INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 9, Issue 1, January-March 2018: 137-150 www.ijcs.uaic.ro

STUDY OF THE MANUFACTURING TECHNIQUE AND CHEMICAL CHARACTERIZATION OF AN ETHIOPIAN ICON IN THE COPTIC MUSEUM IN CAIRO

Mona F. ALI[1 *], Alaa E. ALI[2]

[1]Conservation Department, Faculty of Archaeology, Cairo University, Giza, Egypt
[2] Conservation Department, Egyptian Museum, Cairo, Egypt

Abstract

Ethiopian icons played an important role in Ethiopian arts in the period between mid-fifteenth centuries and the twentieth century. The religious ties between Egypt and Abyssinia witnessed a prosperous phase in the period after the introduction of Christianity in the fourth century AD. Several previous studies have dealt with Ethiopian icons in terms of their artistic and pictorial side; however, there are no similar studies in Egypt discussing their manufacturing techniques, deterioration, and proper treatment and conservation methods. Therefore, this study aims to study the manufacturing technique of an anonymous Ethiopian icon (registration number 4881) kept in the storagerooms of the Coptic Museum in Cairo. This icon depicts St. George riding his horse and handling in his hand spears in the form of an X. Its dimension 123.5 cm long, 113.4 cm wide . The analytical techniques utilized in this study were optical microscopy (OM), scanning electron microscopy (SEM) equipped with an energy dispersive X-ray detector (EDS), X-ray diffraction (XRD), and Fourier transform infrared spectroscopes (FTIR). The results indicated that the icon was done on a cotton canvas, and the identified pigments are the blue of lapislazuli, yellow of lead chromate, white of anhydrite and black of carbon black from bones. The ground layer is made of anhydrite (calcium sulphate).

Keywords*: Ethiopian; Icons; Coptic; Canvas; Painting; Pigments; Binder*

Introduction

The Ethiopian icon art from the Ethiopian Orthodox churches derive its roots from many different arts such as Byzantine, Coptic, and the European Renaissance art of painting [1]. The arts of bilateral icon, which date back to the late seventeenth century, depicting the Holy Family in Egypt and St. Gebre Menfes. It also stated that portray the Virgin was one of the most photographed subjects in the Abyssinian icons since the fifteenth century [2]. The art of Abyssinian icons clearly evident in the middle of the fifteenth century, where the results are based on facts there is no icons found in the beginning fifteenth century [3, 4].

In general the Ethiopian icons are distinguished by the use of red, green, blue colors and graphic black. With the founding of Gondar School in the seventeenth century, the Virgin's garments were depicted in dark color using impasto technique and this is the most important characteristic of this school [5-7].

* Corresponding author: monalyeg@yahoo.com

Styles of Ethiopian Icons

Since the second half of fifth century until the beginning of the first decade of the sixteenth century, three types of styles appeared as an expression of the evolution of the art of the Ethiopian Icons [8]. The first one depict the faces in a moon - style, characterized by faces round in shape with a scraggly beard, small mouth, narrow eyes with the end lines of a variety of lengths, arched eyebrows, and Painted of clothe folds with wide strata. The background of icon is painted with a clear color (Fig. 1a). The second one is of Italian influence found in the fifteenth century and painted by the two Italian artists Brancaleone and Bicini**.** This style is characterized by round shape face, and also Painted of clothe folds with wide strata; the background of the icon is painted with a clear color influenced by local traditions of Ethiopian art (Fig. 1b). The third one is a Transition style of the sixteenth century, characterized by the use of hard parallel lines (Fig. 1c).

Fig. 1. Coptic icons: a - Triple icon, depicting the Virgin and Child, from mid-and late fifteenth century, belonging to the moon styles - unknown artist; b - Bilateral icon, of the Italian artist Nicoló Brancaleon, depicting the Virgin and Child from the late fifteenth century and the beginning of the sixteenth century; c - Triple icon, depicting the Virgin, from the seventeenth century, and belongs to the technique of parallel; d - Triple icon, depicting the Virgin and Child, chronicling the late seventeenth century and belongs for first Gondar style; e - Triple icon depicting the Virgin in Monastery in Egypt Metmāq, the eighteenth century belongs to the second Gondar Style, unknown artist; f - Ethiopian icon registered number 4880 Coptic Museum, seventeenth century and belongs to the first Gondar style

In the seventeenth century Gondar art began to spread, and this name was taken from the city Gondar the capital of the Ethiopian Empire [9]. The first Gondar style developed, especially in the reign of Emperor Fāsilades (1632 – 1667 AD), and also in the era of Emperor Yahannes (1667 -1682 AD), where he encouraged the production and the spread of the icons, especially in the private imperial ceremony (Fig. 1d). The second Gondar Style developed during the reign of King Iyāsu 1st (1682 - 1706 AD), at the end of the eighteenth century and reached the summit of prosperity during the reign of King Iyāsu II (1730 - 1755 AD). This style is similar the Italian Style in the fifteenth century, and is characterized by the influences from the European Baroque art (Fig. 1e and f).

Ethiopian icons in Egypt

Coptic art influences from the Ethiopian art were the pictures of St. Habashi in many Coptic icons. For example, a Coptic icon of St. Tackla Habashi in the Church of Elmalak El Kepli (old Cairo), represents the St. Tackla riding his horse,holds a fine spear, and his head is surrounded by a light halo (Fig. 2a). The second example of a Coptic icon of St. Tackla Habashi, in the Church of St. Mina Fom El Kleg (old Cairo) represents St. Tackla with Priesthood, Holding in his right hand stick supplication , in his left hand Bible,His head is surrounded by a yellow color halo which is defined in red color (Fig. 2b).

Fig. 2. Coptic icons: a - Coptic icon of St. Tackla Habashi - Church of Elmalak El Kepli, old Cairo, b - Coptic icon of St. Tackla Habashi, the Church of St. Mina Fom El Kleg, old Cairo, c - coptic icon depicting St. Tackle haimanot Habashi, the Church of St. George Haret Zuwayla, Cairo; d - Coptic icon depicting St. Tackle haimanot Habashi, El Mialka church, Cairo; e - Coptic icon, depicting Mary Abyssinian sitting on the throne and carrying Jesus, both wearing a crown, and above them two angels, Tribal Church, Cairo; f - Coptic icon, depicting the Virgin and Child, there are outstanding in Old Church, Cairo

The third example of a Coptic icon is depicting St. Tackle humanoid Habashi, in the Church of St. George Haret Zuwayla from Cairo (Fig. 2c). This icon depicts the Saint Tackla humanoid Habashi with long hair hanging on his shoulders,and has a long gray beard ,wearing the uniform of a priest and pointing with his right hand to give the pond, while carrying in his left hand the Bible .

Another Coptic icon depicting St. Tackla humanoid Habashi, El Mialka church in Cairo (Fig. 2d), shows the Saint Tackla humanoid and his name written in Arabic. Furthermore Icon of Mary the Ethiopian ,where she was depicted sitting on the throne and carrying Christ, with black features, with Byzantine influences in the gilded background (Fig. 2e). Another Ethiopian influences icon in Egypt , the Icon of the Virgin and Child in the Hanging Church (Fig. 2f) [10-18].

An investigation conducted by Ethiopia's National Museum, and the Smithsonian Institute using Light Polarized Microscopy, Ultraviolet Fluorescence, Infra Red Reflectography and EDAX analysed six Ethiopian Icons, [6], and it was found that wooden panels were used as secondary support while cotton canvas were used as the main support, gypsum mixed with binder was used as preparation layer and also as white color. According the James study [6], of pigments used in Ethiopian Icons, the colored materials are local and some of them imported. In 2008, *Higgitt* [7] analyzed an Ethiopian Icon in the British Museum dated back to the nineteenth century, using Fluorescence XRF and Infrared FTIR and the results shown the presence of acotton canvas, white color of silt white clay, carbon black, red vermilion, lead red as coloring materials. The blue colors appeared as: Prussian blue, industrial synthetic ultramarine, and cobalt blue, which contains a blue glass-smalt. Green color was identified as a mixture of blue and yellow color (orpiment), while the brown color is a mixture of yellow and red lead and vermilion red , animal glue was used as a binder.

The present paper takes into study the anonymous Ethiopian icon of *St. George* riding his horse and handling in his hand spears in the form of an X (Fig. 3a). This icon was found in bad condition in the storage rooms of the Coptic Museum in Cairo. The registration number of this icon is 4881. Besides the analytical characterization of the icon materials and layered structure of painting, the paper also describes the conservation state and the conservation methodology used.

Experimental part

Materials and methods

6 Samples (Fig. 3a) from this icon was studied using several analytical techniques.

Microscopic Investigation

USB optical microscope examination with optical zoom 50 X was used, to examine the coloring layer and the canvas.

SEM-EDAX

Scanning electron microscopy coupled with electron beam microprobe analysis using an energy - dispersive X-ray detector (SEM-EDAX) were employed in order to characterize the stratigraphic morphology and determine the elemental composition of each paint layer [19, 20-27]. The scanning electron microscope used was a Quantom 3D 200 I) (FEI Philips – Holland) coupled with EDX. Column pressure 60PA, low vacuum, in back scattered mode (BSED) with a feature to obtain images and showing the distribution of the elements for each layer of preparation and the coloring layer (Fig. 6).

Fourier Transform Infrared Spectroscopy (FTIR)

Using an analysis by FTIR sampling technique based on reflectance measurements. The increasing application of drifts is related to the development of optical devices using special attachments for standard spectrometers. FTIR spectra were obtained using a FT-IR Thermo Nicolet 760. The resolution is about: $4cm^{-1}$ (Region: $4000\text{-}400cm^{-1}$, Absolute threshold: 0.002,

Sensitivity: 50). This technique is particularly useful in the investigation of powdered samples, that is because it needs a very small quantity of powdered sample is needed (5–10mg) [20-28]. (I donot agree – the amount of sample is quite large and this means destructive technique!)

Infrared spectra were obtained in the MID-range using JASCO-6100 FTIR spectroscopy. About 1 to 3mg from the samples were ground with 99-97 mg of KBr in an agate mortar. The spectra were collected in transmittance in the range of 4000–400cm^{-1} with 4cm^{-1} resolution. It has been identified that the medium used in ground and painting layers is Arabic gum, which matches the findings from literature [16, 17, 22-30] (Table 2 and Fig. 7).

X-ray diffraction analysis

XRD analysis of the samples was performed with a Philips X'Pert PW3710 Diffractometer, using Cu Kα radiation (40kV, 30mA), high-resolution graphite monochromator, rotating sample holder and proportional detector. Measurements were carried out in the range $5° < 2\theta < 90°$ with a step of 0.02°; the ICDD data bank of standard X-ray powder spectra was used for phase identification [18-22].

Results and Discussion

Cross-sectionsobservation under microscope [13-17] showed that the painting ground does not exceed 2mm (Fig. 3b), with a thin layer of paint and there is no varnish layer. Figure 3c shows the image of cotton fibers from the canvas support in polarzed light.

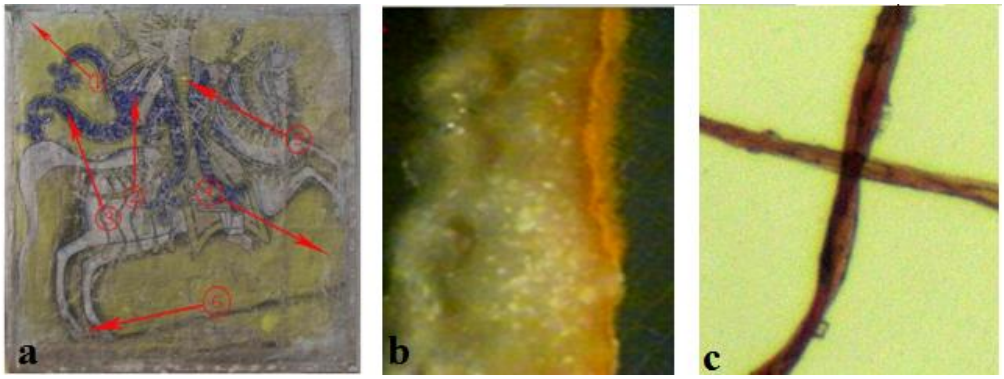


Fig. 3. Sampling locations from the icon: a. Sampling positions (1. ground layer; 2. light blue color; 3. dark blue; 4. light yellow, 5. dark yellow; 6. black); b - Optical photomicrographs of the polished cross-sections of the ground layer with yellow pigment optical zoom 50 X; c - Fibers under USB microscope,magnification 50 X, proved that canvas from cotton

The results indicated that painting ground is made of Anhydrite, while the pigments identified are lapis lazuli, yellow chrome, anhydrite and carbon black from animal bones (Table 1 and Figs. 4 and 5).

Table 1. XRD results shows the abbreviation of minerals

Sample	Compounds	Symbols
Ground layer	Anhydrite, Halite	Anhy, Hal,
Blue color	Lazurite, Zincite, Anhydrite	Laz, Zin, Anhy
Dark blue	Lazurite, Zincite, Anhydrite	Laz, Zin, Laz
Light yellow	Zinc oxide, Gypsum, Anhydrite	Zin, Gyp, Anhy
Dark yellow	Lead chromate, Anhydrite, Gypsum	Cro, Anhy, Gyp
Black	Graphic black, Gypsum, Anhydrite	Gra,Gyp, Anhy

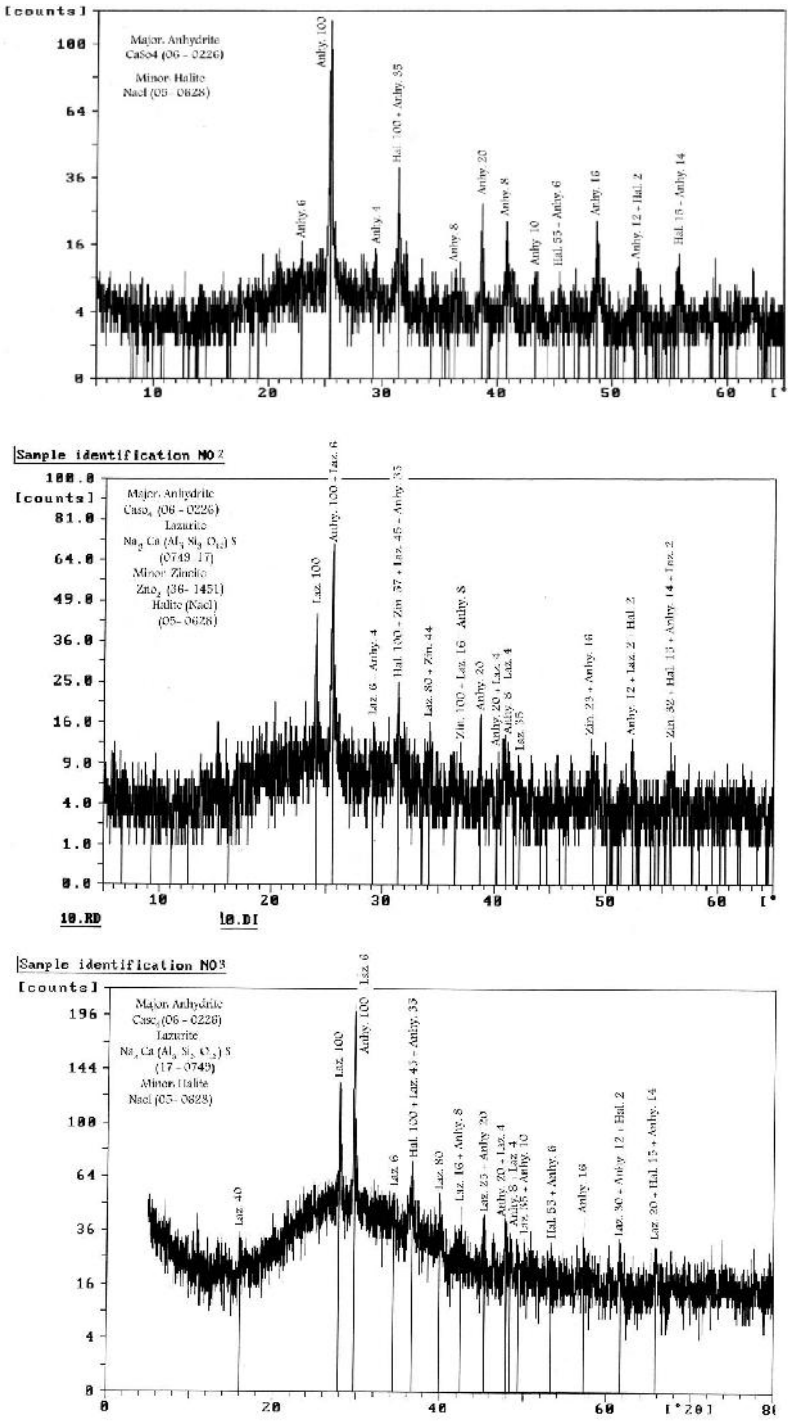


Fig. 4. XRD diagrams: a - ground layer indicating the presence of Anhydrite and Halite; b - Blue pigment indicating the presence of Lazurite, Anhydrite, Zincate and Halite; c - Dark blue pigment indicating the presence of Lazurite, Anhydrite, Zincate and Halite

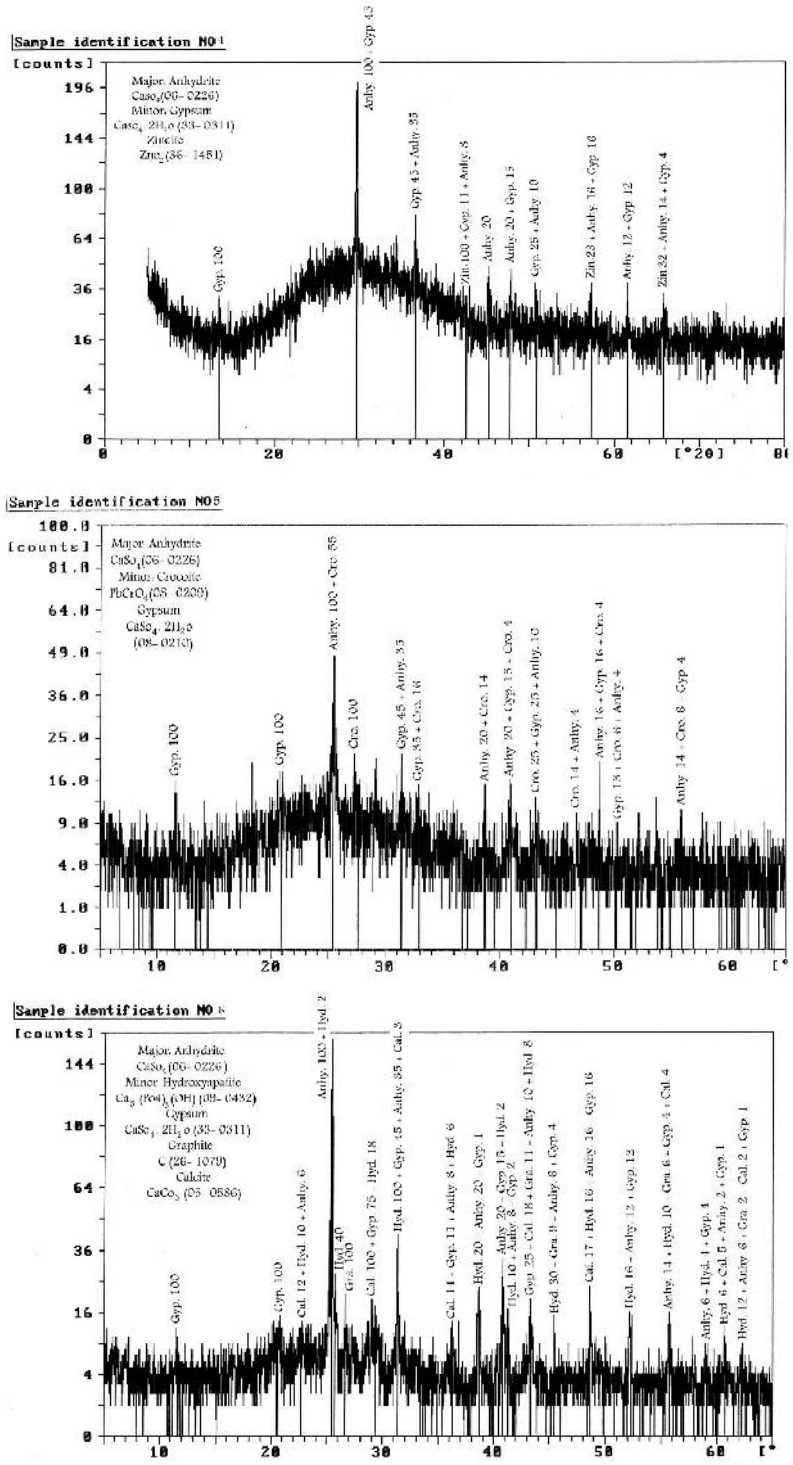
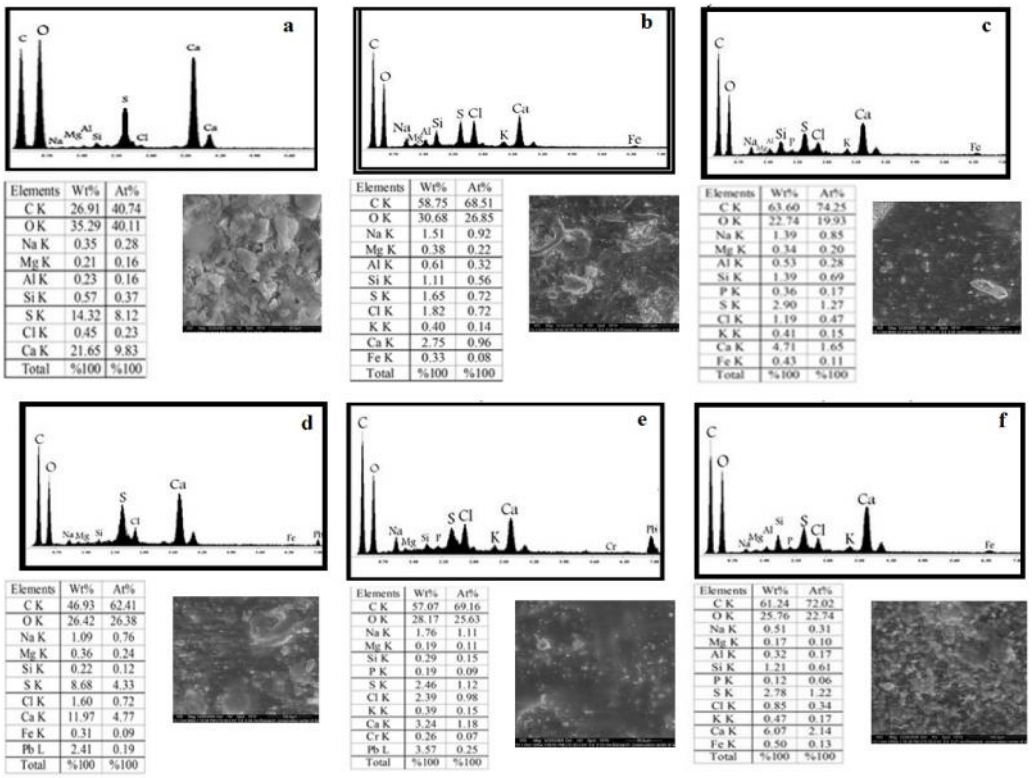


Fig. 5. XRD diagrams: a - Yellow pigment indicating the presence of Anhydrite, Zincate and Gypsum
b - Dark yellow pigment indicating the presence of Anhydrite, Lead chromate Zincate and Gypsum.
c - Black pigment indicating the presence of Graphite black, Gypsum, Anhydrite



Elements	Wt%	At%
C K	26.91	40.74
O K	35.29	40.11
Na K	0.35	0.28
Mg K	0.21	0.16
Al K	0.23	0.16
Si K	0.57	0.37
S K	14.32	8.12
Cl K	0.45	0.23
Ca K	21.65	9.83
Total	%100	%100

Elements	Wt%	At%
C K	58.75	68.51
O K	30.68	26.85
Na K	1.51	0.92
Mg K	0.38	0.22
Al K	0.61	0.32
Si K	1.11	0.56
S K	1.65	0.72
Cl K	1.82	0.72
K K	0.40	0.14
Ca K	2.75	0.96
Fe K	0.33	0.08
Total	%100	%100

Elements	Wt%	At%
C K	63.60	74.25
O K	22.74	19.93
Na K	1.39	0.85
Mg K	0.34	0.20
Al K	0.53	0.28
Si K	1.39	0.69
P K	0.36	0.17
S K	2.90	1.27
Cl K	1.19	0.47
K K	0.41	0.15
Ca K	4.71	1.65
Fe K	0.43	0.11
Total	%100	%100

Elements	Wt%	At%
C K	46.93	62.41
O K	26.42	26.38
Na K	1.09	0.76
Mg K	0.36	0.24
Si K	0.22	0.12
S K	8.68	4.33
Cl K	1.60	0.72
Ca K	11.97	4.77
Fe K	0.31	0.09
Pb L	2.41	0.19
Total	%100	%100

Elements	Wt%	At%
C K	57.07	69.16
O K	28.17	25.63
Na K	1.76	1.11
Mg K	0.19	0.11
Si K	0.29	0.15
P K	0.19	0.09
S K	2.46	1.12
Cl K	2.39	0.98
K K	0.39	0.15
Ca K	3.24	1.18
Cr K	0.26	0.07
Pb L	3.57	0.25
Total	%100	%100

Elements	Wt%	At%
C K	61.24	72.02
O K	25.76	22.74
Na K	0.51	0.31
Mg K	0.17	0.10
Al K	0.32	0.17
Si K	1.21	0.61
P K	0.12	0.06
S K	2.78	1.22
Cl K	0.85	0.34
K K	0.47	0.17
Ca K	6.07	2.14
Fe K	0.50	0.13
Total	%100	%100

Fig. 6. EDX results of six samples: a - ground layer; b - light blue pigment; c - dark blue pigment; d - light yellow pigment; e - dark yellow pigment; f- black pigment

Table 2. The functional groups attribution for theArabic gum reference and samples analyzed

O-H Position	C-H Position	C-O Position
Gum Arabic (reference)		
3600-3200cm^{-1} Stretching bands 1650cm^{-1} Bending band	3000-2800cm^{-1} Stretching bands 1480-1300cm^{-1} Bending bands	1300-900cm^{-1} Stretching bands
.Painting Ground		
3399.89cm^{-1} stretching bands 1644.02cm^{-1} Bending band	2923.56-2857.02cm^{-1} stretching bands 1455.99 -1427.07 -1378.85cm^{-1} Bending bands	1281.47-1241.93 - 1160.94-1114.65 - 1032.69 -917.95cm^{-1} Stretching bands
Blue Colour		
3414.4cm^{-1} stretching bands 1652.9cm^{-1} Bending band	2970.5 – 2925.1cm^{-1} stretching bands 1426.9cm^{-1} Bending bands	1155.2 – 1043.5cm^{-1} Stretching bands
Yellow Colour		
3545.0 – 3410.9cm^{-1} stretching bands 1625.7cm^{-1} Bending band	2923.8 – 2855.3cm^{-1} stretching bands 1423.9cm^{-1} Bending bands	1123.1cm^{-1} Stretching bands
Black Colour		
3528.13 – 3410.49cm^{-1} Stretching bands 1647.88cm^{-1} Bending band	2923.56cm^{-1} Stretching bands 1458.89 – 1423.21 – 1388.5cm^{-1} Bending bands	1148.4cm^{-1} Stretching bands

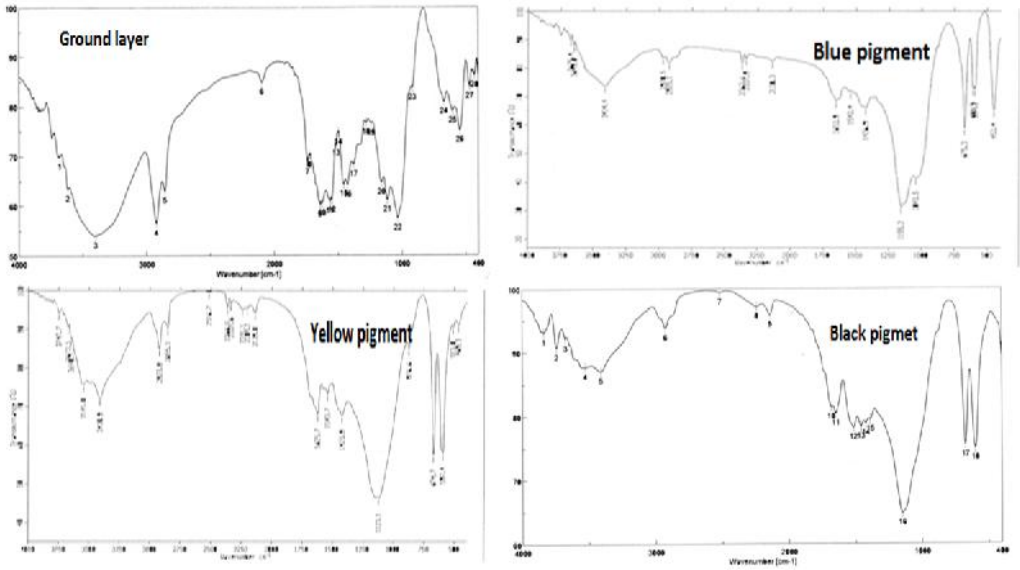


Fig. 7. FTIR spectra of a painting layer and pigments indicating the presence of Gum Arabic

In the analysis of the medium used in icon of the after comparing the results with the standard sample of Arabic gum indicated that the appearance of some characteristic groups of gum Arabic. H-hydroxyl group O-H appeared in preparing layer at 3399.89 and 1644.02cm^{-1}, blue color at 3414.4 and 1652.9cm^{-1}, yellow color at 3545.0, 3410.9, and 1625.7cm^{-1}, and black color at 3528.13, 3410.49 and 1647.88cm^{-1}.

While the hydrocarbon group C-H appeared at 2923.56, 2857.02, 1455.99, 1427.07 and 1378.85cm^{-1}, in preparing layer, at 2970.5, 2925.1 and 1426.9cm^{-1}, in blue color, at 2923.8, 2855.3 and 1423.9cm^{-1} in yellow color, and at 2923.56, 1458.89, 1423.21 and 1388.5cm^{-1} in black color. The group of carbon dioxide C-O group appeared at 1281.47, 1241.93, 1160.94, 1114.65, 1032.69 and 917.95cm^{-1}, in preparing layer, at appeared at 1155.2 and 1043.5cm^{-1} in blue color, at 1123.1cm^{-1} in yellow color, and appeared at 1148.4cm^{-1} in black color.

Conservation Process

Study of deterioration aspect

After the identification of techniques Ethiopian icon, inventory and documentation the Aspects of deterioration, which was in the weakness and fragility of the layer color, ground painting and also there are many tears in canvas. The main damage of the icon the weakness and fragility of the layer color, ground painting and also there are many tears in canvas.

Visible UV and IR imaging

Photographed the icon using infrared and ultraviolet Sony A6000 camera, was done, to receive all infrared wavelengths in the presence of a dedicated LID torch for UV and IR production with complete darkness chamber [23-26]. It was found that the cracks and gaps in the icon exist in different sizes and shapes. There is a gap in the right part of the top followed by a longitudinal rupture. There are lateral ruptures and longitudinal ruptures on the left side of

the top. In the left and right part of the bottom there are gaps. Places of writing are missing in front of the horse's face. As for the photographic floor and the color layer, they are very rough and have been completely lost on all sides of the icon.

The infrared icon was filmed to show the fine details such as the writings, which we could not see with the naked eye, as well as trying to find out the artist who photographed this icon or its history (but unfortunately we did not find any signature or specific date for this icon).The icon was shot also in the ultraviolet light to see the previous repairs to the icon in advance. It is noted that this icon has not been made any recent additions to color (Fig. 8.).

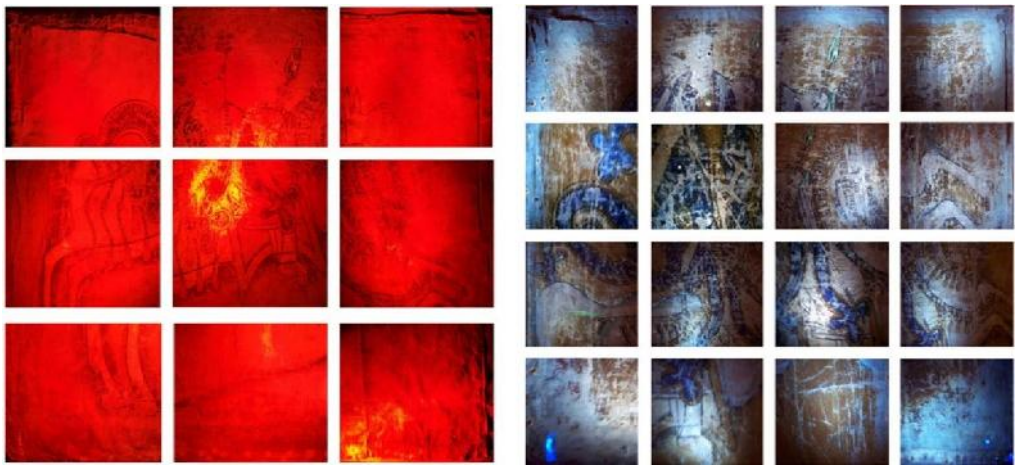


Fig. 8. Infrared image of icon (on the left) and the ultraviolet (on the Right) to observe the main damage and the old written

Fig. 9. Steps of Mechanical and chemical cleaning; Consolidation the icon using Beva 371 dissolved in toluene 3%;Stages of dissolved canvas from new support; Steps of protecting the tear before the lining stage;The steps lining of the icon using natural cotton and using Beva 371 dissolved in toluene concentration of 30%;Steps of Install the icons on new support; Steps of retouch using the colors of the type of Winsor Newton.

Conservation and Treatment

It was necessary to carry out conservation treatment of this icon [27-30], which was started by mechanical cleaning using scalpels and soft brushes and chemical cleaning using Saliva (human saliva), which was able to remove dust, particularly fatty dust, and subsequently consolidation the icon using Beva 371 dissolved in toluene and that in two steps. The first step of consolidation by using 3% concentration in order to be able to penetrate inside the pores of the icon The second step concentration of 7% in order to be able to surface consolidation of the icon, and then it was the work of lining of the icon using natural cotton with the same specifications and using Beva 371 dissolved in toluene concentration of 30%.

Fig. 10. The icon after conservation treatment

The operation was conducted lining using irons heat at a temperature not exceeding 50ºC, and then it was the work of an fulfill of the ground painting by Italian Gesso mediator of Glue rabbit skin, after a drought, ground painting was the work of retouch using the colors of the type of Winsor Newton and then it was the work of varnish layer by Dammar varnish to protect the painting and finally sterilized by Trichlorophenol in the end we chosen a suitable place to display this icon, in order to be the best witness to the presence of Ethiopian icons in Egypt (Figs. 9 and 10).

Conclusion

Optical microscopy was used to study the layered structure of the icon which comprised a cotton canvas, a ground layer, multiple paint layers and a varnish layer. The chromatic palette and ground layer composition were determined by Scanning Electron Microscopy (SEM), equipped with an Energy Dispersive X-ray detector (EDS), X-ray

Diffraction (XRD) and FTIR spectroscopy. The identified pigments were blue of lapislazuli, lead chromate (yellow), anhydrite and carbon black of bones. The identified Ground material was Anhydrite. The FTIR was used to determine the medium used in ground layer, as well as the paint medium applied. gum Arabic was identified as a binder. The identification of chrome yellow and lithopone (Barium zinc sulfate) (where the lithopone is discussed? I did not find this in the Experimental part) was the keynote in dating this icon to the technique of application, it could be suggested that the icon dated to the end of the 19th century and was painted by a local imitator (this finding should be better explained in the text not only in the Conclusions).

References

[1] S. Stedman, *The Christian Art of an African Nation*, **African Arts**, **12**(3), 1979, pp. 82-83.

[2] G. Balance, *Religious and Secular Art of Ethiopia*, **African Arts**, **10**(3), 1977, pp. 66-67.

[3] S. Chojnacki, **Ethiopian Icons** (Catalogue of the collection of the Institute of Ethiopian Studies Addis Abeba University), in Collaboration with Carolyn Gossage, Addis Abeba, 2000, pp. 22-57.

[4] S. Bengt, S. Christopher, **A History of Church in Africa**, Cambridge, UK, New York, 2000, p. 151.

[5] Csilla Fabo Perczel, *Ethiopia: Folk Art of a Hidden Empire*, **African Arts**, **17**(1), 1983, pp. 82-82.

[6] E.E. James, *Technical Study of Ethiopian Icons, National Museum of African Art, Smithsonian Institution*, **Journal of the American Institute for Conservation**, **44**(1), 2005, pp. 39 - 50.

[7] C. Higgitt, **Materials and techniques of a nineteenth century Ethiopian Orthodox Painting from the collection of The British Museum**, London, 2008, pp. 1-6.

[8] S. Chojnacki, *Two Ethiopian Icons*, **African Arts, 10**(4), 1977, pp. 44-47.

[9] Y.V. Moskvicheva, *Ethiopian Orthodox Scroll-Charms of XIX-Beginning of XX Century,* **Vestnik Slavianskikh Kultur-Bulletin of Slavic Cultures-Scientific and Informational Journal, 41,** 2016, pp. 187-193.

[10] G. Gabra, M. Eaton-Krauss, **The illustrated Guide to the Coptic museum and churches of old Cairo,** American University in Cairo Press, New York, 2007, p. 186.

[11] M. El-Meskyn, *L' Icônes, Instrument de Dieu*, **Le Monde Copte (**Revue Semestrielle de culture Égyptienne, Editors: P. de Bogdanoff and A.I. Sadek), **19,** 1976, p. 64.

[12] P.T. Malaty (Marie-Gabrielle de Boncourt), *L' Église, Maison de Dieu*, **Le Monde Copte** (Revue Semestrielle de culture Égyptienne, Editors: P. de Bogdanoff and A.I. Sadek), **19**, 1976, p. 76.

[13] I.C.A. Sandu, V. Vasilache, I. Sandu, C. Luca, M. Hayashi, *Authentication of the Ancient Easel-paintings through Materials Identification from the Polychrome Layers III. Cross - section Analysis and Staining Test,* **Revista de Chimie, 59**(8), 2008, pp. 855-866.

[14] J. Plesters, *Cross-Sections and Chemical Analysis of Paint Samples*, **Studies in Conservation**, 2(3), 1956, pp. 110-157.

[15] M. Derrick, L. Souza, T. Kieslich, H. Florsheim, D. Stulik, *Embedding Paint Cross-Section Samples in Polyester resins: Problems and Solutions,* **Journal of the American Institute for Conservation**, **33**(3), 1994. pp. 227 - 245.

[16] I.C.A. Sandu, S. Bracci, I. Sandu, M. Lobefaro, *Integrated Analytical Study for the Authentication of Five Russian Icons (XVI–XVII centuries),* **Microscopy Research and Technique, 72**, 2009, pp. 755–765.

[17] I.C.A. Sandu, S. Bracci, M. Lobefaro, I. Sandu, *Integrated Methodology for the Evaluation of Cleaning Effectiveness in Two Russian Icons (16th-17th Centuries),* **Microscopy Research and Technique, 73**(8), 2010, pp. 752-760.

[18] M. Uda, G. Demortier, I. Nakai, **X-rays for Archaeology**, Springer, Netherlands, 2005, pp. 159-162.

[19] H. Berke, *The invention of blue and purple pigments in ancient times*, **Chemical Society Reviews, 36**(1), 2007, pp. 15-30.

[20] V. Desnica, K. Furic, M. Schreiner, *Multianalytical characterization of a variety of ultramarine pigments,* **e-Preservation Sience**, 1, 2004, pp. 15-21.

[21] M.E. Heldman, *Frē-Seyon: A Fifteenth Century Ethiopian Painter*, **African Arts**, **31**(4), Special Issue: Authorship in *African Art*, Part 1 (Autumn, 1998), 48, pp. 55-90.

[22] R.A. Cristache, I.C.A. Sandu, A.E. Simionescu, V. Vasilache, A.M. Budu, I. Sandu, *Multi-analytical Study of the Paint Layers Used in Authentication of Icon from XIXth Century,* **Revista de Chimie, 66**(7), 2015, pp. 1034-1037.

[23] C. Marinach, M.C. Papillon, C. Pepe, *Identification of binding media in works of art by gas chromatography–mass spectrometry*, **Journal of Cultural Heritage, 5**(2), 2004, pp. 231–240.

[24] M. Abdel-Ghani, H.G.M. Edwards, B. Stern, R. Janaway, *Characterization of paint and varnish on a medieval Coptic-Byzantine icon: Novel usage of dammar resin,* **Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 73**(3), 2008, pp. 566–575.

[25] S. Daniilia, K.S. Andrikopoulos, S. Sotiropoulou, I. Karapanagiotis, *Analytical study into El Greco's baptism of Christ: clues to the genius of his palette*, **Applied Physics A, Materials Science & Processing**, **90**(3), 2008, pp. 565-575.

[26] V. Ganitis, E. Pavlidou, F. Zorba, K.M. Paraskevopoulos, D. Bikiaris, *A post-Byzantine icon of St Nicholas painted on a leather support. Microanalysis and characterisation of technique,* **Journal of Cultural Heritage, 5**(4), 2004, pp. 349-360.

[27] M. Munteanu, I.C.A. Sandu, M.M. Lupascu, V. Vasilache, I. Sandu, *The importance of a complete and modern information gathering protocol in the conservation process of a XVIII-th century icon,* **International Journal of Conservation Science**, **7**(4), 2016, pp. 995-1008.

[28] M. Favaro, P.A. Vigato, A. Andreotti, M.P. Colombini, *La Medusa by Caravaggio: characterisation of the painting technique and evaluation of the state of conservation*, **Journal of Cultural Heritage**, **6**, 2005, pp. 295–305.

[29] V. Vasilache, I.C.A. Sandu, S. Pruteanu, A.T. Caldeira, A.E. Simionescu, I. Sandu, *Testing the cleaning effectiveness of new ecological aqueous dispersions applied on old icons*, **Applied Surface Science, 367,** 2016, pp. 70-79. DOI: 10.1016/j.apsusc.2016.01.128

[30] M. Munteanu, I. Sandu, V. Vasilache, I.C.A. Sandu, *Disadvantages of Using Some Polymers In Restoration of Old Icons on Wooden Panels,* **International Journal of Conservation Science,** 7(Special Issue: 1), 2016, pp. 349-356.

Received: May 30, 2017
Accepted: February 28, 2018