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## THE PRESENCE OF CEMENT MORTARS IN THE ADDED CHAMBERS OF EL SAKAKENY PALACE: A CASE STUDY

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### ABSTRACT

A comprehensive investigation has been undertaken on the used mortar in construction of El Sakakeny palace dating to the 19<sup>th</sup> century designed by Antonio La Schiac. The analytical instruments used for this investigation were X- ray diffraction and Scanning Electron Microscopy coupled with EDX. The analysis shows that the mortar used in the fire place chamber was cement on other hand the mortar in the love chamber was calcium hydroxide mixed with silica as popular mortars were used before starting to use cement mortars in Egypt.

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**KEYWORDS:** Mortar, El Sakakeny palace, Cement, XRD, SEM, EDX.

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## 1. INTRODUCTION

Cement is a complex mixture of inorganic phases, mainly constituted by clinker (calcium silicates, aluminates and aluminosilicates) and gypsum (Ridi, 2011), the cement is consisted of three materials:

1. Calcium carbonate  $\text{CaCO}_3$ .
2. Silicon dioxide  $\text{SiO}_2$
3. Aluminates dioxed  $\text{Al}_2\text{O}_3$

The cement appears in construction historic palaces in 1906 by the foreigners engineers specially La Schiac.

El Sakakeny palace (Fig.1) was built for Habib el sakakeny pasha (the owner of the palace ) in 1897 or before using cement in Egypt for construction, the whole space of the palace is 2698 m<sup>2</sup>. It is consisted of three floors, that palace is famous because of it's decoration as the mural paintings on ceilings and on walls. The son of Habib el sakakeny pasha Henerry add many chambers to the palace in 1939 constructed with cement mortar.



Figure 1 One of the statues in El Sakakeny

## 2. MATERIALS AND METHODS

Samples were collected carefully from the destroyed edge, using a micro scalpel, to identify the constituents and degree of salts. All the analyzed and investigated samples were carefully collected from areas without aesthetic value or from severely damaged parts.

The X-ray diffraction patterns of the mortar from the walls of El Sakakeny palace were obtained using a diffract meter (Philips PW 1840), operated at 40 kV and 25 mA, using Cu Ka radiation and a receiving slit of 0.2 mm. The measurements were made at room temperature. Preparation of each sample consisted of grinding it in the dry form, by using a

mortar and pestle to obtain a fine powder ( Stuart, 2007).

The microstructure and morphology of mineral constituting of the paintings were analyzed with a Scanning electron microscope FEI Quanta 200. The microscope operated at 30 kV accelerating voltage. Sample preparation consisted of application of a superficial gold film by sputtering to prevent electrostatic charge.

## 3. RESULTS AND DISCUSSION

### 3.1 X-ray diffraction (XRD)

The XRD patterns of the samples from mortars used in building El Sakakeny palace indicate the following results which are resumed in Table 1 and Fig. 2.

Table 1. The approximate XRD analysis results of four samples of El Sakakeny palace

Compounds %	1s	2s	3s	4s
Gypsum	---	56.5	61.3	45.8
Calcite	17.3	---	9.5	9.5
Silica	58.3	28	---	---
Molonite	17.9	---	---	---
Orthoclase	---	---	---	0.7
Halit	---	10	21	38
Albite	---	---	6	---
Hematite	---	5	---	---

The XRD analysis results revealed the following:

1. The added chambers as in fire place chamber was built using cement according to the XRD patterns of the major three compounds (Calcite - Quartz - Kaolinite) were found (Fig. 2 A).
2. The original mortar in the love chamber consisted of Gypsum and Quartz colored with Hematite.( Fig. 2 B).
3. The original mortar in library chamber consisted of Gypsum with a little percentage of Albite (Fig. 2 C, D).
4. The original mortar from the outside wall of love chamber contained Gypsum, Calcite, Orthoclase with high percentage of Halite.
5. Halite constitutes 5.3% of the modern mortar and 21% of the original mortar and 38% in the outside original mortar from the love chamber that result assured the occurrence of deterioration which can cause detachment in the future (Arnold et al.,1987), which caused the detachment of painting layers (Ashurst, 1998).

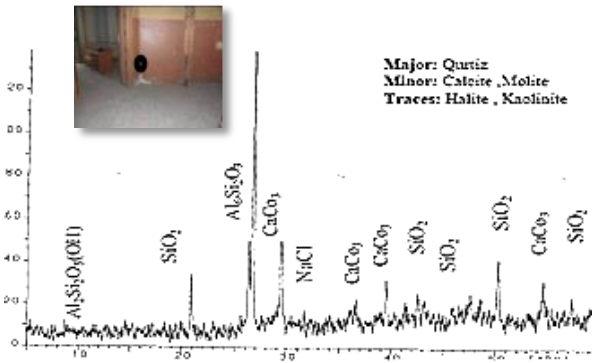


Figure 2 (A) X-Ray diffraction pattern for sample of the walls from the addition of hennery El Sakakeny in the fire place chamber consisted of quartz ,calcite, molite and Kaolinite which assured the presence of cement .

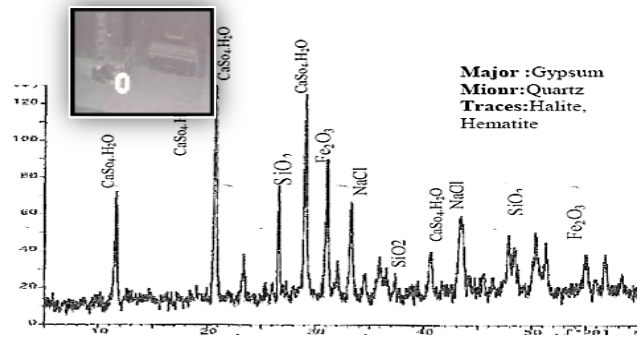


Figure 2 (B) X-Ray diffraction pattern of the original mortar in love chamber consisted of Gypsum and Quartz and a little percentage of Hematite and Halit

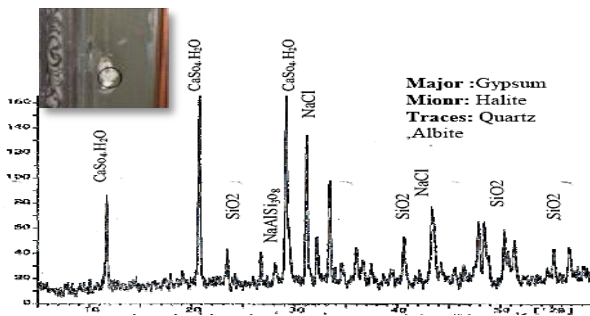


Figure 2 (C) X-Ray diffraction pattern of sample from the original mortar in library chamber consisted of Gypsum , Quartz ,Halite and Albite

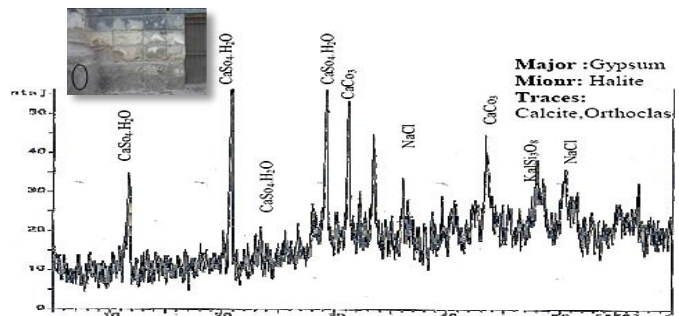


Figure 2 (D) X-Ray diffraction pattern of the original mortar from the outside love chamber is contained Gypsum, Calcite, Orthoclase with high percentage of Halite

### 3.2 Scanning electron microscope coupled with EDX

The EDX patterns of the mural paintings from El Sakakeny palace indicate the following results which are resumed in Table 2 and in Fig.3 to Fig.6. The observations made by SEM of deteriorated mural paintings samples show the appearance of Halite crystals (the salt was identified by XRD) on surface and depth, as well as the Calcite crystals are homogenously surrounded with big crystals of Quartz.

Table 2 The results of X-ray Fluorescence analysis of four samples of El Sakakeny palace 's mortars The results are confirming the results of X-Ray diffraction analysis

S	Elements %									
	Ti	P	Si	S	Ca	K	Fe	Cl	Zn	Cu
1s	0.01	0.53	17.38	1.31	39.76	0.27	1.01	0.42	0.25	0.18
2s	0.20	--	5.21	15.82	2.84	0.96	1.56	2.84	2.62	3.05
3s	0.19	--	0.51	18.34	34.68	0.67	0.46	1.16	1.12	0.21
4S	0.80	--	2.21	14.64	28.29	3.20	0.81	5.65	5.22	0.50

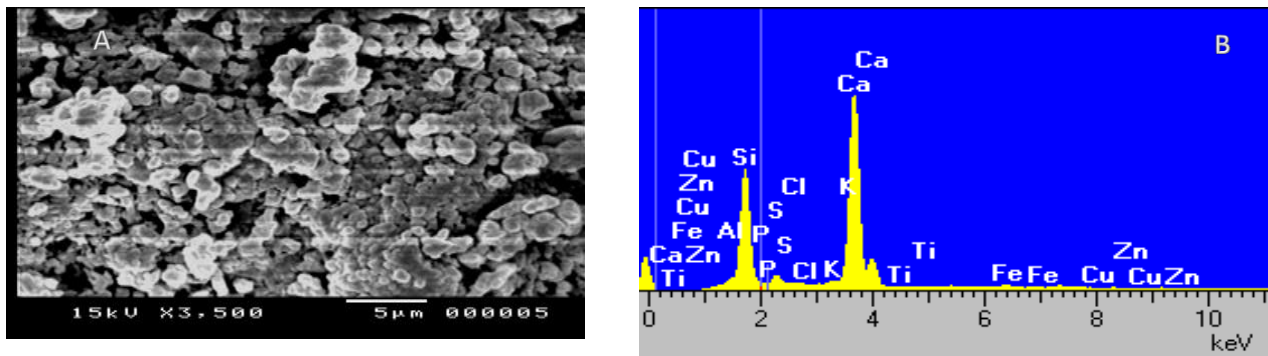


Figure 3(A) SEM show the big Quartz crystals which approved the homogeneity of the mortar. (B) the elemental structure of the Sample from powder of the walls added by Hennery El Sakakeny in the fire place chamber consisted of elements (Ca, Zn, Si, S) which assured the XRD results as the presence of quartz ,calcite, molite and kaolinite related to the cement

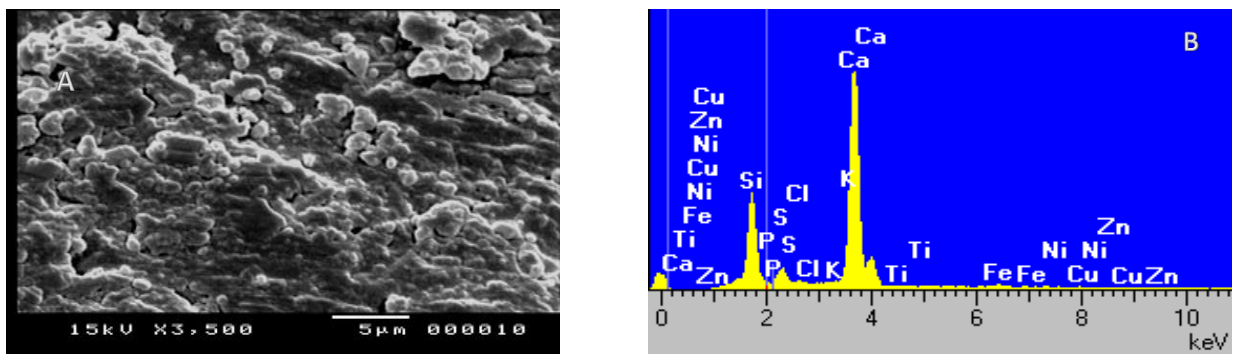


Figure 4. (A) SEM of Sample taken from the original mortar in love chamber show the big crystals which approved the homogeneity of the mortar (B) The elemental structure of the Sample consisted of elements (Ca, Si, S) as the results of XRD assured the presence of Gypsum and quartz.

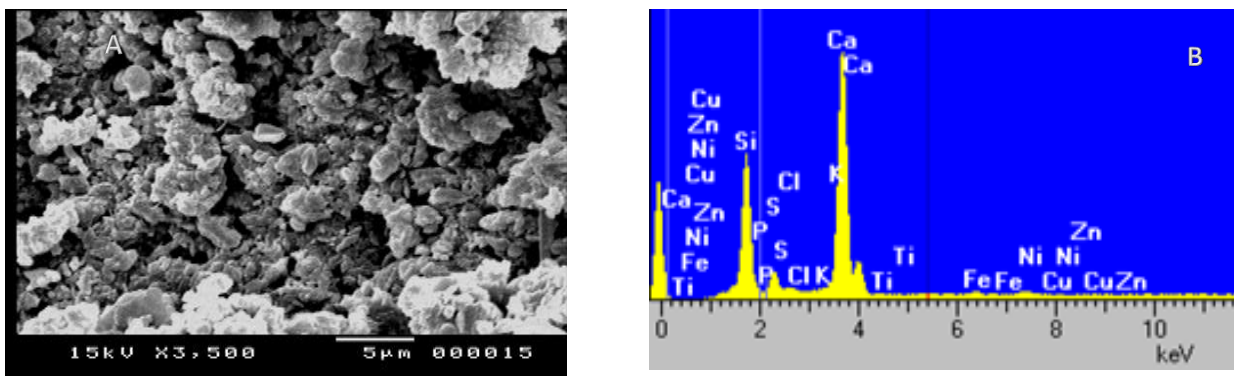


Figure 5 (A) Sample taken from mortar and show the big quartz crystals connected with Gypsum which approved the homogeneity of the mortar.(B) The elemental structure of the Sample consisted of elements (Ca, Si, S,Cl) as the results of XRD assured the presence of Gypsum , quartz and halite.

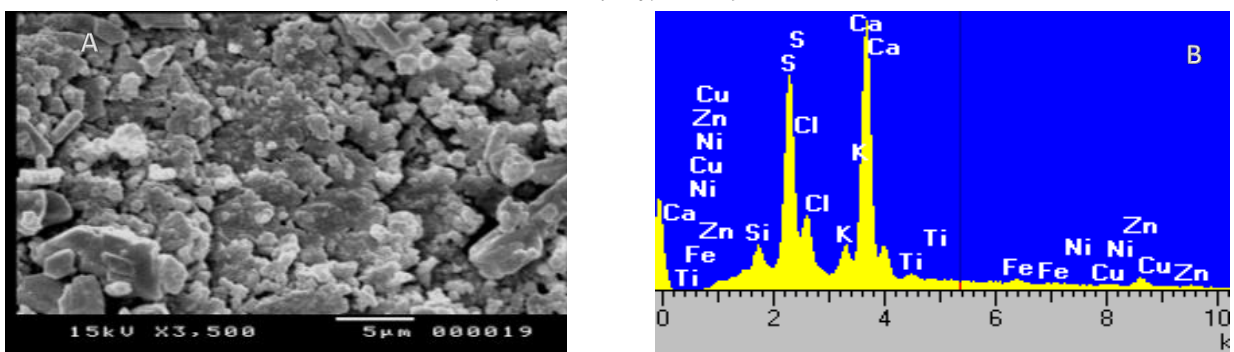


Figure 6(A) SEM of Sample from The original mortar from the outside wall of love chamber show the homogeneity of the mortar (B) The elemental structure of the Sample from The original mortar in the outside wall of love chamber consisted of elements (Ca, Si, S) as the results of XRD assured the presence of Gypsum , Calcite , Orthoclase with high percentage of Halite.

## CONCLUSION

It was presented the initial stages for restoration of El Sakakeny palace focused mainly on the compounds of the mortars in the original building and in the added chambers in El Sakakeny palace. Based on the analysis and testing results below are the findings and conclusion:

1. the modern added chambers in El Sakakeny palaces were built using cement mortar.
2. The main chemical components of the original mortar are Calcite, Quartz, and little percentage of gypsum.

3. The main reason for deterioration and fell down of the walls in layers was the halite which was the main reason of its crystal erosion.
4. The highest percentage of halite was in sample three which taken from the original mortar in outside the love chamber, because of the ground water which raised in the walls of the basement of the palace.

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