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A Study of the Causes of Damage to the Walls of the Karnak Temples, Which Are Built of Mud Bricks, Luxor and Suggested Methods of Treatment

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Abstract

Mud bricks were made in Egypt from the Nile silt, which is a mixture of clay and sand, which is sometimes mixed with pieces of organic materials and then mixed with water to make mud bricks, the oldest mud bricks were found in tombs dating back to Naqada and in Abydos, and parts of the central state pyramids were built from it, geological study and hydrogeology of the site were studied, mud bricks were studied by XRD and SEM, the main components and properties were studied, the mud bricks were made according to a local technique in industry and construction, the walls of Karnak temple become weak fragile materials due to their exposure to various damaging factors, the study put a recommended treatment of damaged mud bricks walls which surrounded of Karnak temple.

Keywords

Karnak, Mud Bricks Walls, Hydrogeology, XRD, SEM, XRF, Decay, Durability, Treatment

1. Introduction

1.1. Archaeology Study of Karnak Temple Walls

Luxor city is located south of Cairo, and it was the ancient capital of Egypt (Figure 1). It is located on the sedimentary plains represented by the smaller agricultural plain, which represents the central part of the Nile Valley, in addition to some newly reclaimed plains on the outskirts of the Nile Valley [1]. The Luxor area is the most important cultural center for ancient Egyptian antiquities. The Karnak

Figure 1. Location map of study area, Google 2021.

and Luxor temples represent the most important monuments on the eastern bank of Luxor [2].

Karnak temples are located on the eastern bank of the Nile, about 2700 m away from Luxor Temple, the mud walls that surround the temple on its four sides, with a maximum height of 25 meters, or containing eight doors, including the main gate of Karnak temples, It is clear from the previous study that the presence of different materials and the rate of their deterioration and the situation on them before any Remedial operations. It was also noted that high relative humidity has an important role in the damage to those walls [3].

1.2. Geologic Study

The area has been studied by many authors as Said1981 1990 [4], Wendorf and Schield 2002 [5], Kamel 2004 [6], and was controlled by studies of Cuvillier 1938 [7], Youssef 1949 [8], Ghorab1956 [9], Said 1960 [10], El-Naggar 1963 [11], 1968 [12], Awad and Ghobrial 1965 [13], Butzer and Hansen 1968 [14], Philobbos, 1969 [15], Ghanem *et al.* 1970 [16], Wendorf and Schild 1976 [17]. The sedimentary sequence within the Luxor area is often distinguished (from top to base) into Quaternary, Tertiary, and Upper Cretaceous rock units (**Figure 2**). The Quaternary rock units are divided from top to bottom into the Holocene deposits.

1.3. Hydrogeology

The hydrogeologic setting the study area is well addressed by many authors like works of Dawdy *et al.* 2004, Ismail *et al.* 2005 [18], Tuscan 2005 [19], Aly 2007 [20], Zhiming *et al.* 2007 [21], El Tahlawi *et al.* 2008 [22], Ahmed 2003 [23], Abdin and Gaafar 2009 [24], Jonson and and Bhattacharyya 2010 [25], Tyson 2010 [26], Ahmed and Ali 2011 [27], Abdin *et al.* 2011 [28], Elwaseif *et al.* 2012 [29] and McCarl *et al.* 2013 [30], by the surface water hydrology of the world is principally represented by the River Nile and irrigation canals, the Quaternary aquifer

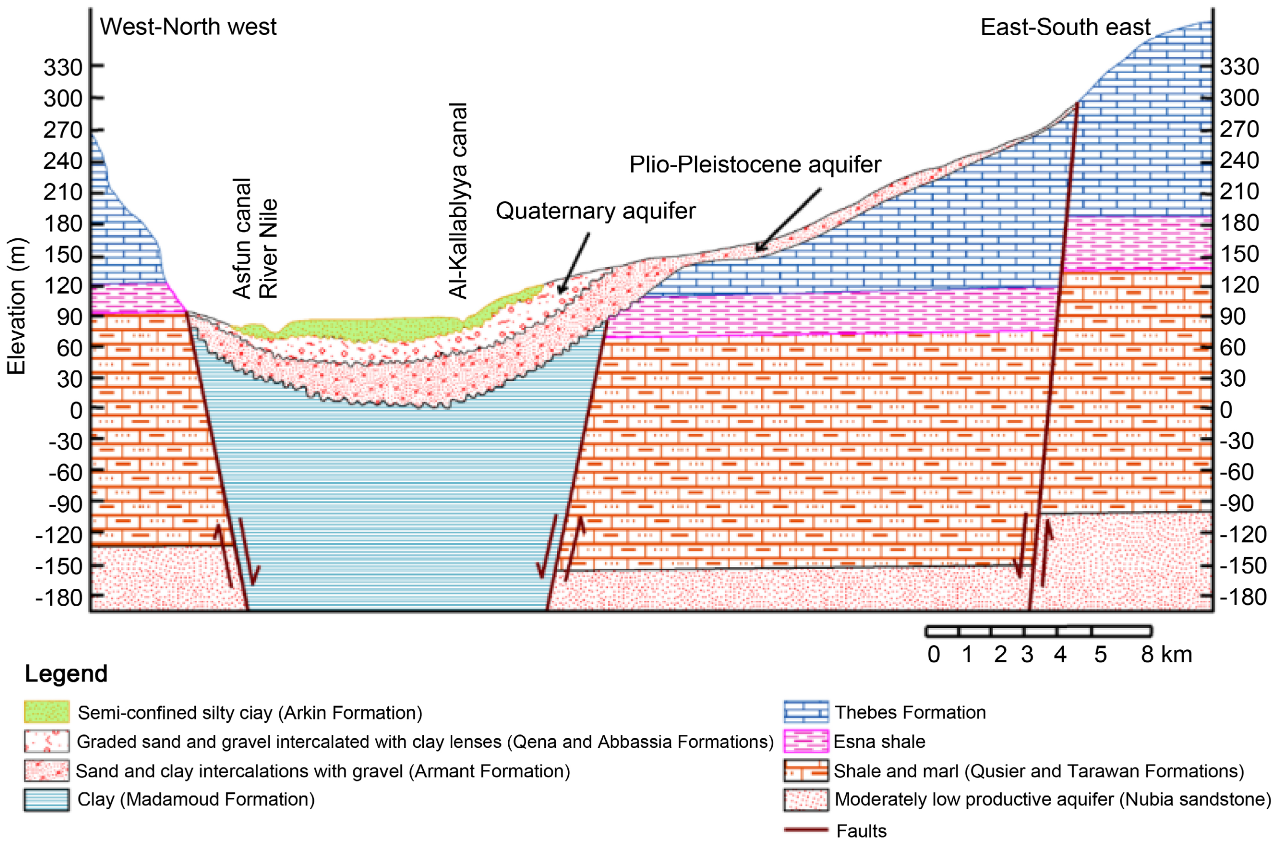


Figure 2. Cross section of Hydrogeologic (RIGW 1997, Kamel 2004, Ahmed & Fogg 2014 [37].

occupies the central strip on the Nile Valley forming the old cultivated lands on each side of the Nile and forms the foremost important water-bearing formation in Luxor area, (Abu-Zeid 1995 [31], Shamrukh *et al.* 2001 [32], Brikowski and Faid 2006 [33], Shamrukh and Abdel-Wahab 2008 [34]). Discharge of this aquifer is thru groundwater pumping for irrigation and drinking purposes (Shahin 1991 [35]). The Plio-Pleistocene aquifer represents the secondary aquifer within the study area (Awad *et al.* 1997 [36]). The aquifer has more thickness near the Quaternary aquifer and reduces towards the Eocene limestone boundary on each side of the Nile valley.

1.4. Evolution of the Use of Mud Bricks

The variety of walls materials to be considered, the bulk modulus k for material in its linear elastic region relates the hydrostatic pressure P to the volumetric strain r as follows.

$$P = Ke = k\left(\varepsilon 1 + \varepsilon 2 + \varepsilon 3\right)$$

where $\varepsilon 1$, $\varepsilon 2$ and $\varepsilon 3$ are the principal strains, young s modulus E and Poisson's ratio v which

$$K = E/3(1-2v) \quad [38]$$

For statically determinate structure, the reactions and internal actions can be determined from equations of equilibrium together with condition equations. For such structures, forced deformations (settlement of supports, shrinkage, temperature changes…) don't produce reactions or internal actions, in order to analyze the structure, for such structures, forced deformations generally produce reactions and internal actions [39]. The process of different constructive elements landfall was accounted a year ago [40] [41] (**Figure 3(a)**).

Loads include dead loads and living loads, which dead loads are layers of ground [42], living loads are very small because there is no dangerous living loading presented at the area of the study and dynamic loads, which are the most dangerous loads by effects on the mud walls [43]. It should be mentioned at this point that the settlement of structures even resting as follows [44].

$$\Delta \eta \text{sub} = \eta \text{submax} - \eta \text{submin}$$

where ηsubmax and ηsubmin, respectively, maximum and minimum settlement of the particular structure.

Mud brick has been used as a building material for thousands of years and has been used widely across the globe. It has been used since the pre-dynastic era, and the origins of mud bricks in Egypt were on the banks of the Nile Valley, where the ancient Egyptians used the thick layer formed over thousands of years in the manufacture of mud bricks. The development of ancient Egyptian thought in the use of clay and seemed to form clay molds and began to build from mud bricks different buildings, the use of mud bricks in ancient Egypt is due to the availability of the raw material necessary for the manufacture of mud bricks, whether they used clay materials or bonding materials represented in sand, hay and animal dung that make the mold of poorly connected materials more solid, there are two types of mud bricks used in ancient times in Egypt, the first type

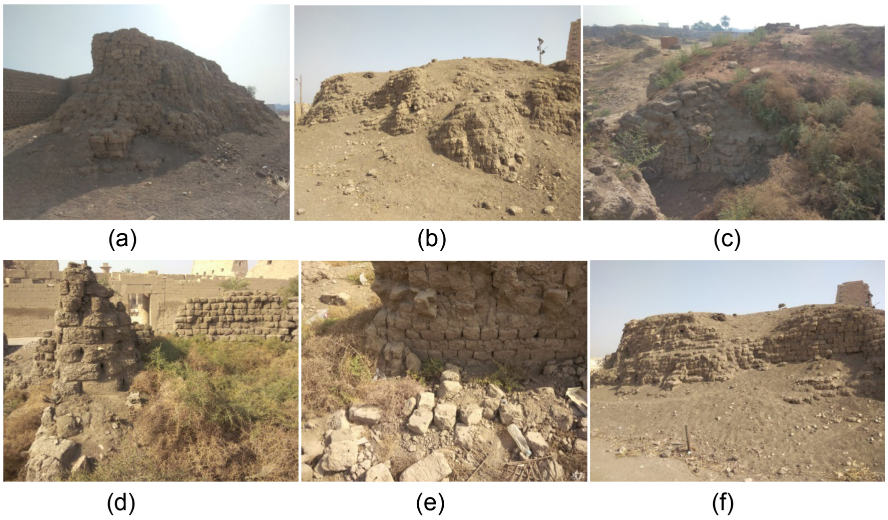


Figure 3. Parts of the mud-brick walls that surround the Karnak temples, where the mud-bricks appear in different locations, showing the different methods and stages of construction of the old mud-bricks, in addition to the presence of many different manifestations of damage.

which is a large-sized mud brick used in the construction of temple walls and palaces and the other type is a small-sized mud brick used in the construction of houses and tombs, mud bricks are made of a natural material that mainly consists of clay, water, and bonding materials in different proportions. Bricks are made of Nile silt, which is a mixture of clay and sand, the ratio of clay to sand are different depending on where the silt is and one of the most important physical properties of mud bricks is the property of morphology and mechanical property or strength, Tensile, compression, color property, porosity and permeability.

Recent excavations have provided a clear view of the types and uses of mud bricks and the engineering techniques for their use [45]. The simple clay brick is also considered a potential source of cultural information in terms of chronology, technology, identity, resources [46]. These buildings are built of mud bricks to suit the climatic conditions in Egypt and due to their low thermal conductivity [47]. Therefore, conservation the brick buildings is a big challenge in front of different conservation methods [48]. Preserving cultural heritage is in order to protect it from loss [49]. Preserving cultural heritage is an urgent necessity to preserve the identity of indigenous peoples [50]. In the past, it used old bricks to make new bricks.

The vast majority of mud brick buildings have lost their weak ability to resist damaging factors in addition to the lack of interest in them. Three-dimensional applications in archaeological studies are considered important processes for registering and preserving heritage and for creating a database for monitoring future erosion [51]. The ancient Egyptians left buildings surrounded by mud-brick wall to suit the climatic conditions in Egypt and due to their low thermal conductivity [52], recent excavations have provided a clear view of the types and uses of mud bricks and the engineering techniques for their use Based on the recognition that these places remain essential to the continuity of the identity of the indigenous peoples [53]. Mud brick is an essential building material in the Mesopotamian period.

1.5. Mud Bricks Decay

Heterogeneous physical composition is one of the internal damage factors that play an important role in mud brick damage. The rates of hardness and cohesion differ between the components of the mud bricks, according to the different components they contain, as well as the different manufacturing methods across different eras in addition to the quality of the additives during the manufacturing process. The bricks components absorb water or moisture, and it spreads through porous caused swelling. In the event of a drought, it loses its water content and shrinks caused cracks in the mud bricks, swelling and shrinkage leads to a breakdown and fragmentation of the mud brick structure (**Figure 3(b)**), also, rain, ground water and wastewater have a devastating effect and the resulting swelling, shrinkage and crystallization of salts inside mud bricks or on the surface. Also, animals, birds, and insects, especially termites and wild bees [54], have a general role in destroying mud bricks. Microorganisms have significant physical and chemical effects on mud bricks [55] (**Figure 3(c)** & **Figure 3(d)**).

Many cracks results in a failure of the ability of soil to bear the wall on it, mud brick damage has been studied through thermal effects, structural cracks, oblique walls and granular disintegration [56]. It is not only required to preserve the building, but also to give a signal to understand and study the original of mud bricks [57] (**Figure 3(e)** & **Figure 3(f)**).

2. Materials and Methods

Samples of non-destructive mud bricks were taken from the surrounding wall of the Karnak Temple to study its damage In order to determine the most appropriate methods of proposed treatment, polarizing microscope. JEOL JSM5500LV, central lab, South Valley University, Egypt, was used. Mineralogical composition for the bulk sample powders were determined by X-ray diffraction (XRD) employing a philips X-ray diffraction equipment model model PW/1710 with monochromator, Cu k-á radiation (1.542 = λÅ) at 40 kV, 35 mA at X-ray diffraction lab, physical Department, Faculty of Science, Assiut University, Assiut, Egypt. The SEM images of crusts and salt samples and microprobe analyses were performed by (SEM JEOL JSM5500LV) to spot textural and mineralogical changes and altered of the bricks surfaces, the analysis of X-ray fluorescence (XRF), central lab, South Valley University, Egypt to evaluate and diagnose the state of the mud bricks materials.

3. Results

A study of mud bricks were done through studying, examining and analyzing the building materials that were used, by analyzing the X-ray diffraction and studying with the polarized microscope and the scanning electron microscope and X-ray fluorescence.

By using Petro graphic study that it is clear from the visual observation that the ancient brick samples in the Karnak temple wall are of dark gray color, volumetric density (1650 kg/m^3), porosity (3.22%), swelling degree (1.5%), and percentage of organic matter (13.4%), compressive strength (81.35 kg/cm^2) (**Table 1** & **Table 2**). It was also found that the mineral composition of sand (250 - 125 microns) for the mud brick samples in the study area, where it represents quartz (65%) and the percentage of orthoclase (6%), while the percentage of plagioclase (5%), Hypersthene (5%) and epidot (4%) and the percentage of Hornblende is (3%), biotite (6%), muscovite (3%) and opaque material (3%) (**Table 3** & **Figure 4**).

The results showed that the physical, chemical and mechanical properties of mud bricks differ greatly from one location to another, and that the samples have become weak fragile materials due to their exposure to various damaging

Table 1. Physical properties.

Colour	Dark gray
Bulk density	1650 kg/m^3
Swelling	1.5%
Porosity	3.22%
Organic matter	13.4%
Compressive strength	81.35 kg/cm^2

Table 2. Analysis of grain size.

Sample No.	Total Weight	Intervals	Wt. %.
sample 1	25 gm	>2.0 mm	1.9
		>1.0 mm	1.8
		>0.5 mm	2.6
		>0.25 mm	10.9
		>0.125 mm	21.6
		>0.063 mm	3.9
		<0.063 mm	57.3

Table 3. Mineral composition of sand fraction.

Mineral composition	250 - 125 micron
Opaques	3%
Quartz	65%
Orthoclase	6%
Plagioclase	5%
Hypersthene	5%
Epidote	4%
Hornblende	3%
Biotite	6%
Muscovite	3%

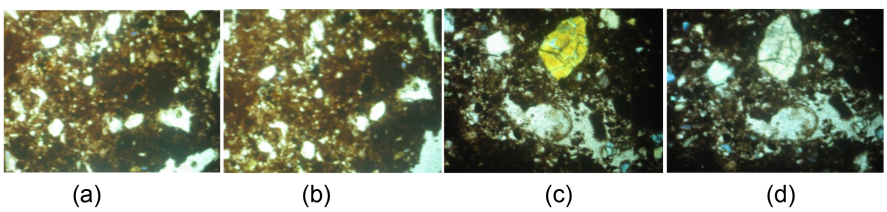
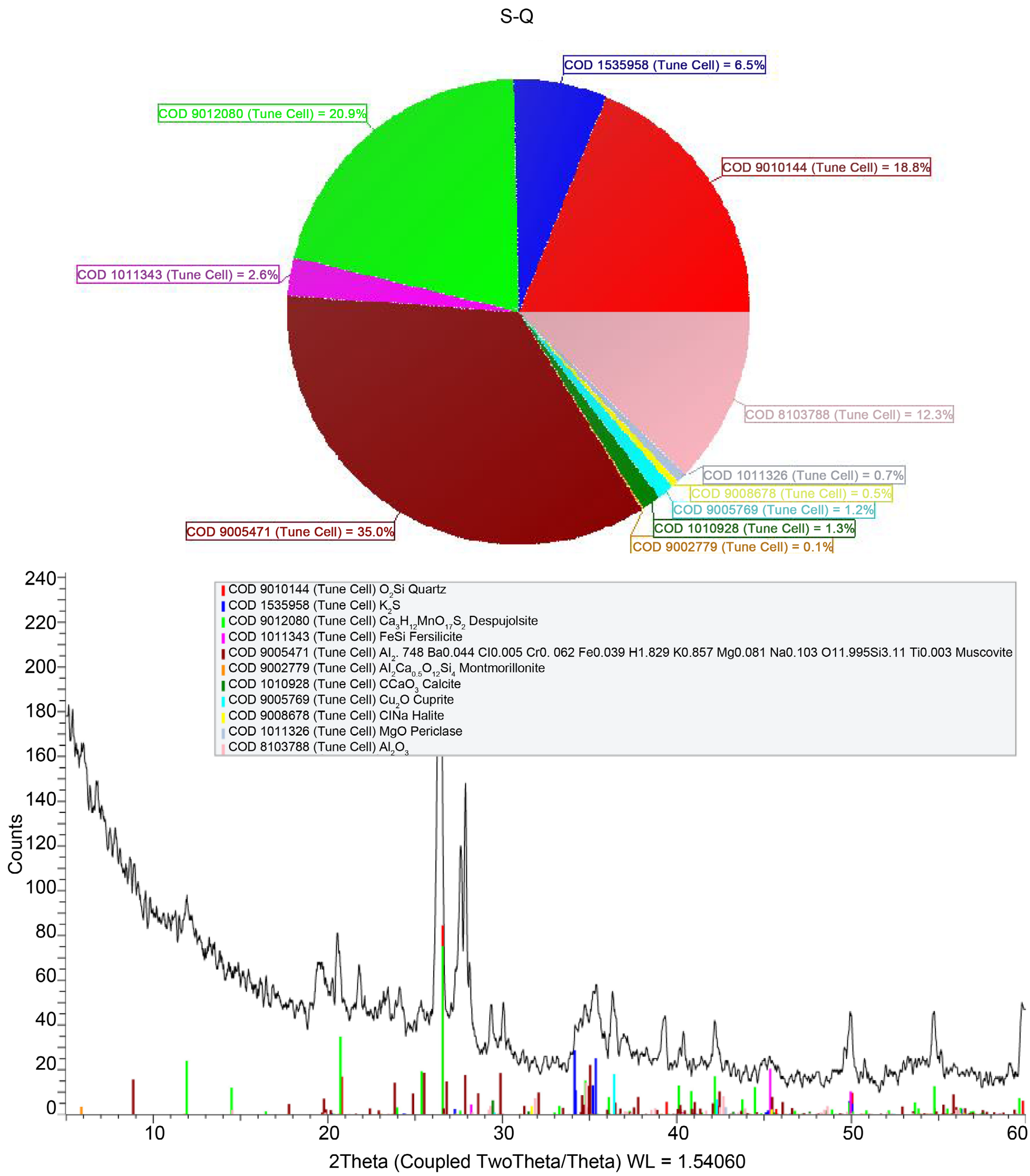


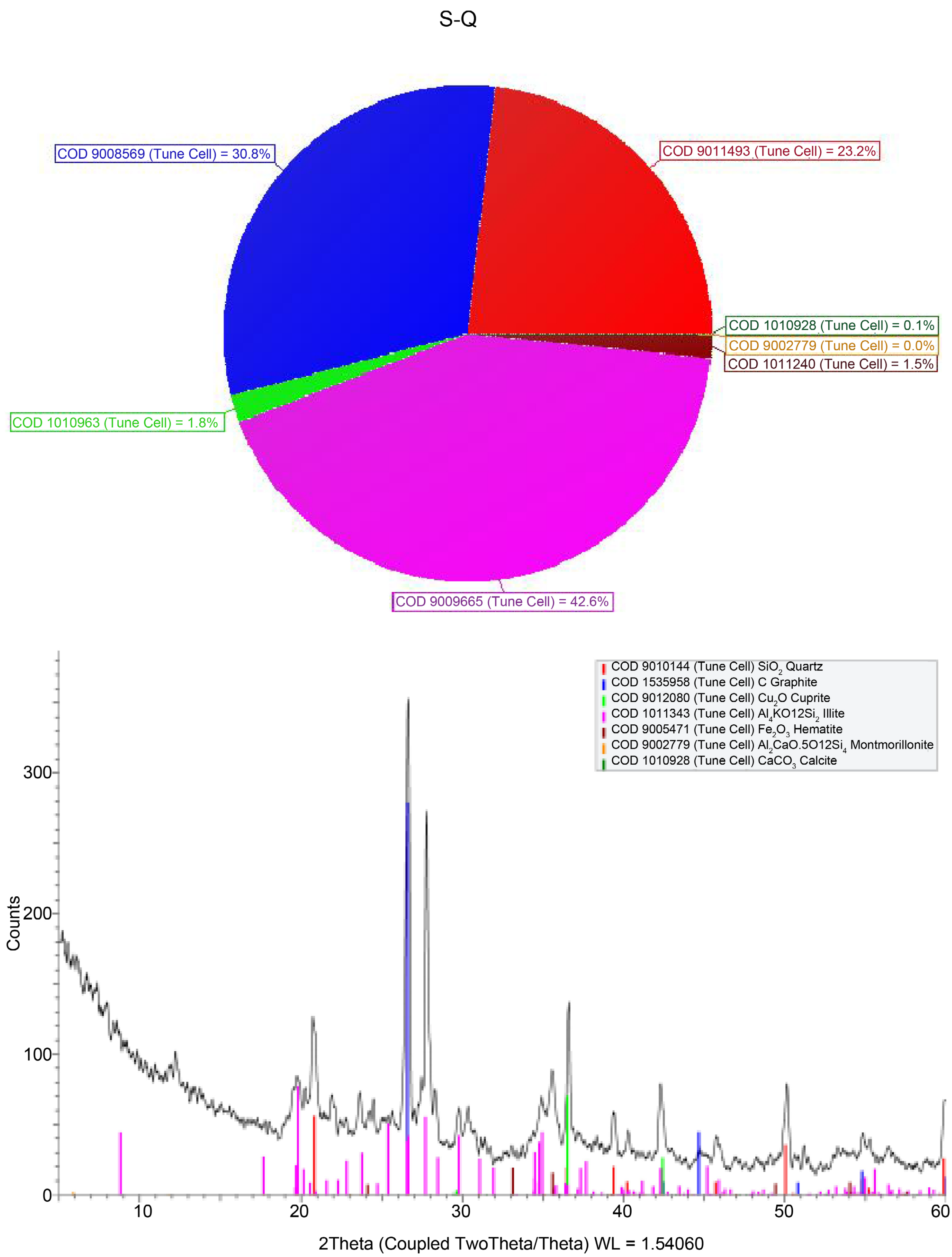
Figure 4. Sand fraction (250 - 125 μm) showing quartz grains sphen, epidate as secondary minerals, under cross Nicole.

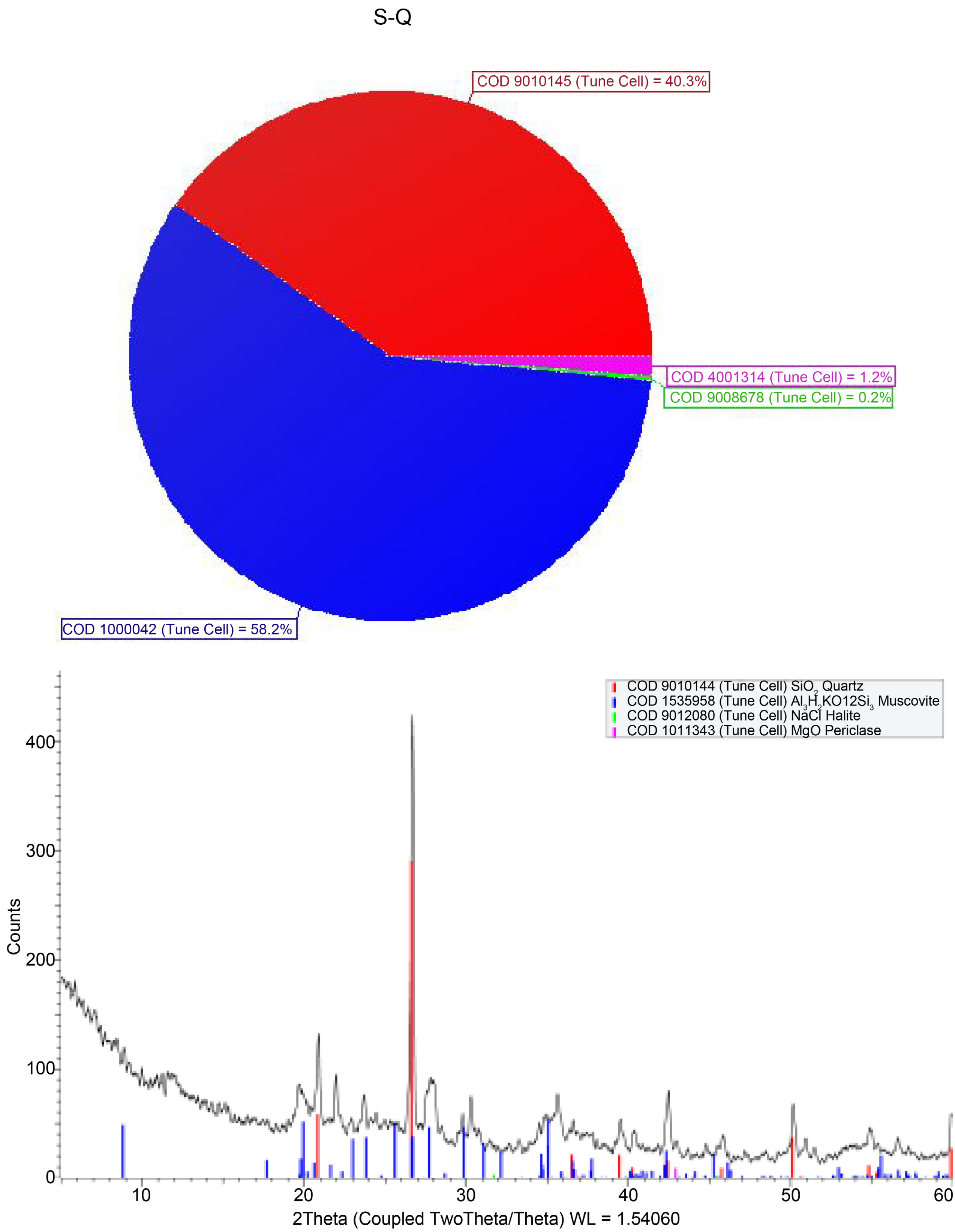
factors.

The results of the XRD analyzes of samples of fallen mud bricks showed the appearance of many compounds such as: SiO_2, Quartz, K_2S, $Ca_3H12MnO17Si_2$ Despujolsite, FeSi fersilicite, $Al_3H_2KO12Si_3$ Muscovite, $Al_2CaO.5O12Si_4$ Montmorillonite, $CaCO_3$ Calcite, Cu_2O Cuprite, NaCl Halite, MgO Periclase and Al_2O_3 (**Figure 5(a)**). As shown by another sample: SiO_2, Qurtz, C Graphite, Cu_2O Cuprite, $Al_4KO12Si_2$ Illite, Fe_2O_3 Hematite, $Al_2CaO.5O12Si_4$ Montmorillonite and $CaCO_3$ Calcite (**Figure 5(b)**). While another sample showed: SiO_2, Qurtz, $Al_3H_2KO12Si_3$ Muscovite, NaCl Halite, MgO Periclase (**Figure 5(c)**).



(a)


S-Q
COD 9008569 (Tune Cell) = 30.8%
COD 9011493 (Tune Cell) = 23.2%
COD 1010928 (Tune Cell) = 0.1%
COD 9002779 (Tune Cell) = 0.0%
COD 1011240 (Tune Cell) = 1.5%
COD 1010963 (Tune Cell) = 1.8%
COD 9009665 (Tune Cell) = 42.6%
COD 9010144 (Tune Cell) SiO_2 Quartz
COD 1535958 (Tune Cell) C Graphite
COD 9012080 (Tune Cell) Cu_2O Cuprite
COD 1011343 (Tune Cell) $Al_4KO12Si_2$ Illite
COD 9005471 (Tune Cell) Fe_2O_3 Hematite
COD 9002779 (Tune Cell) $Al_2CaO.5O12Si_4$ Montmorillonite
COD 1010928 (Tune Cell) $CaCO_3$ Calcite
Counts
0
100
200
300
10
20
30
40
50
60
2Theta (Coupled TwoTheta/Theta) WL = 1.54060
(b)



(c)

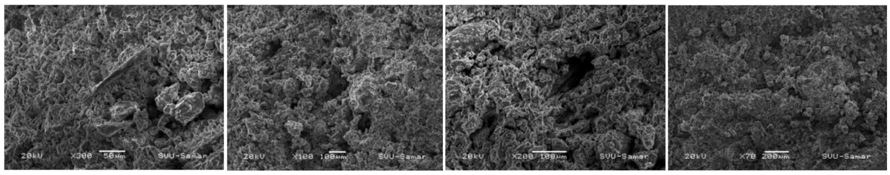
Figure 5. (a), (b) & (c) XRD analysis of mud bricks samples.

SEM scanning was presented to identify quartz (SiO_2) (**Figures 5(a)-(c)**) and other salts by XRD and XRF as halite (NaCl) and gypsum ($CaSO_4 \cdot 2H_2O$). The extent of deterioration of quartz grains was also demonstrated (**Figures 5(a)-(d)**), as well as the extent of dissolution and weakness of the cement materials, in addition to the appearance of fractures in the granules of plagioclase and calcite (**Figure 5(c)**). Other samples also showed a differential in some quartz grains as it turns out a breakdown of the internal structure of the mud bricks (**Figure 6**).

The sample analyzed by XRF illustrated that the main components Wt% were SiO_2 (40.71%), Al_2O_3 (11.89%), Fe_2O_3 (11.28%), CaO [6.33%], SO_3 (1.87%), Na_2O (1.35%) and K_2O (2.83%) (**Table 4**).

Table 4. wt% of main components of the samples by using analyses of XRF.

Main Components	Wt% a	Wt% b	Wt% c
SiO_2	40.71	41.66	42.53
TiO_2	3.79	3.52	3.27
Al_2O_3	11.89	11.22	11.41
Fe_2O_3tot.	11.28	10.74	9.96
MgO	1.69	1.83	1.72
CaO	6.33	7.82	6.58
Na_2O	1.35	1.25	1.33
K_2O	2.83	2.62	2.53
P_2O_5	1.60	1.54	1.57
SO_3	1.87	1.73	1.69
CI	1.12	1.1	1.14
LOI	14.23	13.69	15.12
Cr_2O_3	0.064	0.057	0.038
CO_3O_3	0.017	0.015	0.013
MnO	0.457	0.389	0.328
NiO	0.0143	0.0136	0.0146
V_2O_5	0.125	0.113	0.132
ZnO	0.045	0.041	0.043
Rb_2O	0.047	0.039	0.044
Ga_2O_6	0.001	0.003	0.005
Y_2O_3	0.004	0.003	0.007
ZrO_2	0.279	0.261	0.246
SrO	0.211	0.312	0.235
Nb_2O_5	0.003	0.004	0.007
CeO_2	0.036	0.029	0.038



(a) (b) (c) (d)

Figure 6. Sample of mud brick under SEM.

4. Treatment Plan Recommendation

Mud Brick Preservation of Earthen Ruins need more studied [58]. Modern scientific studies have revealed the necessity of restoring and maintaining clay buildings because they constitute an important link in the civilization and architectural development, and given the severe damage to the ruins of mud bricks as a result of not taking the necessary precautions to protect these ruins from the harmful effects of weather changes.

It includes the Modify of the sanitation system in the temple, as the gathering of rain water and ground water under the Temple walls leads to severe damage them, which threatens it to collapse and control of this problem, through the work of a system to drain this water away from the construction site. The drain must be sloping or tilted to prevent water from gathering near Temple walls. The treatment of the foundations of the Temple walls is also done, and this is done through restoration and consolidation of the foundations in the style of pillows bolsters which means building one or two rows of building material that are identical to the original, where a wall of mud bricks and clay mortar is fused with the original foundation and is not separated from it and increases in depth and width And construction is done so that the wall width is 40 cm - 20 cm inside the foundation and 20 cm outside it, and this method is done in the case of non-dangerous foundations that have been damaged and eroded and have gaps where one part after another of the foundation is replaced and the method of pitting and the introduction of new bricks with the same specifications are replaced. Treatment is also carried out by way of injection and pumping construction materials in a liquid state inside the voids of the Temple walls, and these materials often have the properties of strengthening the crumbling mud bricks. The foundations are also strengthened to maintain the balance of the Temple walls, especially the parts where there is a loss of the lower piles, as well as the surface coverage of the Temple walls through the use of wooden or metal umbrellas to protect the walls from the impact of rain, noting that this method is difficult to apply on the site because it is preferred with application with small sites. The covering method is used using mortar layers, especially when the surface of the wall is not sufficiently uniform as in the wall of Karnak temples. In addition, surface coverage can be made using modern mud bricks, where they are used when the surface of the wall is suitably organized so that it has the ability to resist the damaging effect of water Rain also reduces mechanical and human damage. The Temple walls are also treated for the effects of biological damage and termites are treated according to Abd-Elkareem, E. Fouad, H., 2016.

Ground water is disposed of in Karnak temples, especially under the surrounding mud brick walls, by installing several pipes at specific depths and at points that are determined geometrically after making engineering measurements according to the ground water levels at each point. Then a group of wells are drilled connected to them to collect water. The excess ground, which is withdrawn from each point, and then these wells are connected to the main station located inside the Karnak temples, as they are equipped with suction machines and pumps for suctioning water from the wells, where it is purified using special filters before being discharged to the Nile River, taking into account that the process of lowering the level is carried out in a gradual manner and with accurate calculations So that the soil does not subside as a result of the withdrawal of clay with the water, which leads to the collapse of some parts of the mud walls. In order to achieve the best ways to reduce the risks of ground water on the study area, it is necessary to ensure the effectiveness of the water and sewage networks in the area, in addition to establishing small drains around the walls to withdraw water gradually by aerating the soil with a layer of gravel with a depth of one meter. Also, the sources of ground water supply in the area must be completely cut off. With the use of horizontal and vertical drainage to draw water.

The dirt that distorts the surface and insoluble salts and biological and microbiological damage products are removed in order to preserve the aesthetic and historical value of the effect and to preserve it for the longest possible period. Mechanical cleaning is used, where loose dirt and insect droppings are removed by means of various types of brushes, brushes, and scalpels, which scrape these strange bodies from the surface of the mud bricks. Chemical cleaning can also be used through the use of organic solutions to moisten the lime scale suspended on the surface, taking great care when using it due to the sensitivity of mud bricks to chemical solutions, the structural cracks on the surface are treated by removing the dust and salts in these cracks and then moistening them by spraying with light water and then filling those cracks with suitable mortar With the components of mud bricks, the fallen brick blocks are removed from the bottom of the mud walls and re-manufactured again to produce new bricks, and the consolidate process is done using modern bricks for weak and fallen parts. Sensors are also made at the bottom of the building to see the ability of the foundations to withstand the pressures and loads falling on it. The process of rebuilding the fallen parts of the walls or the architectural elements in the walls is done with blocks of modern bricks that have the same characteristics and specifications of the old bricks, and the walls that are falling apart are dismantled by modern scientific methods and the blocks are separated. Mud bricks are separated from each other and consolidated by using modern chemicals. The walls can also be covered and reinforced with a mortar consisting of (8 parts clay, 1 part sand, 1 part cement, water) and the remaining layers of construction are preserved and consolidated by using some consolidants such as polyvinyl acetate or Using ethyl silicate with the work of a rainwater drainage system away from the foundations of the mud walls, and the foundations are reinforced, whether completely or partially lost as a result of exposure to rainwater or ground water bees, where new molds are made of mud bricks that have the same characteristics as the old bricks, but some are added to them Materials to improve the physicochemical properties, such as breaking the molds falling into the water in appropriate proportions according to the nature and characteristics of the molds. Lime is added by 15%, and it is also possible to add Primal, and many methods can be used to reinforce the foundations of mud walls through the support of pillows (pillars) or the gradual replacement of the foundations or the treatment of foundations and walls by injection. Cracks and gaps in the foundations are also treated by removing dust, salts and remnants of other damage files, then the surface is moistened The interior of those gaps and cracks using a light mist of pure, salt-free water. Then these cracks are filled with clay mortar consisting of silt, sand and lime in small proportions, and the mixture is added to the paralloid or silica as a strengthening material at a rate of 5%. In several ways, the most important of which is the restoration of jaw, reconstruction and treatment of cracks by the method of bonding (buttoning). Chemical treatment is also used for mud walls, which have lost their mechanical force of mud brick blocks, and many chemical solutions are used to consolidate the mud bricks. Several conditions must be found in these materials, the most important of which are. These hardeners are characterized by a low viscosity degree in order to easily penetrate into the bricks, and hardeners are used that dissolve in organic solvents. It does not dissolve in water, as the water works to swell the clay minerals, chemicals are used that dissolve slowly, and the material used must improve the mechanical strength of the bricks and increase their resistance to damage factors. Chemicals must also be carried into the bricks in homogeneous quantities so as not to cause future pressures on the bricks, causing damage with their ability to resist various damage factors with no color change for the bricks while not causing damage to the user. The study recommends cultural awareness of how to deal with these walls built of mud bricks with giving these facilities value and the necessary documentary study and work to preserve them from extinction. Also, work must be done to stop the urban sprawl next to these walls in order to ensure their survival. Mud buildings have been used widely, it is necessary to study the local methods of making mud bricks [59]. Also, 3D recording of clay buildings must be made by combining 3D laser scanning with GPS [60].

5. Discussion

The study of mud bricks samples clarified that they contain a high percentage of montumorlinite mineral which can absorb more humidity than in the kaolin mineral found at bricks. Likewise, microorganisms can affect mechanically in a destructive manner, which shows the weak coherence of the mud brick granules in addition to the chemical effect as this results in oxalic acid, which plays a destructive role for the mud brick granules through an interaction with calcium carbonate producing calcium oxalate.

Mud bricks were made in Egypt from the Nile silt, which is a mixture of clay and sand, which formed and pressed into rectangular molds open from the top and bottom and then left to dry in the sun. The oldest brick bricks were found in tombs dating back to the pre-dynastic period in Naqada and in royal tombs in Abydos, and parts of the central state pyramids were built from it.

Clay buildings are considered the most exposed to damage, even if they are not highly exposed to damage, as it will collapse over time due to differential damage or stability as a formless blocks. Therefore, conservation of the brick buildings is a big challenge in front of different maintenance methods.

Conservation is a human action that is part of the process by which cultural heritage is transferred to the future. The simple clay brick is also considered a potential source of cultural information in terms of chronology, technology, identity, resources and environmental conditions. It is not only required to preserve the building, but also to give a signal to understand and study the original appearance. And in some buildings old brick walls are combined with others newer ones, and this is what we see in Shunet El-Zabeb in Abydos [61].

Also, the ancient brick mud industry in Egypt has local schools that differ from one location to another. In the past, it used old brick bricks to make new bricks [62]. Clay architecture is most prevalent in ancient Egypt, especially in building houses and was used alongside stones in the construction of tombs and temples. The vast majority of mud brick buildings have lost their weak ability to resist damaging factors in addition to the lack of interest in them [63]. Three-dimensional applications in archaeological studies are considered important processes for registering and preserving heritage and for creating a database for monitoring future erosion.

Nile Clay is the main source of clay bricks that are mixed with water to become a kneadable. These clay blocks are then left in the sun to dry, at hand, the oldest mud bricks were found in pre-dynastic tombs at Naqada and Abydos, and mud bricks also continued to be used to build houses and palaces.

Where the results obtained by this research showed, the chemical and mechanical properties, where the clay bricks differ greatly from one site to another, and a scientific survey was conducted on different samples of clay bricks in the walls of Karnak temples, collected from the most degraded and showed that the physical structure of these samples as decayed by moisture, rain water, ground water and biological factors (ants are considered one of the most biological factors that affect the mud bricks, these minerals affected by moisture will increase the water content in the mud bricks).

The study of mud brick buildings has become appreciated in recent times, especially for those who want to preserve mud bricks, samples of mud bricks were studied by PLZM and analyzed by XRD and studied and analyzed by SEM equipped With the EDS unit.

A study of the mud brick samples using a polarizing microscope revealed the presence of quartz, calcite, and hydrated iron oxide minerals by analyzing the mud brick samples taken from the mud walls of the surrounding Karnak temple by X-ray diffraction. analyzed using XRF, there are oxides of silicon, aluminum, calcium, iron, elements sulfur, chlorine and sodium, biogeochemical conditions play a big role in the damage of clay bricks due to the presence of organic materials such as one of the components of clay bricks such as animal dung and crushed straw. Clay bricks are attacked by termites and by microorganisms that attack aggressively, because they feed on the organic matter present in the clay brick formation, resulting in some pitting and leaving deep grooves, which causes the clay bricks to turn into powder.

6. Conclusions

The construction of mud bricks spread in the past because of the availability of its raw materials, ease of obtaining, and environmental friendliness due to the decrease in the thermal conductivity of mud bricks. The results showed by studying the chemical composition of mud bricks and through studying various tests on the loss of mud bricks for the consistency of its components. As the structural cracks represent one of the serious damage that affects the mud buildings. It depends on the extent of the ability of the mud bricks to damage and the extent of their susceptibility to damage factors to the type of raw materials used and the construction methods used in addition to the site in which it is located. Climate and weather conditions have an important role in assessing the impact of the mud bricks by the factors damaged [64]. The goal is not only maintenance, but the study aims to identify the original appearance of what the buildings were [65].

Termites have caused the decay of the mud bricks inside its components and at the lower places of the building through digging tunnels under the founding layers of the building until erosion has occurred in the soil and inclinations have occurred in some areas due to the failure of the soil exposed to damage in its ability to resist loads of mud bricks falling on it and as a result of the weak interconnection between components Structural construction [66].

As the mud brick was made according to a local technique in industry and construction [67], also, the mud bricks are believed to be some of them were manufactured by using old bricks, losing their ingredients or the purpose for which they were created, in order to save time and speed in implementation, meaning that the old bricks were reused within the components of newer bricks, the analysis of mud bricks is one of the most important mechanisms for identifying the properties of mud bricks.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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