AN INTERDISCIPLINARY APPROACH TO RESTORATION: THE INVESTIGATION OF A 17th CENTURY PAINTING BELONGING TO THE CULTURAL HERITAGE OF SICILY

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Abstract

Analytical techniques and methods applied to the study of artwork can offer insight into both the historical techniques employed by artists, but also a better understanding of the degradation processes that can affect such artefacts. The aim of this paper is to present an interdisciplinary approach to the restoration and conservation of a 17th century oil on canvas painting belonging to the cultural heritage of Sicily. Scientific research was carried out to provide technical support for the current restoration. The study focused on identifying original painting materials and techniques by means of several complementary investigation strategies such as non-invasive UV-light florescence, coupled with invasive analyses of paint samples by optical microscopy (OM) and scanning electron microscopy (SEM-EDX). The study revealed the extent of previous restorations, and helped identify problem-areas, with a direct impact on the restoration strategy employed from that point forward, thus reinforcing the need for interdisciplinary approaches when dealing with the conservation and restoration of cultural heritage.

Key Words: *SEM-EDX, canvas painting, pigments, restoration*

1. Introduction

The identification of original painting materials used in objects from the cultural heritage [1, 2] is extremely helpful to restorers when choosing a strategy for the conservation and restoration processes. Without scientific analysis of the materials [3, 4], diagnosis could be erroneous, leading to irreversible damage to the artwork during restoration procedures [5].

The 17th century oil on canvas painting of “Madonna del S.S Rosario” (in translation, Virgin with Rosary) was planned for restoration in 2007 and thus had its paint stratum protected by means of a facing consisting of *coletta* glue and Japanese paper prior to its relocation for restoration treatment in 2007. However, such treatment was delayed by 3 years, during which time the painting underwent serious damage. At its arrival in the restoration laboratory of ABADIR in 2010, the painting exhibited severe water damage, cuts and tears, and a loss of adhesion in several areas of the initial facing, which was unable to prevent further loss of painting material. As a result, any investigation and diagnosis of the artwork was carried out only after consolidation treatment by means of lining with *collapasta* and linen. Due to the large amount of animal glue deposited on the surface of the painting during the consolidation stage, non-invasive assessment of the conservation status was employed only after preliminary cleaning of the surface with organic solvents. As a first step in the diagnosis of the painting, photographs under UV- light were taken, as to identify problem-areas where over painting or damaged varnish were present [6,7]. Variation in the fluorescence exhibited by painting materials prompted the need for further scientific investigation of several areas, as it was unclear whether indistinctive surface appearance in such illumination was caused by new materials used in previous restoration procedures.

The use of specific analytical techniques enables the identification of complex natural mixtures, namely of inorganic compounds (pigments) [8] and locate them in the corresponding layer of the painting [9]. In this case, microscopic investigations were desired for obtaining pigment information that would best help understand the particular painting techniques used, and also clarify some of the conservation issues involved. Moreover, it was thought that such characterisation would prove useful for restorers when attempting to attribute the artwork to a specific artist or old masters' school.

This paper presents analytical data collected from six samples removed from the painting's surface and back, and investigated by means of OM and SEM-EDX. Results were interpreted and grouped into coherent and specific technique and conservation related data, in an interdisciplinary effort to understand one of the unassigned artworks of Sicily.

2. Experimental

2.1. Painting under study

The painting, depicting the Virgin of the Rosary, central figure in Sicilian culture, belongs to the church of the SS Rosario, of Castelbuono, Palermo County, and is part of the national cultural heritage of Italy. For such reason, its restoration falls under strict legislation and is controlled by the committee for regional cultural heritage, Sopraintendenza dei Beni Culturali di Palermo. The canvas of 3m by 4m was commissioned by the church clergy in 1629 [10,11] to an unknown artist, though art historians credit Sicilian painter Giuseppe Salerno for its creation, due to similarities to its style of painting and the presence of the artist in the region at that time.

2.2. Samples

Paint samples have been taken from areas with white, black, violet and red pigments (both exhibiting uncharacteristic UV fluorescence) and also an area with recent over paint. A canvas sample was taken from the back of the painting, at the joining point of the two linen canvases that supported the painting. Figure 1 shows the location of samples collected for further investigation (A, B, C, E samples are from the original paint layers, where D is collected from a previously restored area)

The volume of each paint sample was about 3mm^3, to ensure representative sampling of both the pigment and the subjacent supporting layers, while limiting damage to the artwork. The samples were first examined by SEM-EDX at low vacuum. OM was used after the samples were priory embedded in synthetic epoxy resin "Ropoxid 510" (manufactured by Policolor Bucharest) and polished with abrasive paper grades 800, 1000 and finally 1200.

Figure 1. Location on the paintings' surface of sampling points (shown in red, listed A to E)

2.3. Methods and instrumentation

In order to reveal specific morphological characteristics of the samples, OM was employed. Elemental composition at various layers within the samples was determined by SEM-EDX.

2.3.1. Optical microscopy

The paint samples were studied using a Nikon SMZ 800 microscope, equipped with a binocular eyepiece and a Nikon D300 digital camera. Samples were photographed at magnifying powers adequate for obtaining useful information regarding the succession of composing paint layers (usually 20x or 40x).

2.3.2. SEM-EDX

Scanning electron microscopic investigation was carried out using a JEOL JSM 5510 LV microscope equipped with an energy dispersive X-ray spectrometer (EDX). The analytical conditions were as follows:
-observed energy range of X-ray: 1-12 keV;
-accelerating voltage: 15-25 kV;
-data acquisition: 145-500 s;
-working distance: 10 mm.
Due to analyses in the low vacuum mode, it was not necessary to coat the samples with a conductive material prior to microscopic investigation. For two of the samples, X-ray mapping of specific [9] was carried out in order to differentiate between adjacent layers of subtle composition variation.

3. Results and discussions

3.1. Paint samples

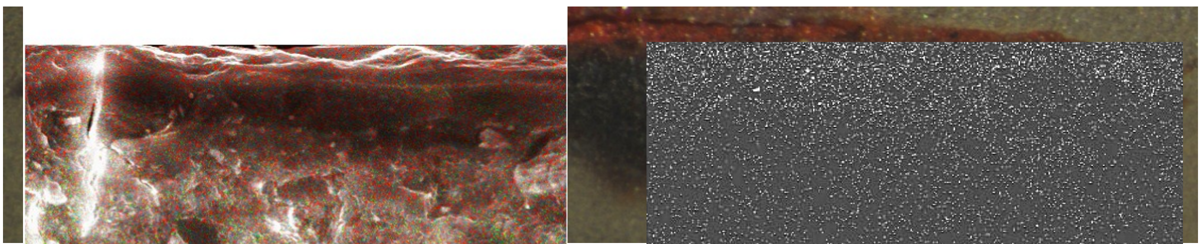
Optic microscopy and SEM-EDX analyses of the paint samples provided useful information regarding the succession and composition of the layers within each micro-fragment. Table 1 presents the main elements identified by EDX in various layers of each paint sample. Trace

Pigment identification was carried out by correlating the presence of major elements with impurities (specific for certain natural minerals employed in seventeenth century painting techniques), with data regarding trading routes and imported painting products in Sicily at that time [12] and with literature data concerning sixteenth and seventeenth century common artists' practice [13].

By means of optical microscopy, an assessment of the number of different layers within each sample was made possible, with a focus on the composition of the red (Figure 2.) and violet paint samples, for whom the paint was comprised of two different layers, one thicker, of inorganic nature, one very subtle, transparent, of organic nature. The presence of the organic-based reddish coating on top of the inorganic pigment was highlighted by plotting X-ray maps of C and Pb for the uttermost exterior layers of the samples (Figures 3 and 4), which revealed a higher concentration of Carbon and a lack of Lead in the top layer, as compared to the subjacent pigment stratum.

OM also revealed the existence of two different preparatory layers underneath the color, in samples A and B, while for the more central regions of the painting (samples C and E), only one layer was present. SEM-EDX had the most important contribution in determining the nature of the original materials employed. Thus, it was concluded that the black pigment was carbon black, admixed with low quantities of ivory black (C as major component, with traces of P) [14, 15], while the white colour was identified as white lead, a mixture of the lead carbonates cerussite ($PbCO_3$) and hydrocerussite ($2PbCO_3 \cdot Pb(OH)_2$) [16].

The red pigment was identified as cinnabar, HgS (or its synthetic variety, vermillion), due to the presence of mercury in the paint layer.



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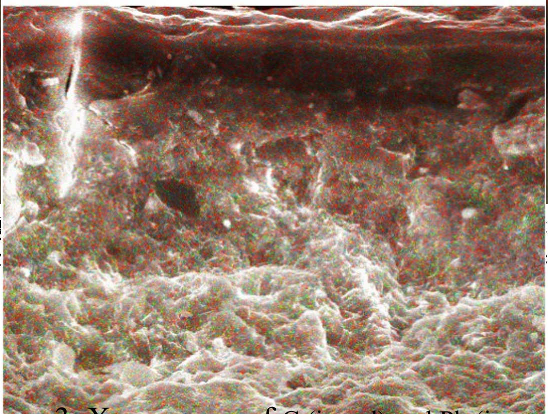


Figure 3. X-ray maps of C (in red) and Pb (in green) plotted against SEM image of red paint sample

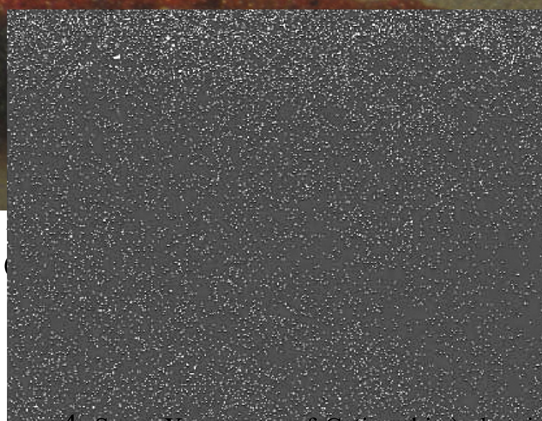
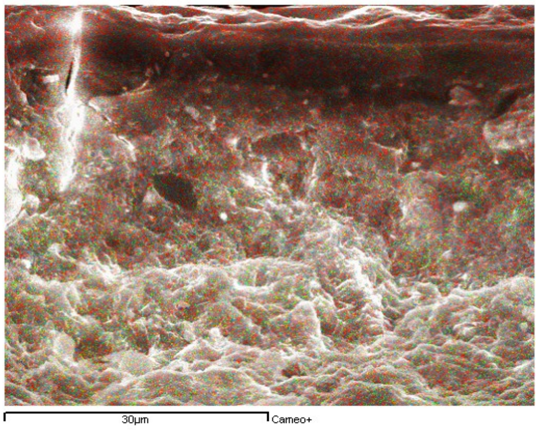


Figure 4. Same X-ray map of C (in white) showing a higher concentration of the element in the upper layer

Figure 3. X-ray maps of C (in red) and Pb (in green) plotted against SEM image of paint sample

Figure 4. Same X-ray map of C (in white) showing a high concentration of the element in the upper layer



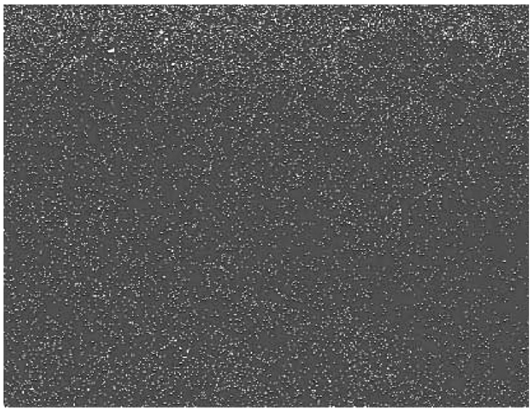


Table 1. Analytical results

Sample	Cross section of paint sample	SEM-EDX microanalysis results (percentage given after each element)	Pigments and materials identified
A	Brown-red layer	O 57,7%; C 25,6%; Si 9,6%;Al 4,3%; Fe 1,8%, (Ca 0,3%); (K 0,6%)	Carbon black, red ochre
	Grey layer	O 57,5%;C30,3%; Pb8,9%; Fe1,4% (si 0,7%), (Ca 0,3%)	Lead white, carbon black, impurities of red ochre
	Thick black layer	C 60,4%; O 31, 4%, Pb 3,7%, Ca 2,5%, P 0,7%, Si 0,9%, (Al 0,4%)	Carbon black, ivory black, impurities of white lead
B	Brown-red layer	O 40,5%; C 38,8%; Si 8,4%; Al 3,6%; Fe 2,1%; (Ca 0,3%); (Mg 0,4%);(K 0,7%)	Carbon black, red ochre
	Grey+ blue layer	C 63,7%; O 27,1%; Pb 8,4%; (Cu 0,4%) (Ca 0,3%), (Al 0,3%)	Lead white, carbon black, azurite
	Blue layer+ thin red layer	C 55,5%; O 29,3%; Pb 13,1%; Cu 1,5%; (Al 0,3%)	Azurite, red lake
C	Grey layer	C 62,9%; O 29,4%, Pb 7,8%; (K 0,7%), (Ca 0,2%)	Lead white, carbon black
	Red inorganic+ organic layer	C 61,9%; O 20,455; Pb 14,9%; Hg 1,7%; (Al 0,6%), (Ca0,4%)	Cinnabar (vermilion), red lake
E	Grey layer	O 59,2%; Pb 9,1%; C 31,1%, (K 0,6%)	Lead white, carbon black
	White layer	C 62,8%; O 28,2%; Pb 7,5%; (Ca 0,7%)	Lead white

Observations and comments: The presence of O, C and Pb in all samples indicates the use of a drying oil, and a metal based siccative (the most commonly used was litharge, PbO [15]). The presence of traces of K in the vicinity of the canvas support indicates animal glue, though its presence cannot be attributed to the ancient painting technique, nor can it be denied, as such material was also introduced during consolidation treatment

Copper in sample B (see table) was indicative of the presence of the blue pigment azurite, $Cu_3(CO_3)_2(OH)_2$ [15, 17].

EDX analyses revealed the presence of the trace element Al in the upper layers of samples A and B (see Table 1), leading to the conclusion that the organic layer is in fact a lake pigment (as painters usually extracted such coloured tinctures by precipitating them with alumina [12] prior to use in paintings). Presence of a red lake dye on top of red and blue pigments is indicative of specific painting technique employed by the artist, very similar to Flemish practice of the time. Such lake dyes have prevented the alteration of underlying pigments, as was proven in other scientific studies of 17th century oil paintings [18]. Therefore, they were maintained on the surface of the colour layers and were not removed during further cleaning.

The ground layers were found to consist of red ochre and carbon black, in the proximity of the canvas support, and white lead and carbon black as the direct pigment support.

Scanning electron microscopy revealed that for the violet colour sample there is a loss of adhesion between the two preparation layers, which could lead in the future to further damage to the painting.

3.2. Over paint

Optical microscopy revealed the presence of two distinct painting materials for sample D, both of which were exhibiting a different morphology as compared to that of the original materials used in the painting. Moreover, the lack of adhesion between such layers, which resulted in an almost total detachment of the upper one, was observed (see Figure 5).

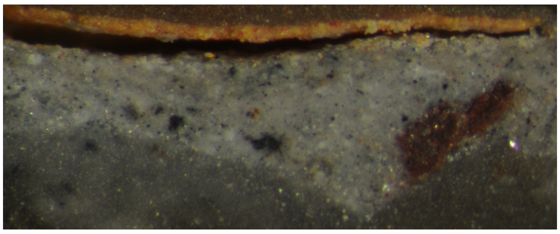


Figure 5. Microphotograph of over paint, revealing two superimposed layers of colour (yellow) and ground (white) (magnification 20x).

SEM images of the sample (not presented here) revealed a more compact structure for both materials, especially for the paint layer. Main elements in the sample were C and O, with minute traces of Pb and Si for the colour stratum, and C, O, Pb for the subjacent layer, thus implying that the over paint is recent, and is of organic nature.

By clearly identifying the use of new materials employed during previous restoration work, conservators were able to remove such strata of recently applied ground and over paint, without damaging the original paint layers, such decision being supported by the fact that such new materials had already started to alter.

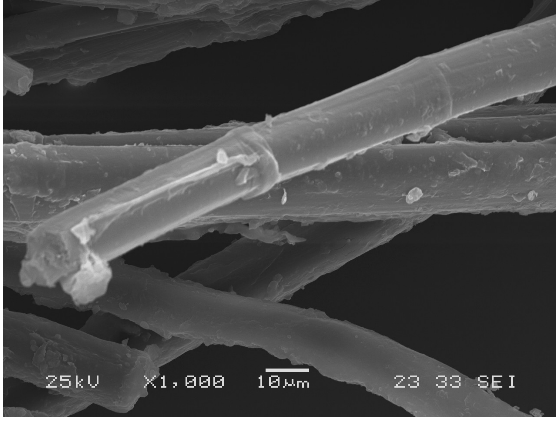


Figure 6. SEM image of the fibers collected from the back of the canvas, showing the typical structure of linen (magnification

3.3. Canvas

SEM analysis revealed the typical structure of the linen natural fibres [19], namely long tubular-like structures with central nodes (Figure 6). The fibres appeared to be in a relatively good conservation state, as their structure was not altered by cellulose decay or bacterial growth. It was therefore concluded that damage observed during restoration procedures was not caused by the natural ageing and degradation of the support, but by localised specific external factors such as water and animal activity.

Elemental analysis (results not shown here) revealed the presence of several main elements typical to plant fibres, such as C, O, Fe, Zn, Ca and Cu. However, no traces of K were found, suggesting that if the canvas was protected against the oxidising effect of the oil [20] by means of applying animal glue, such a material was probably applied in a gel state [13] and not a liquid form, as it did not penetrate through the canvas layer.

4. Conclusions

Scientific investigation of the canvas painting Madonna dell S.S. Rosario (1629) carried out during its restoration helped set up a more coherent conservation strategy, as several problem-areas were identified. Analyses of the original painting materials and their succession in the ground and colour layers hinted that the painting technique was related to the Flemish school, but this did not exclude Giuseppe Salerno as author of the painting, as 17th century Sicily was an important artistic center, with many converging foreign influences.

Though interdisciplinary collaboration proved to be advantageous in what it revealed some significant information about the painting, scientific investigation of works of art has its drawbacks. Collaboration between people of different training backgrounds in not always possible due to a lack of common basis between the scientific and restoration fields. Moreover, investigation methods commonly applied to research and industry-oriented domains do not always apply to restoration, where sampling and collecting fragments for destructive investigation is the least desired way of achieving painting materials' characterisation, and a more gentle approach is preferred [21, 22].

However, interdisciplinary collaboration revealed significant information about painting techniques employed around 1620 in Sicily, and prompted the idea of setting up a library of collected data regarding painting materials and techniques from unsigned artwork in Sicily, in order to facilitate comparison for attribution to a specific school or artist.

6. Acknowledgements

This work has been partially co-funded from the contract Estia-Earth: 142418-2008-GR-Erasmus-ENW, of the European Community, Direction General Education and Culture, Education, Audiovisual and Culture Executive Agency and National Technical University of Athens.
This paper was supported by the project "Improvement of the doctoral studies quality in engineering science for development of the knowledge based society-QDOC" contract no. POSDRU/107/1.5/S/78534, project co-funded by the European Social Fund through the Sectorial Operational Program Human Resources 2007-2013.
The authors would also like to thank the Committee for Cultural Heritage of Palermo, Sopraintendenza dei B.B. C.C. A.A. di Palermo, for allowing diagnosis work and sampling to be done on the painting, abbot Salvatore Leonida, head of ABADIR, for his support, and last but not least Paolo Amico, for his collaboration in photography.

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