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Desert Environment Effect on the Deterioration of Ancient Building Materials in Archaeological Buildings (El- Bagawat Tombs, El - Kharga Oasis as an Example)

Shaimaa Sayed Mohamed El-Sayed[1], Rabea Radi Abdel Kader[2], Ahmed Abo-El Yamin[3]

[1]Conservation Department, Faculty of Archaeology, Luxor University, Egypt.
[2]Researcher and General Manager of Conservation Authority, Ministry of Tourism and Antiquities, Egypt.
[3]Manager of Sohag's Antiquities Restoration Authority, Ministry of Tourism and Antiquities, Egypt.
E-mail: Egyptianconservators2013@gmail.com

Abstract:
Environmental changes have severe effect on the deterioration of archaeological buildings, desert environment distinguishes with the climatic changes daily and seasonally , which affect badly on the ancient building materials, air temperature variation, relative humidity and wind are the main factors that cause the materials degradation. This research aims to shed the light on desert environment's effect on ancient building materials at El - Bagawat tombs in El- Kharga oasis – Egypt, these tombs, return to early Coptic era, building materials samples were taken mainly mud bricks and mortars , examined and analyzed by scanning electron microscope (SEM) , EDAX unit attached to SEM and polarizing microscope to study the desert's effect , environmental measures were mentioned also like air temperature degrees , relative humidity percentages and wind's direction and speed. El-Kharga oasis is characterized by climate changes throughout the year, these changes reflect on the degradation of building materials in El-Bagawat tombs like mud bricks and mortars.

Keywords:
desert environment; deterioration; building materials; el- bagawat tombs; mud bricks; mortars.

I. Introduction

El- Bagawat tombs locate on El-Kharga oasis in western desert – Egypt, they return to an early Coptic era (3 – 7 Century A.D), distinguishes with vaults and domes as important architectural elements(1), the building materials there are mud bricks(2), there were many reasons to choose "mud brick " as building material, one of them was poor economic conditions this time and the plenty of raw material " mud " in El-Kharga oasis(1), Figure (1).

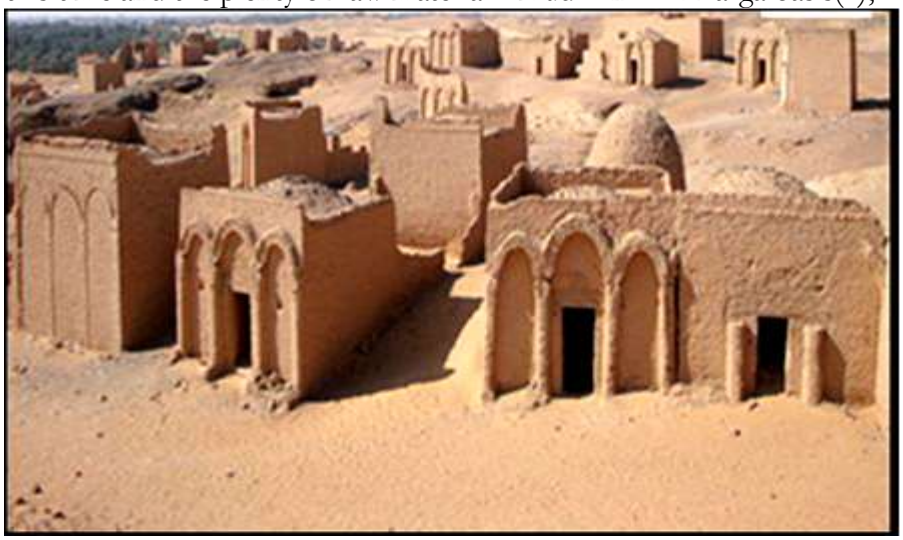

Figure 1. Shows El-Bagawat tombs at El – Kharga oasis

II. Review of Literatures

Climate of El-Kharga oasis:

The climate of El – Kharga oasis is continental which resulted from sequential geological ages, air temperature varies daily and seasonally (annual average 35 ^{0}C , summer's great end is 45 ^{0}C and the winter's great end is 20 ^{0}C – summer's lower end is 30 ^{0}C and the winter's lower end is 10^{0}C).

Relative humidity (%) varies in summer and winter (General annual average 44 %) - the highest average of it is 70% in winter and the lowest average is 30 % in summer.

Wind speed is the most important factor which affects severely on tombs facades, annual wind's speed , average 15 km/h, it increases during March (reaches to 35.4 km/h and decreases in December 10.8 km/h, the wind's direction is north west most of the year , the wind is the main reason of sand dunes in the oasis(2).

III. Research Methods

Samples were taken from essential and secondary building materials, mud brick is the essential building material in the tombs there and the secondary one is mud mortar. The samples were examined and analyzed using scanning electron microscope, EDAX and polarizing microscope to identify their components and the deterioration caused by the desert environment's effect, figure (2-9).

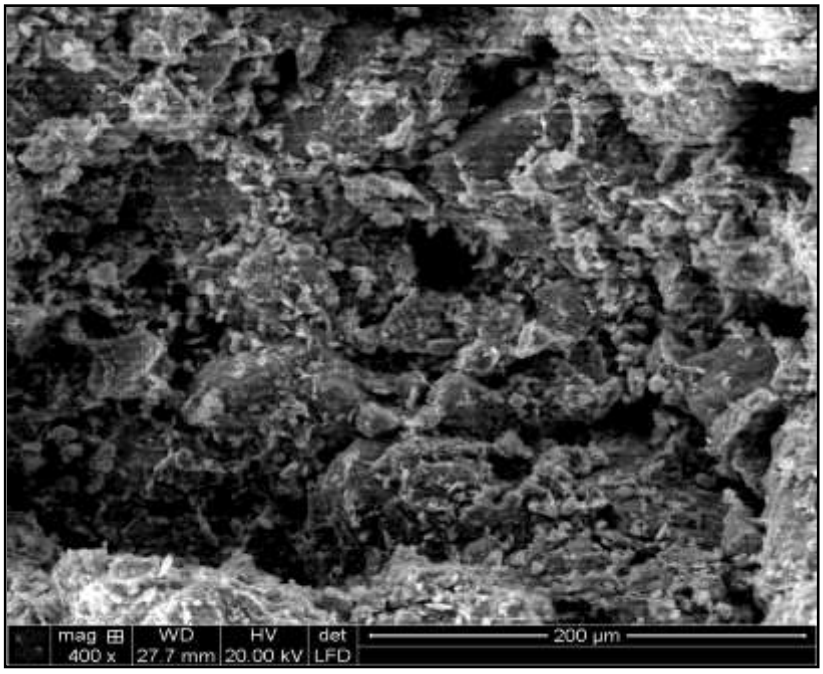

Figure 2. Mud brick's sample examination with SEM (mag 400×)

(2) Abo El Yamin, A.(2014). Mural Painting in the tombs of El Bagawat in El – Kharga Oasis: the Current status and the Methods of treatment and conservation applying on one of the selected tombs. Unpublished PhD thesis, Conservation department, faculty of Archaeology, Cairo University, Cairo, Egypt.

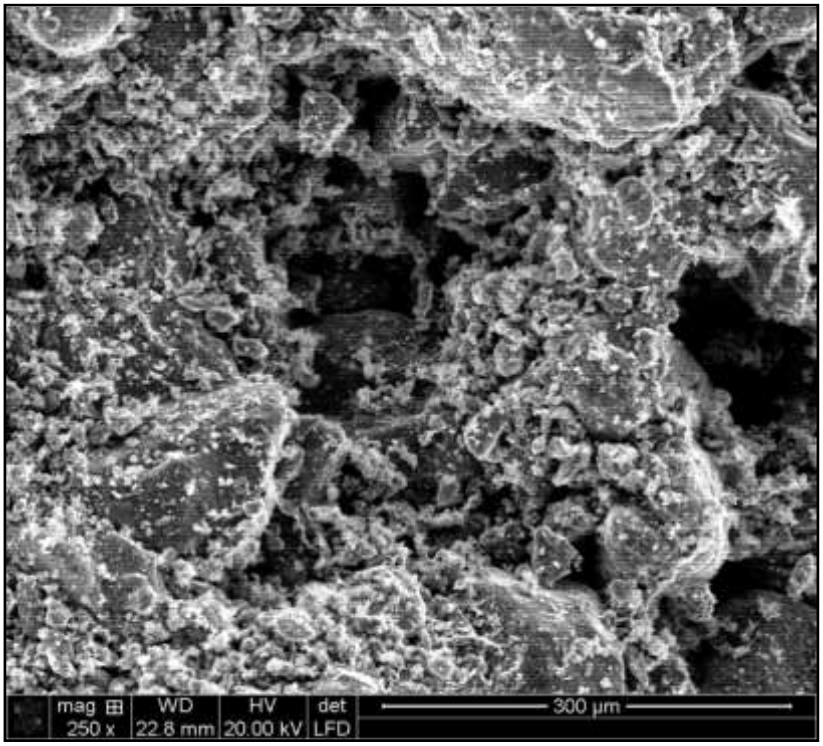

Figure 3. Mortar's sample examination with SEM (mag 250×)

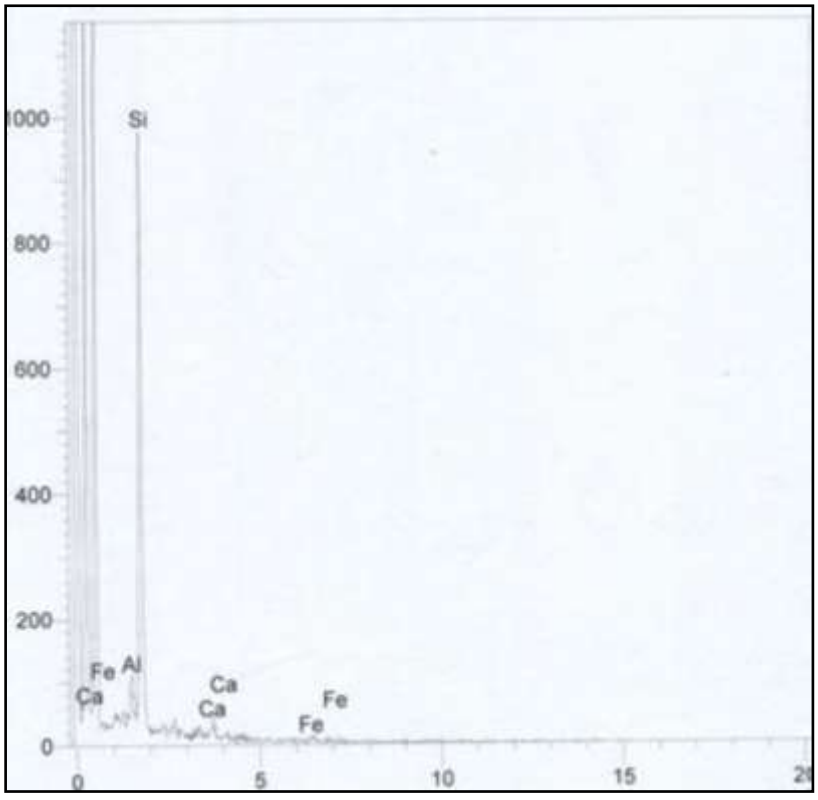

Figure 4. EDAX analysis of mud brick's sample

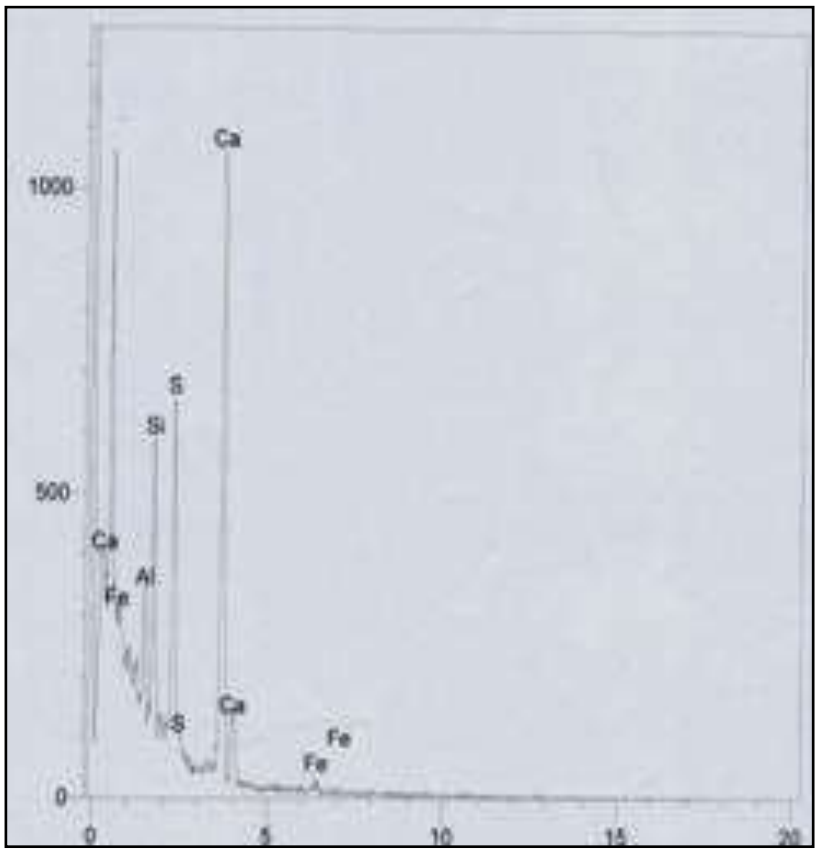

Figure 5. EDAX analysis of mortar's sample

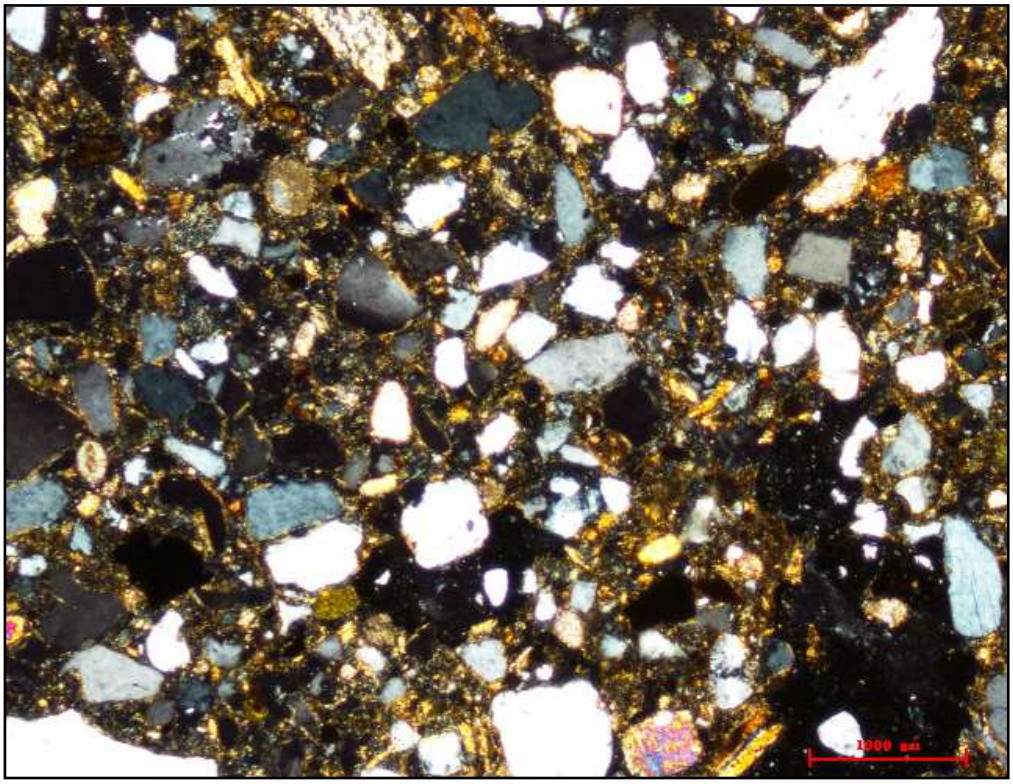

Figure 6. Mud brick's examination by polarizing microscope

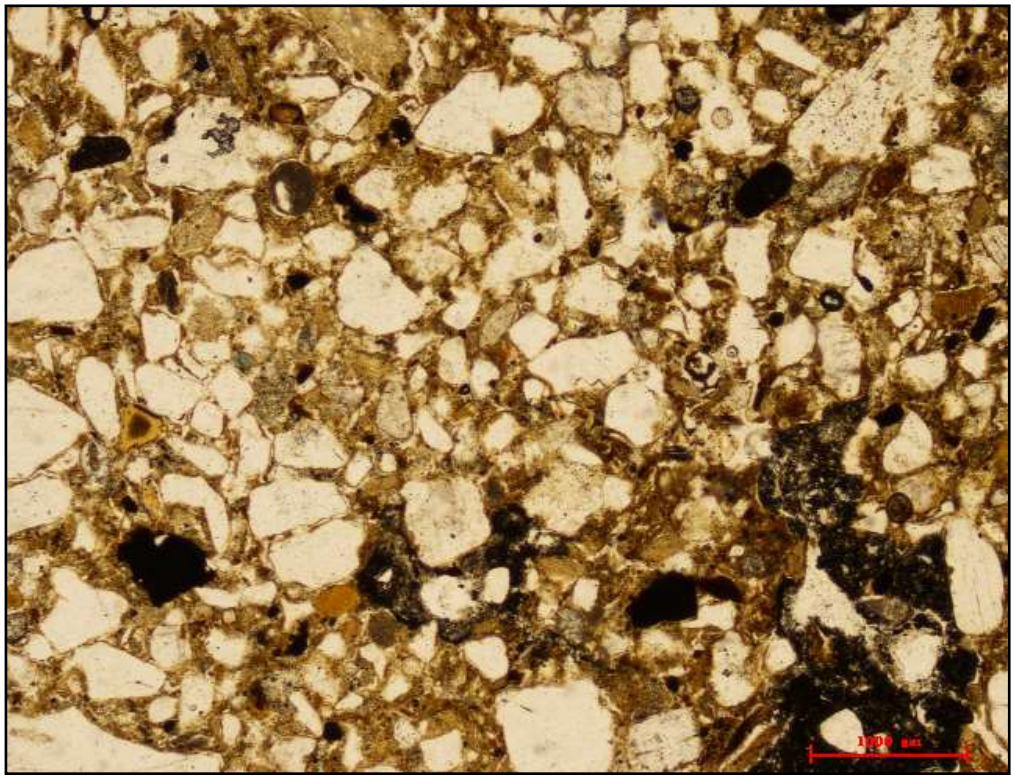

Figure 7. Mud brick's examination by polarizing microscope (Analyzer absence)

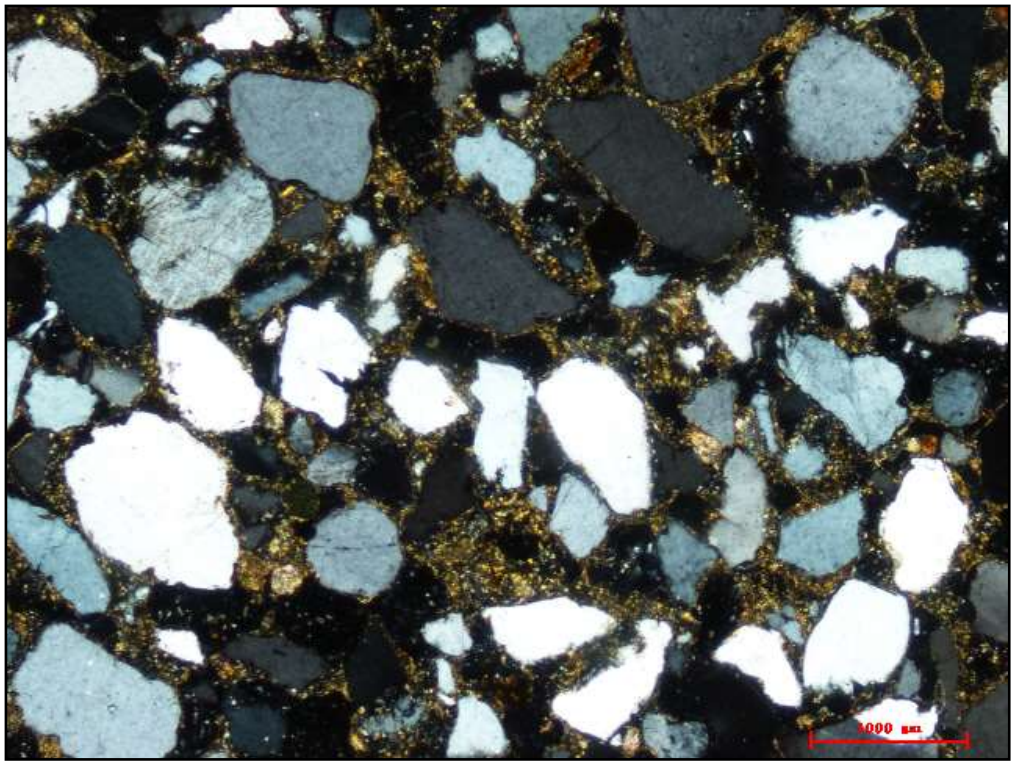

Figure 8. Mortar's examination by polarizing microscope

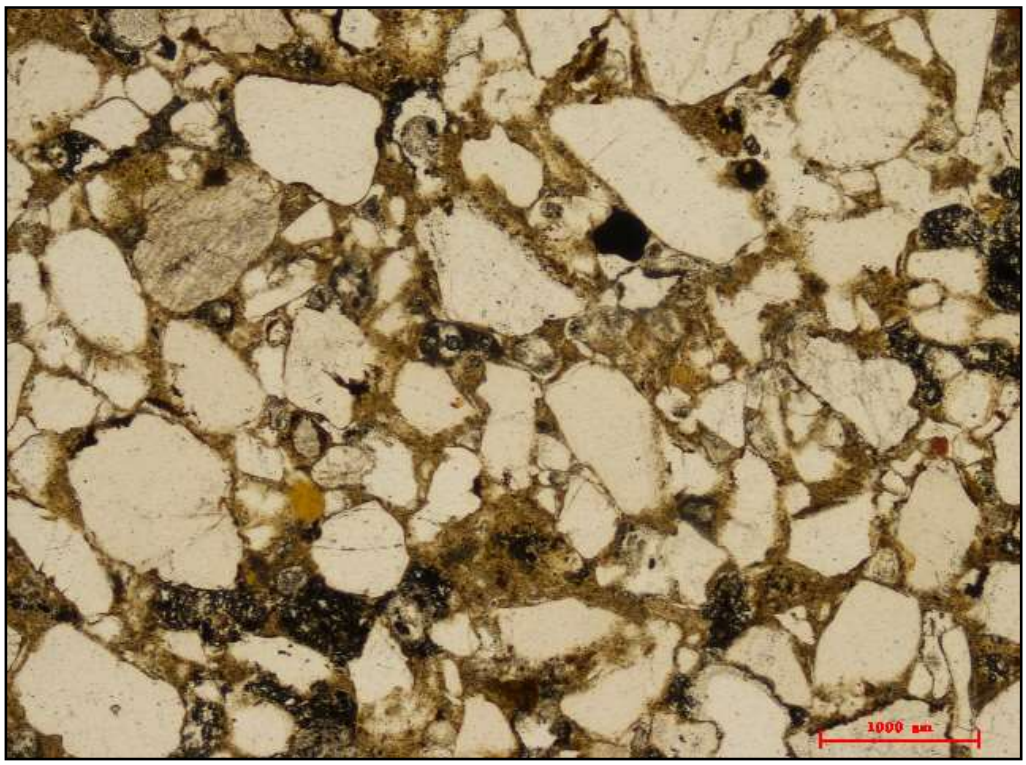

Figure 9. Mortar's examination by polarizing microscope (Analyzer absence)

IV. Discussion

4.1 The Results of Samples Identification are as Shown:

a. Scanning Electron Microscope (SEM):

The mud brick sample is examined by SEM to study the surface's case with magnification powers, mud brick is very weak, there are many pores inside the texture and crystals are deteriorating because of environmental effect. The mortar sample also is examined to study its case, it is very weak, and the internal texture is deteriorated and separated.

b. EDAX unit attached with (SEM):

EDAX refers to Energy Dispersive X-ray Analysis; it's an elementary analysis, the analyzed sample of mud brick consists of (Si, Al, Mg, Na, k) the elements of clay minerals like: Kaolinite and Illite, also (Ca, Fe) which refer to the existence of Calcite and Hematite. Mortar elements are (Al, Si, Ca, Fe) which refers to the existence of clay minerals beside Calcite and Hematite (mud mortar).

c. Polarizing microscope:

Thin sections of mud brick and mortar are examined in the existence of the polarizer and analyzer, in the absence of analyzer also, mud brick crystals refer to Quartz, Albite, Potassium feldspars (Microcline), Kaolinite and Illite, and on the other hand the crystals of mortar refer to Quartz, Calcite, Kaolinite and Illite.

d. Effect of desert environment on the deterioration of El- Bagawat tombs building materials:

It was noticed From the previous results that desert environment effect is physical, it doesn't affect chemically on the components of building materials , air temperature variation cooperates with wind and relative humidity to weaken the building materials at El-Bagawat tombs, the big difference between air temperature degrees daily and seasonally causes cracks

and exfoliation of mud bricks and mortars, mud bricks are low conductivity materials , they absorb heat during the day, it leads to minerals expanding and their shrinkage at the night, the expanding and shrinkage rates differ from mineral to the other, the result is many cracks in the mud bricks and mortar.

The wind carries many materials like sand, dust and pollen grains, when it hits any building, it causes the erosion, especially facades and deposits these materials outside the building, mud brick is a weak building material so the wind causes the severe erosion of it and deposits sand inside and outside the tombs, the same situation applies on mud mortar, figure (10- 15).

Figure 10. Wind's erosion of mud bricks at El-Bagawat tombs

Figure 11. Wind's erosion of tombs façade and weakness of mud bricks

Figure 12. Tombs façade weakness due to wind erosion

Figure 13. Sand deposits outside the tombs due to the wind

Figure 14. Heavy sand deposits inside the tombs due to the wind

Figure 15. Mud bricks weakness and cracking due to air temperature variation

V. Conclusion

Environment has a severe effect on the deterioration of archaeological buildings and sites, there are agricultural, marine and desert effect (1, 2, 3, and 4). El-Bagawat tombs from the early Coptic era suffer from desert environmental effect on the deterioration of their building materials like: mud bricks (essential building material) and mud mortar (secondary building material), not only these materials but also wall paintings layers and pigments inside them, so environmental effect is an important phenomenon deserves to be studied at El-Kharga oasis, desert environment deterioration factors threaten this precious cultural heritage. The researchers recommend cultivating trees around the borders of the tombs to work as bumpers because wind is the main deterioration factor of the desert environment, by this way, tombs facades will be preserved from wind erosion.

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