INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 1, Issue 1, January-March 2010: 19-26 www.ijcs.uaic.ro

THE MATERIALS AND TECHNIQUES OF POLYCHROME BAROQUE WOODEN SCULPTURE: THREE WORKS FROM BAIÃO, PORTUGAL

Carolina BARATA[1,2*], António João CRUZ[2,3], Jorgelina CARBALLO[1,2], Maria Eduarda ARAÚJO[4]

[1] School of Arts, Portuguese Catholic University, R. Diogo Botelho, 1327, 4169-005 Porto, Portugal,
[2] Research Center For Science and Technology in Art (CITAR), Portuguese Catholic University, R. Diogo Botelho, 1327, 4169-005 Porto, Portugal
[3] Department of Art, Conservation and Restoration, Polytechnic Institute of Tomar, Estrada da Serra, 2300-313 Tomar, Portugal,
[4] Department of Chemistry and Biochemistry, Faculty of Sciences, University of Lisbon, Campo Grande, Ed. C8, 1749-016 Lisbon, Portugal

Abstract

Three polychrome wooden sculptures, made between the last quarter of the 17th century and the first half of the 18th century, from a monastery in Northern Portugal, representing an episode of the Passion of Christ, were analyzed with three aims: to identify the materials and techniques employed; to clarify the relationship between the three sculptures; to reveal previous restorations. Techniques such as radiography, energy dispersive X-ray spectrometry, optical and polarized light microscopy and Fourier Transform infrared spectroscopy were employed. White lead, vermillion, umber, carbon black, gypsum, anhydrite and chalk were identified as pigments and fillers. These materials and the layer structure led to the conclusion that sculptures 1 and 2 were treated as a pair of sculptures and that they underwent at least two restorations: the first was probably done in the workshop where they were made. During the second restoration, the heads were replaced. Sculpture 3 is not restored and its poorer style seems to have correspondence to materials of lower quality.

Keywords: *Polychrome sculpture; materials; techniques; analysis; pigments.*

Introduction

The Monastery of Santo André of Ancede, in Baião, Northern Portugal, was established in the 12th century, but since then, several works of refurbishment and enlargement were made. The most important of them were undertaken during the 17th and 18th centuries. In the church's sacristy, there are three polychrome wooden sculptures, 1.3-1.4 m high, representing Jesus Christ after the Flagellation (Fig. 1). Their formal characteristics allow us to classify them as Baroque pieces.

Sculptures 1 and 2 display very similar stylistic and technical characteristics. Although they cannot be classified as erudite pieces, they show notions of proportion and anatomy that endow them with a certain artistic quality. The heads were carved separately from the rest of the

* Corresponding author: cbarata@porto.ucp.pt, tel. +351-226196240, fax: +351-226196244

bodies. This was a common practice, since it facilitated the carving process [1]. However, there is also the possibility that both sculptures were first made from a single piece of wood and that the heads were replaced in a subsequent period, due to their poor conservation condition. In fact, several marks of termite damage are visible along the wooden supports, mainly at the bases. On the neck of sculpture 2, one of these marks is suddenly interrupted near the separation line between the body and the neck and does not reach the head. Besides, both heads are made of several wooden elements, and some of them are not positioned in a natural way, which puts forward the hypothesis that the heads were restored in the past. Sculpture 3 shows a lower artistic quality, which is evident from the lack of proportion and anatomic details. It was carved from a single block of wood. The stylistic characteristics suggest that sculptures 1 and 2 were made in the first half of the 18th century and sculpture 3 in the last quarter of the 17th century. In spite of the differences mentioned, there is a general resemblance between the three, which suggested the possibility that sculpture 3 was used as a model for sculptures 1 and 2.

Fig. 1. The studied polychrome wooden sculptures.

Those doubts about the relationship between the different sculptures and between the different elements of the two more recent ones, together with the questions in regard to the number and extension of restorations, led to the development of a scientific study. That study also intended to reveal whether the visible differences between sculptures 1 and 2 and sculpture 3 had correspondence to the materials and techniques employed. Those issues are of a more general interest, since the published studies about the materials and techniques of the Portuguese polychrome Baroque wooden sculpture are very scarce (with few exceptions, they were developed within the context of an international project concluded in 2002 [2]).

The obtained results are presented in the present paper.

Experiment

The study of the three sculptures was mainly done with non-invasive X ray techniques. For the study of the construction features of the wooden supports a Yxlon X-ray tube, model SMART 160E/0,4, and an Agfa 3JSLY D, D7 film were used. Energy dispersive X-ray fluorescence spectrometry (EDXRF) was employed for the identification of pigments and fillers with a portable spectrometer, equipped with an Ag anode, a Be window, 7 mm in diameter and a multichannel system Amptek MCA Pocket 8000A. Stratigraphical examination of cross sections taken from the same areas, that were previously analyzed through EDXRF, was carried out using an Olympus binocular microscope, model BX41, equipped with an Olympus Digital C-4040 Zoom camera with infinity corrected optical system. Two samples were also analyzed by Fourier transform infrared spectroscopy (FTIR) on a Mattson Sattellite spectrophotometer. Samples were analyzed as discs obtained from a dispersion of material on anhydrous KBr.

Results and discussion

Wooden support

Through radiography, we could confirm that sculpture 3 was made out of a single block of wood and that no nails or other metallic elements for the reinforcement or joining of different pieces were visible. In the case of sculptures 1 and 2, due to the presence of high atomic number elements in the ground and paint layers, it was not possible to obtain a clear image of the wooden support. However, the radiographs revealed that these two sculptures were made from a single block of wood up to the neck line. The evidence of metallic nails on the heads confirmed that they were made of several different elements (Fig. 2).

Fig. 2. A detail of the radiograph of sculpture 2 showing metallic nails on the head.

Ground

By optical microscopy (OM), the cross sections revealed that the three sculptures have a white, granular and translucent ground layer applied over the wooden support (Fig. 3).

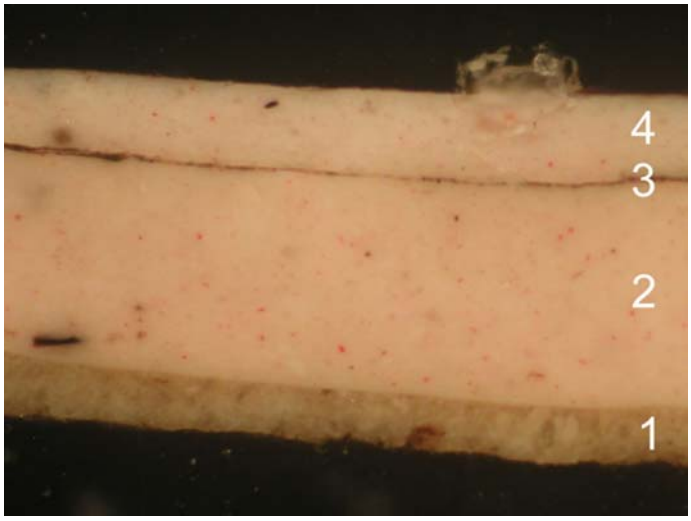

Fig. 3. Cross section of a sample removed from the chest of sculpture 1. Layers:
1 – ground (partial); 2 – original flesh tone layer; 3 – varnish; 4 – overpainted flesh tone layer.

In the case of sculptures 1 and 2, the ground layer is more translucent and less compact in the head area than on the rest of the body. Although the ground can mainly be composed of gypsum ($CaSO_4 \cdot 2H_2O$) or chalk ($CaCO_3$), in Portugal, according to the published studies [3] and to documentary evidence [4-5], gypsum is more common. In sculpture 2, in the body area, there were traces of a mixture with white lead ($2PbCO_3 \cdot Pb(OH)_2$). The FTIR spectrum acquired for sculpture 3 shows a mixture of gypsum and anhydrite ($CaSO_4$) in the ground (Fig. 4).

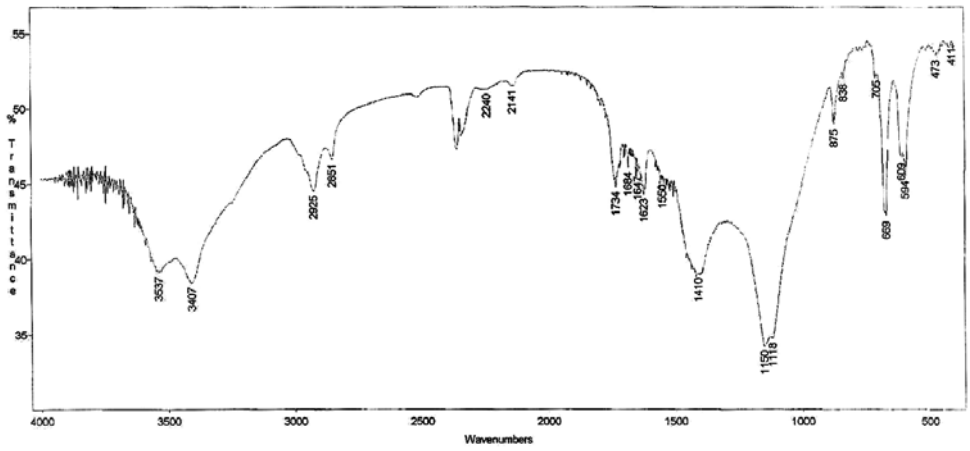

Fig. 4. FTIR spectrum of a sample removed from the shoulder of sculpture 3
showing peaks of gypsum (3537 and 3407 cm^{-1}) and anhydrite (1150 and 1118 cm^{-1}).

For sculpture 2, the spectrum revealed that gypsum and white lead were the more abundant materials in the sample. Certainly, there was gypsum present in the ground layer. But, as the sample also had a small portion of the flesh tone layer adjacent to the ground layer, white lead may only exists in the flesh tone layer.

According to documents, ground layers should consist of several layers [4-5]. However, in the three sculptures only one was detected through OM, although the presence of gypsum and anhydrite in sculpture 3 may indicate a two layer structure [6]. These unexpected results may have been caused by several reasons: consecutive layers with the same composition are difficult to distinguish; the number of layers may be related to the sculpture's artistic quality; the instructions presented in treatises and working contracts were not followed in the workshop procedures.

Flesh tone and blood areas

In sculptures 1 and 2, there is a clear distinction between the paint layer that covers both heads and part of the necks and the paint layer that covers the bodies. The face flesh tone has a homogeneous dull aspect and presents thin and superficial cracking lines. Nevertheless, on the rest of the body, the flesh tone has a paler shiny surface (probably polished) with deep and dark cracking lines.

The samples observed by OM show that the face flesh tone presents a single layer, while over the body there are two layers with a varnish coating between them (Fig. 3). The varnish coat implied that the top layer was painted over during a restoration process. In all of the analyzed points of sculpture 3 only a single layer was found, which indicated that it was not restored in the past. In the three sculptures, through OM, we observed that the flesh tone layers contain a white matrix with small red particles dispersed in low concentration. The flesh tone layers of sculptures 1 and 2 are similar, irrespective of area analyzed. In particular, the two layers observed in the bodies have similar structure and granulometry, although they were applied at different times (Fig. 3). The different number of layers observed in the heads and in the rest of the bodies indicate that the heads are not original, although the similar structure of the layers indicates that the two sculptures were made in the same workshop, and that they were also restored at the same time. That also indicates that the restoration was made soon after the sculptures were made, when the materials and the techniques in the workshop were still the same. The flesh tone layer in sculpture 3 is more heterogeneous and the coarse particles of a filler indicates a poorer quality.

The most prominent peaks in all EDXRF spectra obtained for the flesh tone areas were due to Pb, which may mean white lead. For sculpture 3, the spectra also show a small peak for Ca and a minor peak for Fe. For sculptures 1 and 2, besides Pb, some spectra show minor peaks for Ca and Fe. The presence of Ca in the flesh tone layers may be attributed to the filler (probably chalk), which, as already mentioned, seems to be more abundant in sculpture 3. Fe should be an impurity from the white lead or from the filler. As no element as Fe or Hg, was detected in any concentration, that may undoubtedly indicate a red pigment. Particles of this colour in the flesh tone layers must be from minium or red lead (Pb_3O_4). Although the spectra also allow the hypothesis that the red pigment may be an organic material (a red varnish), there was no indication thereof in the OM.

The spectra obtained for the blood marks in the flesh tone areas of sculpture 3 and the face of sculptures 1 and 2, besides the peaks due to the flesh tone layer, show the presence of Hg, which implies that vermilion (HgS) was employed in the blood marks. However, in the

body of sculptures 1 and 2 no significant difference was found between the spectra obtained for the blood marks and the spectra obtained for the adjacent areas. Therefore, the red color of the blood must be due to minium or, more plausibly, to an organic red dye. The difference in the composition of the blood marks between the head and the body of sculptures 1 and 2 indicates that the body and the head were restored in different times.

Hair areas

In the hair areas, the EDXRF spectra obtained for the three sculptures show the presence of Pb and Fe and, with small peaks, Mn and Ca (Fig. 5). For sculptures 1 and 2 the spectra also show the presence of Hg.

The cross sections obtained for the hair areas of sculptures 1 and 2, show that the brown layer is applied over a layer containing white lead mixed with spread of red bright particles that appear to be vermillion, when observed through polarized light microscopy (PLM).

The components of this layer were similar to those identified in the flesh tone. The brown layer is composed of a brown matrix with red and black particles.

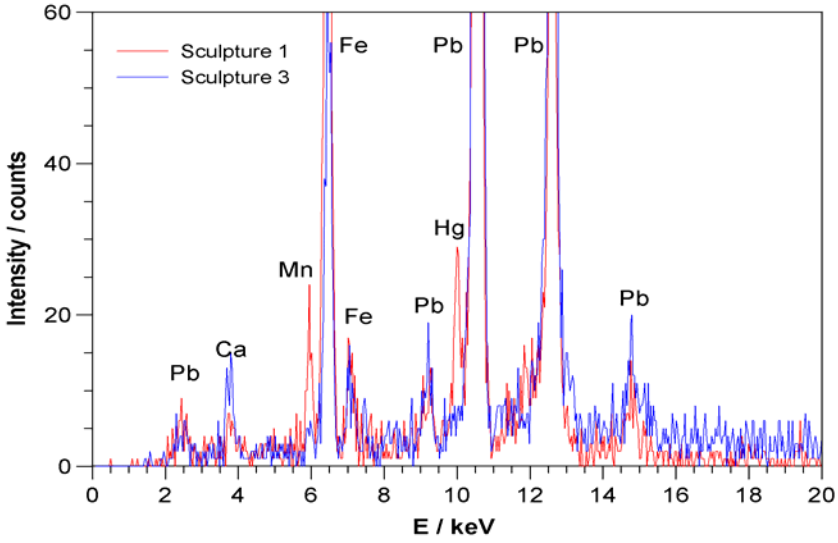

Fig. 5. EDXRF spectra for the hair in sculptures 1 and 3.

The identification of Hg means that the red particles correspond to vermilion. As for the presence of Fe and Mn, and also of the black particles, several explanations are possible. The black particles could be related to a black pigment composed mainly by C (bone black, carbon black or charcoal black). Although, less plausibly, they could also correspond to manganese black (MnO_2) or another compound of Mn. However, Mn can also be related to the use of umber (mixture of FeOOH, MnOOH and clay), which has a dark brown colour. Fe can be related either to umber or to brown ochre (FeOOH). However, the ratio between the Fe and the Mn Kα peak area is approximately constant (between 6.9 and 7.5 - Table 1). Therefore, it indicates that the two elements are associated and, thus, they are present as umber. Moreover, the mean value of 7.2 is compatible with the known values for the Fe/Mn ratio for umber (between 1 and 8, according to some sources [7]). This suggests that the brown pigment used is

umber and the black pigment is a carbon black. The Pb and Ca peaks indicate white lead and a Ca filler, respectively.

Table 1. Area of Kα peaks for Mn and Fe and their ratio

Location	Mn (cps)	Fe (cps)	Fe/Mn
Sculpture 1, shoulders	6.59	47.8	7.2
Sculpture 1, head	8.47	63.8	7.5
Sculpture 1, shoulders	9.56	65.7	6.9
Sculpture 1, head	4.45	32.0	7.2
Sculpture 3, head	3.27	35.8	10.9

For sculpture 3 the situation was similar, except that no red pigment was detected by EDXRF, OM or PLM. In that case, the value of 10.9 was obtained for the Fe/Mn ratio, which, considering the diversity of composition of natural pigments and the possible mixtures, namely with ochre, is still compatible with umber. About this pigment, which is the least common of the mentioned pigments, a 17th century Portuguese painting treatise mentioned the umber proceeding from Sintra, in the neighborhood of Lisbon, under the name of *sombra de Sintra*, that is, shadow of Sintra [4]. However, in some contracts from the 18th century, *sombra de Colónia* (umber from Cologne) is mentioned [5].

Drapery areas

As revealed by OM, the drapery areas of sculptures 1 and 2 have two white layers above the ground layer. The lower one should be the original and the upper one should be from a restoration, as observed in the flesh tone area. The EDXRF spectra obtained from the upper layer show peaks only for Pb, which may indicate white lead. A sample taken from the gold color motif at the drapery edge of sculpture 1 indicated that the color is actually gold applied over a yellow bole layer (a mixture of clay and ferrous compounds). That layer was applied over the white layer of the drapery, which was applied during the restoration. The sample also indicated that the original drapery was made in a similar manner, because a similar three layer sequence was observed beneath the upper paint layer. However, in the lower sequence the bole has a red color. According to the EDXRF spectra, the blood marks may contain minium or an organic red dye, just as the ones in the flesh tone area.

In the drapery area of sculpture 3, only one white layer is visible. It contains white lead as well. However, at some points, a thin layer of vermilion was observed by PLM, applied above the white layer. This indicated that the area used to be red, even though there were just a few small fragments left.

Conclusions

The spectra acquired by EDXRF, complemented with the data obtained by OM, PLM and FTIR spectroscopy, made possible the detection of white lead, vermillion, umber, carbon black and, possibly, an organic red dye and minium. In some cases, those elements were found mixed with a Ca filler. The composition of the ground layer of sculpture 3 is different from that of sculpture 2 and, probably, sculpture 1. We identified gypsum, anhydrite and chalk in sculpture 1 and gypsum and, possibly, white lead in sculpture 2.

The materials and the layer structure revealed that sculptures 1 and 2 were always treated as a pair and that they underwent at least two restorations. The results indicated that the first restoration, which involved an additional layer of paint, was done in the workshop where the statues were made, shortly after they were finished. In the second restoration process, the heads were replaced. Sculpture 3 was not restored.

We can conclude that sculpture 3 differs from the others not only in style, but also in materials. Moreover, the poorer style of sculpture 3 seems to have correspondence to materials of lower quality.

Acknowledgments

We would like to thank Ana Calvo and Vítor Teixeira for their helpful advice and information, Luís Bravo for the radiographs and Rui Barbosa for the pictures.

References

[1] D. Barbour, J. Ozone, **The Sacred Made Real. Spanish Painting and Sculpture 1600-1700,** National Gallery Company, London, 2009, pp. 59-71.

[2] A.I. Seruya, A. I. (ed.), **Policromia. A escultura policromada religiosa dos séculos XVII e XVIII. Estudo comparativo das técnicas, alterações e conservação em Portugal, Espanha e Bélgica**, Instituto Português de Conservação e Restauro, Lisboa, 2002.

[3] M. Serck-Dewaide, *Les techniques utilisées dans l'art baroque religieux des XVIIe et XVIIIe siècles au Portugal, en Espagne et en Belgique*, in **Policromia. A escultura policromada religiosa dos séculos XVII e XVIII. Estudo comparativo das técnicas, alterações e conservação em Portugal, Espanha e Bélgica**, (ed. A. I. Seruya), Instituto Português de Conservação e Restauro, Lisboa, 2002, pp. 119-155.

[4] F. Nunes, **Arte da Pintura, Symmetria e Perspectiva**, Lisboa, 1615.

[5] N.M.F. Alves, **A Arte da Talha no Porto na Época Barroca. Artistas e Clientela, Materiais e Técnicas**, Arquivo Histórico da Câmara Municipal do Porto, Porto, 1989.

[6] I.P. Cardoso, *18th Century Altarpieces in Algarve, Portugal: A Comparison of the Historical Documents to the Results of the Microscopical Analysis,* **Infocus**, **41**, 4, (2006) p. 64-68.

[7] G. Buxbaum, G. Pfaff, **Industrial Inorganic Pigments**, Wiley-VCH – Weinheim, 2005, p. 101.

Received: February 15, 2010
Accepted: February 26, 2010