Egypt. J. Anal. Chem., Vol. 15, pp.200-208 (2006)

Analytical Study of the Decorative Materials of the Ceilings of the Mosque of EL-MOTAHER (1744 A.D.) Cairo, Egypt

Atef A. Brania

Cairo University, Faculty of Archaeology, Conservation Department.
E-mail: atefbran@yahoo.com

Summary. The main objective of this study is to analyze and investigate the decorative materials (pigments & painting ground) on the ceilings of the Mosque and Sabiel of El- Sheikh Motaher, for determination accurate components of these materials which unfortunately, often much less is known about its composition, which need more scientific studies. X- Ray Diffraction (X.R.D.) Scanning electron microscope S.E.M (EDAX) Light Optical microscope (L.O.M.) and Fourier transform infrared spectroscopy (FTIR), were adapted for analysis and investigations. The results of the study and a brief conclusion are presented.

Introduction

The mosque and Sabiel of El- Sheikh Motaher origin was El- Syofia Madrasa, dates back to the Ayubied period. The prince Abd El-Rhman Katkhoda renovated it in 1157A.H and 1744 A.D. "Ottoman period.[(1)] Paints thinned with water have along history .from the earliest times artists decorated surfaces with pigments bound in adhesives (Gums "acacia or Arabic ", Glues and egg white or yolk). The paintings on the wood ceilings were applied as follows: the wood panels are covered with a layer of chalk ground bound with glue and the paintings are carried out in a tempera technique (tempera is painting that employs a medium that may be freely diluted with water but upon drying becomes sufficiently insoluble to allow over painting with more tempera or with oil and varnish mediums.[(2)] In a civilization where learning and arts played an important role, great care was taken in the manufacture of writing and painting materials. The pigments cames from different sources[(3)](as mentioned in Arab texts):-

- A white pigment came mainly from white lead, though bone white was mixed with sometimes. Red pigments came mainly from cinnabar (mercuric sulfide), and red lead, though clay ironstone containing red veins among the clay was used. Lac, a dark red resinous incrustation deposited on certain trees by the lac insect was also used.

- Yellow pigment were derived mainly from orpiment (arsenic trisulphide) though yellow ocher's (forms of clay iron ores) were also used in addition massicot monoxide of lead) was mentioned in Arab texts, as also saffron, which was employed together with other pigments.
- Blue pigments came from the mineral lapis lazuli, though azurite (a form of copper carbonate) was also used, as were Smalt, Prussian blue[(4)] and indigo.
- Green pigments were mainly derived from basic copper carbonate verdigris (zinjar) and from mineral malachite. In addition different greens, including those with plant –like hues, were manufactured by mixing other varieties of pigments.

If they were water–based, all these pigments required a binding medium, which was usually mixed with the pigment. Gum Arabic was the most common binder, though glues (especially fish glue) and glair were employed. Paintings were protected with a varnish a typical recipe of the tenth century AH (sixteenth century AD) was to add a naphtha solvent to a thick mixture of sandarac and linseed oil .the solution was applied two or three times to the surfaces being protected.

Experimental

The decorative materials, (pigments, painting grounds and mediums "binders" of the Mosque and Sabiel of El-sheikh Motaher, were investigated and analyzed. The samples have been taken from the ceilings of El-Sabiel, El-kotaab and Dekt El-Mobalgh. X-ray diffraction method (X.R.D), Scanning electron microscope S.E.M (EDAX) Light optical microscope (L.O.M), and Fourier transform infrared spectroscopy (FTIR) were used to investigate and analyze the collected samples which mentioned before.

Results and Discussion

X-ray diffraction method (X.R.D)

X-ray diffraction method (X.R.D) was adapted for analyzes of the studied samples, but unfortunately as a result of the samples were so small the pattern of XRD was not scientifically acceptable, so I depend on the S.E.M (EDAX) to achieve this objective.

Scanning electron microscope S.E.M (EDAX)

The scanning electron microscope (SEM) photographs and microanalyses were carried out by utilizing S.E.M. Philips XL 30 attached with EDX unit, with accelerating voltage 30 K.V., magnification 10X up to 400.000X and resolution for W. (3.5nm). These samples were coated with carbon for investigation and analyses the samples as follows, (fig.1-12).

- Sample A-BLUE pigment with painting ground from El- Sabiel ceiling. (The result of SEM (EDAX) microanalyses and the attached Photomicrograph show that Smalt (SiO_2, K_2O, As_2S_3, CoO, and Al_2O_3) is the main component plus some impurities. Smalt was the earliest of the cobalt pigments. It is moderately finely to coarsely ground potassium glass of blue color; the blue is due to small but variable amounts of cobalt added as a cobalt oxide during manufacture. Since smalt is a coarsely ground glass it can be easily recognized at low magnifications. The particles show conchodial fracture and thin sharp edges of glass splinters.[5]
- Sample B-DARK RED pigment with painting ground from El- Sabiel ceiling. (The result of SEM (EDAX) microanalyses and the attached Photomicrograph shows that Red lead "Minium "(Pb_3O_4) is the main component plus some impurities.
- Sample C-BROWN pigment with painting ground from Dekt El-Mobalgh ceiling. (The result of SEM (EDAX) microanalyses and the attached Photomicrograph shows that Red lead " Minium " (Pb_3O_4) is the main component together with a very small quantity (traces) from Ferric oxide Fe_2O_3 plus some impurities.
- Sample D-DARK RED (brown) pigment with painting ground from El-kotaab ceiling. The result of SEM (EDAX) microanalyses and the attached Photomicrograph shows that Red lead "Minium" (Pb_3O_4) is the main component together with a very small quantity (traces) from Hematite Fe_2O_3, plus some impurities.
- Sample E-RED pigment with painting ground from Dekt El-Mobalgh ceiling. The result of SEM (EDAX) microanalyses and the attached Photomicrograph shows that Red lead "Minium" (Pb_3O_4) is the main component together with a very small quantity from "Cinnabar" mercuric sulfide HgS, plus some impurities.

- Sample F-PAINTING GROUND from El- Sabiel ceiling. (The result of SEM (EDAX) microanalyses and the attached Photomicrograph show gypsum $CaSO_4.2H_2O$ is the main component together with a small quantity from Chalk $CaCO_3$ plus some impurities.

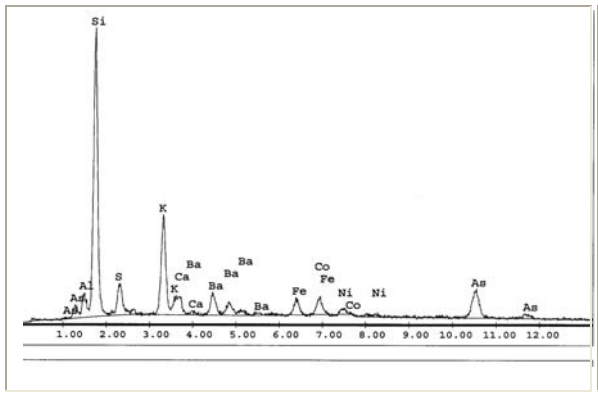

Fig.1 -SEM (EDAX) microanalyses of blue pigment with painting ground (El-Sabiel ceiling) .A.

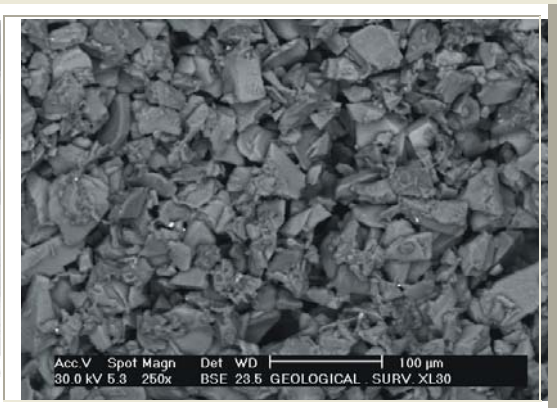

Fig.2- SEM Photomicrograph shows Silica (angular grains) is the main component. A.

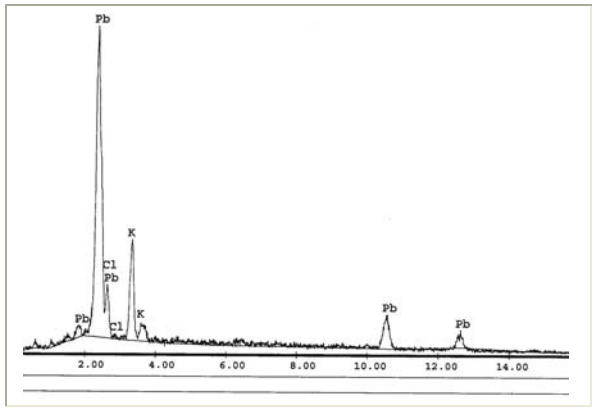

Fig.3- SEM (EDAX) microanalyses of dark red pigment with painting ground from (El- Sabiel ceiling) .B.

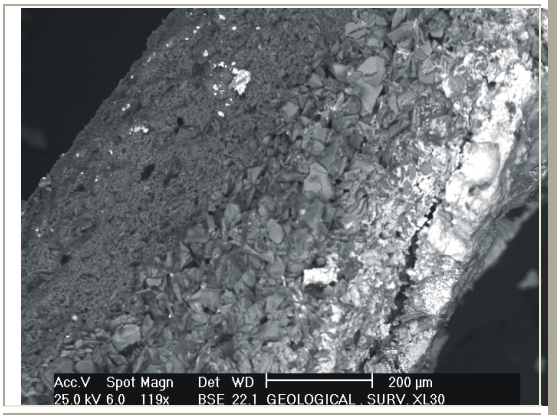

Fig.4- SEM Photomicrograph shows the red pigment coated the painting ground on the right hand. B.

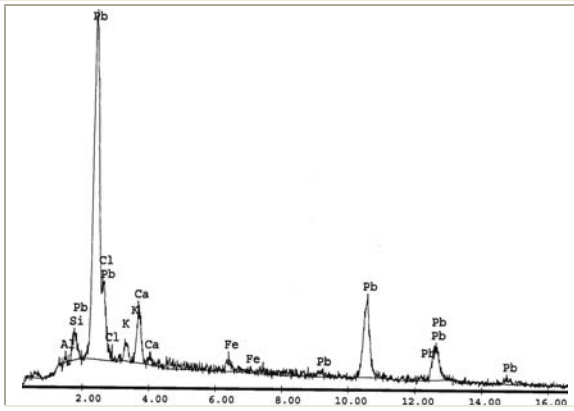

Fig.5- SEM (EDAX) microanalyses of brown pigment with painting ground from Dekt El-Mobalgh ceiling. C.

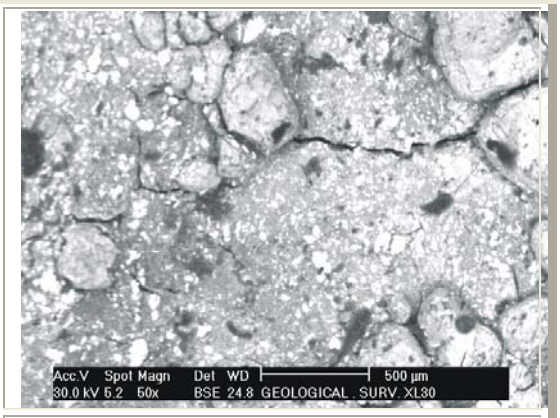

Fig.6- SEM Photomicrograph shows the deteriorated brown pigment on a background of the painting ground. C.

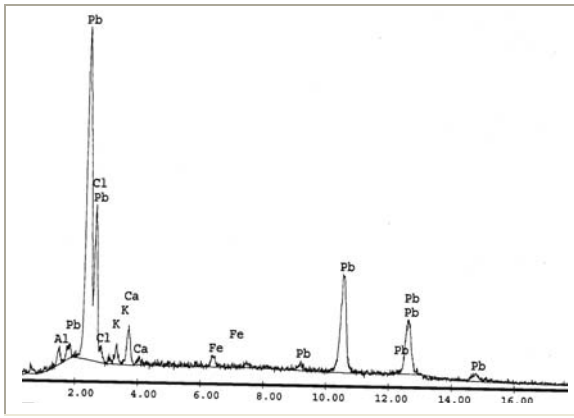

Fig.7- SEM (EDAX) microanalyses of dark red pigment with painting ground from El-kotaab ceiling. D.

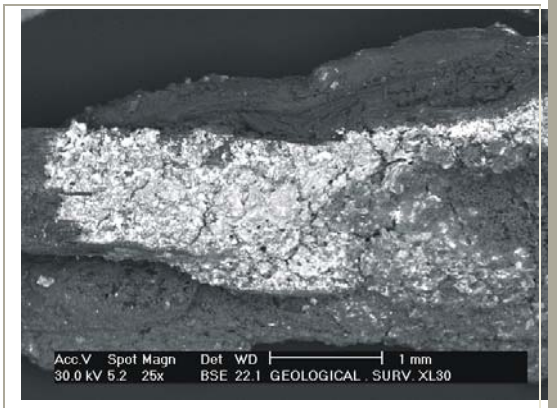

Fig.8- SEM Photomicrograph shows the deteriorated brown pigment (white) on a background of the painting ground. D.

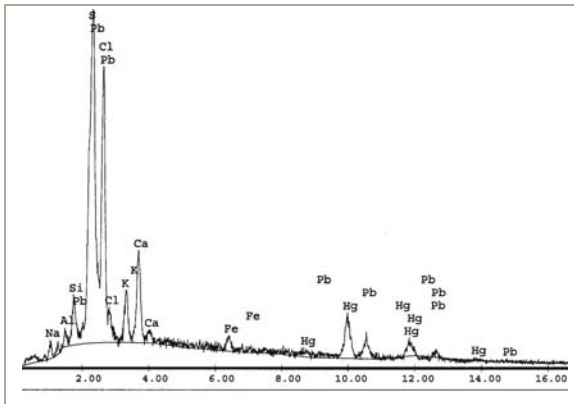

Fig.9- SEM (EDAX) microanalyses of red pigment with painting ground from Dekt El-Mobalgh ceiling. E.

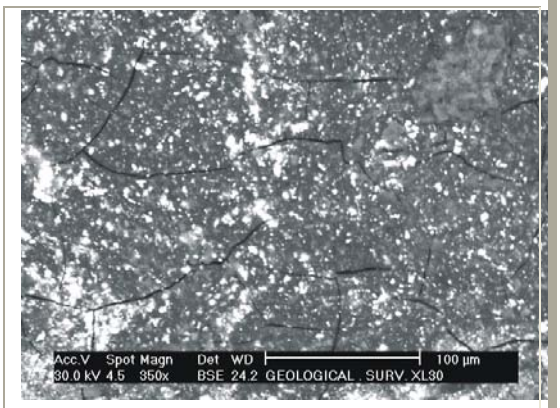

Fig.10- SEM Photomicrograph shows the red pigment (white spots) on a background of the painting ground. E.

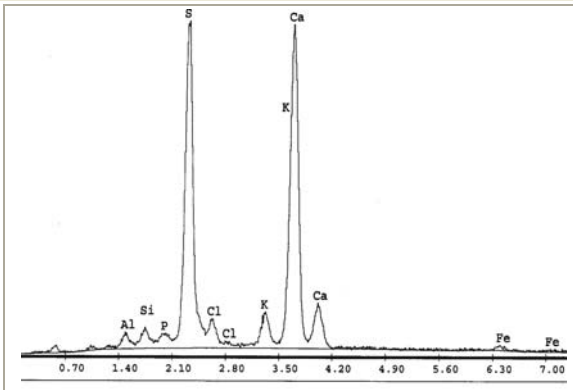

Fig.11-SEM (EDAX) microanalyses of the painting ground (El- Sabiel ceiling). F.

Fig.12- SEM Photomicrograph shows Gypsum on a Chalky background of the painting ground. F.

Light Optical Microscope (L.O.M.)

L.O.M with X63 magnification was used to investigate surface samples of the blue, red and the brown pigments; the samples were covered with Linseed oil to make it to be so clear to see the grain size distribution. The results are shows the fading of the blue pigment and severe deterioration of the red and brown pigments as a result of different deterioration factors as follows (Fig.13-16).

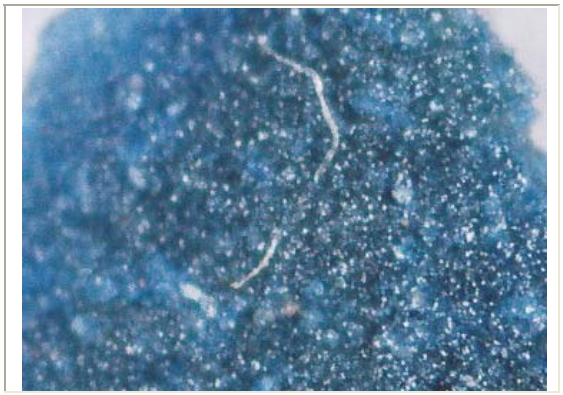

Fig.13- LOM Photomicrograph shows the fading of the blue pigment (El- Sabiel ceiling) magnification X16.

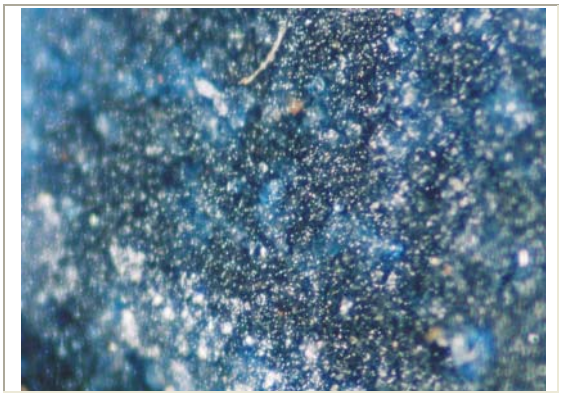

Fig.14-Detailes from the previous photo. Photomicrograph magnification X63.

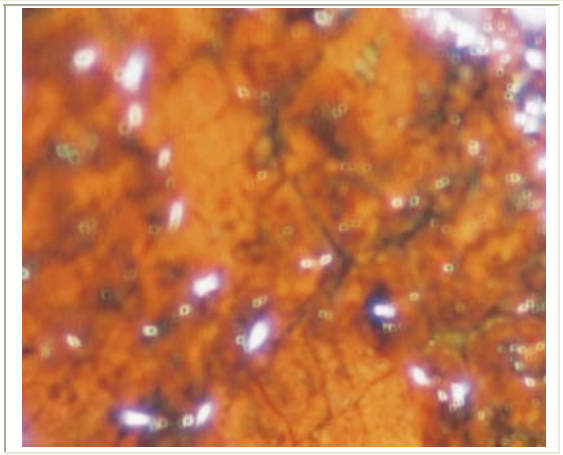

Fig.15- LOM Photomicrograph shows the red pigment (El-Sabiel ceiling) magnification X63.

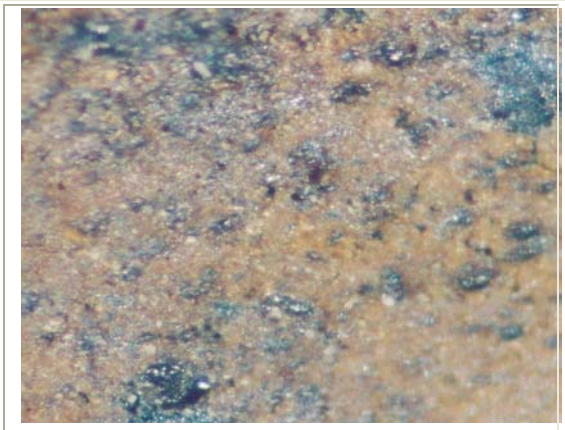

Fig.16- LOM Photomicrograph shows the brown pigment (El-Sabiel ceiling) magnification X63.

Fourier transform infrared spectroscopy (FTIR)

In the analysis of painting materials, infrared spectrometry can be used for analyses of many pigments (both organic and inorganic), binders and varnishes. Many organic compounds with similar chemical composition and structures have similar pattern of in the IR range. This is true, fore example, of protein containing binders, such as glue, egg white (glair) and yolk. Thus, this instrumental technique is useful for the identification of the general class of a binder, but not usually for specific binder identification [6, 7]. The most modern generation of infrared spectrometers, called "Fourier transform". FTIR was adapted here for analyses of the pigments binders from the mosque, which revealed from studying the pattern, the functional groups and the comparative study with standard organic binders that, the binders are protein compounds including Amides and Amine groups, indicating to the glue (Fig.17 a-c).

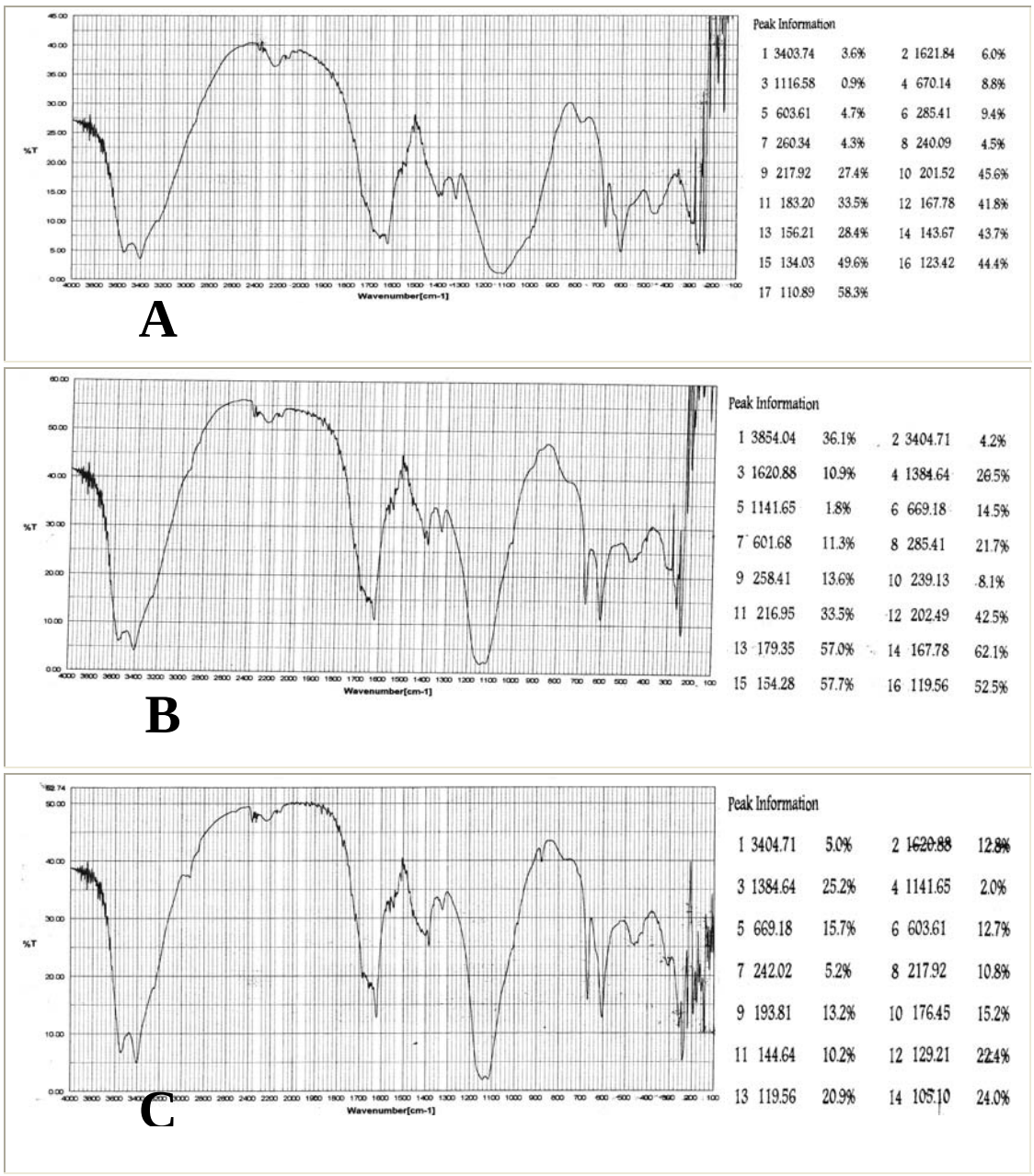

Fig.17 -FTIR spectra for the blue pigment (A), red (B) and brown (C) from the mosque.

Conclusion

According to the previous study, results concluded as follows: -

- Minium (Red lead Pb_3O_4) was used as a red pigment at El–Sabiel ceiling.
- Smalt (SiO_2, K_2O, As_2S_3, CoO and Al_2O_3) was used as a blue pigment at El–Sabiel ceiling.

- Red lead (Minium Pb_3O_4) plus a small quantity from red ore (Hematite Fe_2O_3) were used as a red pigment at El–Kotaab ceiling.
- Minium Red lead Pb_3O_4 with a small quantity of red ore (Hematite Fe_2O_3) were used as a brown pigment at Dekt El-Mobalg ceiling.
- Minium (Red lead Pb_3O_4) was used as a red pigment together with a very small quantity from Cinnabar (Mercuric sulfide HgS), at Dekt El-Mobalg ceiling.
- Gypsum ($CaSO_4.2H_2O$) is the main component together with a small quantity from Chalk $CaCO_3$ plus some impurities of the painting ground.
- Glue is the binder of the pigments.

References

1) M. Abo El- Amaym**;** Athar El- Kahera fy El–Asr El Osmany, 1 Istanbul, **299**, (2003).

2) R. Mayer; The artist's handbook of materials and techniques, the Viking Press Inc., New York, **264**, (1991).

3) A.Y. Al-Hassan and D. R.Hill; Islamic technology an illustrated history, Cambridge University Press, UNESCO, Paris, **170:174** (1986).

4) Z.S. Ramadan; El- Askf El-khashabeia fy El-Asr El-Osmany, master theses, Islamic Dept., Faculty of Archaeology, Cairo University, (1992)

5) B.Muhlethaler, and J.Thissen; Identification of the materials of paintings, Smalt, Stud. in cons., 14, **47:61**(1969).

6) Jr. w. Stanley Taft, and W. J. Mayer ; The science of paintings, Springer, New York, **171: 173** (2000)

7) K. J.*Van den Berg*, et al., Darkening and surface degradation in 19th-and early 20th-centuary paintings: an analytical study. In: 13th-Triennial Meeting Rio de Janeiro **22-27** September 469, (2002).