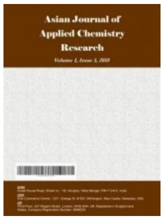

*Asian Journal of Applied Chemistry Research*

*2(2): 1-18, 2018; Article no.AJACR.45266*

# A Comparative Study of Two Albanian Post-Byzantine Icons Attributed to *Simoni i Ardenices*

**Enrico Franceschi[1*], Dion Nole[1] and Stefano Vassallo[2]**

*[1]Department of Chemistry and Industrial Chemistry, University of Genoa, Italy.*
*[2]Mibac Sabap Liguria, Genoa, Italy.*

***Authors' contributions***

*The authors worked in close contact and discussed the results of the work together. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/AJACR/2018/v2i229668
Editor(s):
(1) Dr. Endang Tri Wahyuni, Professor, Department of Chemistry, Gadhah Mada University, Indonesia.
(2) Dr. Gadang Priyotomo, Lecturer, Research Center for Metallurgy and Material, Indonesian Institute of Sciences, Kawasan Puspiptek, Serpong, Tangerang, Indonesia.
Reviewers:
(1) Rosario García Giménez, Universidad Autónoma de Madrid, Spain.
(2) Antonino Cosentino, Cultural Heritage Science Open Source, Italy.
Complete Peer review History: http://www.sciencedomain.org/review-history/27887

*Original Research Article*

***Received 12 September 2018***
***Accepted 03 December 2018***
***Published 20 December 2018***

## ABSTRACT

**Aims:** The present study is part of a project concerning the characterisation of a limited number of selected Albanian Byzantine and post-Byzantine icons, through the identification of pigments, of painting technique and the state of conservation of the artworks. The Albanian iconographers produced an extraordinary amount of icons from the 14$^{th}$ till the 19$^{th}$ century, and over six thousand of them are kept in the Museum of Medieval Art of Korça (Albania). This paper refers to the results obtained in the study of two artworks, the first one by *Simoni i Ardenices* an important Albanian painter of XVII century, and the second one attributed to him.
**Study Design:** The present work is part of a more general study concerning Albanian Byzantine and post-Byzantine icons.
**Place and Duration of Study:** Museum of Medieval Art of Korça, Albania, between June 2008 and July 2009.
**Methodology:** The work was conducted by non-destructive methods, X-ray fluorescence, visible light reflectance spectrophotometry and UV fluorescence analysis, according to a systematic procedure developed in the same Chemical Physical Laboratory for Cultural Heritage. A number of areas, for each painting, were chosen in order to carry out the measurements. With this procedure, we could identify the inorganic pigments from their characteristic features. Moreover, the study of

**Corresponding author: Email: franceschi@unige.it;*

the chemical physical properties of paintings is of fundamental importance for any accurate restoration intervention.

**Results and Conclusion:** The present work, concerning the study of two icons of the second half of 17th century by *Simoni i Ardenices*, has allowed us to identify the painting technique and the palette used in these works of art. Moreover, the areas of the paintings in which old restorations have been made have also been identified.

*Keywords: Albanian post-byzantine icons; archaeometry; pigments; X-ray fluorescence; reflectance spectrophotometry; UV fluorescence.*

## 1. INTRODUCTION

Albania maintains numerous artistic treasures, especially related to the Byzantine and post-Byzantine wall paintings and icons. In the last years, several studies on Albanian Byzantine and post-Byzantine icons have been done [1–8], but these are only a negligible number of studies compared to the large amount of not yet studied artworks held in the Museum of Korça and in the other Albanian museums and art sites. The Museum of Medieval Art of Korça, located in the southeast of this Country, almost on the border with Greece, conserves over six thousand icons. Among the iconographers, we mention many important masters, such as Onufri, Onufri Qiprioti, Konstantin the Teacher, Konstantin Jeromonaku, Konstantin Shpataraku, David of Selenica, and the Çetiri brothers, a family of painters from Grabova, a village in the Korça district. The present study was aimed at characterising two artworks attributed to *Simoni i Ardenices*, an important exponent of the Albanian iconographers, who operated in the XVII century AD.

## 2. MATERIALS AND METHODS

The artworks, presented in Figs. 1-2, are respectively, a tempera paint on wood, depicting St. George on the horse, coming from the Monastery of Ardenica, Lushnja and the Regal Doors, part of an Iconostasis, painted for the St. Mary Church of Vithkuq (Korça district).

Saint George, riding a white horse, wears a military outfit, a red mantle on his shoulders. The saint is spearing the dragon. Behind him there is the image of a young man, a slave that Saint George saved from slavery (or from the dragon), according to ancient legends that surround the figure of the Saint. All around him there are people applauding while playing musical instruments; others offer him the keys of the city, as he was a victor. An angel puts a crown on his head; on the corner of the icon God is blessing.

The icon is painted on a wooden panel (56.5 X 43 X 3 cm, Inventory number 6732) with tempera technique. The wooden table is carved out forming a frame, adorned by a band in red and blue, coloured and decorated with floral patterns. A canvas is covering the entire surface of the panel.

In this study we used almost exclusively non-invasive methods of analysis, as described below; only one micro-sample was carried out on the back of a door (Inventory number 5850) of the Regal Doors. A variety of areas for each artwork were chosen for identifying the pigments, the painting technique of the artist and the restoration interventions.

### 2.1 Optical Microscopy and Macro-photography

Optical observation and photographic documentation was achieved using a Dino-lite portable digital microscope and a Canon EOS 350D camera equipped with a Canon Zoom Lens EF-S 18-55 mm.

### 2.2 UV Fluorescence

This analysis [9] was carried out using a ceiling light with four Sylvania black-light-blue F18W/ BLB-T8 tubes. The digital camera used for recording images is the same as for macrophotography, without barrier filter [10]. This non-destructive superficial analysis allows identifying the presence of one or more film-forming substances such as varnishes applied on the artwork (resins, oleoresins, proteins, etc.) and generally every previous intervention.

Also, it lets to assess the whole condition of the paint, enhancing the presence of restorations, biological attacks, even when they appear indistinguishable to the naked eye. Moreover, it can give some information on pigments based on their own particular fluorescence. Typical examples are: the red-purple of cinnabar, the brightness of lead white, the darkening of iron oxides.


**Fig. 1. St. George on the horse, 56.5 X 43 X 3 cm, Inventory Number 6732, painted in 1690 for the Monastery of Ardenica (Lushnja, Albania). Numbers indicate the points of analyses**

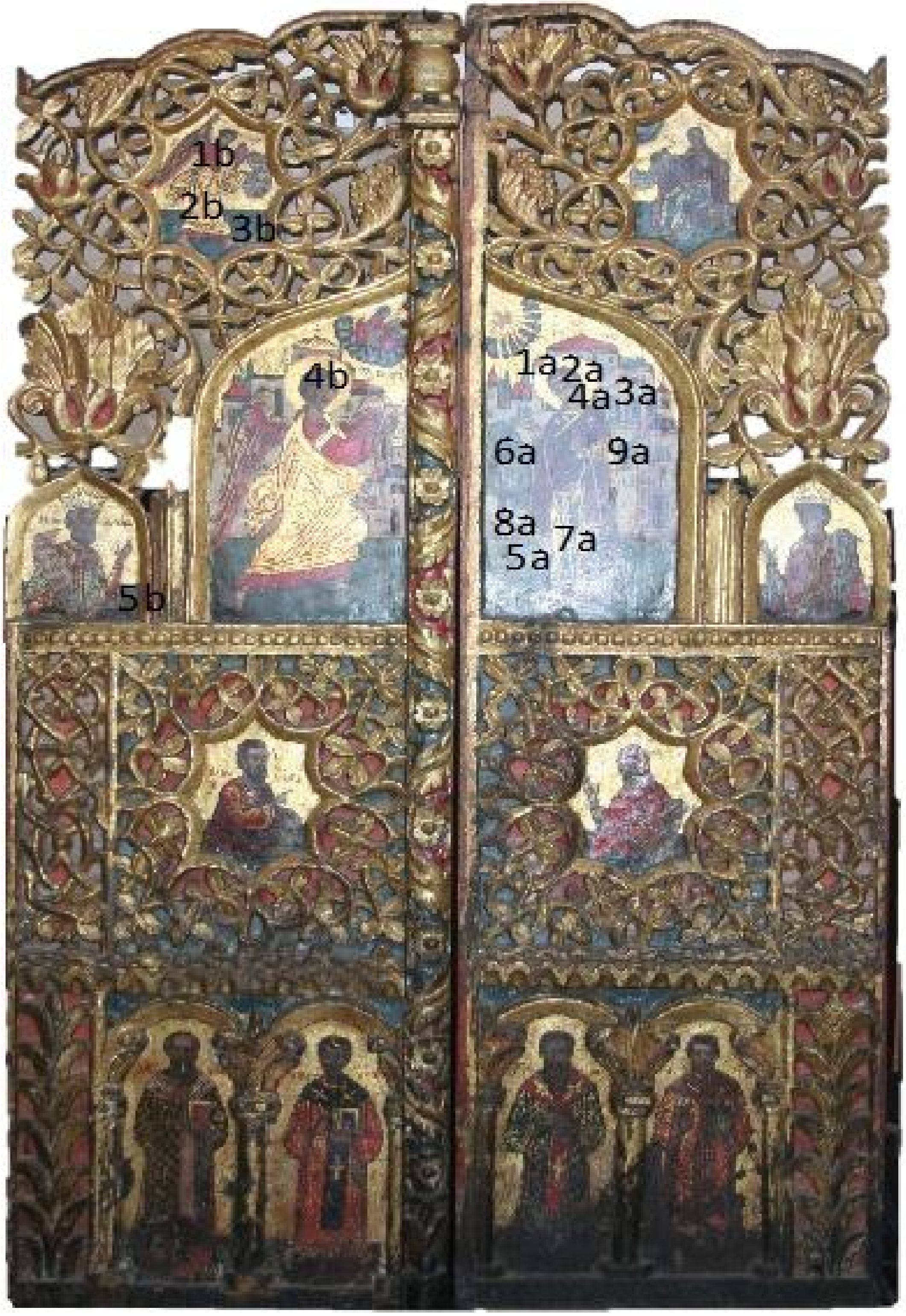


**Fig. 2. The Regal Doors, Inventory numbers 5850 and 5851, painted for the Iconostasis of St. Mary Church, Vithkuq (Korça District). Numbers indicate the points of non-invasive analyses**

### 2.3 X-Ray Fluorescence Spectrometry

Elemental analysis was performed using a Lithos 3000 portable system; the apparatus consists of a molybdenum tube, a zirconium filter and a semiconductor silicon (Li) detector, cooled by Peltier effect. The operating parameters were: 25 kV, 0.1 mA, and 240 seconds of acquisition time. An appropriate Lithos program by Assing allowed processing the data. The elements with the highest intensity detected on the paintings, such as lead, iron or mercury, have been used as internal standards.

### 2.4 Reflectance Spectroscopy

This technique is commonly used in the study of cultural heritage. For example, it allows a fast and safe characterisation of pigments [11], paper, papyrus, wood [12], textiles [13] or metals [14] and their alteration state. The spectroscopic reflection method allows to obtain a colour measurement, translating the visual stimulus into numerical data and into spectrophotometric curves as a function of the wavelength of visible light (between 400 and 750 nm). Measurements were made with a Minolta portable CM 2600d spectrophotometer. In these measurements, the measure of a reference standard white is set equal to 100.

## 3. RESULTS AND DISCUSSION

The results, helpful to identify the pigments and the painting technique of the two artworks, are discussed separately, showing the contribution that each analytical technique has provided.

### 3.1 St. George on the Horse

Looking at the edges of the table and cracks in wooden planks, it is evident that an intermediate canvas was used beneath the painted surface. The inorganic pigments employed for the painting have been identified by means of their principal characteristic elements, their relative abundance and by comparing the reflection spectra with the literature data and with those of a pigments database developed in collaboration with the *Soprintendenza per i Beni Architettonici e Paesaggistici della Liguria.*

#### 3.1.1 Macrophotography and UV fluorescence

We have done macrophotography, UV photography and raking light photography with the purpose of investigating the surface, textural irregularities of painting, the eventual presence of a canvas covering the table and the detachment or distortion of paint layer. In Fig. 3 a warped/cracked panel can be seen.

Areas containing cinnabar or vermillion become purple under the UV illumination; iron oxide presents a typical darkening behaviour, clearly showing the painting technique used by the artist, with strokes applied to form continuous layers as painting basis and thin strokes as overlayers (Fig. 3).

Figs. 4 and 5 show two other details of the icon, indicating the use of lead white, iron oxides and cinnabar. The background is formed by using brown ochre, probably mixed with animal glue, the so-called bolo; no typical behaviour of gold was observed neither in the background nor in aureole, suggesting the use of yellow ochre in these areas (traces of gold have been individuated only by means of X-ray fluorescence in limited areas).

#### 3.1.2 X-ray fluorescence

The data obtained by X-ray fluorescence (XRF) measurements have been processed as reported in the literature [15]; we have identified various materials on the surface and in the different layers of the painting. The experimental data, obtained by XRF measurements, are summarised in Table 1 and visually shown in Fig. 6. The occurrence of the most abundant elements - detected on the basis of the counts measured for the main peak of each element - in the different analysed areas - is plotted. In the case of simultaneous presence of arsenic and lead, their principal peaks As $K_\alpha$ and Pb $L_\alpha$ are superimposed at about 10.5 keV. In order to obtain a correct evaluation, in the case of simultaneous presence of the two elements, we considered the counts of $K_\beta$ (11.73 keV) and $L_\beta$ (12.61 keV), respectively. The counts of the peaks of the elements have been normalised for graphical presentation.

We should preliminarily observe the absence of gold in the various areas investigated, in particular in the background and in the aura of the Saint. As regarding the pigments, a typical element detected is arsenic (spots 2, 4, 6, 11, 13) which indicates the presence at least of two possible pigments: orpiment and realgar, two different arsenic sulphides. The Scheele's green pigment [16] should be excluded because its discovery by the Swedish chemist Scheele goes back to 1775.

**Fig. 3. The figure shows a detail, next to a breakage of the paint film. From the top to the bottom the images are in visible light, under UV radiation and with raking light**

**Fig. 4. A detail of the icon. Comparison between visible light (top) and UV radiation (bottom) images, showing the areas containing cinnabar, lead white and iron oxides**

**Fig. 5. A detail of the icon. From the left to the right the images are in visible light, under UV radiation and with raking light**

In the spot 13, corresponding to the brown hair of the Saint, probably a mixture of brown ochre, cinnabar, realgar and minium was used.

We suggest the use by this famous painter of the mixture of indigo and orpiment, also known with the term of vergaut, in obtaining the green hue (spots 4, 6); mixed with a white pigment (like lead white) in grey- green areas (spot 11). Vergaut has been used since the roman period, and it was obtained following ancient recipes as reported by [17,18].

Ad viridem fatiendum. Invenies auripiumentum et indicum de Bagadon et tere bene cum aqua et cum residerit, tere cum aqua gumata, fiet viridem. Et si tibi placet, acipe de auro piumento et tere et simul missce de biacha et de indico et fac ut supra et erit viridis [17].

*Verde è un colore el quale si fa d'orpimento le duo' parti, e una parte indaco; e triasi bene insieme con acqua chiara. Questo colore è buono a dipingere palvesi e lancie, e anche s'adopera a dipingere camere in secco* [18].

In the spot 2, corresponding to a flesh tone, the presence of vergaut arises from the green-blue line of the sky.

The presence of barium and zinc (spots 5,8, 9,11) indicates modern restorations [19,20] of the icon. The same one can observe for the presence of Cr (spot 15). Regarding the occurrence of Sr, this element should indicate the use of gypsum, both as a white pigment and as a binder for restoration [21].

The elements manganese and nickel, evidently, have to be connected with the type of ochre used by the artist.

### 3.1.3 Reflectance spectroscopy

The results obtained by the reflectance measurements [22] are shown in the following Figs. 7, 8 and 9, divided according to the colour.

Observing the green colours reported in Fig. 7, the curve behaviour is clearly different from that of malachite and verdigris, while is similar to the shape of the measured curves of vergaut found in a byzantine icon [7]. Further analysis would be required to ascertain with certainty the use of this pigment.

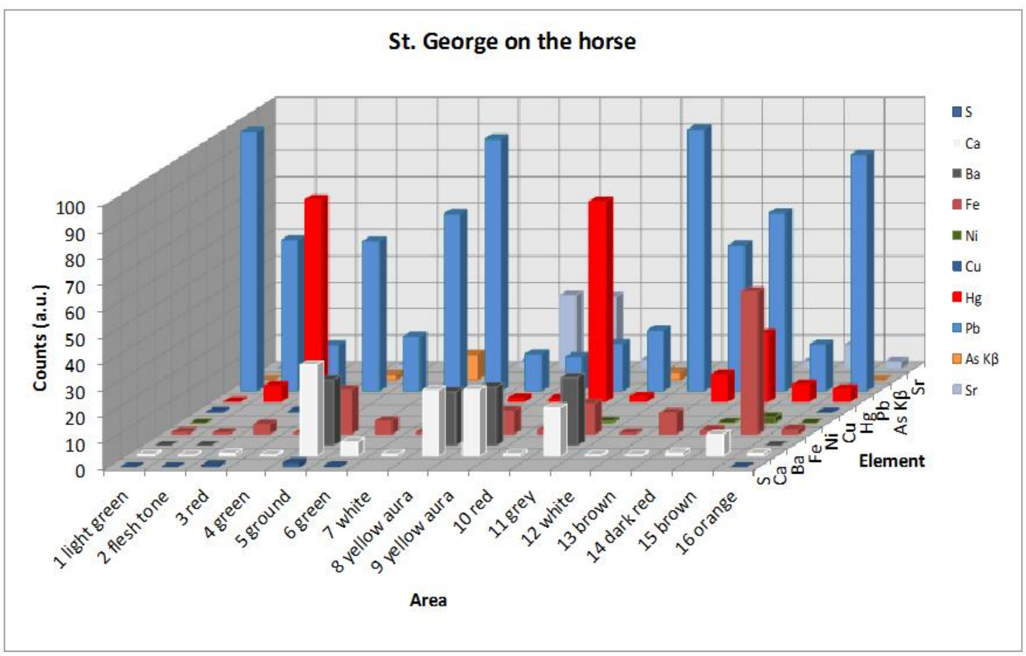


**Fig. 6. The occurrence of the most significant elements in the 16 analysed areas of St. George on the horse**

**Table 1. The counts of the main peaks of the elements detected in the analysed areas of St. George on the horse (tr = traces)**

| Spot | Colour | S | Ca | Ba | Cr | Mn | Fe | Ni | Cu | Zn | Hg | Pb $L_{\alpha}$ or (Pb $L_{\alpha}$+As $K_{\alpha}$) | As $K_{\beta}$ | Pb $L_{\beta}$ | Sr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | light green | | 91 | | | | 126 | | 41 | | | 13085 | tr | | |
| 2 | flesh tone | | 98 | | | | 170 | | | | 1628 | 15222 | 1780 | 7748 | |
| 3 | red | 91 | 148 | | | | 467 | | 53 | | 9576 | 2158 | | | |
| 4 | green | | 105 | | | | 157 | | 38 | | | 11953 | 412 | 8113 | 328 |
| 5 | ground | 27 | 553 | 396 | | | 270 | | | 20 | | 330 | | | |
| 6 | green | 36 | 443 | | | | 414 | | | | | 5503 | 795 | 624 | 387 |
| 7 | white | | 108 | | | | 134 | | | | | 12470 | | | 352 |
| 8 | yellow aura | | 507 | 414 | | | 189 | 15 | 13 | 11 | 28 | 284 | | | 566 |
| 9 | yellow aura | | 496 | 436 | | 47 | 176 | | | tr | 23 | 256 | | | 541 |
| 10 | red | | 100 | | | | 210 | | | | 8600 | 2020 | | | |
| 11 | grey | | 370 | 508 | | | 232 | 16 | | 15 | 39 | 454 | 60 | 329 | |
| 12 | white | | 68 | | | | 77 | | | | | 14757 | | | |
| 13 | brown | | 121 | | | | 2015 | | | | 2562 | 13727 | 2945 | 3507 | tr |
| 14 | dark red | | 166 | | | 39 | 197 | 36 | | | 3159 | 8245 | | | 377 |
| 15 | brown | | 353 | | 83 | tr | 2276 | 101 | | | 277 | 740 | | | 385 |
| 16 | orange | | 160 | | | | 265 | tr | | | 665 | 12433 | | | 396 |

**Table 2. The counts of the main peaks of the elements detected in the analysed areas of The Regal Doors (tr = traces)**

| Spot | Colour | S | Ca | Fe | Cu | Au | Hg | Pb $L_{\alpha}$ or (Pb $L_{\alpha}$+As $K_{\alpha}$) | As $K_{\beta}$ | Pb $L_{\beta}$ | Sr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | yellow aura | 45 | 534 | 148 | 130 | 1892 | | 226 | | | 319 |
| 2A | red | 52 | 392 | 188 | 377 | 1456 | 4276 | 977 | | | 393 |
| 3A | white | | 106 | 77 | 51 | | 477 | 12204 | | | tr |
| 4A | flesh tone | 107 | 128 | 199 | 73 | | 2236 | 12662 | | | |
| 5A | red | 108 | 174 | 70 | 118 | | 7591 | 619 | | | 448 |
| 6A | green | | 154 | 264 | 242 | | 1861 | 13515 | | | |
| 7A | green and gold | | 127 | 117 | 77 | 1598 | | 4938 | | | 234 |
| 8A | green | | 116 | 193 | 208 | | 1459 | 10152 | | | |
| 9A | dark green | 44 | 187 | 134 | 77 | | 2140 | 8054 | | | 297 |
| 1B | red | 100 | 150 | 100 | 100 | | 7200 | 400 | | | 700 |
| 2B | gold | 59 | 224 | 156 | 115 | | 5457 | 1667 | | | 408 |
| 3B | ground | 29 | 1027 | 149 | 81 | | | 3690 | 522 | 503 | 315 |
| 4B | brown | 30 | 200 | 150 | | | 5200 | 1600 | | | 500 |
| 5B | green | 33 | 952 | 171 | 80 | | | 3148 | 404 | 588 | 322 |

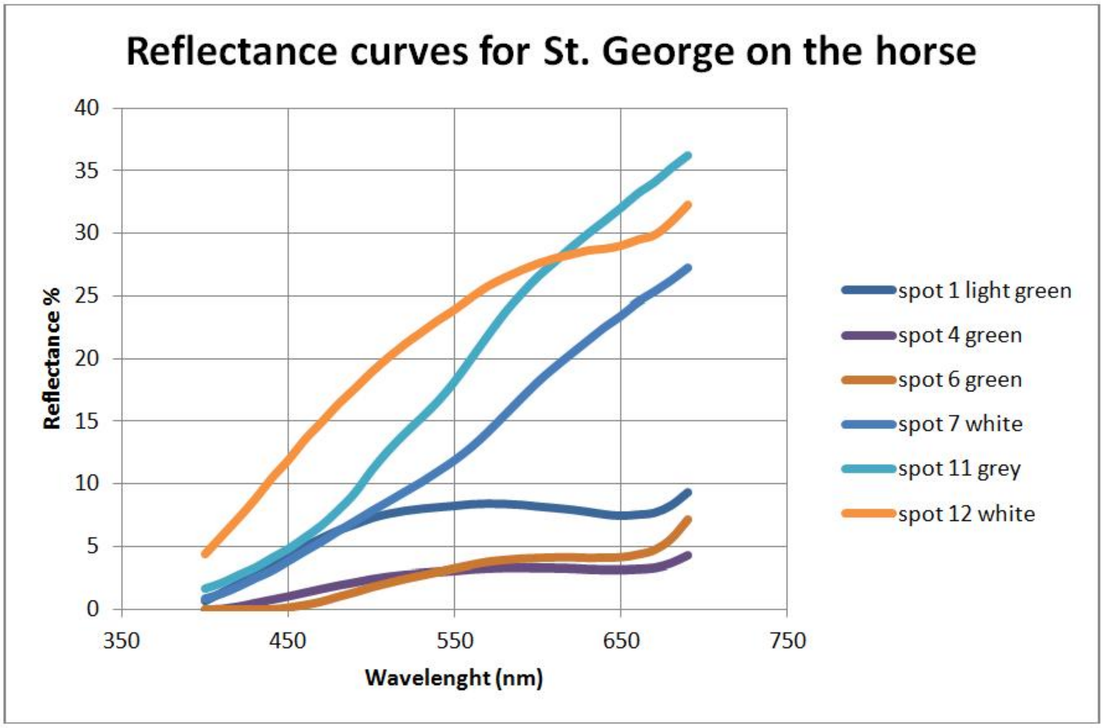


**Fig. 7. Comparison of the reflectance curves for white and green tones**

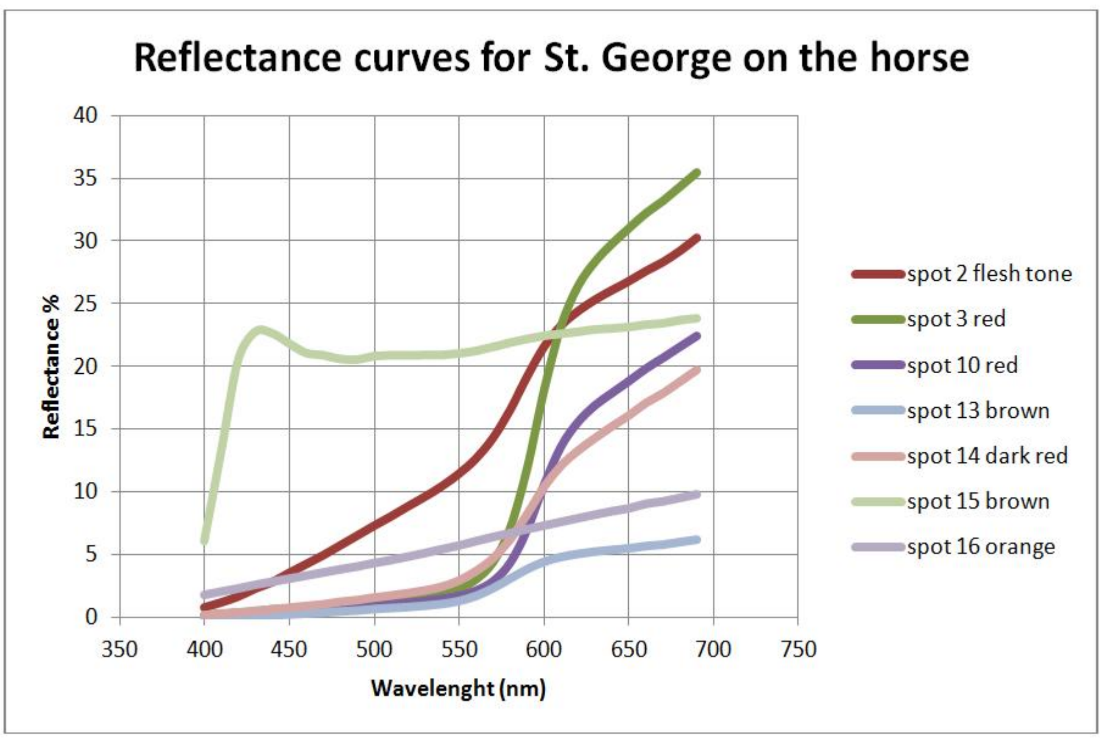


**Fig. 8. Comparison of the reflectance curves for red and brown tones**

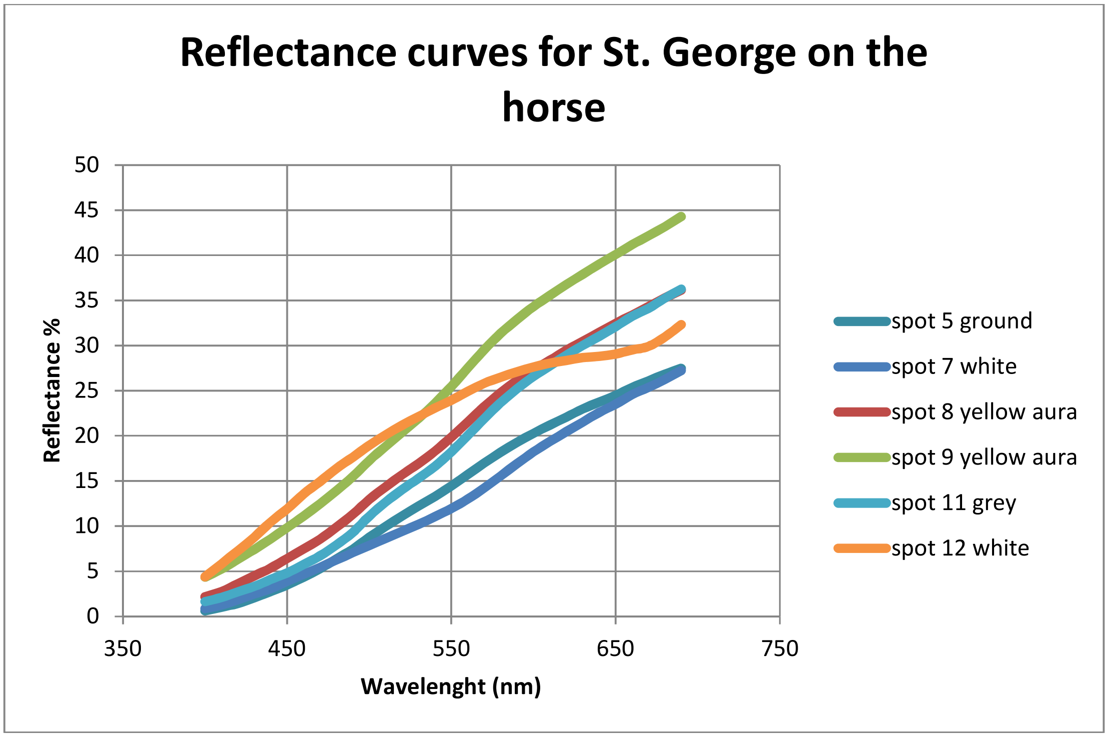


**Fig. 9. Comparison of the reflectance curves for yellow and white tones**

The red and brown tones have been obtained employing a mixture of red pigments, red ochre, red lead and vermillion or cinnabar, as shown by the shape of the reflectance curves; the spots 2 and 10 showing the highest content in cinnabar. This obviously is a perfect match in the XRF analytical data. We can note that the curve corresponding to the spot 15, brown colour, is completely different in accord with the presence of Cr, used in a modern restoration intervention.

As regards the colour white, the curves (Fig. 9) reflect the use of lead white as colour basis.

## 3.2 The Regal Doors

### 3.2.1 Macrophotography

The whole painting of Fig. 2, as the details shown in Figs 10-12, allow to recognise easily the painting technique and the overlap of colours used by the painter. You can also appreciate the delicacy of the details of the painting.

It is possible to observe immediately a significant difference between The Regal Doors and the St. George paintings, concerning the preparation of the table. In St. George is a canvas glued to the wooden support, while not present in The Regal Doors.

### 3.2.2 UV fluorescence

Observing the Figs. 13 and 14, it is possible to detect the use of some special pigments. One can observe the fluorescence typical of calcium carbonate (which becomes yellowish) and azurite (with a blue accentuated). Pronounced darkening reveals the presence of iron oxide.

### 3.2.3 X-Ray Fluorescence

Considering the results of XRF analysis, it is possible to observe a first significant difference between the two works studied. This concerns the use of gold foil that is abundant in The Regal Doors and completely absent in St. George's table.

### 3.2.4 Reflectance spectroscopy

The results obtained by the reflectance fourteen measurements taken on a wing of The Regal Doors, inventory number 2850, are shown in the following Figs. 16, 17, 18 and 19, divided according to the colour. Only nine measurement points are coincident with those chosen for the measurement of X-ray fluorescence.

**Fig. 10. A detail of the upper parts of the Regal Doors**

**Fig. 11. A detail of the central part of the icon, illustrating the event of the Annunciation to the blessed Virgin Mary, as in traditional iconography of the iconostasis. At the corners God the Father and the Holy Spirit are depicted. It is curious to observe the cross on the dome on the left**

**Fig. 12. A detail of figure 11, with the building behind the Virgin, showing the technique of painting and drawing colour**

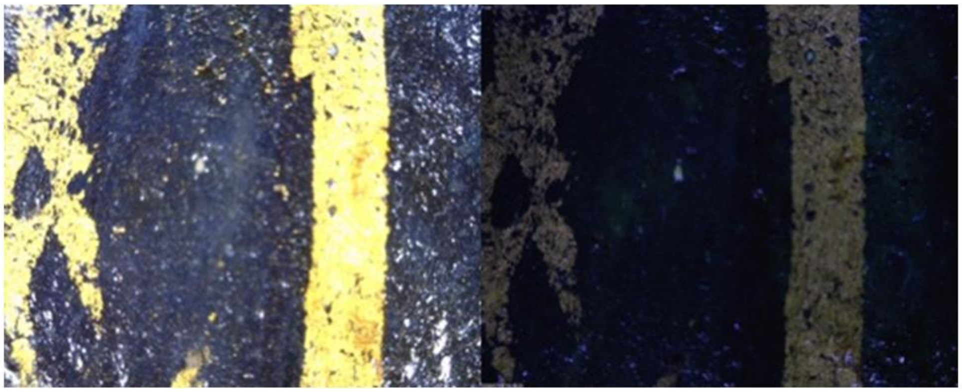

**Fig. 13. A detail of the King David garment, observed through the portable microscope, showing the typical behaviour under UV light (on the right) of the gold in foil and the blue area, containing copper carbonate azurite**

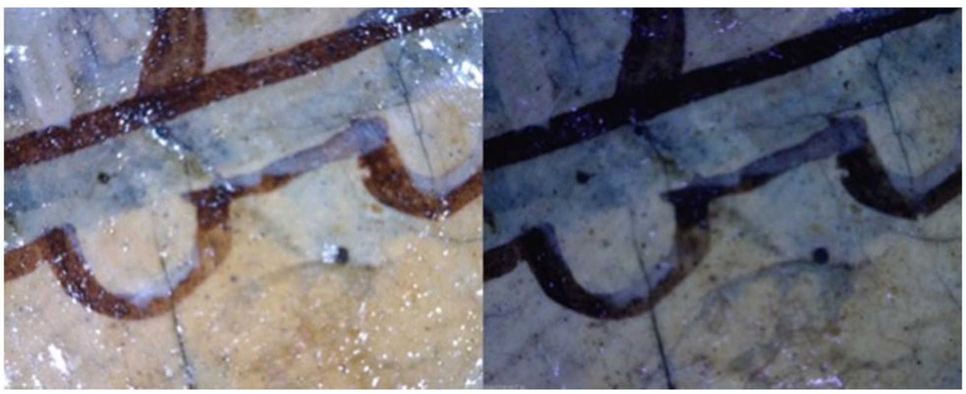

**Fig. 14. A detail of figure 9; the fluorescence (on the right) of iron oxide, copper carbonate and calcium carbonate is shown**

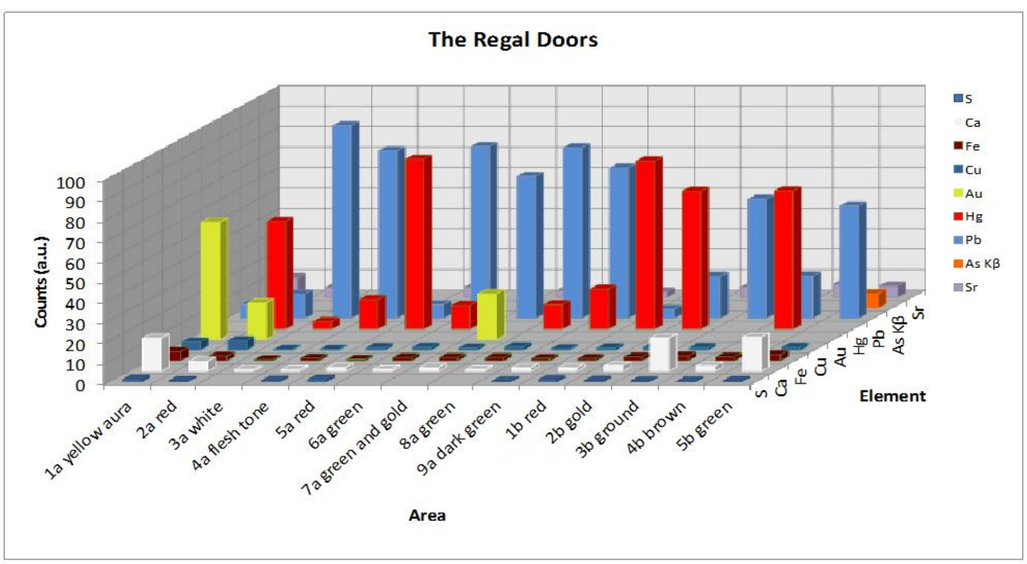


**Fig. 15. The occurrence of the most significant elements in the analysed areas of the Regal Doors**

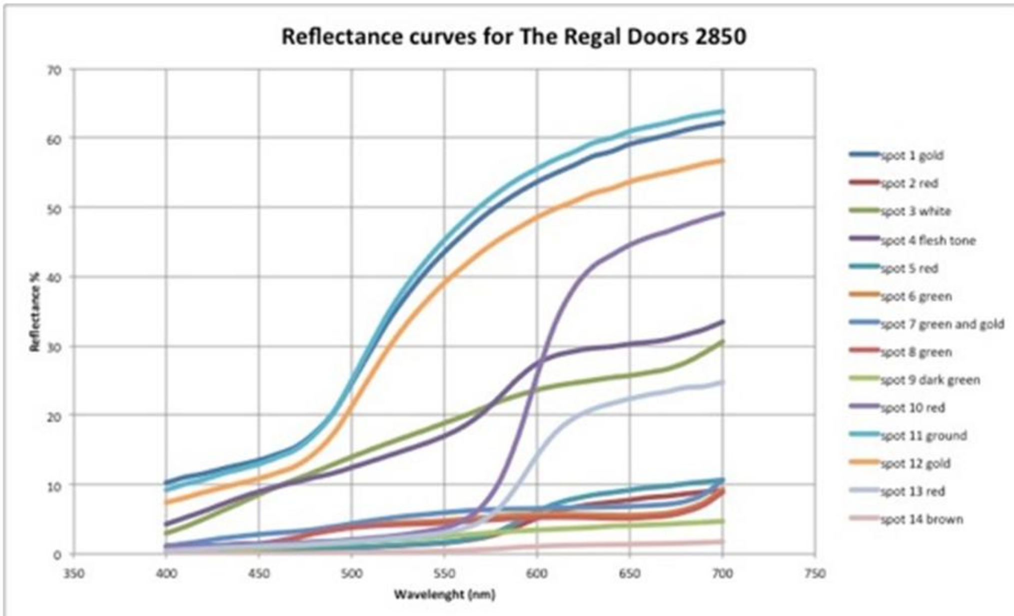


**Fig. 16. The reflectance curves for the regal doors, N° 2850, comparison of the whole data**

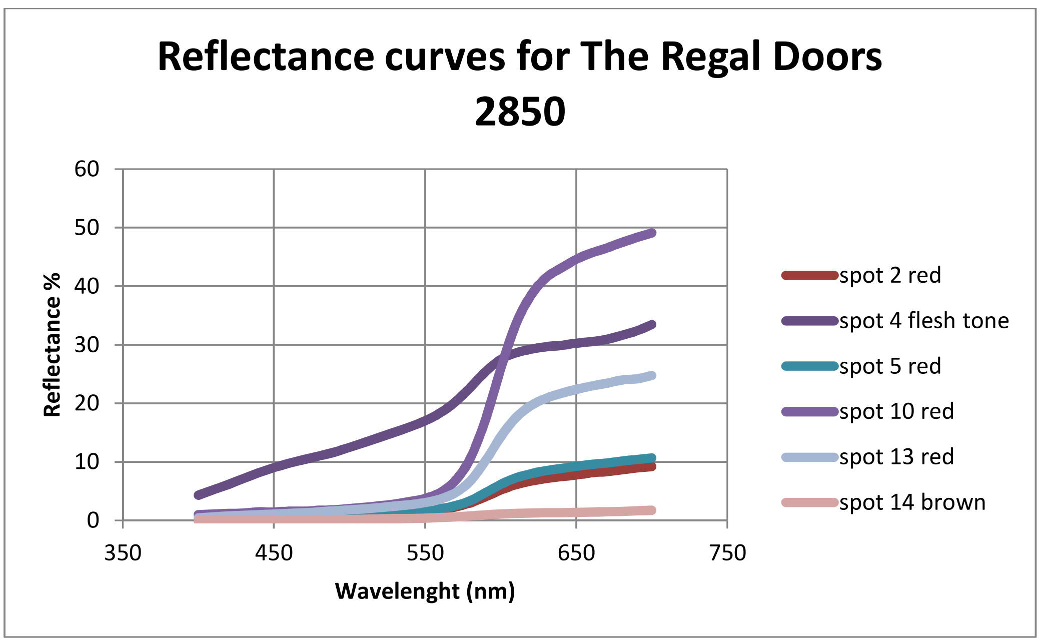


**Fig. 17. Comparison of the reflectance curves for red and brown tones**

For the second door, further nine measures have been carried out, whose results are not shown in the present work.

Considering the measurement points 10 and 13 (Fig. 17), they indicate the use of cinnabar to obtain the red colour, while the other curves suggest the use of red or brown ochre.

The curves reported in Fig. 18 show the use of pure gold, in leaf, while the curve corresponding to spot 3 indicates the use of lead white mixed with a black pigment.

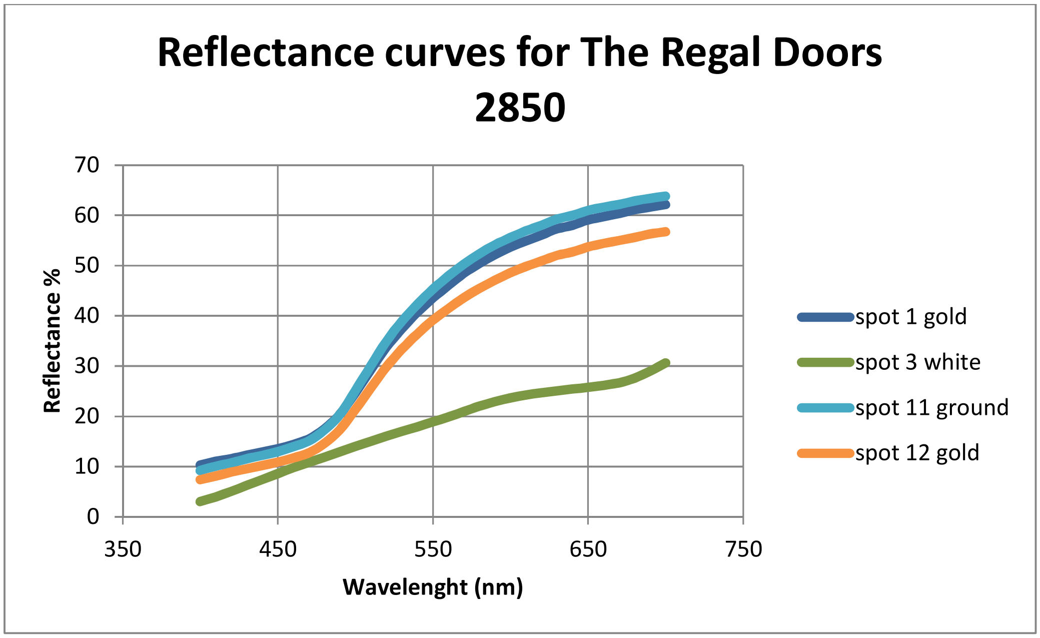


**Fig. 18. Comparison of the reflectance curves for yellow and white tones**

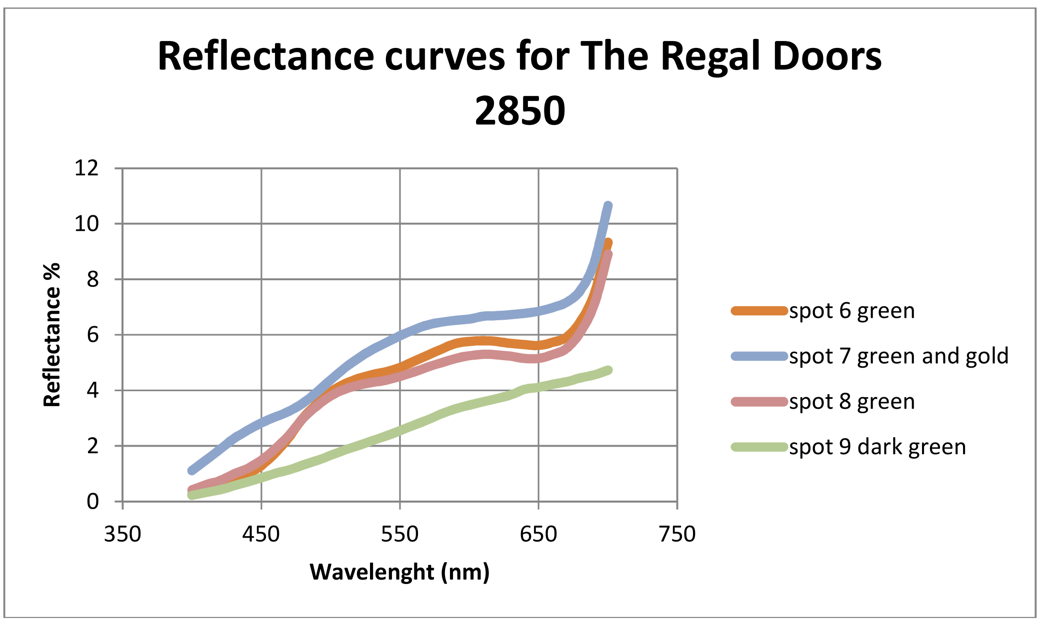


**Fig. 19. Comparison of the reflectance curves for green and dark green tones**

Considering the green colours reported in Fig. 19, the shapes of the reflectance curves is completely different from that of malachite and verdigris, while is similar to the trend of the curves of vergaut found in a byzantine icon [7]. However, as for the previously observed cases, further investigations need to be done to confirm the use of this pigment.

## 4. CONCLUSION

The set of non-invasive methods, which we have employed in the study of these two works of art, provided helpful information to identify the pigments and the preparation techniques. For the ground of St. George on the horse, the painter employed calcium white coloured with an ochre.

In fact, the limited presence of sulphur in this icon suggests the main use of calcium carbonate rather than the more usual gypsum.

The presence of barium and zinc (spots 5,8,9,11) and chromium (spot 15) indicates modern restorations of the icon. The occurrence of strontium derives from the use of gypsum, probably as a binder during the restoring interventions. The painter's palette includes a limited number of pigments, as lead white, cinnabar, red and yellow ochre, brown earth, orpiment and/or realgar, and probably indigo in the green tones. The variety of colour has been obtained through the use of mixtures of different pigments with different proportions and superimposing coloured layers. Simoni i Ardenices follows the iconographic tradition in painting St. George on the horse, with some characteristic features, as discussed above.

Comparing the results obtained for this icon with the study of the Regal Doors, we can observe that the main difference arises from the large use of gold in the latter in place of the yellow ochre used in the St. George icon. A further difference is related to the diffuse presence of strontium and sulphur in the Regal Doors, suggesting the use of gypsum as preparation layer for the panel. Moreover, the canvas is absent in this second artwork. In conclusion, the two artworks object of our study do not seem to belong to the same author.

Through our study, we also detected the previously restored areas of the St. George icon and the kind of pigments utilised by restorers in a period of time from the first half of 1800 (as denoted by the presence of zinc and barium).

Furthermore, the spectral reflectance measurements of the different pigments gathered in this work, in addition to recognising the conservation status of the examined artworks, will also be useful for future restorations.

## ACKNOWLEDGEMENTS

The authors are grateful to the Director Dr. Lorenc Glozheni, Dr. Kirstaq Balli and all the staff of the Muzeu Kombetar i Artit Mesjetar of Korça, for their helpful discussions and their assistance in performing the measurements.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Arapi M, Czerwenka-Papadopoulos K, editors. Percorsi del Sacro. Icone dai Musei Albanesi. Mondadori Electa S.p.A. MilanoItalian; 2002.
2. Civici N, Demko O, Clark RJH. Identification of pigments used on late 17th century Albanian icons by total reflection X-ray fluorescence and Raman micro-scopy. J Cultural Heritage. 2005;6:157-64.
3. Civici N. Non-destructive identification of inorganic pigments used in 16–17th century Albanian icons by total reflection X-ray fluorescence analysis. J Cultural Heritage. 2006;7:339-43.
4. Franceschi E, Nole D, Vassallo S. Icone albanesi post bizantine: Un approccio archeometrico. VI Congresso Nazionale di Archeometria Scienza E Beni Culturali, Atti del Congresso (Pavia, 15 -18 Febbraio 2010). Riccardi MP, Basso E, editors, Patron, Bologna. 2011;1-13.
[ISBN 978-88-555-3181-8, Italian]
5. Franceschi CM, Franceschi E, Nole D, Vassallo S, Glozheni L. Two byzantine albanian icons: A non-destructive archae-ometric study. Archaeological Anthropo-logical Sciences. 2011;3(4):343-55.
DOI: 10.1007/s12520-011-0073-0
6. Franceschi E, Nole D, Vassallo S. The combined use of archaeometric techniques for non-invasive analysis of paintings: The study of Albanian icons by Onufri. Proceedings of the Third Balkan Symposium on Archaeometry - The Unknown Face of the Artwork; 2012:35-44. Radvan R, Akyuz S, Simileanu M, Dragomir V, editors; 2012.
[ISBN- 13978-973-88109-9-0]
7. Franceschi E, Nole D, Vassallo S. Archaeometric non-invasive study of a byzantine albanian icon. Journal of Scientific Research & Reports. 2013;2(1): 17-34.
[ISSN: 2320–0227]
DOI: 10.9734/JSRR/2013/2381
8. Icons from the orthodox communities of Albania: Collection of the National Museum of Medieval Art, Korcë.
Available:https://helios-eie.ekt.gr/EIE/bitstream/10442/8555/1/INR_Drakopoulou_06_01.pdf
9. Cosentino A. Practical notes on ultraviolet technical photography for art examination. Conservar Património. 2015;21:53-62.

10. Cosentino A. Identification of pigments by multispectral imaging a flowchart method. Heritage Science. 2014;2:8.
11. Franceschi E, Cascone I, Nole D, Salotti M. Caratterizzazione archeometrica di due dipinti. In “Dal ritrovamento all’indagine. Due Sacre Famiglie di ambito fiammingo a confronto: storia iconografia, restauro” Paola Martini editor, San Giorgio, Genova. 2008;22-26. Italian.
12. Franceschi E, Cascone I, Nole D, Calvini P. Caratterizzazione chimico - fisica di legni bagnati e confronto con legni archeologici. GRADUS, Rivista di Archeologia dell’acqua. 2008;3(2):79-90. Italian.
13. Franceschi E. La seta con animale alato: Misure del colore. In Mandylion Intorno al Sacro Volto, da Bisanzio a Genova. Gerhard Wolf, Colette Dufour Bozzo, Anna Rosa Calderoni Masetti editors, Skira, Milano. 2004;133-135. Italian
14. Franceschi E, Letardi P, Luciano G. Colour measurements on patinas and coating system for outdoor bronze monuments. J. of Cultural Heritage. 2006;7:166-170.
15. Seccaroni C, Moioli P, Fluorescenza X. Prontuario per l’analisi XRF portatile applicata a superfici policrome, Nardini Editore, Firenze; 2004.
16. West FitzHugh E, editor. Orpiment and realgar. In: Artists’ pigments. A Handbook of their history and characteristics. Oxford University press, New York. 1997;3:47-80.
17. Il Libro dei colori segreti del secolo XV, Olindo guerrini e corrado ricci. Romagnoli Dall’Acqua ed. Bologna; 1887.
18. Cennino Cennini. Available:http://www.liberliber.it/mediateca/libri/c/cennini/il_libro_dell_arte/pdf/cennini_il_libro_dell_arte.pdf
19. Feller RL, editor. Barium sulphate-natural and synthetic. In: Artists’ pigments. A Handbook of their history and characteristics. Cambridge University Press, London. 1986;1:47-64.
20. Kühn H. Zinc white. In: Feller RL, editor. Artists’ pigments. A Handbook of their history and characteristics. Cambridge University Press, London. 1986;1:169-86.
21. Franceschi E, Locardi F. Strontium, a new marker of the origin of gypsum in cultural heritage? J Cultural Heritage. 2014;15(5): 522–527. DOI: 10.1016/j.culher.2013.10.010
22. Cosentino A. FORS spectral database of historical pigments in different binders. e-conservation Journal. 2014;2:57–68.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://www.sciencedomain.org/review-history/27887*