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The use of micaceous pigments for the chromatic reintegration of the gilded stuccoes in the Lante della Rovere chapel of Palazzo Orsini in Bomarzo

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Abstract – **The present paper summarizes the fundamental results of the study and restoration of the gilded stucco decoration of the Lante Della Rovere Chapel of Palazzo Orsini in Bomarzo (Viterbo), which was the subject of a master's thesis in Conservation and Restoration of the Cultural Heritage at University of Tuscia. The diagnostics was fundamental for understanding the executive technique and investigating the problems relating to the state of conservation of the artefact. It was performed by in situ non-invasive techniques such as ultraviolet fluorescence photography and X-ray fluorescence spectroscopy, and in the laboratory by micro-invasive analysis through Fourier transform infrared spectroscopy. After the characterisation of the materials, the execution techniques, and the state of conservation of the stuccoes, some tests were executed on mocks-up to evaluate the possibility of using micaceous pigments to reintegrate the gilded surfaces. The mock-ups were investigated by X-ray fluorescence spectroscopy in mapping modality to evaluate the pigments' composition. The stability over time of the micaceous pigments was evaluated through colour measurement, and hyperspectral imaging.**

I. INTRODUCTION

In this paper the phases of the study and restoration of the seventeenth-century gilded stuccos in the Lante della Rovere chapel, known also as San Moderato chapel (1661-1662), of Palazzo Orsini at Bomarzo (Fig. 1) will be presented, starting from the illustration of the historical and artistic context up to arrive at the study of the technique and the state of conservation of the artifacts and the related restoration through the deepening of knowledge on mica-based pigments in the reintegration of metal surfaces [1].

Fig. 1. Photograph of the stuccoes in the Lante della Rovere chapel of Palazzo Orsini before the restoration.

The construction of Palazzo Orsini, on medieval pre-existences, began in 1519 by Gian Corrado Orsini, the lord of the small fiefdom who hired the architect Baldassarre

Peruzzi to design his noble residence. With the advent of his son Pier Francesco Orsini, known as "Vicino", Bomarzo was hit by a new wave of works which not only involved the Palace, but also saw the creation of the famous Sacro Bosco, also known as Parco dei Mostri [2]. Throughout its history, the residence saw the succession of three noble Roman families: the Orsini, the Lante Della Rovere and the Borghese. It is precisely under the regency of Ippolito Lante Della Rovere that the rooms on the first noble floor were interested by a sumptuous construction site for the modernization of the internal decorations. The large vault of the hall and the small chapel were painted by the artist Lorenzo Berrettini who, as was the custom of the time and of the Cortona school, took care of all the planning of the pictorial and plastic decorations. Concerning the stuccoes, object of the present paper, the research in the archive documents allowed to find many payment notes from the workers who collaborated with Berrettini on the creation of the decorations, among these of considerable importance are the figures of the gilders Vincenzo and Francesco Corallo who, from 1662, took care of gilding all the mouldings on the first noble floor [3]. In order to obtain information useful to address the restoration choices, the stuccoes were investigated by different techniques both at the beginning and during the intervention. The state of conservation of the surfaces was studied through ultraviolet fluorescence photography (UVF) a very relevant technique in the restoration because it gives the essential information to start the intervention, especially the cleaning [4-5]. The surface materials were characterised by X-ray fluorescence spectroscopy (XRF) performed on-site. These on-site analyses allowed to select some points for laboratory deepening by Fourier transform infrared spectroscopy (FTIR) that was applied particularly to investigate the organic components of the stuccoes. An important part of the work was to test the possibility of using micaceous pigments for the reintegration of the surfaces where an original gilding appeared. The tests were performed on mock-ups prepared with commercial selected micaceous pigments that were artificially aged and controlled by colour and hyperspectral imaging measurements.

II MATERIALS AND METHODS

UVF photography was made through a Nikon D800 digital camera modified in full range equipped with a 17–35 zoom lens and by applying two filters in front of the camera lens: filter A and an UV-IR cut filter to remove undesirable components of the electromagnetic spectrum [4]. X-ray fluorescence spectroscopy (XRF) was performed on seventeenth points of the stuccoes surface through a portable instrument, Assing Surface II Monitor, equipped with Ag anode operating at 40 kV and 76 µA. Acquisition time was set to 60s.

FTIR spectroscopy was applied on four micro-samples by using Thermo Nicolet Avatar 360 spectrophotometer operating in the MID-IR with a resolution of 4 cm^{-1}. Samples were examined in diffuse reflectance modality by grounding them with spectrophotometric grade KBr, used as reference and background material.

The commercial products chosen for the experimentation were “Oro Zecchino” (Mica 1) and “Oro Antico” (Mica 3) supplied by CTS Italy and Reddish Gold pigment (Mica 2) from the manufacturer Irison Abralux Colori Beghe. The three micas were applied by two different kinds of binder: gum Arabic (GA) and Regalrez 1126 (R). Mock-ups were prepared in two replicas by applying the micaceous pigments on a layer of mortar made of 1:1 binder-aggregate ratio (1 part of lime putty and 1 of marble dust, about 0.25 mm of particle diameter) by using a clay brick as a support for the mortar. Twenty-four areas were prepared for each replica: nine for the pigments applied with Arabic gum (three replicas for each mica), nine with those applied with Regalrez 1126 and six with the sole binders (three with GA and three with R, Fig. 2). Subsequently the two mock-ups were artificially aged in a chamber equipped with four UV lamps of 36 W each (Philips Model TUV T8 1SL), for thirty days.

The mock-ups were analysed with a benchtop XRF spectrometer in mapping mode, which made it possible not only to detect and quantify the chemical elements present but also to obtain the distribution maps of each determined element. The XRF spectrometer used is the Bruker Tornado M4 equipped with rhodium (Rh) anode, operating at 50 kV, 500 µA current, and 25 µm spot.

To evaluate the surface modifications on muck-ups because of ageing, colour measurements and hyperspectral imaging (HSI) were used.

The instrument used for colour measurements is an EOPTIS CLM-194 portable spectrophotometer and the adopted system is the CIELAB colour space. The data are reported as variations of the parameters L*, a*, b* and as ΔE on the base of the standard UNI EN15886 [6].

HSI measurements in the VIS-NIR (400–1000 nm) region were performed using a hyperspectral camera ImSpector™ V10e (Specim, Finland), with spectral resolution of 2.8 nm, dispersion of 97.5 nm/mm, numerical aperture F/2.4 and slit width of 30 µm, equipped with a 25 mm lens. Pixel resolution was 12 bits. This spectrograph is connected to a CCD camera Blaser A312f equipped with a high sensitivity sensor (Sony ICX 415AL/AQ, 782 × 580 pixels). Illumination was provided by five 100 W flood with cover lens lamps. The calibration of the instrument was obtained by a certified standard target of diffuse reflectance (Spectralon™). PCA was chosen to perform exploratory analysis on the spectral variability of data. PCA allows the decomposition of pre-processed spectral data into linear combinations of the original spectral data, i.e., Principal Components (PCs), collecting the spectral variations in reduced set of factors. The first PCs were used to analyse the common characteristics of samples and their grouping, as the samples characterized by similar spectral signatures tend to aggregate in the score plot of the first components [7-8].

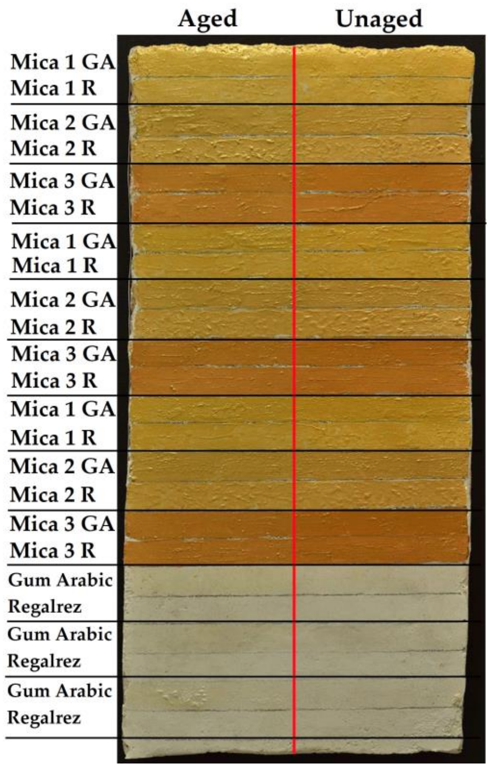

Fig. 2. The mock-up used for the tests on micaceous pigments.

III. RESULTS AND DISCUSSION

The first step in a restoration process is to carefully observe on-site the artwork, object of the intervention. This step, in fact, allows to reveal details that could be omitted by a rapid observation and to help in the choice of the diagnostic path. By this careful observation it has been derived that the gilded stucco frame was created through the indirect method, i.e. by creating the base layer with coarser particle size and then by applying the finishing layer. This last was worked with the help of *modini* and *rafetti*, tools of the sculptors with which the profiles of the modules were defined, subsequently finished and worked freehand with spatulas and sticks. Thanks to the on-site and laboratory analysis further information was obtained on the surface layers, both original and restoration and on the execution technique.

UVF photography gave the result shown in the Fig. 3. The yellow repainting appears black, with no fluorescence under UV, indicating the presence of a recent intervention (executed around 1970). The UVF image shows also an inhomogeneous bluish fluorescence due to surface deposits of dust and various kinds of deposits, both coherent and incoherent. This is visible especially on the left side and can be supposed to derive from the roof water leaks that have occurred in the past [1].

Fig. 3. UVF photograph of the stuccoes in the Lante della Rovere chapel of Palazzo Orsini before the restoration.

The fluorescence visible on the angels and on the clouds can be referred to surface treatments, probably of waxy nature, and, on the Virgin and the Children also due to the presence of fatty materials associated to the touch of the faithful. Lastly, the UVF image shows some grouting characterised by a white bluish fluorescence applied in a previous intervention.

UVF analysis was highly important to obtain a general view of the conservation status of the stuccoes surface and to address the choice of the points to take samples for laboratory investigation.

The other analysis performed on-site was XRF spectroscopy that allowed to detect the chemical elements in the stuccoes. The non-original yellow painting contains iron (Fe) as main element indicating the use of iron oxide pigment. In all examined points calcium was detected as main component of the stuccoes. After an initial cleaning phase which involved the removal of the yellow repainting, another problem emerged affecting the stucco frames: underneath the iron oxide pigment, a consistent green layer appeared. XRF analysis detected copper (Cu) as main element, zinc (Zn) and lead (Pb). It can reasonably be assumed that this layer was that applied in 1899 by the Borghese family to remedy the problem relating to the loss of the original gilding. In fact, between the late 1800s and early 1900s, the *crisocalco* (orichalcum), composed of: copper 90.5%, zinc 7.9% and lead 1.6%, was widely used to imitate gold [9]. The green colour can be associated to the alteration of the components of this layer.

In some points of the frame the original gilding appeared after the removal of the repainting layers. Here, XRF analysis revealed the presence of gold (Au) and Pb. The latter can be associated to the mixture used to adhere the gold on the surfaces. In fact, it can be hypothesized the use of the so-called *missione*, a mixture made of a siccative oil with a terpene resin and lead-based pigments that favourited the siccative process [10]. This hypothesis was confirmed by the analysis of a micro-sample (P1) taken from the frame in correspondence of traces of the original gilding (Fig. 4). The FTIR spectrum of sample P1 shows the signatures of aged siccative oil (cm^{-1}: 2922, 2852, 1708, 1464, 1172). Other signals can be associated to carbonates (lead white and calcium carbonate), oxalate and gypsum, and iron oxides. The presence of lead white is evident by the signal at 1546 cm^{-1} that is due to the formation of lead carboxylates between the siccative oil and the pigment and is typical of aged oils mixed with lead white [11]. FTIR analysis was performed also on the yellow repainting and on the grouting. In the case of the yellow over-painting applied in the 70's, FTIR revealed the use of a tempera binder based on protein; the pigment is composed of silicates, silico-aluminates and iron hydroxides, and calcium carbonate allowing the use of yellow ochre to be identified [1, p. 139].

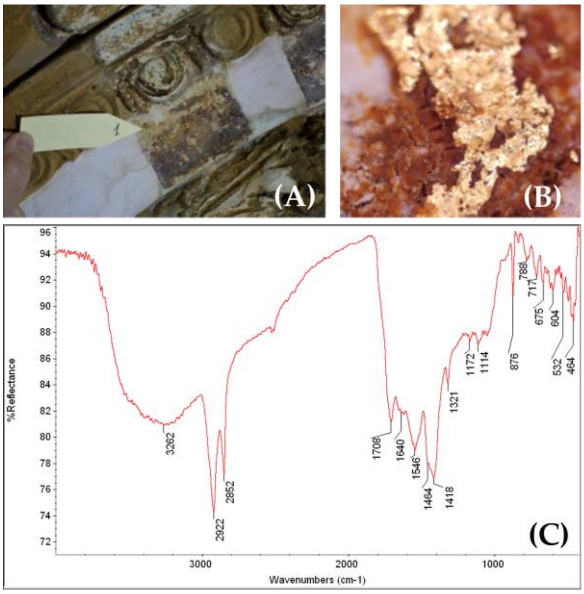

Fig. 4. Analysis of the original gilding. (A) the sampling point P1; (B) detail of the gold traces; (C) FTIR spectrum.

After the phases of artwork materials characterisation, the second part of the restoration work concerned the tests to evaluate the behaviour and stability to light of some commercial micaceous pigments to be used for the reintegration of the original gilding [12]. Before starting the ageing test, XRF chemical mapping was executed on the mock-up, to verify the elemental composition of the micas. XRF mapping made possible to determine the presence of aluminium (Al), potassium (K) and silicon (Si) homogeneously distributed in all micas, being the typical elements of muscovite (Fig. 5). Iron, chromium and manganese exhibit higher counts in Mica 3, probably due to the higher amount of Fe minerals that make this pigment redder in respect to the other two ones. Titanium is present in large quantities in all three types of mica, being the main component of the coating of the muscovite core. There is a general response of calcium, due to the preparatory layer consisting of a mortar based on lime and marble dust.

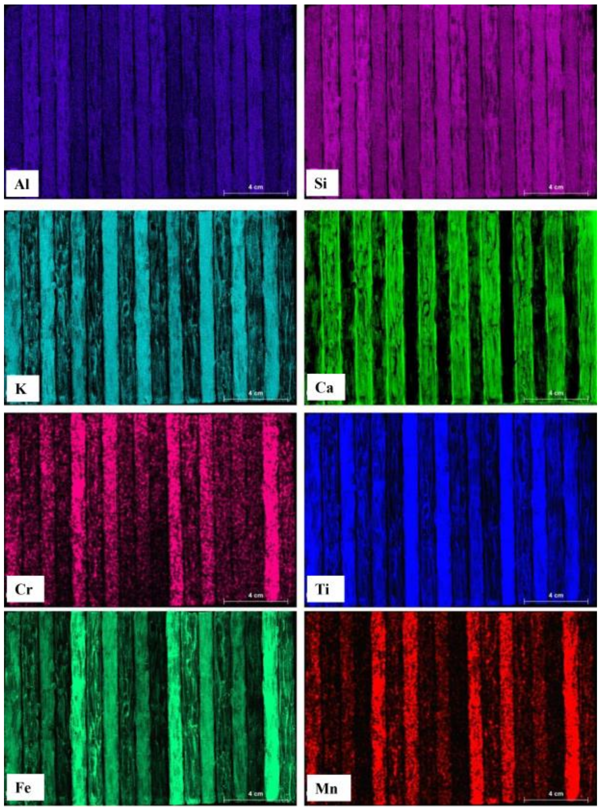

Fig. 5. XRF mapping of the mock-up, concerning only the mica pigments and not the binders' areas (see Fig. 2). The main elements are reported, respectively from top-left to bottom-right: Al, Si, K, Ca, Cr, Ti, Fe, Mn.

The colour measurements and comparison before and after the artificial ageing showed that in all cases some variations occurred, and that gum Arabic is less stable to UV radiation than Regalrez 1126 as expected on the base of binder composition (Table 1). Regalrez is in fact a saturated aliphatic resin resistant to the oxidation phenomena caused by UV. Concerning the pigments applied with gum Arabic, Mica1 underwent the higher changes in colour. The same trend was observed for pigments applied with Regalrez 1124. The data of Table 1 show that the pigments applied with R underwent lower colour changes, apart from Mica1, but the ageing treatment caused a loss of binding power of Regalrez 1126 and the surface of the mock-ups became powdery with detachment of the pigments. For this reason, it was decided to exclude the use of Regalrez 1126 and to focus the attention on gum Arabic.

Table 1. Calculated differences of the chromatic coordinates L, a* and b*, and total colour change ΔE*.*

Sample	ΔL*	Δa*	Δb*	ΔE*
Gum Arabic	-0.32	-0.53	2.62	2.70
Regalrez	-0.04	-0.39	0.45	0.77
Mica1 GA	-1.98	-1.83	-3.85	4.91
Mica2 GA	-1.85	-2.49	-2.70	4.18
Mica3 GA	-0.14	-1.50	-3.89	4.23
Mica1 R	-2.14	-2.90	-5.93	6.98
Mica2 R	-1.44	-2.40	-2.58	3.81
Mica3 R	-0.58	-1.19	-2.21	2.63

A further test was performed through HSI that allowed to obtain the scores shown in Fig. 6. From the scores, it is evident the difference between aged (left) and unaged (right) parts, particularly visible for the binder GA. The image of scores related to the entire dataset mixed with Arabic gum shows in the first two components (i.e, PC1 and PC2) a variability mainly due to the different colour types of used mica (Fig. 6). The image of scores on PC5 better shows the variance between unaged and aged areas. More in detail, PC5 shows more variability in white layers than in darker paint layers. Analyzing the loading plots, it is possible to see how the variability of PC5 is mainly given by the wavelengths around 500, 700 and 900 nm for positive values, while the negative ones are mainly influenced by the regions around 400, 600 and 800 nm (Fig. 7).

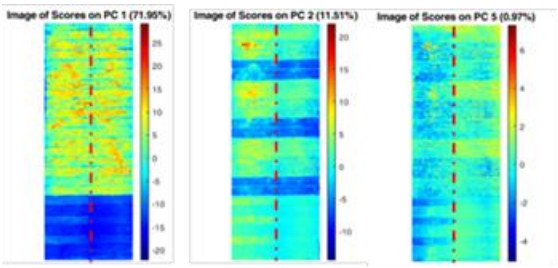

Fig. 6. Image of Scores on PC1, PC2 and PC5.

In order to better highlight the variation detected between the aged and non-aged regions, a ROI (region of interest) was investigated on a single pictorial layer (i.e., Mica 3 CTS mixed with gum Arabic). The results allow to highlight a slight variation between the aged (green) and unaged (red) area (Fig. 8). The detected variation was mainly evidenced by the PC5.

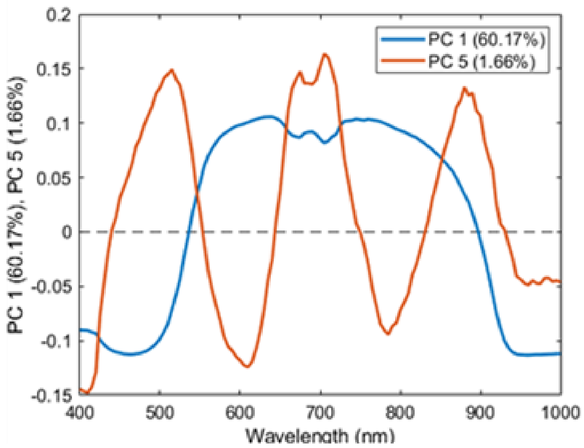

Fig. 7. Loading plot of PC1 and PC5 related to the pictorial layer Mica 3 CTS mixed with gum Arabic.

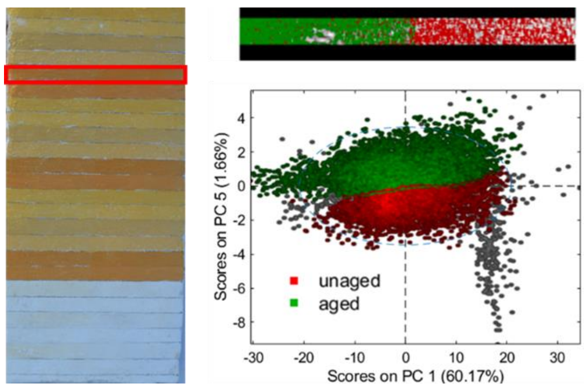

Fig. 8. PCA score plot of PC1 and PC5 related to the pictorial layer Mica 3 CTS mixed with gum Arabic.

IV. CONCLUSIONS

The restoration of the stucco's decoration in the Palazzo Orsini at Bomarzo was the occasion to investigate the original materials and the overpainting in the frame and in the ray emerging from the clouds with the aim at choosing the most suitable procedure for cleaning and reintegration. Due to the presence of an original gilding, hidden by crisocalco in the 19th century and then by a recent tempera yellow painting, it was decided to test the application of micaceous pigments to reintegrate the gilded areas so that to use a material imitating gold but easy recognisable and reversible. Three commercial mica-based pigments were selected and applied on mock-ups by two different binders: gum Arabic and Regalrez 1126. Colour measurements and hyperspectral imaging were used to evaluate the stability of these materials in respect to artificial ageing. The results showed that the pigments applied with R were pulverised after ageing and so this binder was excluded, even if the chromatic changes were lower in respect to GA samples.

Between the three chosen pigments Mica1 and Mica2 were selected because their colour is like that of gold, on the other hand Mica3 is too red.

This work demonstrated once again as the diagnostics and scientific methodologies can help the restoration for the knowledge of artwork materials and, above all, for the choice of the most appropriate procedures and treatments.

In the Figure 9 the artwork at the end of the restoration is shown.

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Fig. 9. The artwork after the restoration.

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