Gilding technique in Islamic monumental decorated ceilings in Cairo: analytical study.

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Abstract:

Gilding has in all times occupied an important place in the ornamental arts of Islamic civilization, especially the decorated ceilings, which is the art of spreading gold over the surface for the purpose of ornament. Unfortunately we haven't sufficient data about its composition and the application techniques. The main goal of the present study is to investigate and analyze samples from gilding materials and its ground from some Islamic monumental ceilings in Cairo to determine the composition, methods of application and its aspects of deterioration. Samples were taken from the gilded areas of the selected ceilings. Scanning electron microscope–energy dispersive X-ray spectroscopy (SEM–EDX), Light Optical microscope (L.O.M.) and Fourier transmitance infrared spectroscopy (FTIR), were adapted for analysis and investigations. The results from samples taken from different gilded ceilings were compared with each other to observe their differences and similarities .Analysis and investigation, methods revealed a further resemblance of the materials and the methodology employed. The deteriorated golden leaves were the main component applied by means of a size, Golden leaves and powder, brass, were used for the previous intervention.

Keywords: gilding, ceilings, SEM-EDS, LOM, *and FTIR.*

Introduction:

- Historical backgrounds:

Generally speaking, gilding is the technique of applying a thin sheet, most commonly of gold, over a firm support. This practice comprises a multitude of different methods, which can be carried

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out on a great variety of substrate materials.[1],[2],[3],[4].Gilding has been used since ancient civilizations, particularly in the art of East and South Asia and the Middle East [5]. Historically, the process has been used since ancient Egyptian times [6].

They discovered that gold is the most malleable of the metals and may be beaten, between layers of animal skin, into very thin leaves of very small thickness. It was then laid on to a substrate made of metal, wood, plaster etc. to give it the appearance of being made of solid gold. On the other hand they can cover large surfaces without a high economic cost[7],[8],[9].Examples of gilding can be traced to 2300 B.C. on ancient Egyptian paintings that show goldsmiths making gold leaf, and the sarcophagi of nobles often had gilding decorating the outer surfaces of the sarcophaque . "Gilding" became popular during the New Kingdom (1570-1070 B.C.). The Romans began to master the technique of "gilding", namely by decorating the ceilings of their temples and palaces. Apparently, the Capitol was the first building where this process was used[10]. On the other hand gilding has in all times occupied an important place in the ornamental arts of the Islamic civilization, especially the architectural gilding, decorated ceilings, the main objective of this paper. It became more

[1]Olga K. and, Russell F.H., Microscopic, mass spectrometric and spectroscopic characterization of the mordants used for gilding on wall paintings from three post-Byzantine monasteries in Thessalia, Greece,Microchemical Journal 94 (2010) 83–89

[2] Duran A., et al., Study of the gilding technique used in polychromed stones and ceramics by dedicated laboratory-made micro X-ray diffraction and complementary techniques Anal Bioanal Chem. ,394 (2009)1671–1677.

[3] Moses J., Gilding techniques care, and maintenance, published by Technical Conservation, Research and Education Group, Edinburgh January (2007).

[4] Shayne R. and Nick U., Conservation of furniture, Butterworth, Oxford, (2003) 148.

[5] Irina C., et al.,Gilding techniques in religious art between east and west, 14th –18th centuries international journal of conservation science Volume 1, Issue 1, January-March (2010) 47-62

[6] Moses J., Gilding techniques care, and maintenance, op. cit.

[7] Duran A., et al., Case study Degradation of gold and false gold used as gildings in the cultural heritage of Andalusia, Spain, Journal of Cultural Heritage 9 (2008) 184-188.

[8] Shayne R. and Nick U., Conservation of furniture, op. cit., 210.

[9] David A. S., A review of gilding techniques in ancient South America in: gilded metals history, technology and conservation, Archetype Publications Ltd (2000) 204.

[10] Irina C., et al.,Gilding techniques in religious art between east and west, op.cit. 47-62

prominent as a widely used internal decorative feature, in mosques, palaces… etc.

Gilding technique:

The process of "gilding" can be employed on various supports, such as: wood, metal, ivory, leather, paper, glass, porcelain, stone and fabrics as mentioned before. Since gold is so malleable, even when cold [35], it was a natural choice to be used to cover other materials (known as substrates) as they form the base onto which the gilding will adhere[11],[12],[13],[14].There were various ways of making the leaf adhere to the surface *by simple mechanical means or with adhesives.* Mechanical gilding, the only type used in the ancient times, begins with gold leaf which is made by hammering gold into paper-thin sheets between layers of parchment. The gold leaf used in the ancient era was typically thicker than today's gold leaf and has consequently survived the centuries quite well but for large areas, a bole or fine red earths were usual[15],[16],[17].

In ancient Egypt Both albumin (egg white) glue (animal or fish) and gum have been suggested as possible adhesives for the gilding[18].For the application of gold on mural surfaces, the mordant gilding technique was generally used; small pieces of gold leaf were attached onto the areas to be adorned by means of an adhesive or so-called "mordant"[19],[20].On the other hand in the architectural

[11] Ibid, 47-62

[12] Shayne R. and Nick U., Conservation of furniture, op. cit., 340.

[13] Moses J., Gilding techniques care, and maintenance, op. cit.

[14] David A. S., A review of gilding techniques op.cit 204.

[15]Irina C., et al.,Gilding techniques, in religious art between east and west, op.cit. 51-52.

[16] Andrew L., gilding techniques of the renaissance and after. in gilded metals history, technology and conservation, Archetype Publications Ltd(2000) 204.

[17] Duran A., et al., Study of the gilding technique, op.cit. 1671–1677.

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[19] Katsibiri O., Investigation of the technique and materials used for mordant gilding on byzantine and post-byzantine icons and wall paintings, MPhil Thesis, University of Northumbria at Newcastle, (2002) 49–53.

[20] Olga K. and, Russell F.H., Microscopic, mass spectrometric and spectroscopic characterization of the mordants used for gilding. op.cit. 83–89.

decoration there are two main techniques of gilding: oil or mordant gilding and water gilding.

Oil gilding: This technique can be used to apply gilding to most internal and external building surfaces. With appropriate preparation oil gilding is applied to a well-prepared, fine ground of either paint or 'gesso', a fine plaster with a size binder. Gold leaf is laid on when the size is touch dry, ready to accept the gold leaf, but retains enough tack for the leaf to adhere. Because of the extreme thinness of the leaf it is manipulated onto the sized surface with tools specially developed for the purpose; a gilder's knife, tip and cushion. After gilding, loose fragments of leaf are brushed from the surface with a skewing mop and if required, the surface can be buffed with fine cotton wool. Finally, a protective coating can be added.

Water gilding: This process requires greater preparation of the surface onto which the gilding is to be applied but, compared to oil gilding; a superior finish can be produced. Water gilding is used mainly for picture frames, furniture, religious artifacts, sculpture, and objects of art and also for the embellishment of stately buildings. The process essentially consists of applying six to twelve coats of gesso to the substrate to produce a very fine smooth surface, followed by four to eight coats of bole, refined clay available in various colors,. The bole is polished to a fine finish (any flaws or grit would ruin the appearance of the gilding), coated with dilute size, glue, and allowed to dry. The surface is then wetted with water and gold leaf is laid onto it immediately; as the water soaks into the gesso it quickly draws the gold into close contact with the surface. When dry, any loose fragments of gold leaf are skewed off as in oil gilding. The gilded layers are then polished using agate (a form of hard quartz like stone) burnishes. Judging when the surface can be burnished is critical.

If the correct degree of dryness has not been achieved the leaf can be easily damaged. Finally the surface is given a protective coat of ormolu size (*Ormolu size is a mixture of weak size and lacquer colored with a little orange-red resin called 'dragon's blood'*.) to enhance the color and uniformity of the gilding. On the other hand, if required, the burnished gilded layers can be toned down using oil based varnishes and pigments[21],[22],[23].Gilding is easily differentiated from cheaper decorative alternatives, such as gold paint. Gilding appears as a solid surface whereas paint will appear more granular, streaky and dull in appearance by comparison. Whilst gold leaf does not tarnish, paint oxidizes and consequently becomes a green-brown color on ageing. This makes gold leaf relatively easy to identify. True gilding retains its characteristic metallic sheen long after paint has lost its original shine. If there is doubt over whether or not gilding is present, the situation should be treated with caution until a professional opinion can be obtained [24].

The main objective of the present study is to investigate and analyze samples from gilding from some islamic monumental ceilings in Cairo. From that we can determine the chemical composition, methods of application, as well as the study of the deterioration changes that have occurred in them during ageing.

[21] Shayne R. and Nick U., Conservation of furniture, op. cit., 340.
[22] Irina C., et al.,Gilding techniques, in religious art between east and west, op.cit. 51-52.
[23]Kevin H, Gilding**.** reproduced from the building conservation directory**,**Cathedral Communications Limited (2009).
"http://www.buildingconservation.com/articles.htm".
[24] Moses J., Gilding techniques care, and maintenance, op. cit.

The state of preservation of the gilded ceilings:

Gilded surfaces may look solid and metallic they are in fact quite delicate and very easily damaged. Most gold leaf is very soft and it is easily marked or dulled if not carefully treated. The ground, usually a gesso, can lose its properties of adhesion and cohesion and separate from the substrate. The commonly observed cracking of the gesso/gilded structure perpendicular to the grain of the wood is a complex phenomenon. It may occur in part because the gesso is under the most stress under low humidity conditions with fractures occurring as the gesso contracts more or less in all directions while the wood does not taking into consideration several things, can go wrong during preparation or application[25]. On one hand, rainwater leaking is one of the most common deterioration factors. Rainwater leaking, ravage water gilding because it dissolve the size, which binds the gesso, in seconds rather than minutes. On the other hand the bad intervention by using solvents attack oil gold size and remove the gold from the surface; or it may dissolve lacquer, removing the intended toning and leaving water gilding unprotected. However, one of the worst causes of damage, simply because of its case of application, is gold-colored paint. Since it became widely available about 40 years ago it has been liberally applied to all kinds of perfectly sound gilded surfaces that simply required professional cleaning, and in many cases not even that. It oxidizes to a dull greenish brown, often within months, entirely destroying the intended effect.

The filed scanning of the studied gilded ceilings, from *Mamlouk period 648-923 A.H- 250- 1517 A.D, Ottoman period 923-1341 A.H - 1517-1922 A.D and Mohamed Ali family period 1220 - 1372 A.H - 1805-1952 A.D*, showed the very bad condition of the decorated gildings and its preparation layers. That status was as a result of

[25] Shayne R. and Nick U., Conservation of furniture, op. cit., 340.

lack of conservation and different deterioration factors. The aspects of deterioration were as follows:

-The surfaces of the majority of the studied gilded ceilings were completely covered with a very thick and concentrated layer from dirties, soot, (surface accumulations), and birds excretes, which causes disfiguring and further deterioration of the gilded decoration.

-The preparation layers of the gilding lost its adhesion to the supports in many places of the gilded ceilings. Cracks and micro cracks, flaking, losing of gilding and the preparation layers were observed, which causing remarkable surface deterioration and weakening the surfaces on a macro and a microscopic level by a progressive action (fig.1-13.).

Materials and methods:

- Sampling:

Samples of gilding were collected for investigation and analyses. The samples have been collected from ten islamic decorated" gilded'' monumental ceilings in Cairo. The selected monuments, from *Mamluk Bahary and Jarkasy, Ottoman and Mohamed Ali family periods*, (table 1).

Table 1 shows the selected monuments for the study.

The monument name	Regist. no.	Date of construction	Period
-Madrasa of El-Nasser Mohamed Ibn Qalaoon.	44	695 -- 703 AH 1295–1303 AD	*Mamluk Bahary*
-Khankah and mausoleum of sultan Beybars El-Jashankir	32	706 -- 709 AH 1306--1310 AD	*Mamluk Bahary*

Mosque of Shraf El-Dien.	176	717 -- 738 AH 1317--1337 AD AD	*Mamluk Bahary*
-Madrasa of Krasonker Elmansory	31	700 AH 1300 AD	*Mamluk Bahary*
Madrasa of El-Zaher Brqoq.	187	786 -- 788 AH 1384--1386 AD	*Mamluk Jarkasy*
-Madrasa of El-Kady Abd El-Baset.	60	822 -- 823 AH 1419--1420 AD	*Mamluk Jarkasy*
- Mosque of El-Kady Yehia Zein El-Dine.	182	848 AH 1444 AD	*Mamluk Jarkasy*
Mosque of Moheb El-Dine Abo El-tayb .	309	934 -- 935 AH 1537--1538 AD	*Ottoman*
-El-Sadat house	463	1070--1168 AH 1659--1754 AD	*Ottoman*
-Palace of prince Mohamed Ali. .		1319--1348 AH 1900--1929 AD	*Mohamed Ali family*

Thirteen samples were taken from the studied gilded ceilings. All samples were taken from areas of the gilded ceilings that were already damaged, to avoid disfiguring the patterns. Their size was sufficient for both the preparation of cross-sections needed for LOM and SEM-EADX, and for the FTIR analysis. The samples were first observed under the LOM.

-Methods of analyses and investigation:

The following methods and techniques were used:-

- **Light optical microscope (L.O.M.):** L.O.M Zeiss standard microscope was used to investigate surface samples from the gilding and the preparation layer (cross sections), (Conservation Dept. Faculty of Archaeology, Cairo Uni.) for W. (3.5nm).
- **Scanning electron microscope - energy dispersive X-ray spectroscopy (SEM- EDAX):**

The scanning electron microscope (SEM) photomicrographs and microanalyses (EDAX) were carried out by utilizing S.E.M. Philips XL 30 attached with EDAX unit, with accelerating voltage 30 K.V., magnification 10X up to 400.000X and resolution

- **Fourier transform infrared spectroscopy (FTIR):** (laboratories of the national research centre, Cairo).

Results and Discussion:

- Light optical microscope (LOM):

LOM the gilded samples and the cross-sections were prepared by using Technovit 2000, followed by grinding by silicon carbide paper, and surface polishing. The samples after that became ready for investigation. Magnification X 64, 120 and 210 were used, for investigation.

The gilded samples from the studied gilded ceilings were investigated by LOM .The results shows the severe damage (disfiguring, losing, cracking, the surface of the gilded samples generally showed an extensive net of 'craquelure', producing small plates) of gilding, which are covered by a thick layer of, dirties and other accumulations. Observation of the prepared cross-section revealed, for the majority of gilded samples, gilding are suffering from a severe damage, in *Madrasa of El-Nasser Mohamed Ibn Qalaoon, Khankah and mausoleum of sultan Beybars El-Jashankir, Mosque of Shraf El-Dien, Madrasa of Krasonker Elmansory (*sever

damage*), Madrasa of El-Kady Abd El-Baset (*bole layer is so clear and deteriorated, indicate to the water gilding method*), Madrasa of El-Zaher Brqoq (* the stratigraphy shows the four preparation layers are so clear, bole is the third one ,from bottom to top, followed by gilding*; and Mosque of Moheb El- Dine Abo El-tayb.* On the other hand, the rest of gilded samples from the rest ceilings are indicating to a relatively damage as well (fig. 14-26, shows these results).

- Scanning electron microscope (SEM- EDAX):

Scanning electron microscopy was carried out on the gilding samples. The analyses were carried out on freshly cut fragments, on raw surfaces Most of the studied samples were in a very bad condition, which reflect the state of the preservation.

The result of SEM EDAX for the gilded samples photomicrographs and microanalyses from all of the studied gilded ceilings, (fig.14b-26b) revealed the presence of a very deteriorated gold leaves, (Au), as the main component plus some impurities (represent the surface accumulation and the preparation layers of gilding). On the other hand, a deteriorated gold leaves (brass Cu, Zn) and powder were registered as the main components of the previous gilding interventions, in *Khankah and mausoleum of sultan Beybars El-Jashankir* and *mosque of palace of Prince Mohamed Ali.*

Fourier transform infrared spectroscopy (FTIR):

IR analysis is considered as one of methods in a scheme for the identification of binding media, varnishes, and adhesives. The preparation procedure for solid materials depends on the form and homogeneity of the sample. For IR analysis, a homogeneous sample can be ground or filed to form fine particles, then analyzed by KBr pellet, KBr micropellet, diffuse reflection, internal reflection, diamond cell, or microscope [26].

With the aim of establishing the possible existence of an organic adhesive that acts as a mordant in the studied gilded ceilings, the

[26] Michele R. et al., Infrared Spectroscopy in Conservation Science. The Getty Conservation Institute Los Angeles(1999) 28, 130.

analytical techniques employed was Fourier transform infrared (FTIR)spectrometry for specific size identification,[27],[28].The modern generation of infrared spectrometers FTIR was carried out(in the national Center of research FTIR lab.) by scraping sample from the gilding samples attached with the preparation layer.The samples (few milligrams) were diluted in KBr and the powder mixture was crushed in a mechanical die press to form a translucent pellet,the standard pellet size for commercial dies is 13 mm, [29]. Samples from all the gilded ceilings were analyzed by FTIR. The results were almost the same, so we used here just two of them, which represent the rest of samples. The two samples are from *Madrasa of El-Zaher Brqoq; and Mosque of Moheb El- Dine Abo El-tayb*.

Before describing the results obtained, three observations should be made: first, since the percentage of organic material existing in each gilding sample is extremely small, the interpretation of the results of FTIR analysis is very complex. Second, this organic material is inevitably greatly deteriorated; it is well known that, in the course of time, the many and varied environmental aggressions are conducive to deterioration[30]. Third, the presence of calcium carbonate and sulphate content as preparation layer and surface accumulations is reflected in an important band in the IR spectrum, caused by carbonate and sulphate groups. This strong band could be overlapping others which is precisely the interval where the absorption of some characteristic functional groups occurs that would unquestionably contribute to a greater understanding of the nature of the existing organic medium. The interpretation of some of the bands of the spectra and consequently any conclusion as to

[27] Van den Berg K, J. et al., Darkening and surface degradation in 19th-and early 20th-centuary paintings: an analytical study. In: 13th-Triennial Meeting Rio de Janeiro (2002) 469.
[28] Stanley Taft JW and Mayer WJ.,The science of paintings,springer, New York,(2000)171-173.
[29] Michele R. et al., Infrared spectroscopy in conservation science, op.cit. 52
[30] Ana EM et al., Mortars, pigments and binding media of wall paintings in the 'Carrera del Darro' in Granada, Spain Journal of culture heritage. (2000) 1, 19–28.

the nature of the organic medium was very difficult. The result of FTIR analyses, were compared with reference spectra, with well known organic adhesives, indicating to the size is a deteriorated protein base (indicating to glue). The glue was used as a mordant for the water gilding leaves and the chalk plus some of gypsum was so clear in the gilding samples representing the preparation layer and the surface accumulations (fig.17).

Conclusion:

The results obtained through SEM-EDAX and FTIR analysis of the samples and the observations made by LOM, lead to the conclusion that there are many similarities in the gilding materials used and the general methodology adopted. The studied gilded ceilings are suffering from a severe damage, as a result of different deterioration factors, which appeared in different aspects, the severe damage of gilding, (disfiguring, losing, cracking, the surface of the gilded samples generally showed an extensive net of 'craquelure', producing small plates). Gildings are covered with a thick layer of, dirties and other accumulations causing disfiguring and further deterioration. The gilding and the preparation layers lost its adhesion to the supports in many places of the studied gilded ceilings. Gold leaves were the main gilding material in the all studied gilded ceilings. Gold leaves and powder (brass Cu& Zn) were used for gilding from Mohamed Ali family period as a new intervention. Chalks (CaCO3) with a small quantity from Gypsum (CaSO4.2H2O) are the main component together with some impurities of the gilding preparation layer. Glue is consider as the main mordant or size for the gilding and the preparation layer i.e. (water gilding).

Acknowledgement.

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10- Irina C., et al., *Gilding techniques in religious art between east and west, op.cit 47-62.*

11- Ibid, *47-62.*
12- Shayne R. and Nick U., *Conservation of furniture, op. cit., 340.*
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26-Michele R. et al., *Infrared Spectroscopy in Conservation Science.*
The Getty Conservation Institute Los Angeles(1999) 28, 130.

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28- Stanley Taft JW and Mayer WJ., *The science of paintings, Springer, New York, (2000) 171-173 .*

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30-Ana EM et al., *Mortars, pigments and binding media of wall paintings in the 'Carrera del Darro' in Granada, Spain Journal of culture heritage. (2000) 1, 19–28.*

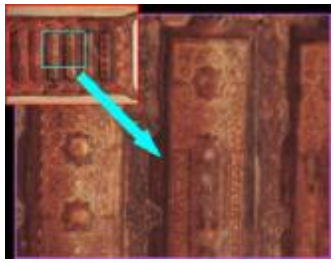


Fig. 1 Photographs (macro and micro) corresponding to the gilded ceiling of Madrasa of El-Nasser Mohamed Ibn Qalaoon shows its status.

Fig. 2 Photographs (macro and micro) corresponding to the gilded ceiling of Khankah and mausoleum of sultan Beybars El-Jashankir shows its drammatic status.

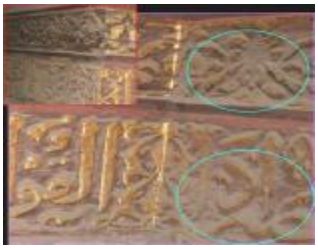


Fig. 3 Photographs (macro and micro) corresponding to the gilded ceiling of Khankah and mausoleum of sultan Beybars El-Jashankir shows its status.

Fig. 4 Photographs (macro and micro) corresponding to the gilded ceiling of Mosque of Shraf El-Dien shows its severe damage.

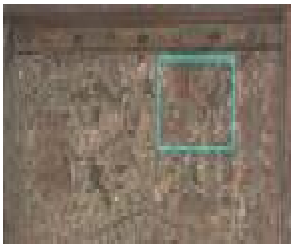


Fig.5Photographs corresponding to the gilded decoration of Madrasa of Krasonker Elmansory shows its status.

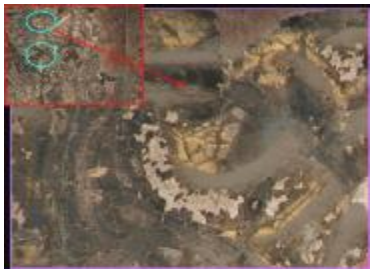
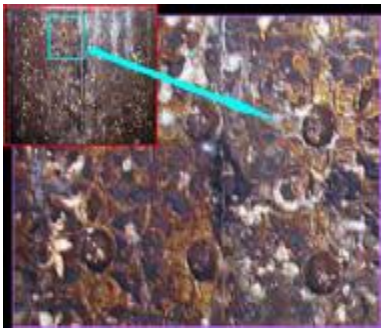


Fig. 6 Photographs (macro and micro) Shows details from fig.3 decoration of the (notice the severe damage of the gilded decoration).

	
Fig. 7 Photographs (macro and micro) corresponding to the gilded ceiling of Madrasa of El-Zaher Brqoq shows its status.	Fig. 8 Photograph corresponding to the gilded ceiling of Madrasa of El-Kady Abd El-Baset shows its drammatic status as a all.
	
Fig. 9 Photographs (macro and micro) corresponding to the gilded ceiling of El-Kady Yehia Zein El-Dine shows its drammatic status.	Fig. 10 Photographs (macro and micro) corresponding to the gilded ceiling of Mosque of Moheb El- Dine Abo El-tayb shows its drammatic status.

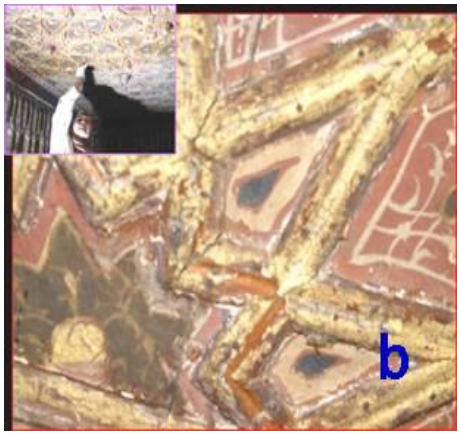


Fig. 11 a,b Photographs (macro and micro) corresponding to the gilded ceiling of El-Sadat house shows its status.(Notice the gilding craquelure).

Fig. 12 Photograph corresponding to the original gilded decoration of the ceiling of mosque of the palace of prince Mohamed Ali shows its status.

Fig. 13 Photographs (macro and micro) corresponding to the ceiling extension of mosque of palace of prince Mohamed Ali (previous gilding intervention) shows the severe damage.

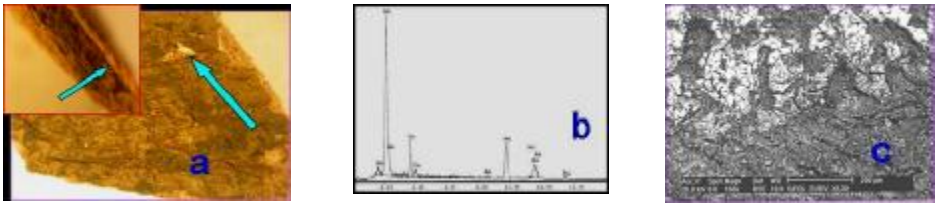


Fig. 14 Gilded sample from Madrasa of El-Nasser Mohamed Ibn Qalaoon: a) Microphotography and cross-section corresponding to the sample showing the layers described: top yellow-gold layer (very deteriorated gilded , an extensive net of 'craquelure', producing small plates); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration very well

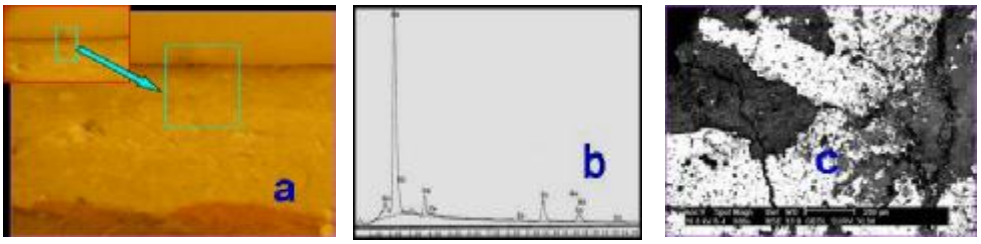


Fig. 15 Gilded sample from Khankah and mausoleum of sultan Beybars El-Jashankir: a) Microphotography corresponding to the sample (deteriorated gilded, applied on bole); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration observed).

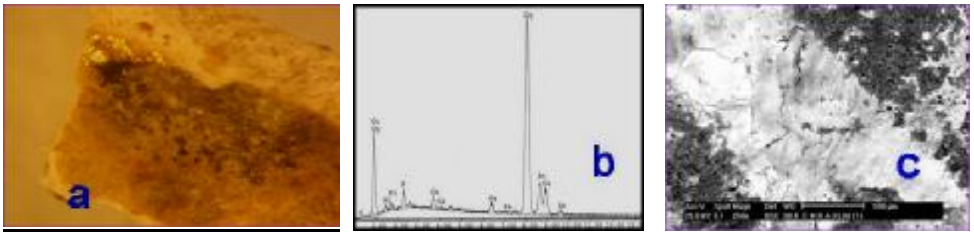


Fig. 16 Gilded sample (previous intervention) from Khankah and mausoleum of sultan Beybars El-Jashankir: a) Microphotography corresponding to the sample (deteriorated gilded); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration observed).

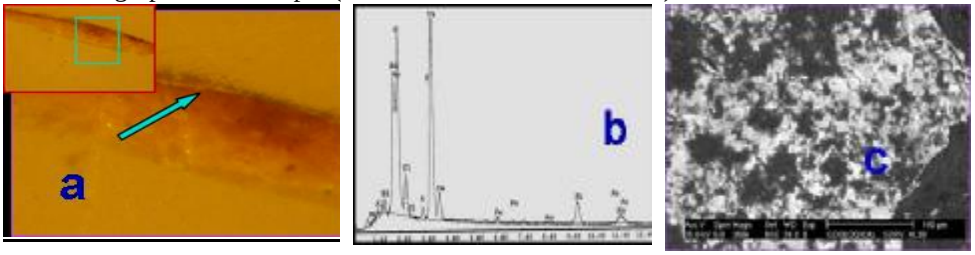


Fig. 17 Gilded sample from Mosque of Shraf El-Dien.: a) Microphotography corresponding to the sample showing the layers described: top yellow-gold layer (very deteriorated gilded); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration observed).

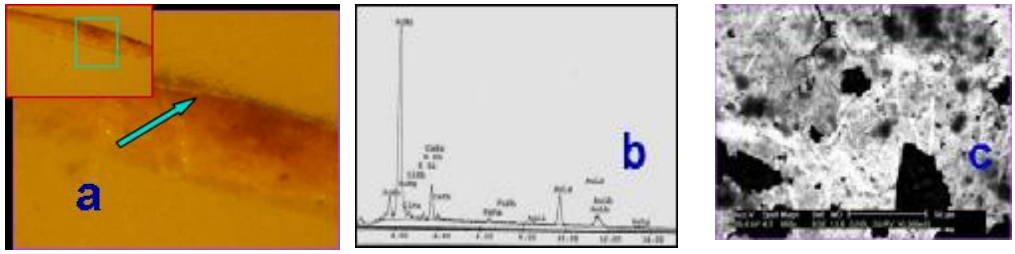


Fig. 18 Gilded sample from Madrasa of Krasonker Elmansory: a) Microphotography of cross-section corresponding to the sample showing the layers described: top yellow-gold layer (very deteriorated gilded); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (missing and deterioration observed).

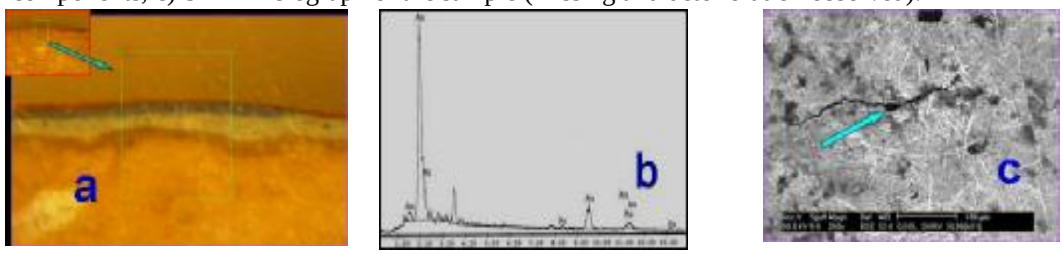


Fig. 19 Gilded sample from Madrasa of El-Zaher Brqoq: a) Microphotography of cross-section corresponding to the sample, the four preparation layers are so clear, bole is the third followed by gilding; b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration observed).

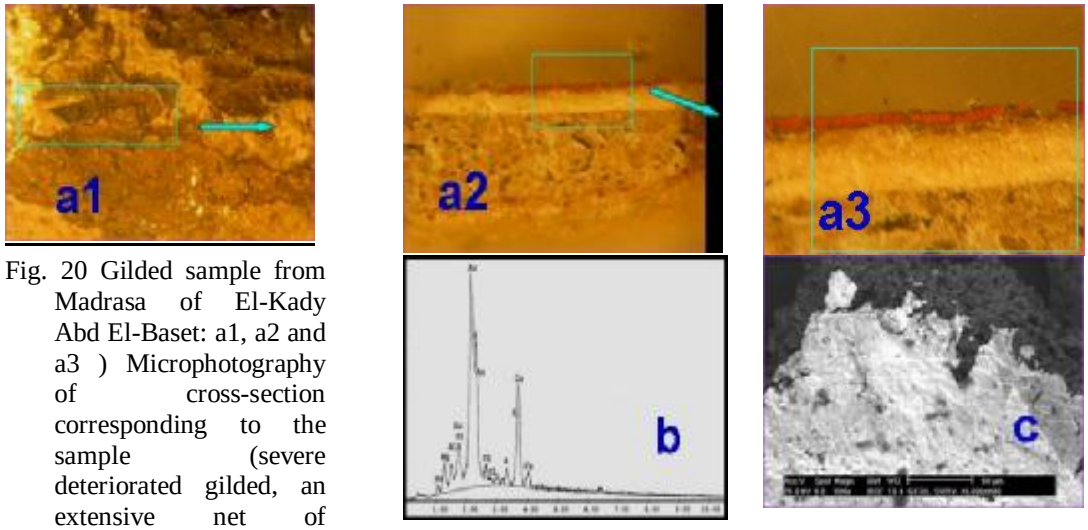


Fig. 20 Gilded sample from Madrasa of El-Kady Abd El-Baset: a1, a2 and a3) Microphotography of cross-section corresponding to the sample (severe deteriorated gilded, an extensive net of 'craquelure', producing small plates) , the red preparation bole layer is so clear; b) EDX analysis in surface layer of the sample shows its

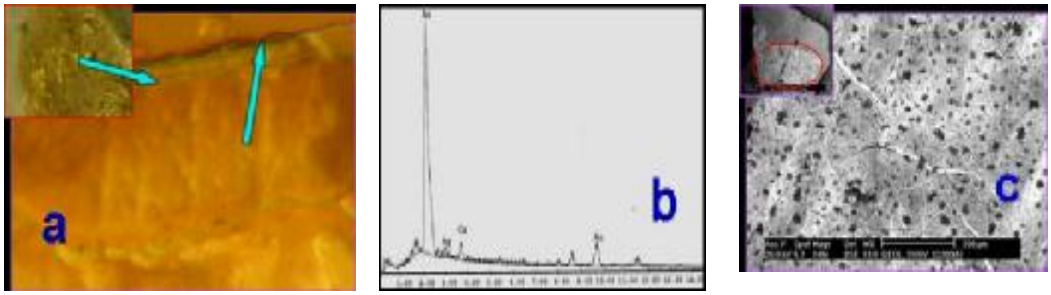


Fig. 21 Gilded sample from Mosque of El-Kady Yehia Zein El-Dine: a) Microphotography and cross-section corresponding to the sample (deteriorated gilded); b) EDX analysis in surface layer of the sample shows its components; c)SEM micrograph of the

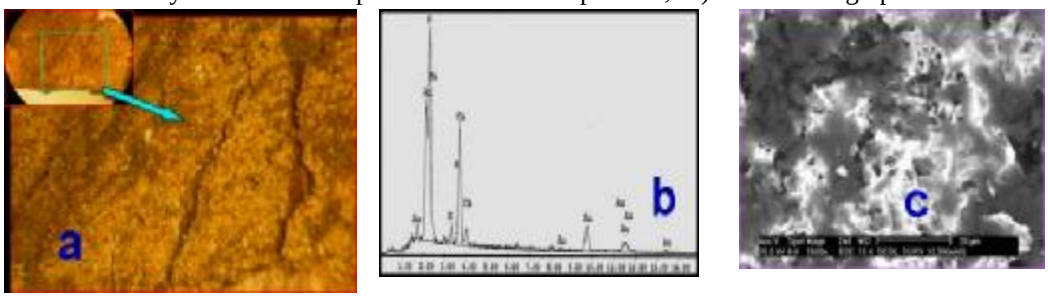


Fig. 22 Gilded sample from Mosque of Moheb El- Dine Abo El-tayb: a) Microphotography corresponding to the sample (deteriorated gilded, an extensive net of 'craquelure', producing small plates); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration observed).

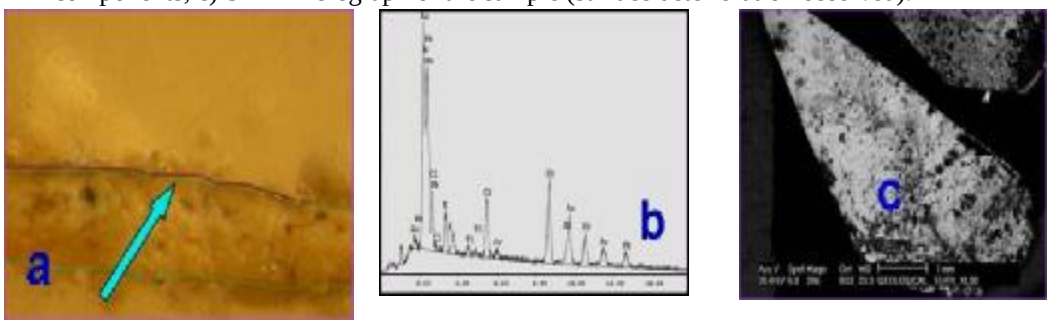


Fig. 23 Gilded sample from El-Sadat house: a) Microphotography of cross-section corresponding to the sample (deteriorated gilded); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration observed).

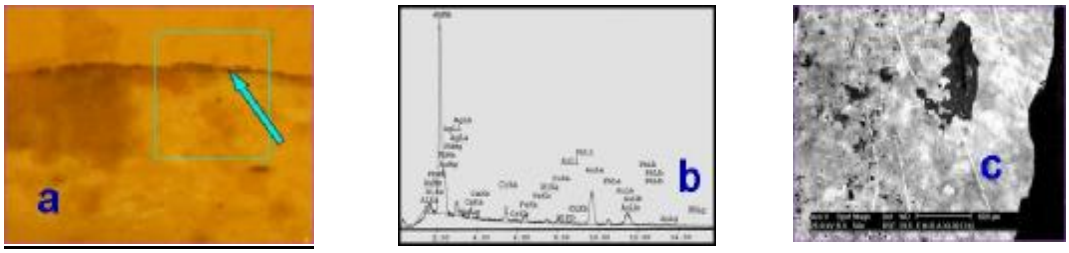


Fig. 24 Gilded sample from palace of prince Mohamed Ali: a) Microphotography of cross-section corresponding to the sample (deteriorated gilded); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (surface deterioration observed).

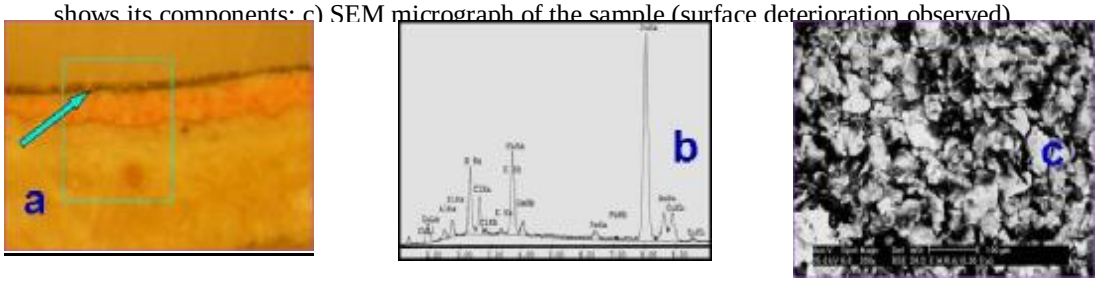


Fig. 25 Gilded sample (intervention) from palace of prince Mohamed Ali: a) Microphotography of cross-section corresponding to the sample (new intervention applied on bole); b) EDX analysis in surface layer of the sample shows its components, brass Cu,Zn,; c) SEM micrograph of the

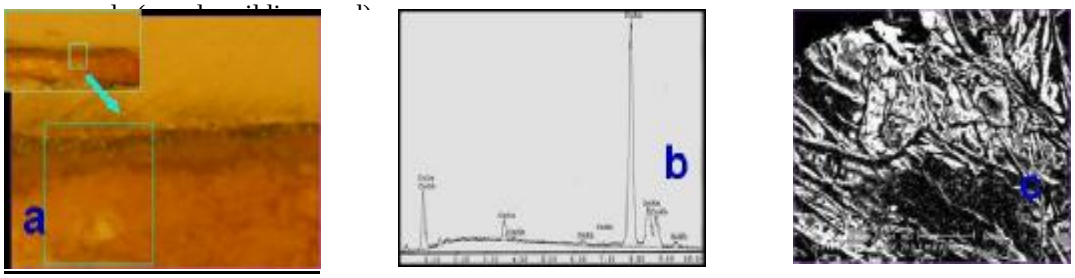


Fig. 26 Gilded sample (previous intervention) from mosque of Palace of prince Mohamed Ali: a) Microphotography of cross-section corresponding to the sample (deteriorated gilded); b) EDX analysis in surface layer of the sample shows its components; c) SEM micrograph of the sample (gold leaves in bad application observed).

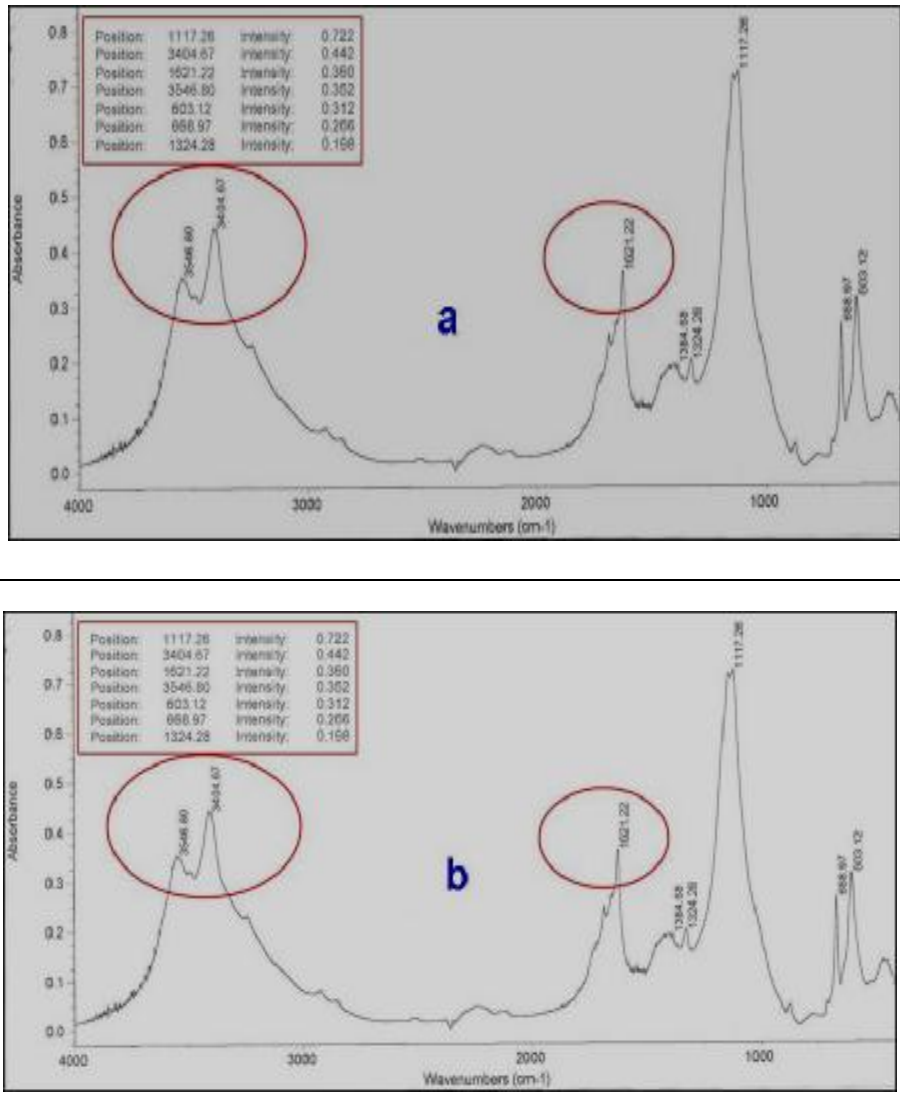


Fig. 27 FTIR spectra gilded sample corresponding to two samples as only examples; a) Madrasa of El-Zaher Brqoq; b) Mosque of Moheb El- Dine Abo El-tayb.