Non-destructive analysis in a study of the religious art objects

Nicoleta Vornicu¹, Maria Geba² and Cristina Bibire¹

¹ Metropolitan Center of Research TABOR, The Metropolitanate of Moldavia and Bukovina, Closca 9, 700066 Iaşi, Romania

² Cultural Heritage Restoration – Conservation Centre “Moldova”, National Museum Complex, Iasi, Romania

E-mail: cmctaboriasi@yahoo.com

Abstract. The icon Descending of the Saint Spirit from Bucium Church, dating in the year 1814 and was done in tempera on wood technology. The characterization of cultural heritage materials is essential for the comprehension of their degradation mechanisms. The present study aims at identifying the pigments in the various layers, establishing the possible existence of an organic binder and scientifically evaluating the state of preservation. To this end, were used non-destructive methods, as: microscopic (SEM), XRF and spectroscopic (FTIR).

1. Introduction

The characterization of cultural heritage materials is essential for the comprehension of their degradation mechanisms. X-Ray Fluorescence spectrometry (XRF) allows a rapid and simple determination of the elemental composition of a material. As a non destructive tool, it has been extensively used for analysis in art and archeology since the early 1970. Whereas it is commonly used for qualitative analysis, recent efforts have been made to develop quantitative analysis even with portable systems.
However the interpretation of the results obtained with this technique can turn out to be problematic in the case of layered structures such as easel paintings. The use of differential X-ray attenuation allows modeling the various layers; indeed the absorption of X-rays through different layers will result in modification of intensity ratio between the different characteristic lines.

To characterize and identify the pigments present in religious painting (icons of wood support) of the XVIIIth century the collection of Bucium Church, Iasi.

2. Experimental
The goal of this research was to know which pigments were applied in this artwork. For this study non-destructive techniques testing were used: microscopic (SEM), X-Ray Fluorescence and FT-Infrared Spectroscopy (FTIR) and chromatographic (HPLC). These analyses have been made with the help of a portable X-ray fluorescence spectrometer Innov X Alpha Series. Source excitement: X-ray tube, the anode Ag W, 10-40 kV, 10-50 µA, up to 5 filters. Detector: Si PIN diode, < 230 eV FWHM at 5.95 keV Mn Kα line and FTIR spectrometer Vertex 70 Bruker, 30-25 000 cm⁻¹.

The retable was analysed in 15 points.

The pigments applied were recognized on the bases of characteristic chemical elements from the XRF spectra. The comparison of the counts per second of different elements with regard to the background offers the possibility to obtain semi-quantitative results.

| Element | Line | Colour | Energy | Can be found in spectrum no. |
|---------|------|--------|--------|-----------------------------|
| Fe      | Kα, Kβ | Blue   | 6.40; 7.06 | 5, 9, 12 |
| Hg      | Kα, Kβ | Cinnabar | 8.64; 9.57 | 14, 15 |
| Pb      | Lα, Lβ | White lead | 10.5; 12.6 | all |
| Ti      | Kα, Kβ | White titanium | 4.51; 4.93 | 1-9 |
| Au      | Lα, Lβ | Gold   | 9.71; 11.4 | 1, 2, 3 |
| Ag      | Kα, Kβ | Silver  | 23; 25  | 6, 14 |
| Fe      | Kα, Kβ | Yellow ochre | 6.40; 7.06 | 1, 2, 6, 7, 8 |
| Cr      | Kα, Kβ |        |        | |

XRF spectrum of the blue pigment obtained by the same instrument from the same position indicates the existence of Fe, Ni, Zn (figure2).
Pigments were subjected to spectral analysis in the field (400-4000 cm\(^{-1}\)), using the FTIR, 620 JASCO, Japan. Technique was applied in direct transmission process using KBr pellet technique.

This comparison allowed the identification of protein peaks in all the icons study (N–H asymmetrical stretching between 3400-3200 cm\(^{-1}\) and C–N stretching 1419-1004 cm\(^{-1}\) range.

Using analysis SEM-EDX could highlight the state of degradation of pigments analyzed; for example in figure 7 is the SEM image of red pigment, cinnabar.

Performances of Tesla BS300 electron microscopy scan used were: 60 A resolution, depth of 1.2 mm, continuous increase in the 20-30000x.

The analysis of pigments by microscopy SEM and FTIR spectroscopy reveals morphological changes induced by endogenous and exogenous factors.
3. Conclusions
The pigments used originally are all commonly applied in the XVIII\textsuperscript{th} century: cinnabar, lead white, yellow ochre, gold, silver blue Prussian and black organic. The presence Pb in all spectra shows that lead white was used also to lighten other pigments, as well as applied in the painting preparation and sometimes as a dryer. Non-destructive analytical techniques have enabled the identification of natural pigments to use icon and allowed restorers use treatment the conservation-restoration adequate. Results have contributed to the completion of a given covering pigment, binders and primers used in XVII\textsuperscript{th}-XIX\textsuperscript{th} centuries.

References
[1] Derrick M 1999 *Infrared spectroscopy in conservation science* (The Getty Conservation Institut)
[2] Comelli D, D’Andrea C, Valentini G, Cubeddu R, Colombo C and Toniolo L 2004 *Appl. Opt.* 43 2175
[3] Comelli D, Valentini G, Nevin A, Farina A, Toniolo L and Cubeddu R 2008 *Rev Sci. Instr.* 79 086112
[4] Alberti R, Florini C, Guazzoni C, Klatka T and Longoni A 2007 *Nucl. Instrum. Meth.* 580 1004
[5] Thoury M, Elias M, Frigerio JM and Barthou C 2007 *Appl. Spectr.* 61 12.