talhado porque pairesse em que est a/centado os pintarão de jalde para que a pa/rede com a brancura da cal não deslus/tre o dourado. As figuras, serafins, es/cultura e a mais obra que estofarem sera/ tudo sobre ouro e não sobre prata ou tin/ta alguma, e as encarnações serão de poli/mento, e não de pincel toda a obra se/ aparelhará com nove mãos de aparelho/ em sua*

<sup>2</sup> Arquivo Distrital de Évora. Santa Casa da Misericórdia de Évora, n.º 27. *Livro de Lembranças que começou em 1728*, fl. 19 v.º-20.

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*conta, que será de retalho de luva/ fino e os estofados das figuras e azas dos/ serafins se estofarão com as cores mais/ finas e os regraxos desta obra de verdes/ estilhados, e lacras muito finas e subidas que o ouro sera todo burnido, e apressen/do a essa meza que se lhe fação alguns/ foscos e serão feytos sobre ouro, o que ficara/ ao arbitrio da mesma determinar se há de/ levar a dita obra os taes foscos ou se ha de ser/ do de burnido...<sup>3</sup>*

For its part, the agreement<sup>4</sup> between Filipe de Santiago and the carthusian fathers, concluded on March 31, 1729, was concerned primarily in defining the preparation of layers for the gilding, this preparation composed of three layers: the first with coarse plaster, the second with fine plaster and the last the bole in a total of eleven “hands” superimposed:

*“elle dito Philipe de São Thiago será obrigado a trazer por sua conta/ na dita obra do dourado do dito retabolo tribuna da dita cappela mayor da dita igreja da/Cartuxa seis pessoas efetivamente cada dia the final conclusão da dita obra; aparelhando/ a mesma com boa e san consciencia para o que elle dito Philipe de São Thiago fará dar/ por sua conta onze mãos de aparelho das quais serão três mãos de jesso grosso quatro mãos de/ jesso mate e quatro mãos de bôllo; E outrossim que elles ditos Reverendos Relligiosos seram obrigados a pagar e satisfazer a elle dito Philippe de São Thiago a importancia das encarnações/ e estofados e mais pinturas que forem necessarias e se fizerem no dito retabolo e tribuna da dita/ capella maior da dita igreja; Como também seram obrigados elles ditos Reverendos Relligiosos/ a pagar e satisfazer a elle dito Philipe de São Thiago dois mil e novesentos e quarenta reis pello/ trabalho de suas mãos por cada hum milheiro de ouro, que lhe dourar<sup>5</sup>.*

In both cases, these first contracts had no effect and the masters were replaced. Therefore, Filipe de Santiago carried out the gilding of the altarpiece of the Mercy of Évora, and Manuel Maia the gilding of the convent of the Charterhouse.

Given the chronological proximity, the belonging to the same local cultural context, the uniqueness of the cross-drafting of the contracts, and the availability of raw materials, we might expect not to find any substantial differences between the decorative campaigns of

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<sup>3</sup> “..first of all, they will gilt all the woodcarved that is in the frontispiece of the church with the most coloured gold and there are some gaps in the wood-carved that seems would be prepared with “jalde” because the whiteness of the lime not tarnish the gold. The figures, seraphs, sculpture and more work that will be “estofado” is all over gold and not silver or paint, and the flesh tones will be polishing, not by brush. The entire work will be prepared with nine “hands” in your account, which will be polished with fine gloves and the upholstery of figures and wings of the seraphs will be “estofado” with the finest colours and „regraxos”. This work of green “estilhados” and lacquers very thin and subtle and the gold will be all burnished, and if the direction of the Mercy will make some dull, will be made over gold, which had been the arbitrariness of it determine whether to take the work dull or if there is to be burnished...”

<sup>4</sup> Arquivo Distrital de Évora. Cartórios Notariais, Livro 1261, fls. 7 e 8.

<sup>5</sup> “Him, Filipe de São Thiago will be required to bring with,/ for the work of the gilt of the altarpiece of the church/ of Chartreuse, six people effectively every day until the end of the work; preparing/ the woodcarving with good and sane conscience for what he, Filipe de São Thiago will give/ at your own, eleven “hands”, and it will be three hands of thick plaster, four hands,/ “mate” plaster and four hands of Bole; and likewise said that they, the fathers will be required to pay and satisfy him, Filipe de São Thiago, the importance of carnation/ and upholstery and more paintings that are necessary, and if done on the altarpiece of that church; as well they will required to/ pay and satisfy Filipe de São Thiago, with two thousand and nine hundred and forty “reis” for/ his work for every thousand of sheet gold, that was gilt...”

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the Charterhouse and the Mercy of Evora. Few samples were taken from the two altarpieces to prove this statement.

Of particular interest is the term used to describe the “regracho” technique. As shown by the *Tratado* of Filipe Nunes, the most widely spread book on painting (1615), the technique must be used for a colour gradation over gilt (NUNES, 1982)<sup>6</sup>.

### ANALYTICAL PROTOCOL

The analytical protocol on several samples taken from both altarpieces aimed to the characterization of the layers in the polychrome structure of the gilding and paint over the carved wood decoration, for a comparative study of materials and techniques.

### Sampling

The following samples were taken: 9 samples from the main altarpiece of the church of Mercy and other 9 from the altarpiece in the convent of Cartuxa. The gilding areas are represented in the samples: PT-AM-IMEv\_1 to 3, 6 (restoration area) and 9 (throne area), PT-AM-CCxEv\_1 to 4, 6 to 8 and 10. The polychromy samples have different colors: red (PT-AM-IMEv\_3 and 4; PT-AM-CCxEv\_4, 6 and 10); green (PT-AM-IMEv\_5 and 7, PT-AM-CCxEv\_1), blue (PT-AM-CCxEv\_7) and white-pink (PT-AM-IMEv\_8 and PT-AM-CCxEv\_5 - flesh tones). The samples, after being labelled with the acronym established for each altarpiece, were stored and are fully documented in the PC database of the Gilt-teller project [SANDU, 2013].

Figure 3 shows some examples of sampling areas and the taken samples.



Sample PT-AM-CCxEv\_1, taken from the medallion from the support of the first column of the left side (green polychromy).

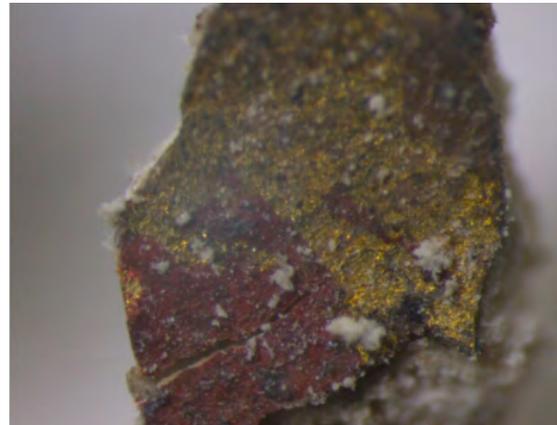
<sup>6</sup> “O que quiserdes regraxar fareis primeiro com branco & preto, mas os altos sejam bem brancos, & os pretos bem pretos. Depois de enxuto e seco tomay o Verdete muito bem peneirado...”.

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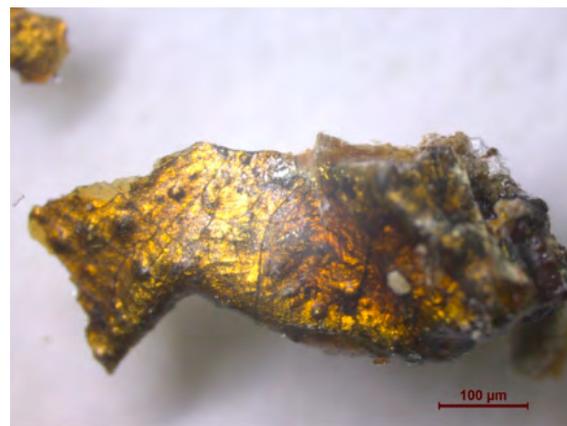
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Sample PT-AM-CCxEv\_1, taken from the mascara head of the support of the first column of the left side (green polychromy).



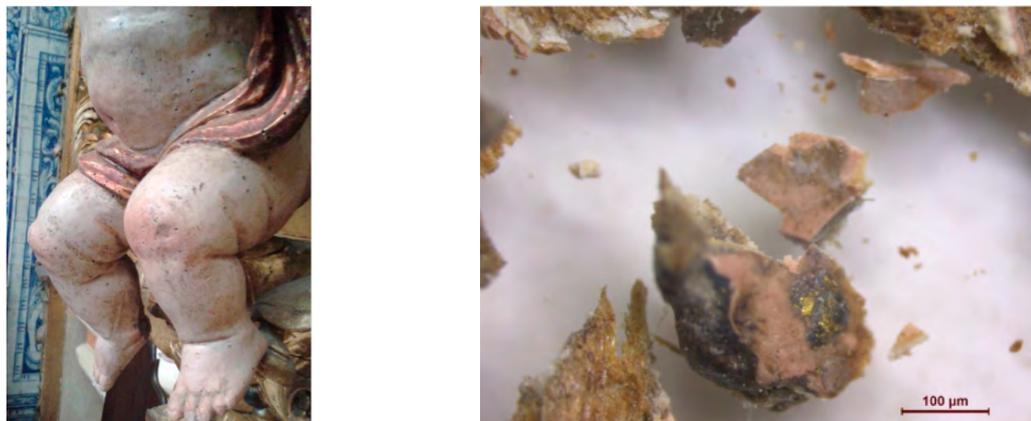
Sample PT-AM-IMEv\_4, taken from the red polychromy of the flower from the pilaster on the left side of altarpiece.



Sample PT-AM-IMEv\_6, taken from the restoration area on the column from the left side of the altarpiece.

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Sample PT-AM-IMEv\_8, taken from the foot carnation (behind) of the canatid angel, left side column.

**Figure 3** – Selection of sampling areas and samples for both altarpieces.

### **Experimental conditions**

The analytical protocol proposed within the Gilt-Teller project [SANDU, 2013] made use of several techniques aimed to characterize the gilding layers and polychromy and to identify the techniques applied by the gilderers/painters in the attempt to establish similarities and differences in the materials and techniques of the two altarpieces. Thus optical microscopy (OM, visible light and UV) was used on cross-sections of samples together with scanning electron microscopy coupled with energy dispersive X-ray spectrometry (SEM-EDS), and Infrared Fourier Transformed micro-spectroscopy (microFTIR). Liquid chromatography with diode array detector coupled with mass spectrometry (LC/DAD/MS) and pyrolysis gas-chromatography coupled with mass spectrometry (Py-GC/MS) were also performed on micro-fragments.

**Cross-sections** were obtained using an Epofix embedding resin with hardener, dry polished with successively finer grades of Micro-mesh abrasive cloths (500, 800, 1200, 2400 and 4000 mesh). A felt was used for the final polishing. For the better optical microscopy observation a drop of glycerol was applied and then a glass lid over the surface of the cross-section.

**Optical microscopy** images were taken from the surfaces and cross-sections at different magnifications (from 100× to 500×) using an LEICA DM2500M binocular microscope, coupled to a digital camera. Visual light observations (illumination position for dark field observation, position 1) were performed in reflection geometry and for the fluorescence observation an UV block filters was used (position 3).

**Scanning electron microscopy** was performed with a HITACHI S3700N interfaced with a QUANTAX EDS microanalysis system, equipped with a BRUKER AXS 5010XFlash® Silicon Drift Detector (129 eV Spectral Resolution at FWHM/Mn K $\alpha$ ). The operating conditions for EDS analysis were as follows: 20 kV accelerating voltage and 10-12 mm working distance.

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During the analysis backscattering images, point analysis and chemical mapping data were obtained on cross-sections that were previously coated with graphite.

For the **Infrared spectroscopic analysis** on 3 samples a Bruker Tensor 27 model spectrometer was used, in the MIR region of infrared. The spectrometer was coupled to a Hyperion 3000 microscope controlled with a software OPUS 7.2, Copyright© Bruker Optik GmbH 2012, with a MCT detector (Mercury Cadmium Telluride ) which allows acquisition of spectra on different points on a sample. The samples were analyzed in transmission mode using a 15x objective and a compression diamond microcell EX'Press 1.6 mm, STJ-0169. The IR spectra were taken within 4000-600  $\text{cm}^{-1}$ , with 64 scans and a spectral resolution of 4  $\text{cm}^{-1}$ .

Only 2 samples (PT-AM-IMEv\_3 and PT-AM-CCxEv\_10) were analyzed by **LC/DAD/MS and Py-GC/MS** to identify the red lake and surface coating (varnish). Each sample was separated in 2, observed under stereomicroscope (each weighing less than 200  $\mu\text{g}$ ), one microfragment for each analysis.

The lake extraction was done according the methodology published by Wouters et al (WOUTERS, 2011). Each sample was placed in a centrifuge vials to which 200  $\mu\text{L}$  of a solution of methanol/acetone/water/hydrofluoric acid (30:30:40:1; v/v/v/v). The extraction took place during 4 hours, at room temperature. Then the solvent for extraction was completely removed by liofilization and the samples were diluted again in 50  $\mu\text{L}$  of methanol/water (1:1, v/v), centrifuged at 8000 rpm for 10 minutes, and then the supernatant was removed and placed into the LC/DAD/MS system.

The samples of surface coatings were put into a stainless steel Eco-cup and derivatized with 10  $\mu\text{L}$  of tetramethylammonium hydroxide (TMAH, 25% in methanol).

The analyses were carried out in a LCQ Fleet Thermo Finnigan mass spectrometer equipped with an electro-spray ionization source and an ion-trap mass analyzer. The MS analysis conditions were: capillary temperature of 300°C, source voltage of 5.0 kV, source current of 100.0  $\mu\text{A}$  and capillary voltage of -7.0 V in negative mode. The analytes were detected in full MS mode (100-800  $m/z$ ) and two segments were used: 10.0 V of source fragmentation from 0-12 minutes and 30.0 V of source fragmentation from 12-30 minutes.

The mass spectrometer was coupled to an HPLC system with autosampler (Surveyor Thermo Finningan) and diode array detector (DAD). The analytic column was a reversed phase Zorbax Eclipse XDB C<sub>18</sub> (Narrow Bore, particle size 3.5  $\mu\text{m}$ , 150 mm x 2.1 mm). Column temperature was set at 30 °C and tray temperature was set at 24 °C. Chromatographic separation occurred at a mobile phase flow of 0.2  $\text{mL min}^{-1}$ , and 20  $\mu\text{l}$  of sample were injected. The mobile phase was composed by an aqueous solution of 0.1 % formic acid (v/v) (solvent A), and acetonitrile (solvent B), using the following elution programme: 0-63 % of solvent B from 0-14 minutes, 63-90% of solvent B from 14-25 minutes and 90% of solvent B from 25-30 minutes. The DAD detector was programmed to collect spectra between 200 and 800 nm. For the analysis by Py-GC/MS a system with a Frontier Lab PY-3030D double shot

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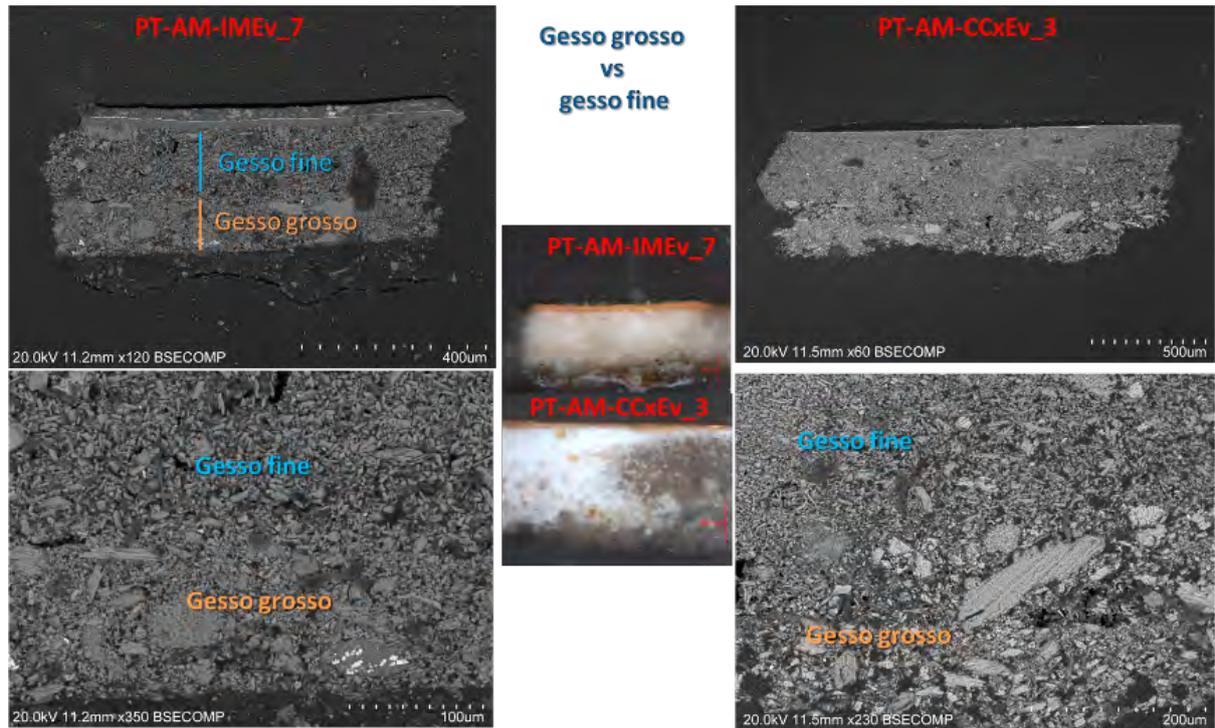
pyrolizer was used. The interface was maintained at a temperature of 280 °C. The pyrolizer was coupled to a Shimadzu GC2010 gas chromatographer, also coupled to a Shimadzu GCMS-QP2010 Plus mass spectrometer. A capillary column Phenomenex Zebron-ZB-5HT (15 m length, 0.25 mm internal diameter, 0.10 µm film thickness) was used for separation, with helium as carrier gas, adjusted to a flow of 1.5 mL min<sup>-1</sup>. The splitless injector operated at a temperature of 250 °C. GC temperature programme was the following: 40°C during 5 minutes, ramp until 300 °C at 5 °C min<sup>-1</sup>, and then an isothermal period of 3 minutes. Source temperature was placed at 240 °C and the interface temperature was maintained at 280 °C. The mass spectrometer was programmed to acquire data between 40 and 850 *m/z*. The samples, previously derivatized in a 50 µL Eco-cup capsule, were placed in the double-shot pyrolizer using an Eco-stick. The capsule was placed in the pyrolysis interface, followed by a 2-minute helium purge. Samples were pyrolyzed using a single-shot method at 500°C during 12 seconds.

## **RESULTS AND DISCUSSION**

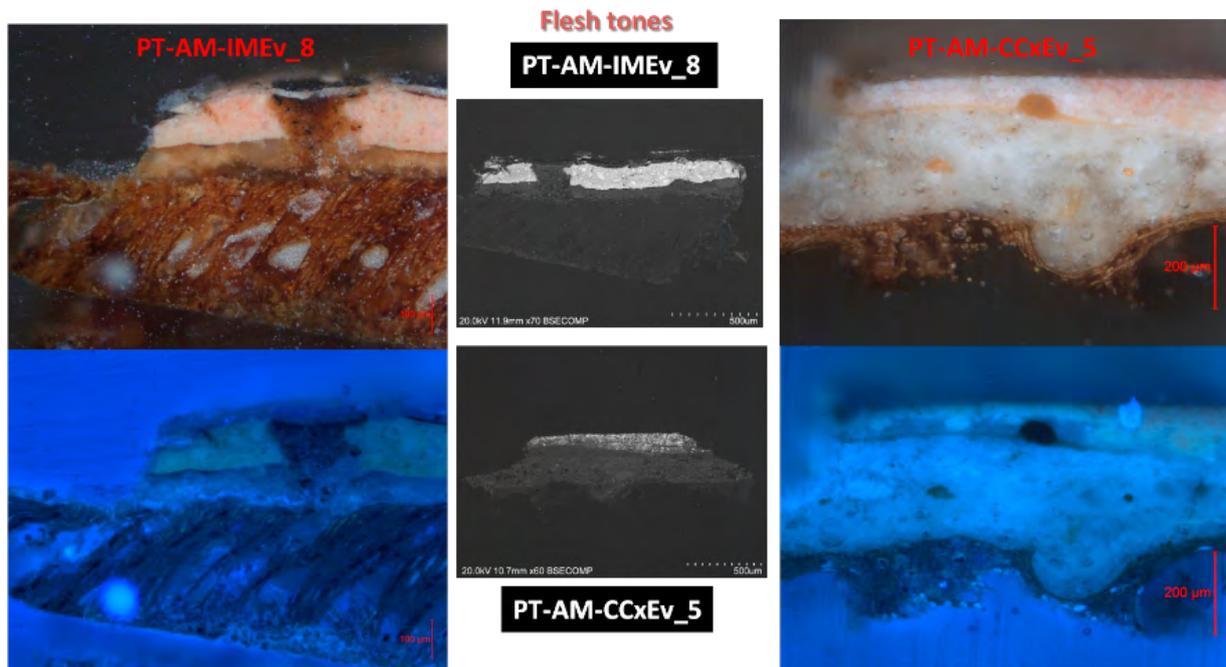
The OM and SEM microscopic observation reveal a similar stratigraphic pattern and sequence of layers. Over the wooden support (visible in samples 1, 6 and 8 from PT-AM-IMEv altarpiece and in sample PT-AM-CcxEv\_5) a thick white ground (250-300 µm for the first altarpiece and 200-500 µm for the second one) was applied and then the red bole layers of 50-80 µm for the PT-AM-IMEv and 40-60 µm for PT-AM-CcxEv. The grounds for both cases are made of the traditional sequence of *gesso grosso* and *gesso fino* (*gesso mate*), as figure 4 shows. Gold leaf was applied on the top of the bole and burnished and in few cases covered with a varnish layer (samples 6 and 10 from Carthusian altarpiece). The polychromy presents different colors according the sampling positions (figure 5). In many cases the paint was applied over gilding. A thick dark layer (ca 100-120 µm) with bluish fluorescence under OM-UV for samples PT-AM-IMEv\_3, 6 and 9 can be observed (figure 5).

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A

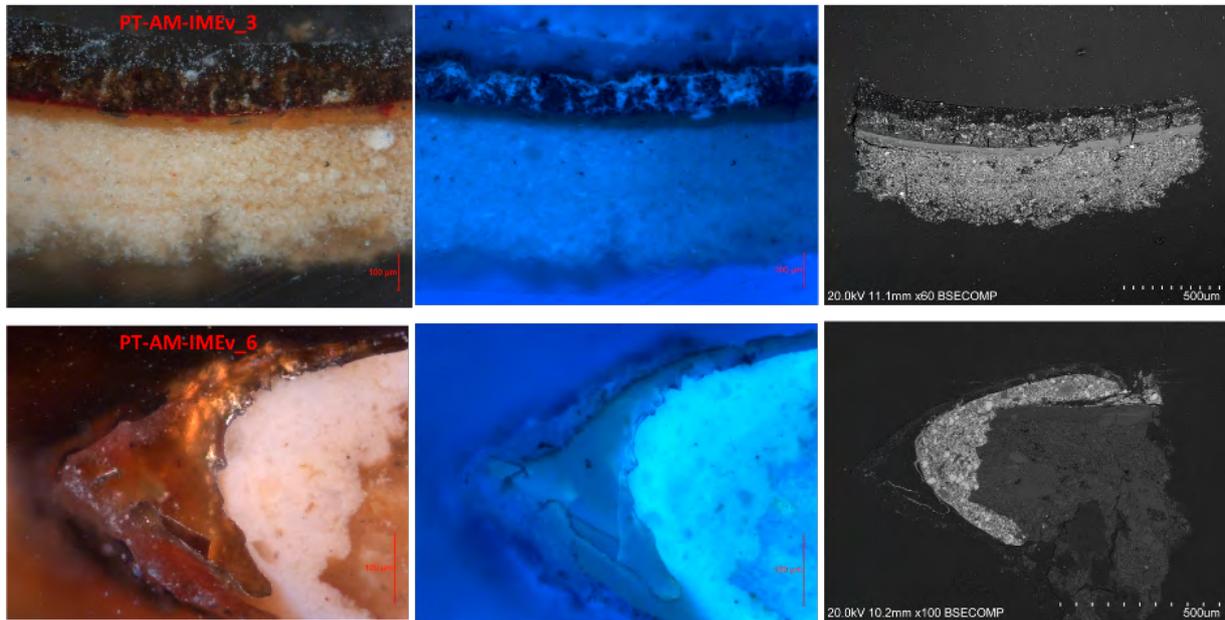


B

**Figure 4** – Comparative imaging under OM and SEM for: A) *Gesso grosso* and *gesso fino* in two samples from the two altarpieces; B) flesh tones stratigraphy in two samples.

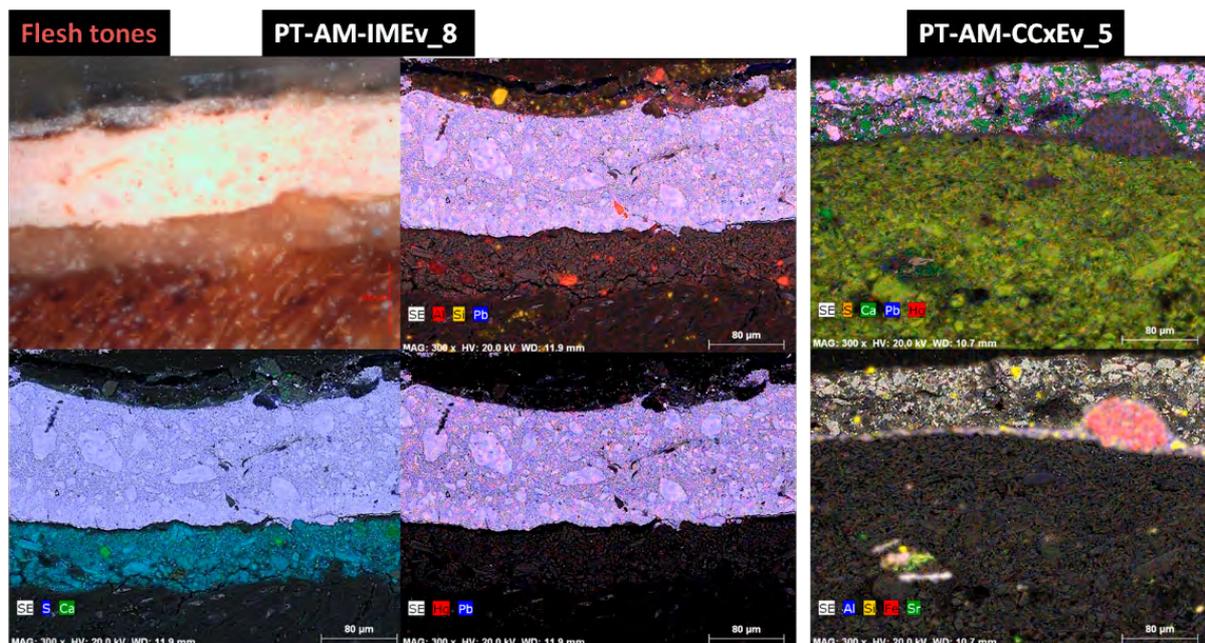
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**Figure 5** – Samples 3 and 6 from the altarpiece in the church of Mercy, observed under OM (vis and UV) and SEM.

Figure 6 shows the comparison in the sequence of layers and elemental mapping by SEM-EDS between the samples taken from flesh tones. The presence of elements such as Pb, Hg, Fe, Al, Si suggest the use of traditional pigments: lead white, vermilion and red ochre with particles of clay minerals, which could come from lower (bole and gesso) or upper (depositions from atmosphere) layers.



**Figure 6** – SEM-EDS elemental mapping on cross-section of two samples from flesh.

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From a compositional point of view the gesso grounds are made of calcium compounds (mainly sulfates) as Ca, S, and O was detected by SEM-EDS, with inclusions of Fe, Si, Al (clay minerals) and Sr. The detection of Sr indicate the presence of celestite, which was also detected in gesso grounds from other Portuguese altarpieces (BARATA et al, 2012, COROADO, 2013, e SANDU, 2014). The literature assesses the possibility that this type of gesso could be imported because the Portuguese geological outcrops are small when compared with other countries as Spain, France or Morroco (Costa, 1986) although the contemporary treatises speak of the use of national gesso coming from Obidos (Leiria) and Soure (Coimbra) (Monteiro & Cruz, 2010).

The red bole layers are made of ochers and aluminium silicates (Fe, Al, Si). The leaf, an alloy of Au, Ag and Cu or only Au /Ag (sample PT-AM-CCxEv\_8) has 23 karats and few micrometers thickness for both altarpieces (figure d), this composition being in agreement with other findings reported in the literature for Baroque altarpieces in Portugal [SANDU, 2013 e 2015]. Leafing with different materials than gold leaf was identified in the case of PT-AM-IMEv, using silver leaf (silvering) in sample 6 and alloy of Cu and Zn for sample 9.

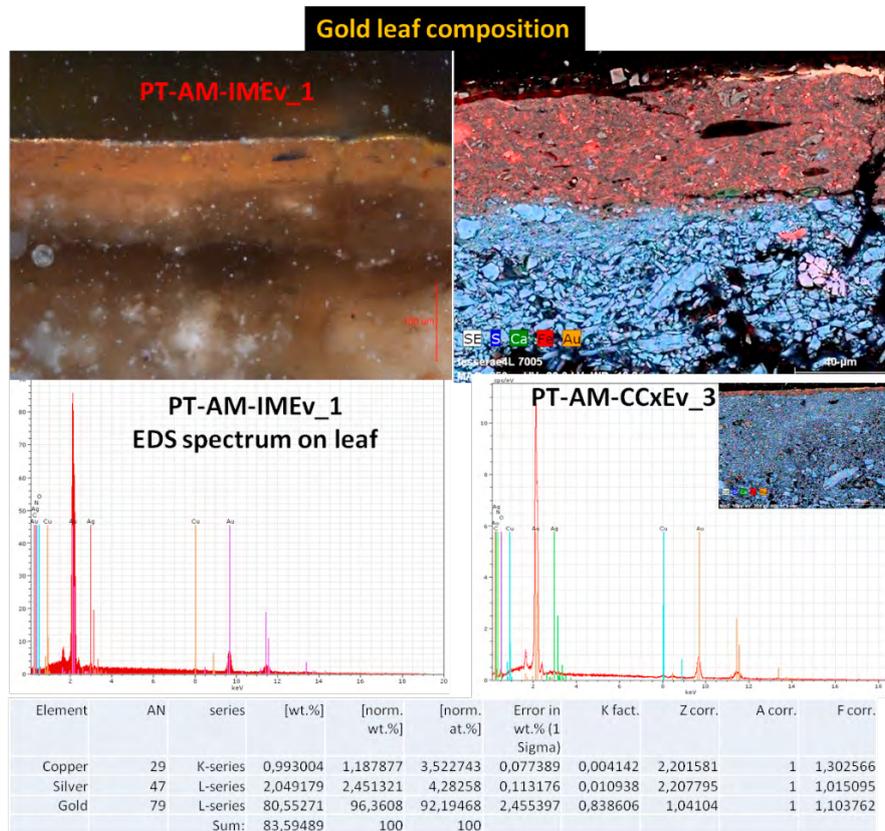
As stated above, the work contract specifies the total number of layers for the gilded areas (11 hands between gesso and bole layers) but from the OM and SEM images is very difficult to assess this, although a distinction between layers is possible when speaking o *gesso grosso* (coarser grains) and *gesso fino*. Nevertheless the total thickness of layers (variable according the sample, between 200 and 600  $\mu\text{m}$ ) and different colors indicates the overlapping of different layers and materials according the traditional recipes.

The main pigments identified by SEM-EDS and microFTIR are: lead white with inclusions of gesso and silicates (Ca, S, Si) in sample PT-AM-IMEv\_4 and with red grains of vermilion (Hg) in sample PT-AM-IMEv\_8 (flesh tones) and sample PT-AM-CcxEv\_5; green pigment (probably a copper resinate) in sample 1 (green) and 7 (blue) from Cartuxa altarpiece, similar to the one from sample 7 in the church of Mercy; vermilion (HgS) in red samples (PT-AM-CcxEv\_4 and 6).

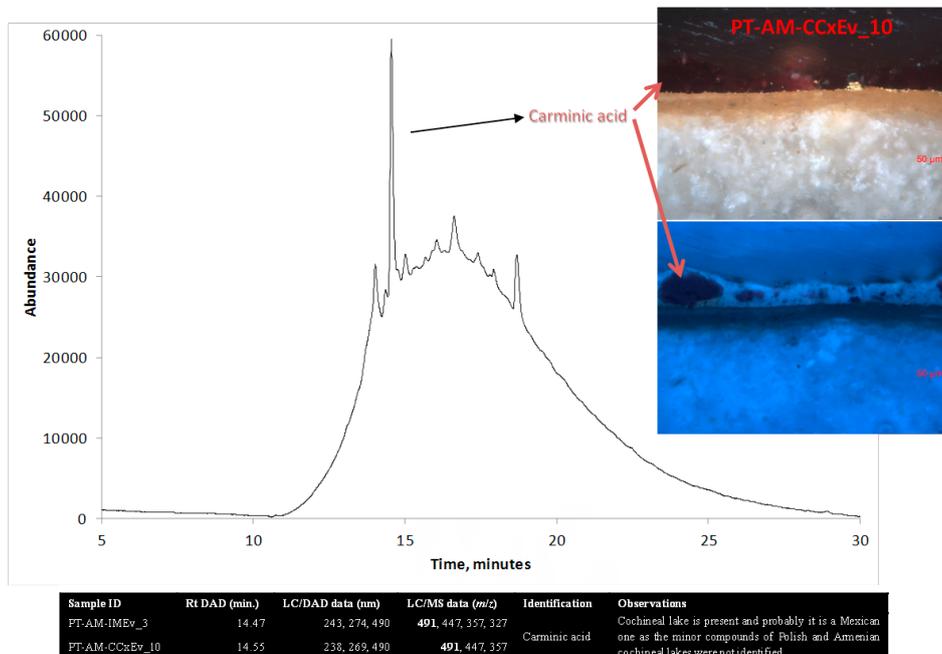
LC/DAD/MS technique allowed to identify the red color organic layer from the surface as cochineal lake of possible Mexican provenance in both cases (figure 8). Beeswax was identified as coating (figure 9) in sample 6 and 10 from the Cartuxa altarpiece, having the same composition as sample 3 from the church of Mercy altarpiece. The presence of copper carboxylates and of a fatty material (oil?) was detected in the microFTIR spectra of green samples (figure 10) in both altarpieces. The carboxylates are the product of the interaction between a metal ion (in this case  $\text{Cu}^{2+}$  of the green pigment) and an acid from an organic compound (probably the oil or even the wax from protective coatings).

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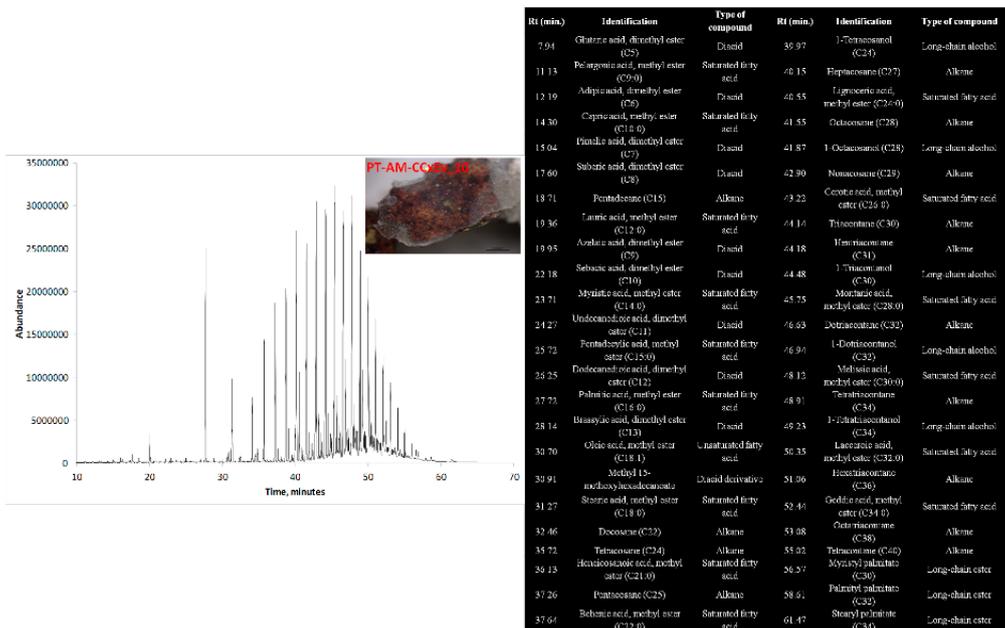
**Figure 7** – Gold leaf composition detected by SEM-EDS analysis for two samples from the two altarpieces.



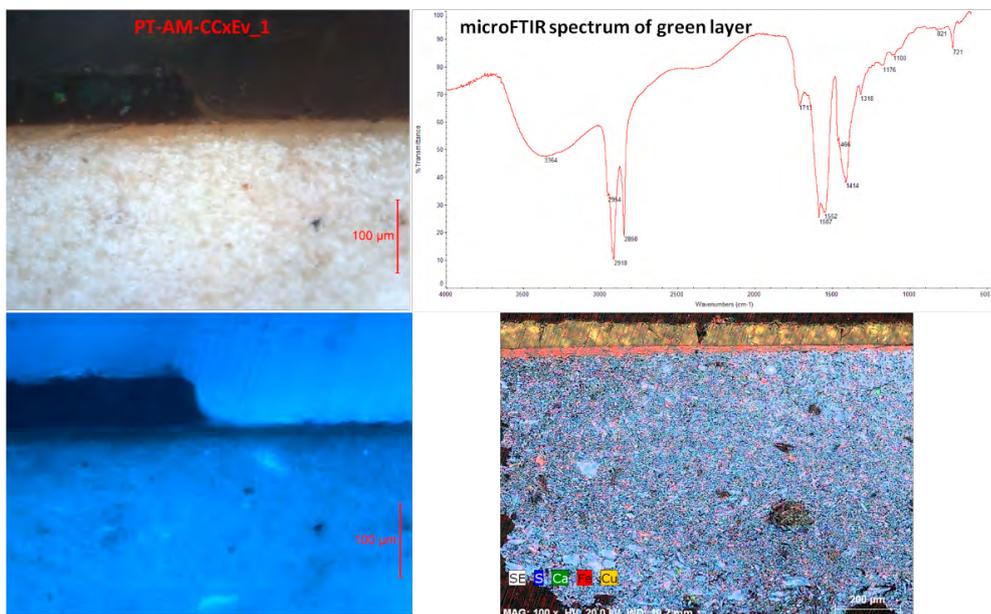
**Figure 8** – LC/DAD chromatographic profile of sample PT-AM-CCxEv\_10 and data obtained from LC/DAD/MS for both red color samples.

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**Figure 9** – Data from Py-GC/MS for sample PT-AM-CCxEv\_10.



**Figure 10** – Characterization of sample 1 from the altarpiece in Cartuxa convent by OM, SEM-EDS and microFTIR.

### CONCLUSION

Following the results obtained from the analytical protocol, the stratigraphic structure and the constituent materials in the gilded and polychrome layers of the two altarpieces seem quite similar.

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The gesso grounds have the same composition, including the presence of Sr (as marker for celestite), and technique (*gesso fino* over layers of coarser *gesso grosso*).

The bole is made with iron oxides and aluminium silicates (clay minerals) and has a reddish colour. We were not able to identify the yellow bole ("jalde") proposed in the first contract of the Church of Mercy, but the thickness and compositional pattern of the gesso-bole layers are confirming the recommendations from the work contracts (11 hands in total).

The leaf is an alloy of Au, Ag and Cu of 23 karats (good quality/purity) with few exceptions in the case of the altarpiece from the church of Mercy where interventions were made using silver leaf and Cu/Zn leaf.

The polychromy is made of pink, red, green and blue hues. Main colouring materials identified are: lead white for white and pink areas, vermillion, cochineal lake and copper resinate (?). The organic materials identified are: oil as binder for the painted areas "regraxos" (identified for green and red samples), and wax as protective layer<sup>7</sup>.

The polychromy of the altarpieces seems to be made in an oil paint technique with organic protective (wax), while the gilding is a water-based technique using leaf of 23 karats and in some cases (for the altarpiece of the church of Mercy) silver or Cu/Zn leaf.

In this case study, the similar results for composition and application techniques of the ground, gilding and painting layers confirm that the belonging to a relatively small community, and the participation in a broad partnership for the execution of large works contributed to the dissemination of relatively homogeneous techniques and artistic practices, allowing the commissioners, with relative ease, to replace the gilders without changing the expected final results.

The dispute between the two masters, Manuel da Maia e Filipe de Santiago, forced both commissioners, the brothers of Mercy and the Carthusian fathers, to write the contracts with very careful details, describing all the process of gilding and the techniques of painting over gold.

### References

BARATA Carolina, CRUZ António João, ROCHA Fernando, Sobre os materiais utilizados na talha da época barroca do noroeste de Portugal – primeiros resultados, in *-Actas do I Encontro Luso-Brasileiro de Conservação e Restauro*, Porto, CITAR, pp.40-50, 2012. [Em Linha] disponível em: <http://citar.artes.porto.ucp.pt/sites/default/files/files/artes/CITAR/Edicoes/actas-I-encontro-luso-brasileiro-conservacao-restauro-2011.pdf>

BORGES Artur, "As andanças de um retábulo eborense", *Catálogo da exposição Documentos para a história da Talha dourada e azulejo em Évora*, coordenada por Celso Mangucci.

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<sup>7</sup> Both sets underwent conservation and restoration works in recent decades. In 2005, Tacula company, led by architect João Sarrazola Martins, presented an oral communication at the Eugénio de Almeida Forum about the intervention of conservation and restoration carried out on the gilded altarpieces of the church of the convent of Scala Coeli Évora.

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Évora: Arquivo Distrital de Évora, 2014. [Em Linha] disponível em: <http://adevr.dglab.gov.pt/wp-content/uploads/sites/4/2014/11/link.pdf>

COROADO João, ANTUNES Vanessa, SERRAO Victor, OLIVEIRA Maria José, DIAS Luís, CANDEIAS António, MIRÃO José, SERUYA Ana Isabel, Presença de Celestite em retábulos Portugueses, V. Serrão, V. Antunes e A.I. Seruya (eds.), *As preparações na Pintura Portuguesa, séculos XV and XVI*, Faculdade de Letras da Universidade de Lisboa, 28-29 Junho 2013, Museu Nacional de Arte Antiga, pp. 75-83, 2013

COSTA J.R.G, O Gesso em Portugal, *Estudos, Notas e Trabalhos do Serviço de Fomento Mineiro*, vol. 28, pp. 93-117, 1986

LAMEIRA Francisco, "O retábulo da capela-mor da Igreja do Mosteiro da Cartuxa de Évora (projecto de José Benito de Churriguera?)", *Catálogo da exposição Documentos para a história da Talha dourada e azulejo em Évora*, coordenada por Celso Mangucci. Évora: Arquivo Distrital de Évora, 2014.[Em Linha] Disponível em <http://adevr.dglab.gov.pt/wp-content/uploads/sites/4/2014/11/link.pdf>

LAMEIRA Francisco, O Retábulo em Portugal, das origens ao declínio, *Promontoria Monográfica História da Arte*, n.º1, Departamento de História, Arqueologia e Património a Universidade de Algarve, Faro, 2005

MANGUCCI Celso, A talha mais moderna. O percurso de Manuel e Sebastião Abreu do Ó em Évora in *Cenáculo Boletim on-line do Museu de Évora*, nº 4, Outubro de 2010.[Em Linha]. Disponível em: <http://museudevora.imc-ip.pt/Data/Documents/Cenaculo%204/B4AbreudoO2010.pdf>

MANGUCCI Celso, "Francisco da Silva, António de Oliveira Bernardes e Francisco Lopes Mendes na Igreja da Misericórdia em Évora in *Cenáculo Boletim on-line do Museu de Évora*, nº 3, Setembro de 2008.[Em Linha] Disponível em:<http://museudevora.imc-ip.pt/Data/Documents/Cenaculo3/B3SilvaBernardesMendes2008final.pdf>

MONTEIRO Patrícia, CRUZ António João, Breve tratado de Iluminação composto por um religioso da Ordem de Cristo. In L.U. Afonso (ed.), *The materials of the image. As Matérias da Imagem*. Lisboa: Cátedra de Estudos Safarditas "Alberto Beniveste" da Universidade de Lisboa, pp.237-286, 2010

NUNES Filipe, *Arte da Pintura Symmetria, e perspectiva com estudo introdutório de Leontina Ventura*. Porto: Editorial Paisagem, 1982

SERRÃO Vítor, *O Maneirismo e o Estatuto Social dos Pintores Portugueses*. Lisboa: IN/CM, 1982

SERRÃO Vítor, *Arte, Religião e Imagens em Évora no tempo do Arcebispo D. Teotónio de Bragança, 1578-1602*. Vila Viçosa: Fundação Casa de Bragança

SERRÃO Victor, CAETANO Joaquim, *A Pintura em Moura nos Séculos XVI, XVII e XVIII*. Moura: Câmara Municipal de Moura, 1999

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SANDU Irina Crina Anca, MURTA Elsa, FERREIRA Silvia, PEREIRA Manuel, CANDEIAS António, MIRÃO José, MIGUEL Catarina Pereira, PABA Francesca, More than gold – an interdisciplinary, complementary study of gilding materials and techniques in Baroque altarpieces from Portugal, in *ECR-Estudos de Conservação e Restauro*, no 6, CITAR, Porto, 2014, pp.13-3. [Em Linha] <http://revistas.rcaap.pt/ecr/article/view/7522>

SANDU Irina Crina Anca, PABA Francesca, MURTA Elsa, COSTA PEREIRA Manuel, RIBEIRO Conceição, Travelling Beneath the Gold Surface – Part I: study and characterization of laboratory reconstructions of Portuguese seventeenth and eighteenth centuries ground and bole layers, *e-conservation journal*, issue 2, 2014, 43-63

SANDU Irina Crina Anca, GILT-Teller: An interdisciplinary multiscale study of gilding techniques and materials in Portugal, 1500-1800, in *Actas das VIII Jornadas de Arte e Ciência - Conservação e Restauro de Artes Decorativas de Aplicação Arquitectónica*, 29 Setembro de 2012, CITAR, Porto, 2013, pp.127-142. [Em Linha] Disponível em: [https://artes.porto.ucp.pt/sites/default/files/files/artes/CITAR/VIII-Jornadas-Arte-Ciencia\\_compressed.pdf](https://artes.porto.ucp.pt/sites/default/files/files/artes/CITAR/VIII-Jornadas-Arte-Ciencia_compressed.pdf)

SANDU Irina Crina Anca, MURTA Elsa, NEVES Eva Raquel, PEREIRA Manuel, SANDU Andrei Victor, KUCKOVA Stepanka, MAURICIO Antonio, A comparative, multi-scale and interdisciplinary study of gilding techniques and materials in two Portuguese Baroque “talha dourada” complexes, in *ECR-Estudos de Conservação e Restauro*, no 4, CITAR, Porto, 2013, pp. 47-71, doi: 10.7559/ecr.4.3080. [Em Linha] Disponível em: <http://revistas.rcaap.pt/ecr/article/view/3080>

WOUTERS Jan, GRZYWACZ Cecily, CLARO Ana, *Studies in Conservation*, 56, pp. 231-249, 2011

### Websites:

[www.gilt-teller.uevora.pt](http://www.gilt-teller.uevora.pt)

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