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Characterization and Treatment of Rock Inscriptions in Wadi Nasib in South Sinai, Egypt, Case Study

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ABSTRACT

The rock art in Wadi Nasib is one of the most important archaeological sites in South Sinai because the valley contained various rock inscriptions dating back to the prehistoric period until the new kingdom. It was discovered by the South Sinai Antiquities area. It includes many different incised and engraved rock inscriptions, where most of the rock art suffer from different phenomena of deterioration as cracking and disintegrating. Some of methods of examinations and analysis were done on the rock art "case study", such as Stereo-Microscope, Polarized Microscope "PLM", Scanning Electron Microscope SEM-EDX, X-Ray Fluorescence "XRF" and X-Ray Diffraction" XRD" to identify the mineral composition and its changes that occurred and explain manifestations of the deterioration of the rock inscriptions in Wadi Nasib in South Sinai. The research proved that the rock inscriptions suffer from different phenomena of deterioration as fracture, cracking, scaling, peeling, fragmentation, honey comb, crystallization of salts on the surface and inside the cracks, as well as weakness and fragile of sandstone being poor mineral composition, and decomposition of cementing material due to physico-chemical weathering processes, or because of mechanical weathering and earthquakes, the man-made deterioration is the writings on the surface of the rock art with a sharp instrument or writing with the soot or chalk due to the poor archaeological awareness of the people, most phenomena of physico-chemical deterioration of the rock art in Wadi Nasib are dynamic and static deterioration factors being the site is a desert environment .Based on the results of scientific treatment studies , the results of examinations ,analysis and field survey, the restoration and conservation of rock art as registration , documentation and the restoration had done by selection of suitable materials and methods appropriating to nature of the damage of rock inscriptions in South Sinai, such as use of mechanical cleaning methods with hand tools and chemical cleaning method where a mixture of acetone and Toluene in ratio of 1: 2" was used to remove the soil deposits, mechanically and chemically extraction of salts were done using a poultice of distilled water, then EDTA, and consolidating of rock art using a mixture of Nano Silica and Wacker H by Methods of spraying and brushing. The Research finds the need to raise the archaeological awareness of the people and specialists as one of the tools for preserving the rock art in Sinai, rehabilitating the site and its developing for sustainable development, and placing it on the tourist map because it represents archaeological and historical importance in South Sinai.

Key words: Sand Stone, Rock Art, Weathering, Deterioration, Decomposition, Disintegration, Peeling, Archaeological Awareness

Introduction

Sinai has a distinct strategic location, it represents the eastern entrance of ancient Egypt, the land crossing between two continents of Asia and Africa from prehistoric periods until now, known by the name of Biao, "the mine ", also known as Khitomfkat " the turquoise land", It is also known as the Tashsmat " the land of the green copper ", which includes many of the mines of turquoise and copper, their people were called by Mnito, and the ancient Egyptian settled Sinai from the Neolithic period where this period witnessed a great activity in the extraction of copper and turquoise. In the old kingdom, interest in Sinai was Increased, as it was confirmed by many rock inscriptions found in Sinai for King Sit Nakht, Zoser, Sanfero, Sahu Ra, Niosar Ra, Bibi I, the same interest continued in the middle kingdom for extracting turquoise and copper, as well as securing the trade between Egypt

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And its neighbors through the Sinai, where the number of rock inscriptions in Wadi of Maghara were 45 inscription" " 22 rock art of the old kingdom, 20 for the middle kingdom, 3 of the new kingdom" as well as rock inscriptions in the Wadi of Nasib to King Amenemhat III, the interest of kings of the new kingdom in Sinai .continued especially during the reign of Hatshepsut and Tuthmosis III to the mines in Wadi of Maghara , Sirappite Elkhadam ,Rawd al-Air and Wadi Nisab (Hawass, 2012) as in fig.(1).

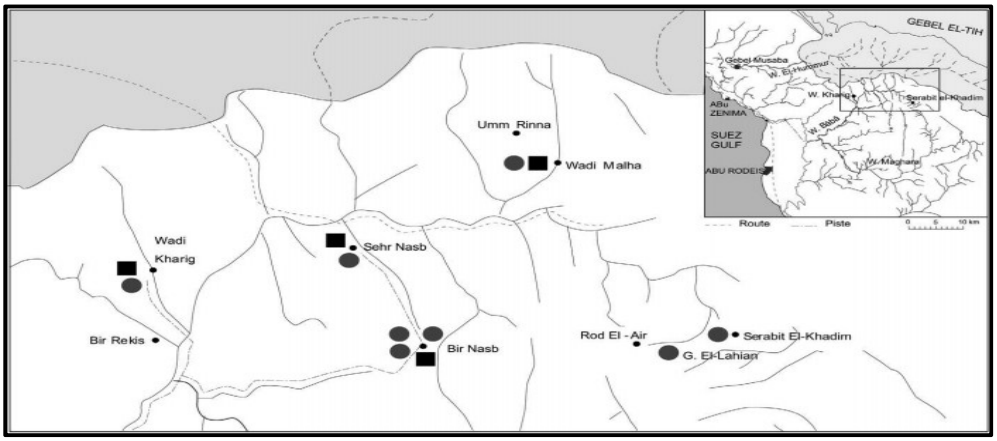

Fig 1: Represents the mining areas and rock inscriptions in South Sinai

Wadi Nasib is located south-west of the Sinai Peninsula to the east of Abu Zeinema in South Sinai. It is a flat quaternary terrace, its rocky slopes are upper Paleozoic sandstone in Wadi Nasib, Metallurgical processes were back to old kingdom, and the work continued to new kingdom, including many smelting furnaces of copper extraction, raw materials and slag , as well as a lot of rock art were carved by Ancient mining missions in the site. Some rock inscriptions were founded on the surface of a mountain slope of the king Amenemhet III (Middle Kingdom), Rameses II and Merneptah (New Kingdom) (Abdel-Motelib *et al*., 2012). Near Wadi Nasib, many of the rock inscriptions were discovered in Rawd al-Air, Wadi Maghara,Wadi Mukkatb and Wadi Ain Hudra, that sites were rocky nubian sandstone hills containing rock inscriptions dating back to different historical periods, including hieroglyphic and Nabataean inscriptions (Hemeda and Walid, 2012), as in fig.(2).

Fig. 2: Represents Wadi Nasab in southern Sinai)

Sandstone is sedimentary rock consisting of round or angular granules of silica that has been deposited and combined with each other's by silica, calcium carbonate, iron oxide or clay minerals. Therefore sandstone differs in its color, hardness, and durability (Attia, 2002), its main mineral composition is silica (Dimes, 1998). There are many factors and manifestations of the deterioration of rock inscriptions in Sinai because of nature of sand stone, which is characterized by different mineral components, which contributed increasing the intensity of weathering process causing cracking, fragmentation and decomposition of the rocks (Muthayya, 1999), Physical weathering broke down rock formations into small rocky blocks, that were turned into smaller fragmented rocky blocks over time. The process of natural fragmentation is called rock fragmentation, and this type of weathering is frequent in dry or very cold areas (Refaat, 1981). The first steps of natural weathering are cracking and breaking in the rock blocks. Increase of stresses causing widening of the cracks, occurring splits through the rock art blocks (Fahmi, 1989). The nature of weathering processes of various rocks, and their impact depend on climatic conditions (Sinha, 1992). Sinai is characterized by desert climate between the dry and semi-dry climate, which is generally dry areas, lacking of rainfall, but there are some floods at irregular times, the temperature in the summer is 40:45˚C which causes extreme changes in temperature between night and day, resulting thermal expansion of grains and contraction during the night resulting cracking sandstone. The thermal expansion coefficient is often 7: 8 micron per millimeter of sandstone, the total expansion is about 140: 200 micron per meter of sandstone. This thermal expansion causes pressures and strains weaking cementing materials among sandstone granules (Leisen *et al*., 2008) due to expansion and contraction processes, Which by repeating causing micro cracks that may allow other weathering agents to play their destructive role (William, 1989), the expansion and contraction also lead to disruption of rock blocks and its transformation into small fragments (Sealey, 1986). The inherently rocks are not good conductors of the heat and its mineral composition is unhomogeneous resulting in what is called exfoliation of rocks (Awadallah, 1981). Rock inscriptions subjected to physical-chemical deterioration due to fluctuation of high temperature and relative humidity, which are the most deteriorated factors of rock inscriptions (Lourenc, 2006). Humidity and its daily and seasonal changes is one of the most important factors of the deterioration and weathering of sandstone (Oliver, 1997), the most important sources of moisture in Wadi Nasib in the south of Sinai are rain , torrent and condensation, the relative humidity is ranging between 60: 80%, it has a significant impact on sandstone deterioration, the durability of sandstone and its compressive strength reduced 60% by soaking dry sandstone for 120 minutes in water (Jeng *et al*., 2004). Water plays an important role in the weathering of the rocks, grabbing rocky blocks, and moving from its place, resulting rock sandstone erosion, its collapse and slipping, as well as water freezing leads to increasing 10% larger than its original size resulting breaking and fragmentation of the rock (Rahn, 1990).

The wind is also considered one of the most dangerous factors of damage to the rock inscriptions in South Sinai, causing deterioration of the rock art surface such as some gaps. Some rocks are found at the base of the mountain due to mechanical weathering or seismic actions (Foster, 1974). In addition to inorganic weathering factors , cracking and breaking of sand stone blocks due to the organic activity of plants and trees causing pressures occurring cracks , fracture and joints or at least its increase and widening (Yaalon, 1993).Chemical weathering causes a chemical change of the rock due to the relationship between the environmental surrounding and the mineral composition of the original rock (Arthur and Brown, 1979), where atmospheric gases play an important role in rock decomposition (Craig, 1993), and their most important processes are oxidation, carbonation, hydration and solubility (Carla and David, 2001). The effect of chemical weathering of sandstone is different, leaving the quartz without any change (Wild, 2001). The weathering factors can be combined both Physical and chemically in breaking, disintegration and decomposition of the rock. Chemical weathering can create holes by dissolving and decomposition of feldspar, helping Physical weathering to play its destructive role (Reineck and Singh, 2000). Minerals such as olvines, pyroxene, amphibole, and biotite decomposed to iron oxides (Simmons, 2002). A huge amount of rock cracking and decomposition is due to the microbiological activity of some fungi and bacteria (McNamara and Mitchel, 2005). Human deterioration is also a destructive factor that may outweigh the natural factors because it can cause damage that is difficult to treat, such as fire, which is one of the most important factors of deterioration of rock inscriptions, resulting physical-chemical deterioration by sudden extreme temperature changes, known as the thermal shock, and generated surface and sub-surface

stresses caused rock cracking, splitting and spalling by difference of thermal expansion of sandstone minerals. Its chemical effect, high temperature causes a change in the mineral composition or cementing material, occurring a poor physical structure of sandstone (McCabe *et al.,* 2010). The deterioration increased by presence of clay in sandstone (Sebastian *et al.,* 2007), there are many fissures, fractures granulation, disintegration, detachment, aggregates, Splitting and exfoliation due to intensive weathering (Siedel *et al.,* 2010). The importance of this study is due to being one of the first studies that deal with diagnosis of deterioration and conservation of rock inscriptions in south west Sinai.

Materials and Methods

Three samples sandstone were selected from Wadi Nasib in South Sinai. In addition to surface sample of crystallized salts, where some examinations, analyzes were carried out for purpose identification of mineral composition And its changes that have occurred to explain phenomena of rock art deterioration in Wadi Nasib in South Sinai, on the basis of these examinations and analyzes, rock art are restored and conserved.

Study Methods

Visual Examination

The visual examination method is the first stage of the examination process to evaluate the condition of the rock art and diagnose the deterioration of sand stone in the site of Wadi Nasib in South Sinai.

Usb Stereo-Microscope

The examination of Usb Stereo-Microscope is one of the most important examination methods of the sandstone morphology. The examination shows what happened to the samples of changes and deterioration, as well as the shape and size of the granules, their relationship with each other and their distribution. The samples were examined using SZ 680/780 Stereo zoom Microscope, it was conducted at the Faculty of Science, University of Cairo.

Petrographic Examination

Polarizing Microscope is an important and excellent method in study of the petrographic structure of the mineral components of sandstone. The petrographic examination of the stone samples shows the changes and deterioration, as well as the shape and size of the grains and their distribution. The samples were prepared in thin section for the petrographic examination using the polarized microscope (Olympus BX51 TF japan attached with digital camera under magnification 4X up to 40X), it was conducted at the Faculty of Science, Cairo University.

Scanning Electron Microscope with Energy Dispersive of X-Ray unit "SEM- EDX".

Scanning Electron Microscope with Energy Dispersive of X-Ray unit "SEM- EDX" provides accurate information on surface morphology, crystalline structure, grains size, grains distribution, texture and deterioration, as well as mineral composition. The examination and analysis are done by using SEM FEI Quanta 250" SEM Environmental Microscope" , the operating conditions were 20 kV and 1×10^{-9}A ، it was conducted at environmental scanning electron microscope Unit at the National Research Center in Cairo.

X-Ray Diffraction Analysis

XRD analysis gives mineral components of sandstone in Sinai, which helps to diagnose damage phenomena of sandstone, understanding its nature, and its mineral changes by the environmental

surrounding to identify the rate and evaluation of deterioration and weathering sand stone. This analysis was carried out by XRD, Model: EMMA, produced by GBC at Central Laboratory at South Valley University.

X-Ray Fluorescence Analysis

XRF analysis gives the elemental structure of the mineral components of sandstone in Sinai, helping to diagnose deterioration phenomena of sandstone. This analysis was performed using the Philips PW 1606 XRF. This analysis was conducted at the Faculty of Science at Cairo University.

Results

Visual Examination

Visual Examination has proved that most of the rock inscriptions in Wadi Nasib in Sinai suffered from accumulation of sand deposits, as well as impact of the rock inscriptions by the environmental deteriorated agents (desert environment), the examination has shown presence of some crystallized salts on the surfaces of rock inscriptions or inside the cracks, it was noted that sand stone was poor physical structure, where it is easily disintegrated by hand pressure, being cementing materials were decomposed, causing the loss of cohesion and bonding between the granules, the examination showed fall of some rock art masses, as well as phenomenon of exfoliation, erosion, gaps , loss of parts and salts crystallization as in fig. (3-A-B-C-D).

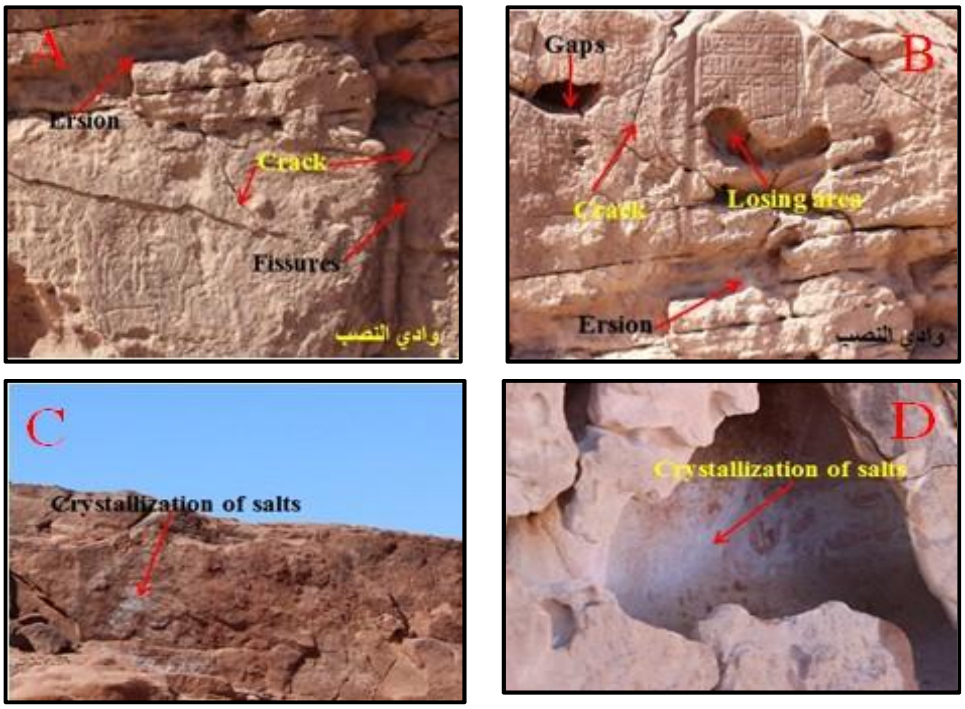

Fig. 3: Represents deterioration phenomena of the rock art in Wadi Nasib in Sinai A: erosion and cracks B: missing parts, cracking and gaps, C: crystallization of salts D: crystallization of salts into the gaps.

Usb Stereo-Microscope examination

Some sandstone samples were examined by Usb Stereo-Microscope, where the examination of first sample showed presence of quartz grains, most of which are round and angular coarse grains

of different sizes and shapes, as in fig. (4-A) ,as well as Iron oxides, clay, crystalline salts on the surface, many gaps and cracks as in fig. (4-B). The second sample was also examined in Wadi Nasib where the examination revealed presence of iron oxides in high rate as banded iron oxides as in fig. (4-C), while the examination of the third fragmented sample showed difference in the size of quartz grains between rounds, sub-round and angular quartz grains by the weathering processes in the site as in fig. (4-D).

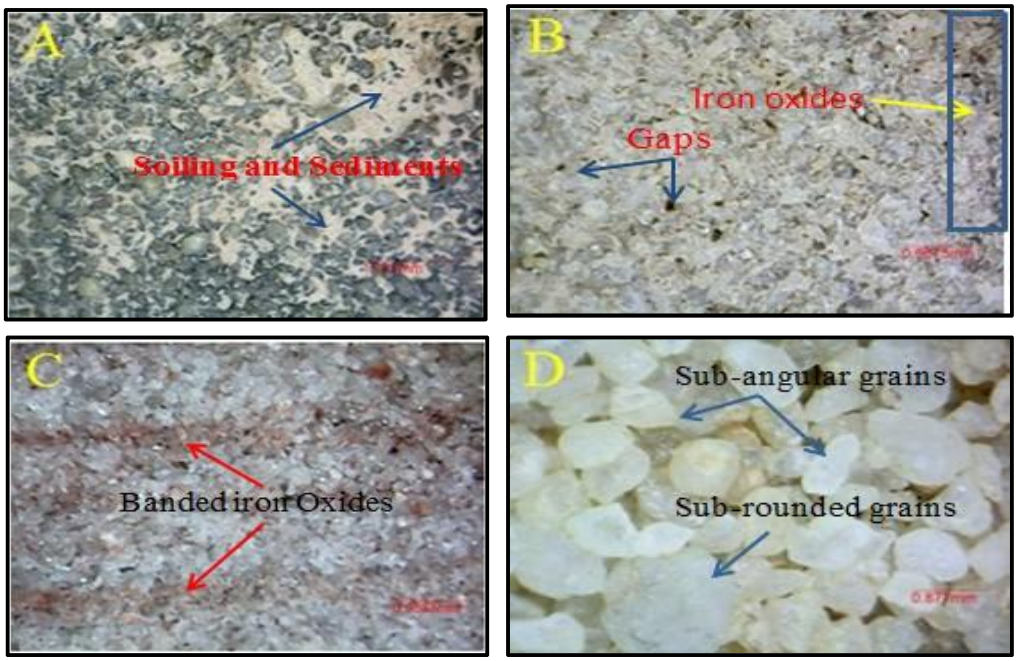

Fig. 4: Microphotograph Usb stereo-microscope of sandstone sample In Wadi Nasib A: Quartz grains" Arenite" and sand deposits, B: quartz grains "Arenite ", iron oxides and some gaps C: banded iron oxide D: various quartz grains.

Polarizing Microscope Examination

Some sandstone samples were examined by polarizing microscope, where the examination of first sample showed presence of round, sub-round and angular quartz grains, most of which are coarse grains of different sizes and shapes, as well as some quartz granules are monocrystalline grains, and polycrystalline granules under magnification(10 X-CN) , as in fig.(5).

The second sample at Wadi Nasib was examined by polarized microscope showing presence of quartz granules, most of which are coarse grains of different sizes and shapes, some are round or sub-round grains and some other are angular and sub-angular quartz grains, as well as presence of zircon grains, under magnification (10 X-CN) as in fig.(6). another part of the sample was examined showing presence of quartz granules, clay minerals as cementing material, as well as cracking of some quartz granules under magnification (10 X-CN) as in fig.(7).

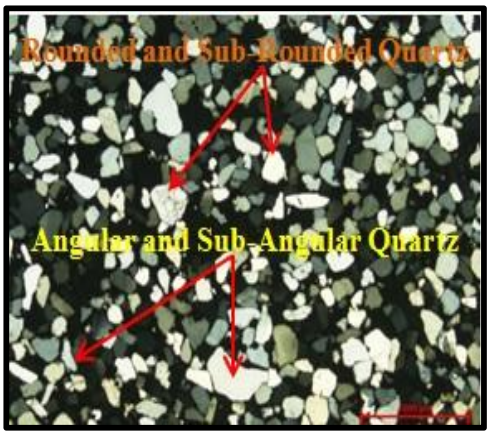

Fig. 5: Petrographic micrograph of the first sample showing presence of round, sub-round and angular quartz grains of different shapes and sizes, (10 X - CN).

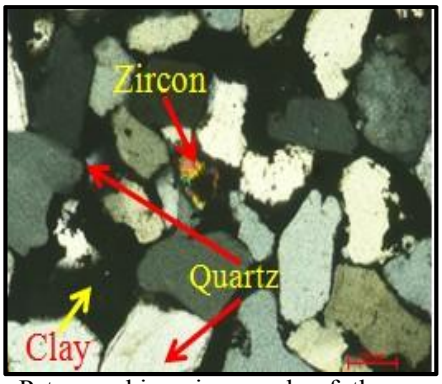

Fig. 6: Petrographic micrograph of the second sample in south Sinai shows the presence of monocrystalline quartz grains, iron oxides and zircon grains under magnification (10 X - CN).

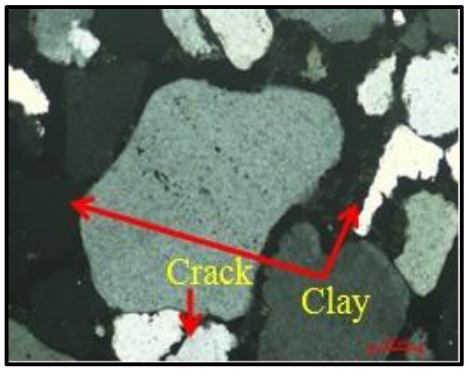

Fig.7: Petrographic micrograph of the same second sample showing presence of quartz granules, clay minerals as cementing material and some cracks under magnification (10 X-CN)

Examination and Analysis by Scanning Electron Microscope coupled with the Energy Dispersive of X-Ray Unit "SEM-EDX".

Three sand stone samples in Wadi Nasib in Sinai were examined by SEM-EDX, which deals with the samples without any prior preparation, and the results were as follows:

Examination by Scanning Electron Microscope

The first sample was examined by the scanning electron microscope (SEM) showing that the sample has a coarse texture where quartz grains are round and some other are angular, in addition to some gaps and crystallization of the salts under magnification (400X) as in fig.(8) .

The second sample also was examined by the scanning electron microscope (SEM) showing the existence of quartz grains, as well as spread of phenomenon of gaps and crystallization of the salts under magnification (800 X) as in fig.(9).

The saline sample also was examined by the scanning electron microscope (SEM) showing existence of quartz grains, as well as spread of phenomenon of fragmentation, gaps and crystallization of salts under magnification (8000 X) as in fig.(10).

X-Ray Fluorescence Analysis

The results of two sand stone at Wadi Nasib in south Sinai were analyzed by X-ray fluorescence analysis, the first sample showed presence of alumina, silica, phosphorus, sulfur, potassium, calcium, titanium, manganese, iron, copper, strontium, zircone, and molybdenum. The

analysis also shows that the main structure of the sandstone is silica, the percentage of silica is between 93: 95%, confirming that sandstone at Wadi Nasib in Sinai is quartz arenite, in addition to presence of iron oxides in high rate as cementing materials, as well as presence of calcite and some heavy minerals elements such as zircon, arsenic and molybdenum as in fig. (11).

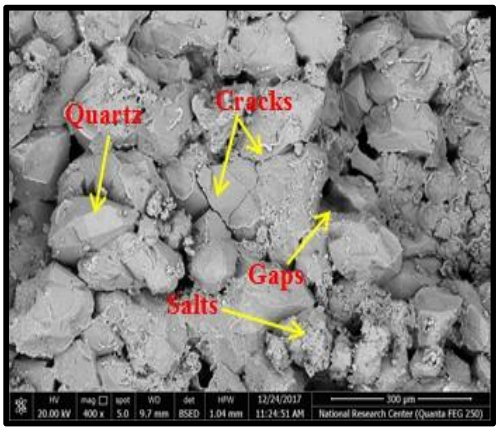

Fig. 8: SEM photomicrograph of the first sandstone sample in Wadi Nasib Sinai shows the existence of quartz grains, some gaps and cracks under magnification (400 X).

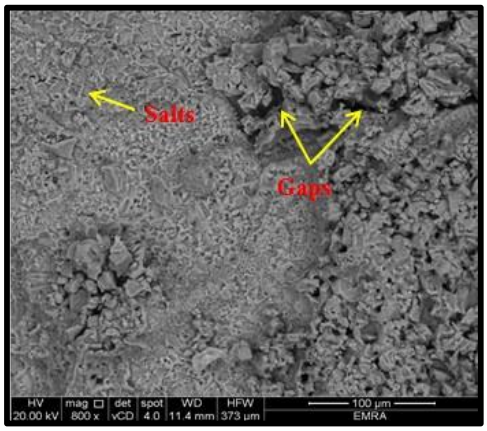

Fig. 9: SEM photomicrograph of the second sample shows the presence of quartz grains, the spread of gaps and the crystallization of salts under magnification (800X).

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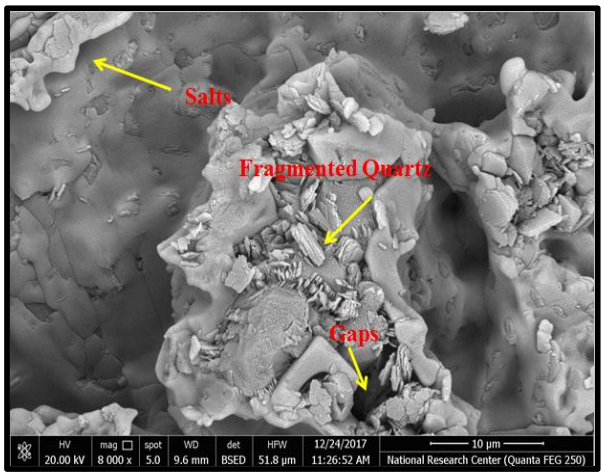

Fig. 10: SEM photomicrograph of saline sample in Wadi Nasib in Sinai shows the presence of the phenomenon of fragmentation and gaps and salt crystallization (8000 X).

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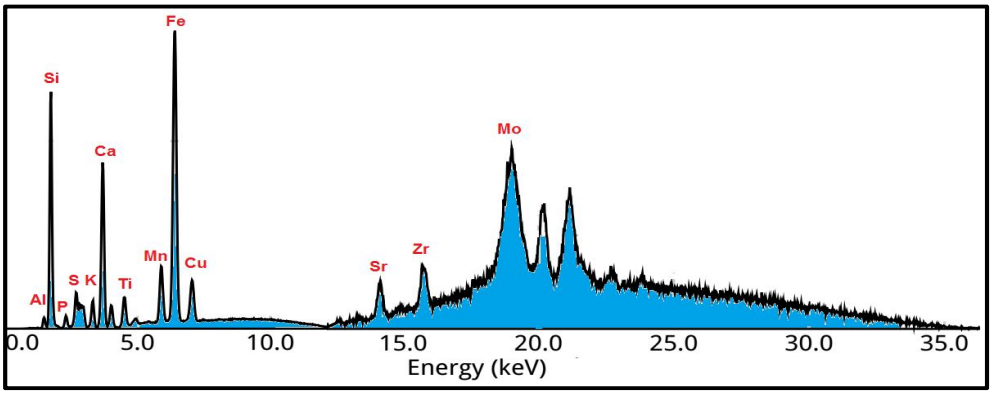

Fig. 11. Represents XRF pattern of the first sandstone sample in Wadi Nasib in south Sinai

The second sample of the sandstone was analyzed by X-ray fluorescence. The results of the analysis showed presence of alumina, silica, phosphorus, sulfur, potassium, calcium, titanium, iron, arsenic, strontium, zircon, nybalium and molybdenum. The analysis shows that the main structure of sandstone is silica "quartz arenite", in addition to presence of a high percentage iron oxides as cementing material, as well as the presence of some heavy minerals elements such as arsenic, zircon, strontium, nybalium and molybdenum, as in fig. (12).

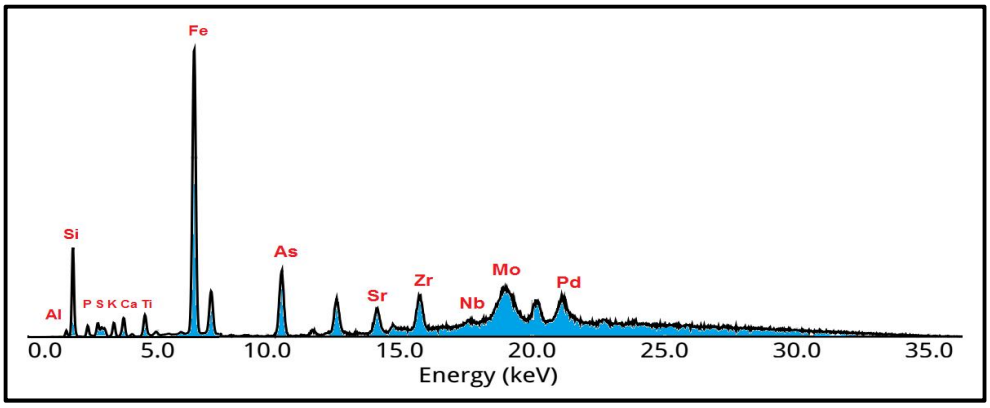

Fig. 12: Represents XRF pattern of the second sandstone sample in Wadi Nasib in south Sinai

Analysis by X-Ray Diffraction

Three sample of sandstone samples were analyzed by x-ray diffraction at Wadi Nasib in south Sinai (2 sand stone samples and one crystalline salt). The analysis of the first sample of sandstone at Wadi Nasib in South Sinai showed existence of some compounds such as SiO_2, $CaCO_3$, and NaCl as in fig. (13).

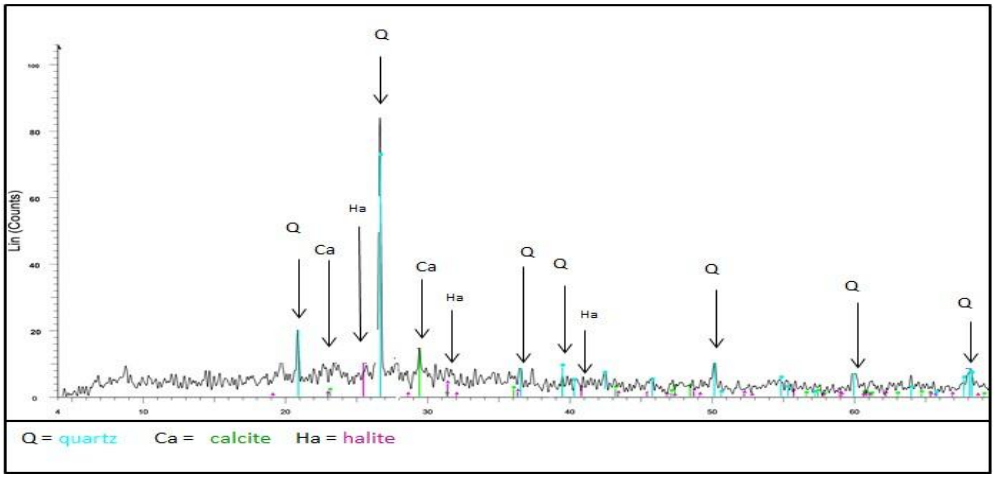

Fig. 13: Represents XRD pattern of the first sample in Wadi Nasib, South Sinai

The analysis of the second sample showed existence of some compounds such as Quartz SiO_2, Albite $NaAlSi_3O_8$, Halite NaCl, and Hematite Fe_2O_3, as in fig. (14).

The analysis of the third saline sample showed existence of some compounds such as Halite "NaCl "and Sylvite "KCl" , as in fig. (15).

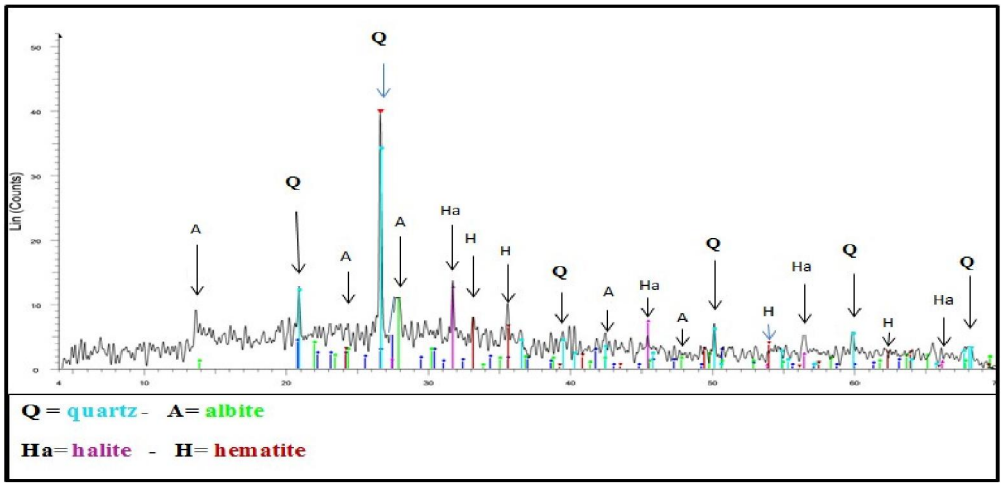

Fig. 14: Represents XRD pattern of the second sample in Wadi Nasib, South Sinai

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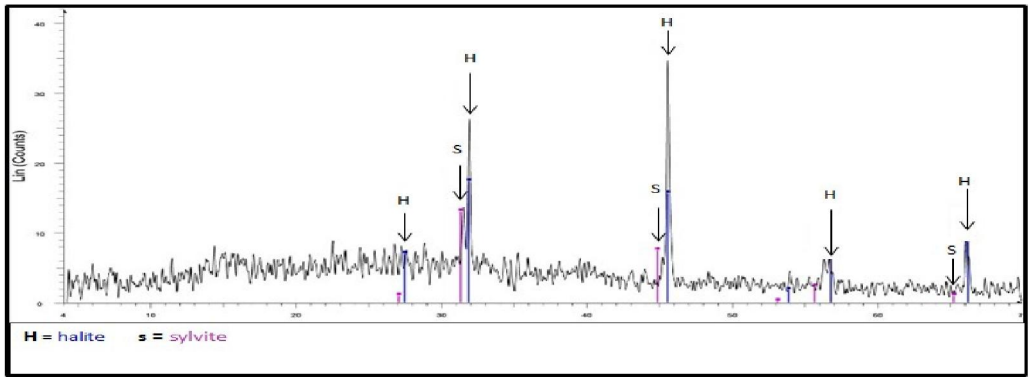

Fig. 15: Represents XRD pattern of the third sample in Wadi Nasib, South Sinai.

Discussion

Through the results obtained from the research, the visual examination results proved existence of some sand deposits on the surface of rock inscriptions, as well as some salts crystallized on surface of the rock art or inside the cracks and gaps, it also proved that sand stone was poor physical structure, where it is easily disintegrated by hand pressure, being cementing materials were decomposed, causing loss of cohesion between the granules.

The visual examination of the rock inscriptions proved that it suffered from presence of gaps , oblique, vertical deep cracks, in addition to spread of phenomenon of fracture , cracking ,gaps , exfoliation, erosion, loss of some parts of the rock art by severe weathering or earthquakes and crystallization of salts mainly depend on water saturation and pore-size distribution (Nazel, 2016a).

The visual examination of the rock inscriptions proved the human deterioration with writing the names on surface of rock art by incision and engraving , or the chalk, as well as phenomenon of the fire below the inscriptions for heating and cooking causing color change, micro cracks, breaking, scaling and discoloration (Nazel, 2016b).

Usb Stereo-Microscope examination showed existence of quartz granules of different sizes and shapes, some are round and some other are angular, as well as presence of iron oxides, clay, gaps, cracks and salts.

The polarized microscope proved that sand stone is quartz arenite, whose main structure is silica SiO_2, it was Ferruginous Sand Stone. It contained different quartz grains and graded from medium to coarse quartz grains.

The petrographic examination showed a nature of the rock texture, where the granules are disordered coarse grains and others are laminated due to gradation of size of the granules, the difference of cementing materials and the pressures that the rock was exposed during formation and Sedimentation

The scanning electron microscope has shown that sandstone is coarse texture of disordered coarse quartz grains, some are round and some other are angular, and it suffers from erosion, where there are some gaps, cracks and crystallization of salts.

The analysis by XRF proved presence of alumina, silica, phosphorus, sulfur, potassium, calcium, titanium, manganese, iron, copper, strontium, zircone, and molybdenum. The analysis also proves that the main structure of the sandstone is silica, the percentage of silica is between 93: 95%, confirming that sandstone is quartz arenite, in addition to presence of iron oxides in high rate as cementing materials.

XRD analysis of the first sample proved presence of quartz SiO_2, calcite $CaCO_3$, and halite NaCl, indicating crystallization of salts .

The analysis of the second sample showed the existence of quartz SiO_2, Albite NaAlSi3O8, halite NaCl and Hematite Fe_2O_3, indicating that the cementing material is iron oxides, as well as crystallization of halite salts.

Treatment and Conservation.

Study of petrographic examination (PLM) and XRF analysis of sandstone samples in Wadi Nasib in South Sinai proved presence of sand deposits, halite, calcite salts, poor physical structure of sandstone, spread of phenomenon of peeling, cracking and gaps due to intensive weathering. Based on those results, restoration and conservation of rock art in Wadi Nasib in South Sinai had done according to its damage nature and the results of examinations, analysis and scientific studies in the field of restoration, treatment and conservation of sandstone monuments, where the restoration process included the following:

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Recording and Documentation

It is a basic and important process because it is sometimes difficult to copy these rock inscriptions due to cracks, gaps, height or slopes. The photographic documentation of various damage phenomena of rock art was carried out, followed by the restoration and conservation process (Nabil and Walid, 2009).

Cleaning

The cleaning process aims to restore the archeological surface to its nature revealing the details of the rock inscriptions (Maureen *et al*., 2003).The mechanical cleaning technique was used by the soft brushes of various sizes for removal of the dust and sand, the air blower was also used to remove the surface deposits some metallic and wooden spatulas and scalpels also were used to remove some solid surface sediments highly adhering to the surface without any damage to the archaeological surface after moisturizing with distilled water so that they can be easily removed mechanically. The mechanical cleaning process continued in the same way. The chemical cleaning was done based on nature of the materials that we want to remove it, where the mechanical cleaning failed to clean it, a mixture of acetone And Toluene in the rate of 1: 2 was used to remove the fragile deposits, the chemical cleaning was Locally done with continuous drying (Nabil, 2013) .

Removal of the Salts

The mechanical cleaning technique was used by the soft brushes to remove crystallized salts on the surface, some metallic and wooden spatulas and scalpels also were used to remove the remaining crystallized salts, taking into consideration that the work by spatulas and scalpels had done under the lenses with a magnification 4X not to scratch the archaeological surface stone (Nabil and Anwar, 2013), poultice of distilled water was used to remove halite salts, and poultice of Japanese

paper saturated with EDTA "Tetra Sodium Salt Ethylene Diamine Tetra Acitic Acid" was used to extract carbonate salts (Eric and Price,2010).

Consolidation

After the mechanical and chemical cleaning of the rock inscriptions, rock art was consolidated by a mixture of nano-silica and Wacker H in the rate of 1:1, spray method were used in consolidation process (Eun Kyung Kim *et al.,* 2009), and restoration and conservations works are illustrated in fig. (16-17).

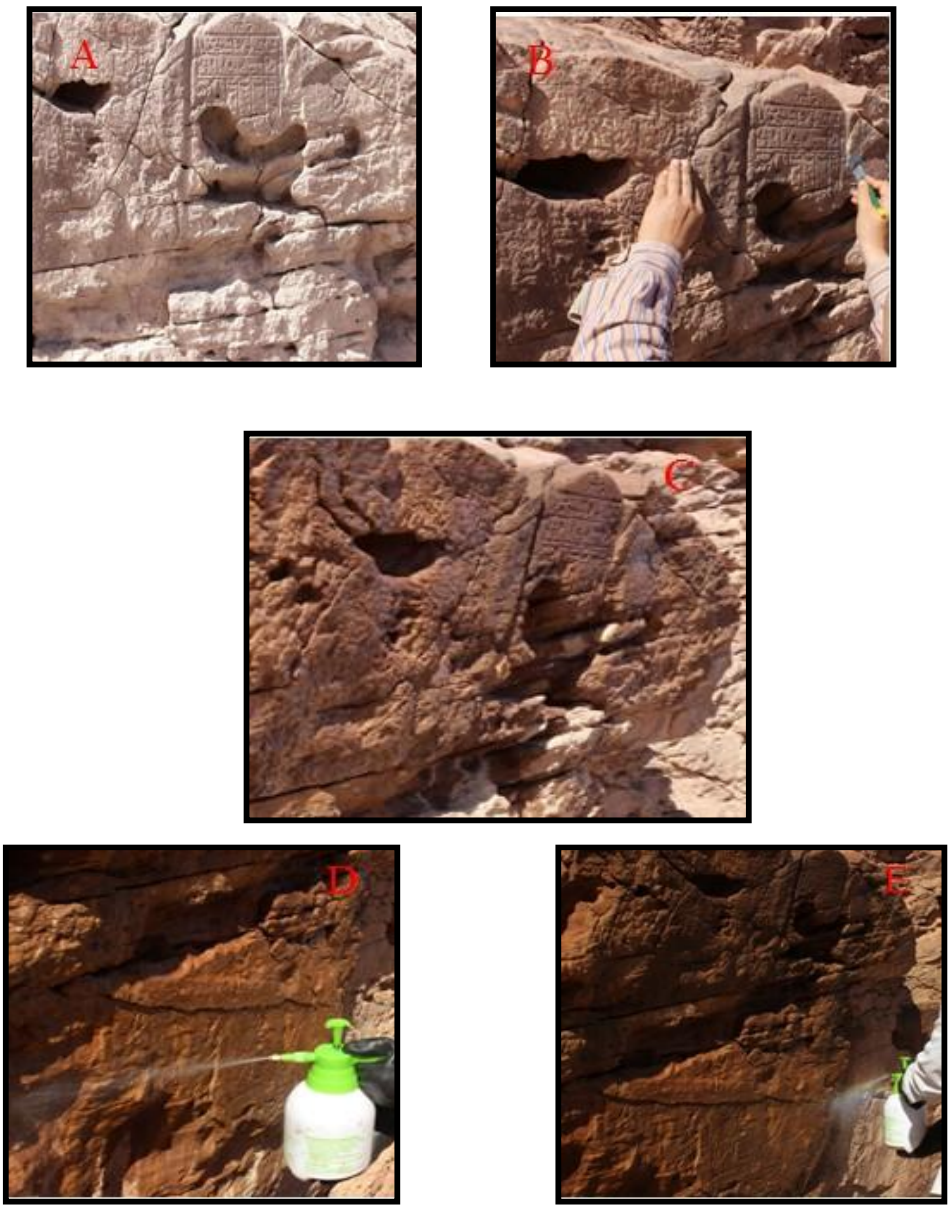

Fig. 16: represents works of the restoration of the rock art in Wadi Nasib, South Sinai A: Inscriptions before restoration B: Rock art during mechanical cleaning C: After chemical cleaning D: Consolidation of the western part of the rock art , E: Consolidation of the eastern part of the rock art.

Fig. 17: Represents the restoration works of the rock inscriptions in Wadi Nasib, Sinai A: Pre-restoration inscription B: Rock art after mechanical cleaning C: After chemical cleaning D: During consolidation by spraying, E: Rock art after restoration and conservation.

Conclusion

The research found a number of great important results in identifying the type of sandstone, nature of the texture and diagnosis of the deterioration, sandstone is quartz arenite of a coarse texture from coarse quartz grains containing a small percentage of cementing materials such as iron oxides and clay minerals, the texture and size of the sandstone grains ranged from medium to coarse quartz grains, they are disordered coarse grains, some are round, angular, and some other are laminated due to difference of the cementing materials or the pressures Which rock are exposed in their sedimentation environments. The research proves that the rock inscriptions in Wadi Nasib suffered from various deterioration phenomena such as fracture, cracking, peeling, erosion, disintegration, and

crystallization of salts on the surface or inside the cracks and gaps, as well as the weakness and Fragility of sandstone due to its poor physical structure and decomposition of bonding material between particles, some rock art blocks are fallen by earthquakes, The human deterioration was done by writing the names on surface of rock art by incision and engraving, or by the chalk, as well as phenomenon of the fire below the inscriptions for heating and cooking, most of deterioration phenomena of rock inscriptions in Wadi Nasib is physical and chemical agents, being the site is in a desert environment including dynamic and static actions .

Based on the results of the scientific treatment studies, examinations and analyzes, The restoration and conservation works of the rock inscriptions had done including the documentation , the restoration and conservation of the precise selection of appropriate materials and methods as according to nature of the deterioration of rock art, mechanical cleaning methods by hand tools and chemical cleaning were used in cleaning process, using a mixture of acetone and Toluene by 1: 2 to remove surface deposits such as sand or dust, the chemical cleaning was done locally with continuous drying. distilled water poultice was used to remove halite salts, the calcareous and the carbonate salts were removed using poultice of Japanese paper saturated with EDTA "Tetra Sodium Salt Ethylene Diamine Tetra Acitic Acid" , after cleaning process, rock art was consolidated by a mixture of nano-silica and Wacker H in the rate of 1:1, spray method were used in consolidation process. The research also pointed to the need to raise the archaeological awareness of the people and specialists as one of the tools for preservation of rock inscriptions in Sinai.

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References

Abdel-Motelib, A., M. Bode, R. Hartmann, Ulrich Hartung Andreas Hauptmann & Pfeiffer, K., 2012. Archaeometallurgical expeditions to the Sinai Peninsula and the Eastern Desert of Egypt, Metalla (Bochum) 19.1/2, 3-5, pp.3-59

Arthur, H., and L.Brown, 1979. Geochemistry, U.S.A., P.318.

Attia, A., 2002. Principles of Geology, Cairo, p.90.

Awadallah, M.F.,1981. Lectures in Geology, Dar Al Ma'arif, p.101.

Carla, W.M., and P.David, 2001. Earth, Then and Now, U.S.A., P.78.

Craig, R.,1993.Soil Mechanics, London, 1993. P 1-2.

Dimes, F., 1998. Sedimentary Rocks , in Conservation of Building and Decorative Stone , Vol. 2 , London , P . 61 .

Eric, D. and C.A.Price, 2010. Stone Conservation, an Overview of Current Research, Second Edition, Getty Conservation Institute**,** Los Angeles, 2010, pp.29-34.

Eun Kyung Kim, Jongok Won', Jin-young Do, Sa Dug Kim, Yong Soo Kang, 2009. Effects of silica nanoparticle and GPTMS addition on TEOS-based stone consolidants, Journal of Cultural Heritage, 10 , pp. 214-221.

Fahmi, H., 1989. Engineering Geology, Dar Al Ma'arif, p. 129.

Foster, R.J.,1974. Geology, fifth Edition, London, P. 68.

Hawass, Z., 2012. Sinai through the ages, Supreme Council of Antiquities, 2012.pp.21-30.

Hemeda, S. and K.Walid, 2012. Evaluating the rate of stone art deterioration in Wadi Maghara and Wadi Mukattab, Sinai,Egypt, in International Journal of Conservation Science, 3(2):p.79.

Jeng, F.S., M.C. Weng, M.L.Lin and T.H.Huang, 2004.Influence of petrographic parameters on geotechnical properties of tertiary sandstones from Taiwan, Engineering Geology, No.73, pp 71–91.

Leisen H., C.Verbeek and S.Krause, 2008. Aspects of conservation in the excavation site of the Athribistemple in Egypt, Environ. Geol, N.56, pp.689–697.

Lourenc, P.,2006. Defects and moisture problems in buildings from historical city centers: a case study in Portugal , in : Building and Environment 41, p. 223.

Maureen E. Young, D.C.M. Urquhart and R.A.Laing, 2003. Maintenance and repair issues for stone cleaned sandstone and granite building facades, Journal of Building and Environment, N.38, pp.1125 – 1131.

McCabe S., B.J.Smith and P.A.Warke, 2010. Exploitation of inherited weakness in fire-damaged building sandstone, the fatiguing of shocked stone , Journal of Engineering Geology, N.115, pp. 217–225.

McNamara, C. and R. Mitchell, 2005. Microbial Deterioration of Historic Stone in Frontiers in Ecology and the Environment, Vol. 3, No. 8 , p. 447.

Muthayya, V.D., 1999. A text book of Geology, 4th edition, Oxford, PP. 1-2.

Nabil, A. and F.M.Awar, 2013. Conservation of the Mural Stucco Ornaments of the mausoleum of Emir Ulmas Al-gib in Cairo , Egypt, journal of e-conservation, No.25, p.161.

Nabil, A. and K. A. Walid, 2009. Deterioration and Conservation Of The Rock Inscriptions In Ain-Huda, South Sinai, Egypt, in journal of faculty of archaeology, Qena, p.26.

Nabil, A. B., 2013. The Dererioration Problems of The Wall Reliefs of Komir Temple , Esna,Egypt, in Mediterranean Archaeology and Archaeometry, Vol. 14 ,No.1, p.217.

Nazel,T.A., 2016a.The Sharaf Al-Dine Mosque in Cairo: a Case Study, journal of Restoration of Building and Monuments" Material Science, Conservation of Architectural Heritage, Sustainable Construction, 22(1):pp.27-36.

Nazel, T.A., 2016b. Fire impact on the mausoleum of Zein El-deen josef in Cairo, Journal of Architectural Conservation, pp.1-2.

Oliver, A.,1997. Dampness in Buildings, London , p.18 .

Rahn, P.H., 1990. Engineering Geology, New Jersey, P. 36.

Refaat, A.M., 1981. Introduction to Rock Science, Dar Al-Qalam, Kuwait.p.107.

Reineck, H. E., and I.B.Singh, 2000. Depositional Sedimentary Environment, 2nd edition, New York, PP.1-10.

Sealey, L., 1986. Earth, Third Edition , London , p. 338 .

Sebastian, E., G.Cultrone, D.Benavente, L.Linares Fernandes and K.Elert and C. Rodriguez- Navarro, 2007. Swelling damage in clay-rich sandstones used in the church of San Mateo in Tarifa (Spain). Journal of Cultural Heritage, N. 9, pp. 66–76.

Siedel, H., S. Pfefferkorn, E.Plehwe-Leisen and H.Leisen, 2010. Sandstone weathering in tropical climate: Results of low-destructive investigations at the temple of Angkor Wat, Cambodia, Engineering Geology, N. 115, pp. 182–192.

Simmons, L. H.,2002. Construction : Principles , Materials and Methods, 7th edition, NewYork, P.92.

Sinha, R.K., 1992. An introduction to Geology, Oxford, P. 93.

Wild, A., 2001. Soils and Environment, London , PP. 39-40

William H. M., 1989. What is Geology? Translated by Mokhtar Nashad, Egyptian General Book Organization,p.126.

Yaalon, D.H.,1993. Weathering and Soil development, London, P.239.