The Negative Role of some Internal and External Factors (Pores, Heat, Pressure, and Internal Grains) in the Deterioration of Sandstone Building: An Applied Study on the Lower Walls of the Luxor Temple

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Abstract: Stone buildings suffer many problems that affect their durability and strength. Sandstone is one of the most archaeological stones that are affected by various deterioration factors. Sandstone deterioration and the physical properties that play an important role in this deterioration, such as porosity, humidity, and drought were examined. Moreover, sandstone properties were studied using X-ray diffraction, x-ray fluorescence, and scanning electron microscopy. The thermodynamics, strength, and elastic properties of rocks were investigated. The electrodynamics of sandstone was also studied to identify the extent of damage to the sandstone structure. The study also concluded that water has a mechanical effect Dangerous for sandstone.

Keywords: Sandstone, Luxor Temple, Pores, accelerating, grains, Heat, Pressure, collapse, treatment

الدور السلبي لبعض العوامل الداخلية والخارجية (المسام والحرارة والضغط الحبيبات الداخلية) في تدهور الحجر الرملي الاثري: دراسة تطبيقية على الجدران السفلية لمعبد الأقصر.

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الملخص
تتأثر المباني الحجرية بالعديد من المشاكل التي تؤثر على متانتها وقوتهاويعتبر الحجر الرملي من أكثر الأحجار الأثرية تأثراً بعوامل التلف المختلفة ، حيث تمت دراسة تلف الحجر الرملي والخصائص الفيزيائية التي تلعب دوراً هاماً في تلف الحجر الرملي مثل المسامية ودور الرطوبة والجفاف في تلف الحجر الرملي، كما تمت دراسة خصائص الحجر الرملي من خلال حيود الأشعة السينية وفلورة الأشعة السينية والمسح المجهري الإلكتروني ودراسة الديناميكا الحرارية للصخور وقوة الصخور وخصائص مرونة الصخور كما تمت دراسة الديناميكا الكهربائية للحجر الرملي للتعرف على مدى التلف الذي ينتج عن ذلك ويؤثر علي الحجر الرملي ،كما خلصت الدراسة إلى أن الماء له تأثير ميكانيكي خطير على الحجر الرملي .

1- Introduction

The Luxor Temple is considered one of the ancient Egyptian temples, and it was established on the eastern bank of the Nile River in Luxor. This place is currently known for its ancient goodness. The kings of the Eighteenth and the Nineteenth Dynasties built it. The Temple is considered one of the best Egyptian temples and the most beautiful in view and construction.

The deterioration of monumental buildings of natural stones is a problem that depends on the strength of the stone and its physical and mechanical properties[1]. The erosion of the stones in polluted urban environments has become one of the major problems facing the buildings and stone installations, especially sandstone[2], which raised caution from the risks of air pollution because of the damage and decay of the stone's sedimentology. Therefore, studying effective preservation of stone buildings[3], especially sandstones shall be carried out. Moreover, the effective role of porosity and the extent of its change in increasing the rate of sandstone damage and its correlation with the change in the relative humidity and temperature should be examined[4].

1-1 Sandstone

Sandstone is one of the types of sedimentary rocks. It has been classified according to the proportion of cement materials[5].

Quartz is the main component of sandstone, which gives sandstone strength[6].

1-2 Decay and Durability

Decomposition and durability of sandstone depend on environmental and internal standards of sandstone, such as mineral composition, texture, pore surface formation, etc[7].

Free oxygen is very important in the decomposition of sandstones, especially those containing oxidants, e.g., iron and sulfur. At normal temperature, free oxygen reactions are slow, while oxidative processes accelerate in the presence of water that is likely to dissolve some fine minerals or other substances because oxygen reactions are faster with dissolved substances[8].

1-3 Rock Porosity

Porosity is one of the main characteristics of solid antique building materials, such as sandstone. Total porosity is the empty volume present in solid materials. It is usually expressed as a percentage and measured in different ways[9].

Within moist pores or in the presence of suspended droplets, the degree of saturation is not reached. That is, relative humidity does not reach one hundred percent, as in thermodynamic equilibrium with the surface of the flying water[10]. The relative humidity is calculated in equilibrium with the semicircular portion of the spherical water drop, and an equation can be applied Kelvin to calculate that, as follows (RH/100) = $(2\sigma V_m / r R T) \cos\theta$

Where the curvature of the bending radius of the water drops, the surface tension sigma and the molar volume in m of the adsorbent liquid σ is 18 cm3, and the angle of contact with the solid surface if θ and cosθ is positive with the wet table surface. If they are negative, they are in relation to the water-resistant surfaces and the gas constant R and the absolute temperature T. In the case of pure water, the Kelvin formula states that the RH logarithm is in equilibrium with the semicircular portion. It is inversely proportional to the radius of curvature of the surface of the water and high levels of RH causing condensation and low evaporation of the RH as the tension of the vapor of the solution is less than the tension of pure water. In the case of moisturizing salts, condensation is expected[11].

The porosity of rocks is caused by many different types of open spaces or pores between individual grains that make up rock texture. Sorting grains by size and shape also affects the porosity of the rocks in terms of water or other fluids moving through the soil or rocks[12] and openings or pores that hold water must be, as follows: First, it is connected so that the water can move continuously from one opening to another. Second[13], the pores are large enough that the friction between the water and the walls of the pores is not an obstacle to the movement of the water[14].

Primary or sedimentary porosity is formed by definition during the sedimentation process. They are two types: Primary porosity can be identified as porosity within granules and porosity between granules. Secondary porosity by definition is formed after sediment deposition. It is considered more varied in formation and more complicated in the formation of the primary porosity. The types of secondary porosity include inter crystalline porosity, fenestral porosity, mold porosity, vuggy porosity, and fracture porosity[15].

When the carnivorous matter of carbonates is subjected to physicochemical conditions, significant changes take place. It may dissolve and precipitate in different degrees, dissolve carbonates, and create a secondary porosity during the reconfiguration process[16].

The role of wetness and dryness in sandstone damage

There is general agreement that a wet condition in the surfaces of sandstone pores has damaging effects in terms of the impact on the results of flow tests based on the relative permeability of sandstone[17].

Wetness and drought cycles create an intensification of the dissolving processes of sandstones that are contained in water or contained within the stone itself. Then, there are salt deposits in the pores of the stone. These salts inside the sandstone pores lead to mechanical pressure, water pressure, and thermal expansion[18].

The most widely discussed reason is that mechanical weathering occurs by salts due to the growth of the crystal in its solutions inside the pores, which constitutes a great pressure that leads to rock cracks[19].

Chemical weathering is more focused on the surface of the grains of sandstone[20] due to the increase in size during the process of chemical weathering[21], which results in the granular disintegration of the sandstone[22]. This process may cause the disintegration of sandstone in areas where no mechanical weathering occurs[23] as it occurs as a result of frosts that result in mechanical weathering due to increasing the volume of frozen water between the grains[24]Fig. 1 a,b,c, and d.

Typically, thermal expansion is expressed as a change in the unit volume of the material for each temperature of a percentage of the temperature change[25]. It ranges from a few million to a few thousand per thousand in relation to ground materials. Thus, rocks and soil consisting of several minerals are subject to differential pressures due to heating or cooling and due to differential expansion or minerals contractions[26].

A

B


C


D

Fig. 1 a,b,c, and d shows damage to the wall at the bottom with some tunnels as a result of insects, such as termites, which represent organic damage that leads to loosening of the soil under the walls. It also shows different cracks between deep, fine, horizontal, and vertical parts. Soil erosion and weakness are evident under the wall along with some tunnels under the wall.

2-Materials and methods

2-1 Petrography of the sandstone in Luxor Temple

Geological analysis can perform important functions, such as sandstone analytic functions and mineral laboratory techniques, e.g., high-precision microscopy and diffraction analyzes that can identify sources of stone components[27].

Samples were collected from many places of the falling layers on the walls and were examined to give information about the morphology of the minerals, structural state, crystal shape, and. Furthermore, the benefit in defining and describing the sandstone minerals and physicochemical alteration.

2-2 Mineralogical composition

The mineralogical composition of the sample's powder was analyzed using X-ray diffraction (Philips X-ray diffraction equipment model PW/1710) with monochromatic, Cu k -á radiation (1.542 =λÅ) at 40 kV and 35 mA at X-ray diffraction lab, Physical Department, Faculty of Science, Assuit University, Egypt). They were recorded from 4 to 90°2Θ. Diffraction charts and relative intensities were studied and compared with ICDD files[28].

2-3 Scanning Electron Microscope (SEM-EDX)

Scanning electron microscopy can be considered a non-destructive quantitative technique that allows us to discover most elements on the site with sample levels in the range of 10-19[29]. SEM images of crusts and salt samples that were obtained from SEM of (JEOL JSM5500LV) to identify textural and mineralogical changes of the stone and altered stone surfaces. EDX was also used (model 6587).

2-4 Chemical analysis by X-ray fluorescence (XRF)

Elemental analysis was conducted using wavelength dispersive XRF spectrometry (Axios advanced, sequential wd_XRF Spectrometer, PANalytical 2005) at the Analysis and Consulting Unit, National Research Center in Cairo.

2-5 Measuring the extent of the pore size

A wide range of pore sizes cannot be covered by a single measurement method since the humidity condition and the type of moisture transport mechanism are determined by the actual size of the cavity available at the site and to determine the distribution of the pore portion through the entire size of the contrasting pores. The contact between the pore surface is useful in measuring the dimensions and proportions of porosity[30].

The pressure of the salts is considered very harmful to the building materials, especially sandstone. When the relative humidity increases in the surrounding area[31], water absorption of the salts occurs, which increases the volume of the brine, causing great pressure on the walls of the pores. This causes fine cracks and fragmentation of the internal granule and perhaps the opposite is expected through precision granules fall into the pore duct[32], which works to clog the pores leading to the small size of the secondary pores, on the one hand, and reducing the movement of solutions within the pore communication lines, on the other, which prevents the supply of fluids. Thus, the low salt supply rate will stop depending on the ratio of the supply rate aqueous that dissolves granules containing salts or dissolves salts directly found between granules[33].

Rocks often contain a quantity of water. They are distinguished into three types of groundwater: Chemically-bound water, physically-bound water, and free water. The presence of chemically-bound water in rocks becomes only visible when heated since it is of great importance because it can lead to a marked difference in the properties of rocks at high temperatures. As heating works to destroy the crystal network of minerals by separating them from the water that is chemically associated with them, a weakening of the rocks occurs, and decomposition occurs. In some cases, this leads to more bonding to the granules, such as what happens in the mud[34] in which the granules are coated with water. The degree of the hydration of the solid surface with the liquid depends on the angle of contact between the horizontal surface of the solid surface and the surface of the liquid drop at the point of contact of the liquid drop with the solid surface[35].

Thermodynamics Rocks

The absorption of heat by rocks is often followed by the appearance of the vibrational or kinetic energy[36] of its vibrating particles and atoms. This is recorded as a change in the temperature affecting the rock and the frequency and amplitude of the molecular and atomic vibration increase whenever there is an increase in the absorption temperature Q and the temperature of the rocks [37-38-39].

$dQ = dQ1+dQ2$

Where $dQ1$ = a portion of the heat that converts into internal energy in the heated body.

$dQ2$ = part of the heat that is spent on external work that leads to (thermal expansion and transformation in various forms)

$dQ1 = CdT$

Where C is the molecular heat (or molar heat) at a fixed volume and the molar heat capacity C, which is divided by unit mass of material being heated, which is known as the specific heat of the rocks c[40].

$c = C/m$

Mechanical methods of breaking rocks create pressure in the presence of bodies different from the nature of the rock, such as fluids, drilling tools, or gases. The effectiveness of these techniques depends on the mechanical properties of the rocks and their strength[41].

With the electrical, magnetic, thermal, and other methods that lead to the breaking of rocks from within it, none of the pressures from outside the rock are introduced. That is, those pressures are created by the rock itself and the field that depends both on the measurements of the external field and on the properties of the rocks. More pressure is generated in the hard rocks than in the soft ones[42]. Consequently, the strength of the rocks is not the only basic measure, as the final effect of breaking the rocks depends on all physical properties[43].

Porosity, density, and specific gravity are combined as properties of rock density. These scales share one important thing that they are not related to any of the external factors, i.e. they are not mechanical[44].

Loosened Rock Characteristics

When its rocks are run, its original composition is always destroyed and removed, which confirms that specific gravity and porosity indicators are only acceptable for separate parts.

Strain and stress in rocks

Anybody exposed to external force leads to a backlash, that is, the internal forces develop and then begin to restore their original form, The surface density of the strength developed within each of the elements in the body can be known as stress which expresses a vector quantity dependent on the internal properties of the rock Anybody exposed to external force, this leads to a backlash, that is, the internal forces develop and then begin to restore their original form, The surface density of the strength developed within each of the elements in the body can be known as stress which expresses a vector quantity dependent on the internal properties of the rock[45].

- The elastic properties of the rocks

The nature of the relationship between stresses and elastic strains depends on the strength of the bonding between the molecules, which is evaluated by evaluating the properties of rock elasticity[46].

Rocks strength

When the pressure from the rocks gradually increases, it collapses. The size of the pressure that is broken, determines the extent of its strength, and the critical values of breaking these pressures depend not only on the properties of the rocks but also on the nature of the impact of those pressures[47].

Gas-dynamics and hydrodynamics of rock

The rocks always contain an amount of water, they are distinguished: the water is chemically bound. Water is physically bound, free water[48].

Heat in Rocks

Heat absorption by rocks is always accompanied by an increase in the kinetic energy of vibrating rock particles and atoms that are recorded as changes in temperature resulting in increased frequency and molecular and atomic vibrational amplitude at higher temperatures[49].

Electrical conduction within rocks may occur through the transfer of matter, i.e. through the electronic ionic process and ionic conductivity, and it may occur without the transfer of matter, i.e. through the conductivity and electronic conductivity[50].

obtain information about Rocks using electrodynamics

Rocks and rock masses are studied by electrical methods so that the relationship between the electromagnetic properties, the natural state of their occurrence and the mineral composition of the rocks, their structure, temperature and stress statistics, and their moisture content, etc. can be known[51].

All current scientific methods of electromagnetic examination can be divided into three methods according to the size of the object to be studied to the following, a. Local examinations of rocks on its surface and in the limited depth of it, b. Regional studies and c. Laboratory research[52].

Rocks breakdown

As is well known, Ohm's law works well at a small voltage

R = constant = Delta I divided by Delta V

Ohm's law applies to those rocks located within the limits of the buffer forces of the rocks, noting that with higher voltages, Ohm's law stops working as the current begins to rise quickly, as the resistance of the dielectric materials in delta I divided by delta-V decreases as the voltage in which it becomes a rate The change between I and V is zero with the breakdown voltage[53].

The study of water and its movement within the pores of stones to reach the stone texture is one of the important studies to identify the activity of water damaged by stones[54-55],These processes continue to operate according to the temperature and pressure content, which affect the mechanical behavior of the stones[56-57], This reflects the response of the stones to the changes caused by the presence of water according to its changing geological nature[58], Where dry stones differ from stones exposed to water in their physical properties due to the changes that water makes in the stones[59-60-61], Also, the presence of water in the stones affects the behavior of the compression axes, such as the compression strength and the rate of elasticity, which indicates the engineering applications of the stones[62], After multiple passes, the compressive strength is affected in the presence of different humidity conditions affecting the stones, whether they are igneous rocks[63-64], sedimentary rocks[65-66-67]or metamorphic rocks[68-69].

As the increase in the water content in the stones leads to a decrease in the strength of the stones, as the interaction between water and silicate minerals converts the strong bonds between silicon and oxygen to weaker hydrogen bonds, which reduces the strength of the quartz-rich sandstones[70], Also, the effect of water on stones depends on the extent of its effect on porosity and the regularity of the engineering linkage between the grains and the texture of the stones and the relationship between them. There is also a negative impact on the strength of the stones in light of the presence of water. The strength of the stones in the presence of water[71], Physical and chemical damage to the stones occurs as a result of the presence of water in them, which affects the rate of strain with them[72-73-74-75], many studies showed the method of reducing the strength of stones as a result of the presence of water in them through a decrease in the internal energy of bonding[76-77] and physiochemical deterioration[78-79] and increase the extent of pressure inside the pores[80-81], the tensile strength decreased [82] and Low friction force [83-84]. There are many mechanisms to reduce the impact of water on stones. This depends on the method of water supply and the quality and properties of the stones [85-86-87].

Results and Discussion

Water affects the mechanical behavior of various stones as a result of chemical and physical deterioration because the stones move with water chemically and physically due to included water. The dissolution of quartz conjointly happens in salt rocks or stone with silicon oxide bond as a result of the presence of water because it acts as a corrosive agent by the analysis of quartz minerals and the breakdown of the robust attraction between Si and the atomic number, turning it into a weak chemical bond[88-89-90] at the identical time. The redoubled external pressure ends up in strain and unfolds further. The degradation of quartz strengthens the stones. Furthermore, the chemical reaction of the quartz might create pores, and the swelling of clay minerals conjointly happens, inflicting pressure that makes cracks cut back the strength of the stones[91-92-93-94].

Sandstone is vulnerable to degradation even in weak environmental acidity. This can increase the consistency of the stones, reducing granular cohesion [95-96-97-98]. The pore pressure will increase because the water cannot migrate freely. After all, the pore pressure can cut back the strength of the stones through a scarcity of effective pressure and traditional pressure [99-100]. The pore pressure causes micro-cracks, and the properties of water-saturated stones are dissent from dry stones [101-102].

td =dm2/ H

where

dm = the minimum distance between the middle of the sample to the free surface

H = hydraulic spreading material

Hydraulic unfold is calculable by

H =kBK / η ɣ

k= materials consistence

K= constant, the biggest for porous materials

η = viciousness constant of the liquid

B and ɣ = Skimpton issue and baiot severally

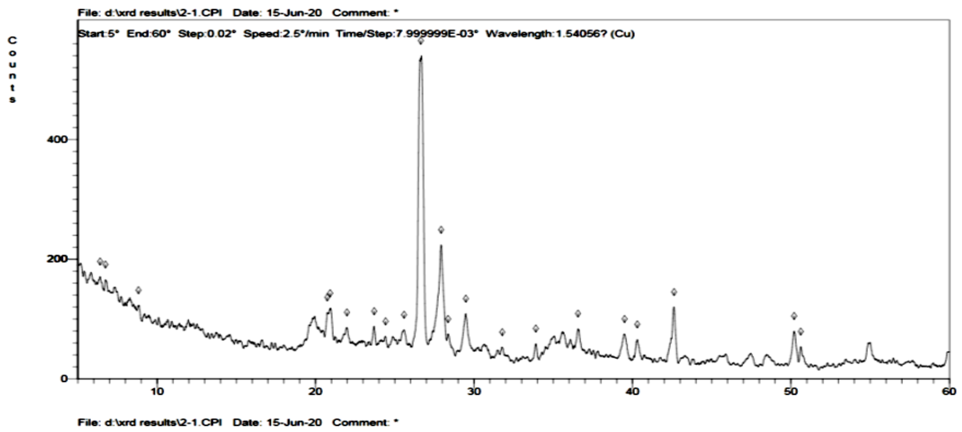
In the case of blending liquids and melting solid gases in liquids, absorption or liberation of warmth may take place, which may typically reach giant values. This temperature is set by experimental laboratory ways through blending in the parts directly within the measuring system to permit the calculation of assorted physics quantities.

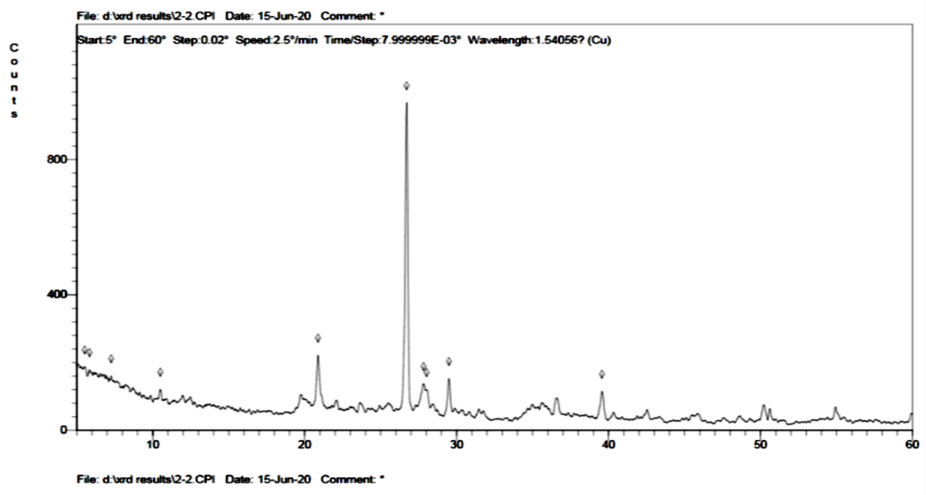
The temperature conjointly depends on the relative quantities of the blending parts that are mixed as if they were taken from the start in their pure state or one amongst the blending parts that were inserted into a solution at a specific initial concentration [103]. Thermal conduction transfer from the hot body to the cold one takes place.

Concentration solutions are the stages whose composition can be observed typically and will be modified unendingly once other to homogeneous mixtures of molecules that are in ionic or atomic states particularly. The mixtures of two or several substances occur in chemical-chemical reactions throughout[104].

1. Mineralogical Study

XRD patterns showed that quartz (SiO2) was the foremost element of the Temple's sedimentary rock, with subordinate amounts spar (CaCO3) and binary compound (NaCl), thenardite (Na2SO4) & mineral & gypsum ($CaSO_4.2H_2O$) (Fig.2 a & b). These results proved that the stone utilized within the temple was the Egyptian sedimentary rock. The harm to sedimentary rock was caused by the mechanical stress that was iatrogenic by the binary compound. Thenardite and mineral crystallization cycles and spar might be cement in the sedimentary rock (Fig. 2 a, b, and c).





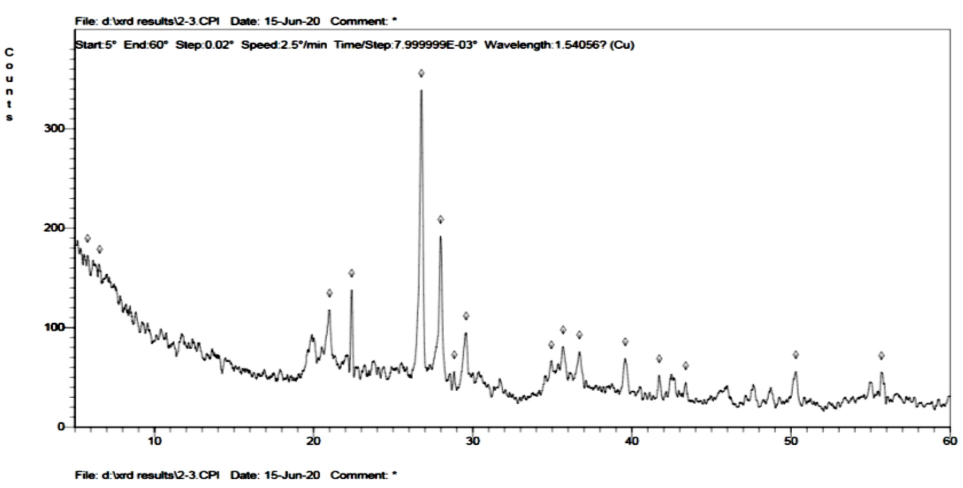
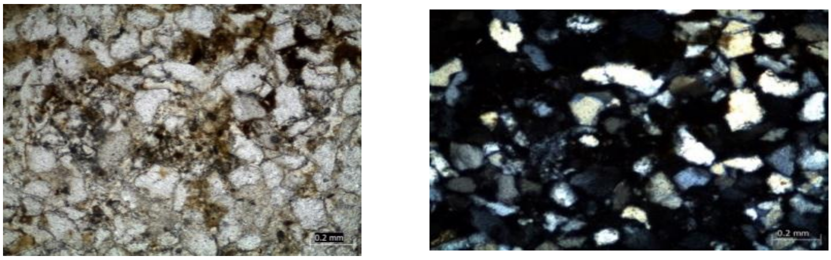


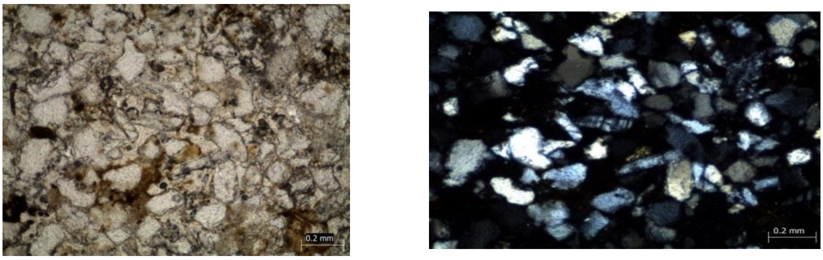
Fig. 2 a, b, and c: A sample of sandstone taken from Luxor Temple analyzed by XRD.

2.Petrographic Study

Samples taken from Luxor Temple were examined under the polarized microscope that showed that the share of quartz gave the best results, rating (94%). It took alternative parts, as follows: Feldspar (5%), rock fragments (0.5%), and cement materials (10%). It was conjointly found that the share of consistency and porosity was high [ ] (Fig.3 a, c). Some clay minerals (Fig.3 a, c) and iron oxides were conjointly found. The crystals of quartz appeared unequal in dimension and volume. They had nice and moderate granulation. Moreover, it was indicated that angular quartz granules were remodeled into semi-angular, showing that they didn’t move mostly throughout the processes of deposition (Fig.3 b, d). In alternative samples, quartz crystals were rounded and semi-rounded. They were affected mostly throughout the processes of deposition. Conjointly, there was the erosion of the sides of some crystals, which extended within half. These results were supported by XRD examination, showing that quartz was the foremost compound with little values after salts (e.g., halite NaCl).



A B

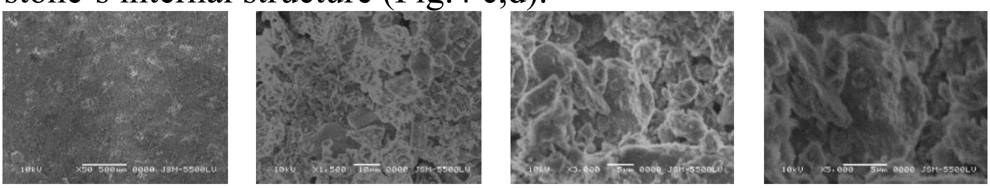


C D

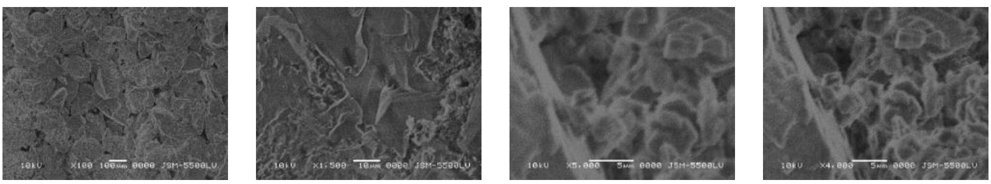
Fig. (3) A sample of sandstone from Luxor Temple X25

Scanning Electron Microscope (SEM)

The samples examined by SEM were called quartz (SiO_2) (Fig.4 a, b, c, & d). Alternative salts were examined by XRD, EDX, and XRF, including common salt (NaCl) and mineral ($CaSO_4.2H_2O$). The samples show the harm of cement materials and breaking within the granules of sedimentary rock (Fig.4 a, b). Alternative samples showed differential of quartz grains and a collapse of the stone's internal structure (Fig.4 c,d).



A B C D



A B C D

Fig. (4): A sample of sandstone examined under SEM, showing the deterioration of cement materials and the granules of sandstone

EDX analytical methods were conducted to identify the samples and assess their parts to indicate that the fundamental arrangement of the samples collected from completely different places could be placed in decreasing order in line with their concentration, as follows: Si(78.92-85.89%), Al (6.09-7.15%), Fe (5.81-2.56%), K (4.65-1.95%), Ti (3.77-2.06%), and Ca (0.76-0.39%)(Fig.5) (Tab.1). This helped understand the weathering mechanisms of the temple. These elements were found in the second sample, Si(77.12-84.32%), Al (6.94-8.09%), Fe (6.44-2.88%), K (4.32-1.84%), Ti (3.93-2.28%), and Ca (2.24-0.59%) (Fig.6) (Tab.2). The first and second samples contained Si (as the most component). However, the absence of Cl and Na indicated the non-crystallization of common salt on the wall reliefs. The analysis conjointly indicated the concentration of Ca indicated the existence of mineral and anhydrite salts on the sedimentary rock. Additionally, the moderate quantity of aluminum (Al) and number 19 (K) could also be attributed to feldspars and phyllosilicates. On the contrary, the presence of comparatively high amounts of iron and tiny amounts of Ti was attributed to the origin of these samples, atmospherical pollution, and minerals, e.g. number 26 – Ti bearing phases that play an enormous role in deterioration.

Fig. (5): EDX spectrum of the sandstones (understudy)

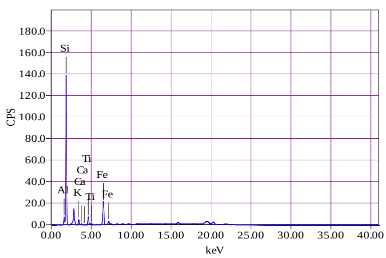
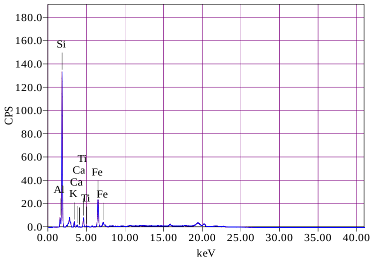


Fig. (6): EDX spectrum of the sandstones (understudy)

Tab. 1: Quantitative EDX (compound %) of sandstones value spot

Element	ms%	Oxide	ms%
Al	6.0947	Al_2O_3	7.1467
Si	78.9230	SiO_2	85.8918
k	4.6501	K_2O	1.9453
Ca	0.7592	CaO	0.3926
Ti	3.7672	TiO_2	2.0611
Fe	5.8058	Fe_2O_3	2.5624

Table (2): Quantitative EDX microanalysis (compound %) of



the value spot sandstones

Element	ms%	Oxide	ms%
Al	6.9397	Al_2O_3	8.0936
Si	77.1218	SiO_2	84.3219
k	4.3238	K_2O	1.8388
Ca	1.2414	CaO	0.5922
Ti	3.9309	TiO_2	2.2776
Fe	6.4423	Fe_2O_3	2.8759

XRF Analysis

The chemical analysis under XRF showed that it contained the following: SiO_2 (95.39-95.22- 95.27%), AI_2O_3 (0.79- 0.75- 0.77%), CaO (0.28- 0.30- 0.27 %), Fe_2O_3tot. (0.34- 0.32- 0.35 %), SO_3 (0.29- 0.27- 0.25 %), Na_2O (0.44- 0.47- 0.45%), P_2O_5 (0.05- 0.07- 0.06%), and CI (0.40- 0.38- 0.37%)

Cao and SO_3 indicated the presence of Na_2O, and Cl indicated rock salt. P_2O_5 is also in the mineralogical composition of sandstone. It was found as a result of the matter of waste around the site of the temple (Tab.3).

Table (3): Main Constituents of sandstone– Luxor Temple

Main Constituents Wt%	Sandstone – Luxor Temple a	Sandstone – Luxor Temple b	Sandstone – Luxor Temple c
SiO_2	95.39	95.22	95.27
TiO_2	0.40	0.43	0.42
AI_2O_3	0.79	0.75	0.77
Fe_2O_3 tot.	0.34	0.32	0.35
MgO	0.12	0.14	0.11
Cao	0.28	0.30	0.27
Na_2O	0.44	0.47	0.45
K_2O	0.16	0.19	0.17
P_2O_5	0.05	0.07	0.06
SO_3	0.29	0.27	0.25
CI	0.40	0.38	0.37

Main Constituents Wt%	Sandstone – Luxor Temple a	Sandstone – Luxor Temple b	Sandstone – Luxor Temple c
LOI	1.27	1.39	1.45
Cr_2O_3	0.011	0.012	0.011
MnO	0.011	0.011	0.010
NiO	0.004	0.003	0.003
CuO	0.002	0.001	0.002
Y_2O_3	0.001	0.001	0.001
ZrO_2	0.036	0.035	0.035
SrO	0.002	0.002	0.002

The microscopic examination of many skinny sections showed that sandstone grains were plagued by mechanical breakage and chemical processes, manufacturing micro-fractures, and cleavages. This normally compounds the quartz grains into many sub-individual grains. additionally, the interaction of spar grains with soluble salts was one of every of the vital alteration processes in sandstone. some alterations were illustrated by SEM micrographs, such as pores and micro cracks. Moreover, XRD results confirmed the petrographic examination, SEM micrographs, and EDX analysis.

They were compared to outline the alteration in sandstone grains and their rate with time. This can facilitate evaluating sandstone's elements below the current environmental conditions. Moreover, several aspects of decay were found.

The appearance of the black crust was the foremost distinguished manifestation of decay because the dirt unfolds heavily on the sandstones, particularly on several sites that weren't subject to any cleanup programs. The high concentration of air pollutants was a transparent manifestation of weathering results of the interaction between the chemical and physical properties of the stone and their environmental conditions. This interaction between the stones and the atmosphere created an awfully specific surface setting in terms of the content of wet and chemicals. Additionally, the movement of water caused a rise in the rate of decay. Consequently, the structure of sandstone became weaker by biological, physical, and chemical processes. This was in the course of a rise in pressure on the stone.

The high concentration of metal (0.7 - 4.2%) and a chemical element (1.7 - 15.5%) were also attributed to the crystallization of rock salt on the walls. These ions were also created from groundwater and the dissolution of rock salt from soil and sediments. A high concentration of salt (15 - 47.4%) and metal (40.8 - 58.7%) ions could be attributed to the crystallization of mineral and anhydrite salts on the walls. The foremost common decayed salts were salt, chloride, and nitrate anions, phyllite, greenstone, and bentonite grains.

These factors magnified harm, inflicting a rise of the pore's diameter (less than one mm), significantly through the crystallization of salts touching the mechanical and physical properties that weaken or increase the deterioration of sandstone. The proportion of clay materials found as carnivorous was a reason for accelerating the rates of decay because of increasing and shrinking sandstone's exposure to wet and drought. In conclusion, various factors influenced the sandstones of the Temple but in numerous degrees, inflicting deterioration. Consequently, some strategic plans should be conducted to keep up with them by dominant factors to decrease the rates of future deterioration. They must, above all, stop water's penetration through the pores. Implementation barriers ought to be accustomed to cut back salts within the pores through the utilization of assorted compresses and increasing the mechanical resistance of sandstone and victimization of some stimulants materials, particularly in areas vulnerable to high degrees of decay.

Recommendations

Luxor Temple is one of many temples that were greatly affected by groundwater wherever in association in space populated area enclosed by an agricultural area. It was also affected by leak water used for irrigation and agricultural waste from inhabited areas. Sandstone was affected considerably owing to its properties of high absorption of water resulting from the dramatic interaction with close environmental conditions, which might result in its deterioration. Thus, vital measures should be taken for urgent treatment of the problems caused by this water. Therefore, the renewal of the sewerage networks and upgrading of the surrounding agricultural drainage systems shall be considered. Moreover, some tonic trendy materials shall be utilized based on the type of sandstone in the Luxor Temple. High-level measures and strategies of treatment should be considered to treat the deterioration that occurs due to weathering. Furthermore, the quantity of leaky water below the sandstone of Luxor Temple, and the constant changes shall be observed to the agricultural and concrete close to the Temple.

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