Deterioration of Wetted Monumental Granite in Ancient Egyptian Buildings and Sites Causes , Symptoms and Conservation Strategy thoughts Two case study

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Abstract

The granite of the two case study - Osireion (Abydos) and Medamud temple & site - (Luxor) these two selected examples which are the most evident and express examples of Buildings stone weathering of dampness in Egypt - that granite relate to Monumental red or pink coarse granite of Egypt (Variety 1) , assimilated in granite remains and elements in the two case study , from which a number of samples of deteriorated (weathered) granitic stones were obtained for examination (investigation) by Scanning Electron Microscopy (SEM) , polarizing Microscopy and were analyzed by X-ray diffraction (XRD) and X-ray florescence (XRF) in some samples , for studying the deterioration of these wetted monumental granites , its symptoms , its causes and conservation strategy thoughts .

For Deterioration Symptoms (the 1st theme of this paper) ; it addresses with Composing minerals transformation and alteration to clay minerals particularly potassium feldspar to clay minerals especially kaolinite which called kaolinization particularly on the surface , Granular Disintegration , Salts Efflorescence and Crypto-florescence(these two symptom are more naked in Osireion than in Medamud temple & site), exfoliation, fracturing (only in Osireion), Bio-

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Deterioration Effects (lichens , algae , plants) erroneous Restorations .

Also Deterioration Causes were addressed plus some general deterioration causes (the 2nd theme of this paper) such as ;Incurring to sun light radiation and variations of air temperature and relative humidity , Agricultural , Housing ,Urban trespasses and Man-made destruction , polluted Ground Water raised tables and lastly Conservation Strategy thoughts of the two case study were addressed starting Dealing with Deterioration Causes then Deterioration Symptoms (the 3rd theme of this paper) .

At the end it is preferred to formulize Results Discussion and Conclusion in form of a Table includes a comparing analysis in deterioration causes , symptoms and conservation Strategy thoughts of the wetted monumental granite of the two case study , to achieve lucidity , consociation arrangement and setout .

1. Introduction

Granites represent - in addition to limestone and Sandstones - the characteristic stone types had been used for the construction of the ancient Egyptian buildings (particularly in Upper Egypt) , since the 1st dynasty onwards , and although it is widely regarded as a strong (hard) [1] and very durable building stone - while its susceptibility to dissolution is very much less than that of calcareous stone , because decay of a multi-mineral material such as granite is a much more complex phenomenon than in single or double mineral stones such as limestone or sandstone, so the weathering rate of granitic rock is generally known to be very gradual, but once the process has begun, exfoliation

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(1) Granite – typically - is composed of 65% feldspar, 25 % quartz, and 10 % hornblende , where the hardness of feldspar and hornblende ranges from 5.0 to 6.5. and the hardness of quartz is 7.0. so , granite is considered as a hard rock

and peeling occurs very rapidly ([2]) so granite is not inattackable from deterioration and decay, suffering deterioration , through mineral alteration , Granular Disintegration , Salts Efflorescence and Crypto-florescence ([3]) , exfoliation , fracturing , Bio-Deterioration Effects .

deterioration of the rock is basically affected by the influence of water, in which solidified remains of weathering caused by the water-rock reaction, contracts in volume and

([2]) Drever, J.L. and Zobrist, J. Chemical weathering of silicate rocks as a function of elevation
in the southern Swiss, Alps, Geochemica et Cosmochemica Acta 56, 1992 , 3209–3216; LEE, C. H. , CHOI , S. W. and SUH , M. , Natural deterioration and conservation treatment of the granite standing Buddha of Daejosa Temple, Republic of Korea , Geotechnical and Geological Engineering 21 , 2003 , p. 63.

([3]) Trujillano , R. , Garcia-Talegbn J., Ifiigo , A. C., Vicente , M. A , . Rives V. and Molina , E., Short Communication , Removal of salts from granite by sepiolite , Applied Clay Science 9 , 1995, p. 459 ; Evans, IS., 1970. Salt crystallization and rock weathering: a review. Rev. Gtomorphol. Dynam., 19: 153-177. hiigo, A.C., Garcia-Taleg6n. J., Vicente, M.A., Vargas, M., Perez-Rodrfguez, J.L. and Molina, E., 1994. Granites employed in Avila-Spain. II. Petrophysical Characteristics. Mat. Construcci6n, 44: 23-37; Arnold, A. and Zehnder, K., 1985. Crystallization and habits of salt efflorescences on walls, part II: Condition of crystalliz.ation. 5th Int. Congr. Deterior. Conserv. Stone, Lausanne, pp: 269-277; Lazzarini, L. and Laurenzi Tabasso, M., 1986. I! Restauro della Pietra. CEDAM (Casa Editrice Dott Antonio Milani), Padova ; Vicente, M.A., Garcia-Taleg6n, J., Igigo, A.C., Rives. V. and Molina, E., 1993. Weathering mechanisms of silicated rocks in continental environments. In: M.-J. Ehiel (Editor), Proc. Int. RILEM/UNESCO Congr. On Conservation of Stone and Other Materials: Research-Industry-Media. Vol. 1. E and F N Spon, London, pp. 320-327 ; Puertas, F., 13lanco-Varela, M.T., Palomo. A., Ariiio, X., Ortega-Calvo, J.J. and Saiz-Jimenez, C., 1994. Characterization of mortars from the mosaics of Itfilica: causes of deterioration. In: V. Fassina, H. Ott and F. Zezza (Editors), The Conservation of Monuments in the Mediterranean Basin. La Photograph-Albignasego, Padova, pp. 577-,584.

progresses the weathering which changes the physical properties ([4])

The study of deterioration changes physical characteristics of granite starting with the surface which are vital for not only comprehension and recognition the symptoms consequently the causes but also for conservation strategy thoughts for monumental granite in ancient Egyptian buildings and Sites .

The symptoms of deterioration of monumental granite in ancient Egyptian buildings have been due to several causes in addition to wetness (dampness) .

These symptoms are - at the beginning - in form of individual superficial losses, then after repetition of deterioration the granite as a building stone begins in losing the aesthetic and functional performance of granite blocks of the elements of the ancient Egyptian buildings .

These granites of the two selected examples have being suffered stone weathering since their construction up till now , but recently throughout the last fifty years and because of several stranger contingent sources of deterioration these stones preservation has become an ever-increasing challenge particularly of moisture or water-related problems (fluid permeability plus water content) which represents the single most important deterioration cause , combined with inadequate sun exposure, and presence of mould in addition to other deterioration factor such as temperature variation , which make new microcracks and minerals alteration in the granite .

This paper addresses also with some thoughts of conservation study .

2. Materials

2.1 Osireion

for Archaeological and Architectural study Revision of Osireion . see : Appendix 1

([4]) LEE. C. H. .et.al. . 2003 . p.63..

Granitic materials in Osireion forms enormous ten pillars (piers) (square Monolithic columns) (up to 100 tons) devoid of decoration (Architecture of the 4^{th} Dynasty of the main chamber, on the central platform (island) seven Monoliths (its dimensions 4 × 2.38 × 2.13) (fig.1) , in two along the long side of the platform carry equally massive architraves and remains of roofing slabs (its dimensions 10 × 2.50 × 1.60 thick) and coping stones ([5]) .

The foundations of the temple are below the current level of the water table, which floods the bottom of the temple. The water level is 6.5 meters higher today than it was in the New Kingdom, but it is assumed that the foundations were intended to be underwater when it was built as a reminder of the rise of the gods from the primordial sea .

The entire temple is built below ground level; no other temple has ever been built like this. It is possible that the temple was built very early, on top of what was ground level then and the inundation of the Nile laid down layer after layer of silt that buried the temple to its existing depth. Some believe that it may predate the Egyptian dynasties entirely.

2.2 Medamud temple & site

for Archaeological and Architectural study Revision of Medamud temple & site, see : Appendix 2 (fig.2 , 22)

The majority building materials of temple complex are Nubian sandstone, limestone , mud brick and granite which remained in the gateway of Amenhotpe II and other elements such as remains of inscribed pillars and remains of unknown element (probably column base) ([6]) .

([5]) Badawy , A . , History of Egyptian Architecture , The Empire (The New Kingdom) , Vol. 3 , Berkeley and Los Angeles , 1968, p. 220 .

([6]) (in : Arabic) El-Derby , A. A. O.D. , The most Important Deterioration factors & Symptoms affecting Medamud temple and some conservation suggestions Journal of The faculty of Archaeology , South Valley University , Volume II , 2007 , pp. 481-482 .

2.3 Identification of granitoids ([7])

They are phanertic igneous rocks with gradational and similar compositions, include granite (two rock varieties) and Granodiorite (for details , see : Appendix 3) .

2.3.1 Identification of granite of the two case study

Granite of both Osireion and Medamud temple & site relate to Monumental Red or Pink Coarse Granite of Egypt (Variety 1) , see : Appendix 3 .

For Osireion see Identification of granite upon the whole : (figs. 3 E. G and 6) .

For Medamud temple and site see upon the whole : (figs. 11 A-F , 12 A, B . 13 A , B . 14 , 15)

3. Methods

3 .1. Osireion

A number of samples of deteriorated (weathered) granitic stones were obtained from the two case study where were taken from Osireion (from the deteriorated lower parts of the seven granite pillars of the main central hall of the structure) (there are three granodiorite pillars) to complete geochemical study using examination (investigation) by Scanning Electron Microscopy (SEM) , polarizing Microscopy and were analyzed by X-ray diffraction (XRD). for composition of granite of Osireion see : (figs. 3 and 6).

3 .2. Medamud temple and site

Also a number of deteriorated (weathered) granitic samples were taken from Medamud temple and site (where were

([7]) The most prominent group is a variety of rich pink to reddish-pink, coarse- grained, porphyric granite, well known as rose-granite and the best known quarries of ancient Egypt lie south of Aswan. where cover an area of about 4 - 5 km. Here. almost all varieties of granitoids used during the ancient Egyptian periods in . . see: Klemm . D . and Klemm . R . . The building stones of ancient Egypt - a gift of its geology . African Earth Sciences 33 . 2001.p. 635..

selected from the deteriorated granite and salty crust from the sanctuary area of the temple (Fig.10 a-d) , which has been subjected to complete geochemical study using examination (investigation) by Scanning Electron Microscopy (SEM) , polarizing Microscopy , were analyzed by X-ray diffraction (XRD) and X-ray florescence (XRF) .

The First Theme

4. Deterioration Symptoms of granite of the two case study

4.1 Osireion

Samples which were taken from the deteriorated lower parts of the seven granite pillars of the main central hall were investigated with Scanning electron microscopy showed the existence of quartz ,Orthoclase , and lamelliform mica , where showed some rhombic crystals of quartz (which is resistant of weathering) , also showed Shuttering of some quartz grains (Fig.3 E).

Also showed transformation and new formation (alteration) of feldspars to clay minerals (Fig.3 C,D,F, G) .

and showed sulphate salt crystals , microfracture , Exfoliation of Orthoclase , and mica (figs. 4,5, 6) , for deterioration symptoms of granite of Osireion , see : (figs. 3 - 9)

4.1.1 Composing minerals transformation and alteration to clay minerals

Identification of Unaltered Granite

Granite - which is composed - mainly - of quartz; feldspar (K-feldspar is mainly composed of orthoclase and microcline) and mica - begins in weathering with the transformations of feldspar and mica - which are less durable than quartz are subjected to - through chemical and mineralogical weathering - particularly rock surface mineral composition - to alteration to clay minerals such as illite and kaolinite - K-feldspar mostly shows large perthite, and strongly altered by sericite. this perthite appears with poikilitic texture with plagioclase) - whereas the hardness and durability of quartz are greater than other granite composing minerals , so the existence of illite and kaolinite is considered indication and evidence of deterioration , and via detecting the amount of these clay minerals we can identify weathering degree of granite ([8]).

The predominant clay minerals reflect the mineral composition of the protolith ([9]).

Also Biotite turned to chlorites, epidote and oxidized iron take after boundaries and cleavage , also changes to weathering products which are interstratified biotite - vermiculite and iron oxyhydroxides , whereas the plagioclases change to a microgranular material by pseudomorphic transformation ([10]) , clay minerals are formed in the gaps between minerals .

([8]) LEE, C. H. ; CHOI , S. W. and SUH , M. , Natural deterioration and conservation treatment of the granite standing Buddha of Daejosa Temple, Republic of Korea , Geotechnical and Geological Engineering 21 , 2003 , pp. 67–69; Banfield, J.F. and Eggleton, R.A. , Analytical transmission electron microscope studies of plagioclase, muscovite and K-feldspar weathering, Clays and Clay Minerals 38, 1990) , 77–89 ; Murphy, S.F., Brantley, S.L., Blum, A.E., White, A.F. and Dong, H. , Chemical weathering in tropical watershed, Luquillo mountains, Puerto Rico: II. Rate and mechanism of biotite weathering, Geochemica et Cosmochemica Acta 62, 1998 , 227–244 ; Nagano, T. and Nakashima, S., Study of colors and degrees of weathering of granitic rocks by visible diffuse reflectance spectroscopy, Geochemical Journal 23, 1989,75–83 .

([9]) such as kaolinite which originated from the weathering of feldspar, and chlorite from biotite,

See :Kirschbaum, A., Martı´nez, E., Pettinari, G., Herrero, S., , Weathering profiles in granites, Sierra Norte (Co´rdoba, Argentina) , Journal of South American Earth Sciences 19, 2005 , p. 479.

([10]) also it is noted that Smectite is formed inside the plagioclase crystals and probably originates from the muscovites contained in these crystals, this being supported by the microscopic study as well as by the increase in volume which is seen when muscovite is transformed into this swelling mineral displacing the iron oxide inclusions which the host mineral originally contained , also The possible evolution of the sericites included in the plagioclases, to smectites , The different evolution of biotite and muscovite which is seen in the weathering of this granite is to be expected due to smectite is formed more easily from dioctahedral micas, where the tetrahedral charge is lower, than from

Granite composing minerals were subjected to transformation and alteration of feldspar (K-feldspar is mainly composed of orthoclase and microcline)- because of its low durability - to clay minerals (kaolinite) (kaolinization) on the surface where seem in SEM micrographs in form of chips , plys and scales surrounding quartz grains - of rhombic crystals - which are more durable , also exhibits a crystal of pyrite (p)(iron sulphide) (fig .3 A, B) , also photographs display - with naked eye- clay minerals ; exfoliation (in addition salt efflorescence) (figs. 3 C, D), Even the quartz grains which of relative high durability have been predisposed to shuttering - as it is showed in SEM micrographs - as a result of moisture (wet) and variation of temperature plus endogenous deterioration causes (fig .3 D) , also thin sections of granite (cross sections) (cross Nichol) display the presence of quartz grains (q) , biotite (bi) , sphene as components of granite (variety 1), in addition to splits planes , where the kaolinite existed and occurred in these planes and at the boundary between quartz and feldspar

trioctahedral micas. Transformation of dioctahedral micas does not implies modifications in the tetrahedral layer, and may take place after a small decrease in the overall charge of the mineral. , - also biotite and amphiboles are transformed to chlorite, epidote and opaque iron minerals (magnetite and pyrite) due to chemical weathering., most secondary minerals such as kaolinite and sericite are changed by the hydration and hydrolysis of feldspar , see : Banfield, J.F. and Eggleton, R.A. ,op. cit.1990 , 77–89.it is proposed the term 'transformation smectite' for smectites derived from micas , also the K-feldspar is mainly composed of orthoclase and microcline, mostly showing large perthite, and strongly altered by sericite. this perthite appears with poikilitic texture with plagioclase . see : Taboada , T.and Garcia , C. , Smectite formation produced by weathering in a coarse granite saprolite in Galicia -NW Spain , Catena 35 , 1999 p. 281 ; Robert, M., 1973. The experimental transformation of mica towards smectite; relative importance of total charge and tetrahedral substitution. Clays Clay Miner. 21. 167–174; LEE, C. H.. CHOI , S. W. and SUH , M. , Natural deterioration and conservation treatment of the granite standing Buddha of Daejosa Temple. Republic of Korea . Geotechnical and Geological Engineering 21 . 2003 . pp. 67–69.

forming membranes on the surface resulting in exfoliation (figs.3 F, G) .

Generally in Osireion the alteration is more naked than in Medamud temple & site
probably due to the longer time of ageing and deterioration , more subjection to alternative cycles of wetting and drying and saline ground particularly with existence of wetness sources since structure construction promotion .

4.1.2 Exfoliation

Exfoliation appears in SEM micrographs and photographs as mentioned above (figs.3 B, C, D, F, G)

4.1.3 Fracturing

Fracturing - which has been a result of exposure to hydrothermal processes of varying intensity. - is one of the most notable symptoms produced by weathering ; iron oxides and silica subsequently filled these fractures, conferring a breccia -like character to the rock.

Fracturing leads and indicates to weathering in quartz and potassium (K) feldspar crystals .

Minute cracks occurred on the inside granite body - most of these show exfoliation characteristics caused by typical flakes that arose from such severe chemical weathering - these have become the moisture path giving rise to acceleration in chemical and mechanical weathering .

Regarding the composition of multi-mineral material and poorness of porosity of granite , so any small variation of temperature can cause thermal cracking because of the high thermal stresses arising from differential thermal expansion between multi-mineral grains produce new micro-cracks or open cracks that are already in existence ([11]) , forming the main fluid permeation pathway in granite because of poorness development of matrix porosity ([12]) , and the reaction between the fluid and the rock at the interface, as

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([11]) Takarli , M. , Prince , W., Siddique , S. ,Technical Note Damage in granite under heating/cooling cycles and water freeze–thaw condition, International Journal of Rock Mechanics & Mining Sciences 45 (2008) 1164–1175; Heard HC. Thermal expansion and inferred permeability of climax quartz monzonite to 300 1C and 27.6 MPa. Int J Rock Mech Min Sci., 1980;17:289–96 ; Wang HW, Heard HC. Prediction of elastic moduli via crack density in pressurized and thermally stressed rock. J Geophy Res 1985; 90(B12):342–50.

([12]) Takarli , M. ,et.al. (2008) 1164 ; Brace WF. Permeability of crystalline rocks: new in situ measurements.J Geophys Res 1984;89(B6):4327–30.

resulting in mineral solution and/or precipitation ([13]), where water reacts - in granite and other silicate rocks - with silicate to break the bond, provoking and causing obscure chemical effects on the physical properties and the microstructure of the rock (granite) ([14]) , any mineralogical change leads to the porous geometry network modification , which enhances or reduces fluid flow in the granite ([15]) , Takarli (2008) observed a slow decrease of the crack permeability
in granite because of the physical deposition of particles initially transported by the fluid ([16]).

SEM micrographs and photos of are - at the beginning - in form of individual superficial losses, then after repetition of deterioration the granite as a building stone begins in losing the aesthetic and functional performance such as a loss of sharpness on corners , edges , carved details and loss of smooth finished surface influencing the appearance of lower parts of granite pillars of central hall of Osireion , Pulverization, granular disintegration and minute cracks which, become the moisture path giving rise to acceleration in chemical and mechanical weathering and produce new micro-cracks or open cracks that are already in existence in

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([13]) Sausse J, Jacquot E, Fritz B, Leroy J, Lespinasse M. Evolution of crack permeability during fluidrock interaction: example of the Bre´zouard granite (Vosges, France). Tectonophysics 2001;336: 199–1024 ;Takarli , M. ,et.al. (2008) 1164–.

([14]) Lockner DA. Rock failure. In: Ahrens TJ, editor. Rock physics and phase relations, a handbook of physicals constants. Washington: American Geophysical Union; 1995. p. 127–47.;Takarli , M. ,et.al. (2008) 1164.

([15]) such as a possibility of complete or partial sealing of discontinuities due to the deposition of secondary minerals within a fracture or a crack wall leading to minimizing - impetuously - its aperture , see : Baudracco J. Etude expe´rimentale de l'alte´ration de roches par percolation. In: Colloque international sur la de´te´rioration des mate´riaux de construction. Lausanne, Suisse: Ecole Polytechnique de Lausanne; 1985. p. 177–85 ; Takarli , M. ,et.al. (2008) 1164

([16]) Takarli , M. ,et.al. (2008) 1164

granite in addition to a loss of sharpness on corners (figs. 3 E and 4 A, B, C).

The fracturing is present in Osireion and absent in Medamud temple & site probably due to the longer time of ageing, deterioration, more subjection to alternative cycles of wetting, drying and saline ground in Osireion particularly with existence of wetness sources since structure construction promotion.

For fracturing see upon the whole (figs. 3 E and 4 A, B, C)

4.1.4 Granular Disintegration

As a general there are more additional external deterioration factors affect the mineralogical and physical characteristics and participate in complexity of deterioration process, which pictures in decomposition, degradation and damage through mineral alteration, flaking, exfoliation – as mentioned before - and granular disintegration into grus in granite of Osireion, run over and revise (figs.4 A, B, C).

Generally in Osireion the Granular Disintegration is less naked than in Medamud temple & site probably due to that the latter is more exposed to the direct variations of temperatures& relative humidity and inadequate sun exposure, because of its normal ground level relatively Osireion and because of the semi-complete loss of walls that meant more exposing to direct solar radiation.

4.1.5 Salts Efflorescence and Crypto-florescence

Salts Efflorescence and Crypto-florescence is one of the most important processes which is responsible for stone deterioration and can lead to total destruction of the stones ([17]).

([17]) (Evans, 1970; Arnold and Zehnder, 1985; Lazzarini and Laurenzi Tabasso, 1986; Vicente and Brufau, 1986; Arnold and Zehnder, 1989; Vicente et al., 1993: Puertas et al., 1994 ; Trujillano, R., et.al, op. cit. , 1995, p. 459.

Although this phenomenon is not specific for given weather conditions, but has been observed under many different circumstances ([18]) , but all conditions of Osireion open up to salts efflorescence , crypto-florescence and aaccumulation and participated in destruction of the granites ([19]) .

SEM micrographs and photos exhibit Salts efflorescence and crypto-florescence

in the lower parts of granite pillars of the central hall of Osireion salts of sulphate (anhydrite $CaSo4$ or calcium sulphate) (figs.5A) .

X-ray diffraction patterns of granite of Osireion display the presence of anhydrite $CaSo4$ (3.1%), Halite NaCl (2.08%) ,Calcite $CaCo3$ (2.46%) and the compounds of granite of Osireion , as follow : Major compounds : Quartz $SiO2$ 53.56% , Minor compounds : (1) Microcline $KAlSi3O8$(18.74%) (2) Albite $NaALSi3O8$(20.63%) (figs.6).

Unfortunately, there are many sources of harmful salts are present in the site where

analysis of water samples of Osireion lead to hypothetical deduct of salt compounds are : sodium chloride halite NaCl ,

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([18]) Trujillano , R. , et.al., op. cit. , 1995, p. 459 .

([19]) Although of the porosity fresh granite is normally much less than one per cent with such materials, contact with an aggressive salt might be expected to have little or no effect, but in case of our two case study Osireion and Medamud - due to long time of suffering – occurred a significant damage , the variation of air temperature cause partial separation of some of the boundaries between the crystals of the rock , consequently increase in porosity and reduction in cohesive strength may then be sufficient to permit the occurrence of salt crystallization damage Porosities greater than normal of granite of Osireion where some of the feldspar has been converted to a clay mineral of the kaolin type , Where they altered the crystals of plagioclase feldspar into aggregates of kaolinite (kaolinization) , see : Honeyborne , D. B. , Weathering and Decay of Masonry , in : Conservation of Building and Decrative Stone , Vol. 1 , 1st edition , Butterworth-Heinmann , London , 1990 , p 154 .

sodium sulphate Na_2SO_4 thenardite, magnesium sulphate, calcium sulphate or magnesium bicarbonate and calcium bicarbonate.

and in another analysis of water samples of Osireion showed the dominant anions are in order : $HCO_3^- > SO_4^{--} > Cl^-$, and the dominant cations are in order : $(Na^+ + k^+) > Mg^{++} > Ca^{++}$ (0 it will be cleared forth coming.

and many ways in which they can be transferred into stones, and regarding the long exposure, much of the external surface may also show decay which it is in the form of crystallization , which in turn will primarily affect those surfaces .

we have to cite here that in Osireion the Salts Efflorescence and Crypto-florescence - the same as in granular Disintegration cleared above - is less naked than in Medamud temple & site probably due to that the latter is more exposed to the direct variations of temperatures& relative humidity and inadequate sun exposure , because of its normal ground level relatively Osireion and because of the semi-complete loss of walls that meant more exposing to direct solar radiation , For the Salts Efflorescence and Crypto-florescence in Osireion see upon the whole (figs. 3 A_G . 5 A –D . 6 . 7 A and 9 C) .

4.1.< Bio-Deterioration Effects :

It assimilate in micro organisms, where inorganic acids and porosity affect this process by inhabitation of bryophytes, lichens and plants, which accelerate mechanical weathering ([20])

([20]) LEE, C. H. ,et.al. , 2003 , p.69; Billings, W.D. Vegetation and plant growth as affected by chemically altered rocks in the western Great Basin, Ecology 31, 1950 , 62–74; Choi, S.W., Yun, Y.H., Suh, M., Kim, G.W. and Lee, C.H. Present states and preservation methods for stone cultural properties of the Chungnam Province, Research Report of the Chungnam Province, Korea, 425p , 1999.

4.1.6.1 Lichens ([21])

It grows on wetted surfaces, adheres to the stone surface change the appearance of that surface and appear in the form of blue or dark green spots and colored light green as a general, the two kinds grow on granite of Osireion are the green and the blue, penetrate to 2 cm deep by spore roots and hyphae, it can penetrate more than 1.5 cm deep into the granite surface, where shows spore roots and rhizoids in the gaps between rock forming minerals in foul and entangled form, also, in the gaps between rock forming minerals and particle boundaries, in form of fibers or bunch states ([22]).

it contribute to physical weathering by penetrating inter-mineral voids and mineral cleavage planes, disaggregating the rock and entrapping the loosened mineral grains in their thalh.

Significant chemical and mineralogical weathering also occurred, including depletion of

potassium from biotite, transformation of this mica into hydroxyaluminium vermiculite,

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([21]) Lichens are an intimate association of fungi and algae, in which the fungal hyphae seek the water and salts necessary for both organisms and the algal cells manufacture organic food for both of them by photosynthesis, Lichens granites (see : Lloyd, A.O. 'Progress in Studies of Deteriogenic Lichens', Proc. 3rd Int. Biodegrad Symp., (eds Sharpley, J.M. and Kaplan, A.M.) Applied Science, 395-402, 1976). The attack appears to be mainly on micas in the granites and to be chemical in nature (see : Bachmann, E. 'The Relation Between Silica Lichens and their Substratum', Berichte der Deutschen Botanischen Gesellschaft, 22, 101-104, 1904 .) However, there are also reasons to believe that the damage is often the result of surface stresses induced when the lichens shrink on drying after remaining wet for long periods (see : Fry, EJ. 'A Suggested Explanation of the Action of Lithophytic Lichens on Rock (Shale)', Annals of Botany, 38, 175-196, 1924 ; Honeyborne , D. B. Weathering and decay of masonry , in : J.Ashurst , J. , Dimes , F. G , Conservation of Building and Decorative Stone . Butterworth-Heinemann is an imprint of Elsevier . 2006 . p. 168 .

– such as Osireion -

([22]) LEE. C. H. .et.al. , 2003 , p.69,.

and new formation of whewellite and calcite in the lichen thalli , new formation of these calcium minerals on a calcium-poor rock such as granite is noteworthy ([23]).

The lichens *Ochrolechia parella* and *Tephromela atra* are contributed to the weathering of granite and their effects can be resumed in penetration in inter-mineral voids and mineral cleavage planes, thus contributing to disaggregation of the granite, and entrap the loosened mineral grains in their thalli (Physical weathering) , reduce grains of feldspar (plagioclase and orthoclase) to powders in some instances, deplete potassium – significantly -

lichen thalli contact biotite crystals in positions the lichen thalli contact biotite crystals (Chemical weathering and transformation and new formation of minerals such as transformation of the biotite into hydroxyaluminium-vermiculite as a result of Lichen-mediated depletion of the interlayer potassium in biotite , Nee formation of whewellite occurred in the thalli of *Ochrolechia parella,* which is unusual given the low calcium content of the granite substrate , New formation of calcium carbonate occurred in the thalli of *Tephromela atra.* ([24]) (fig.7 B and 9 C)

summarized symptoms on granite of Osireion :

(i) Rhizoid Penetration inside the stone

(ii) Forming gelatin film keeps moisture forming internal and external calcareous layers

and external silicic layer , expands and contract with wetness and dryness resulting in

Thallus leading minerals of granite and peeling ([25]).

([23]) LEE, C. H. ,et.al. , 2003 , p.63,.

([24]) Prieto , B., Silva . B., Rivas, T. , Wierzchosb, J.and Ascaso C. , Mineralogical Transformation and Neoformation in Granite Caused by the Lichens Tephromela atraand Ochrolechia parella , International Biodeteriortion & degradation. Vol. 40. No. 2-I , Elsewer Science Llmited , 1997 , p. 193 .

([25]) Pallecchi , P. , et al . Alteration of Stone Caused by Lichens Growth in Roman Theatre of Fiesche (Fireore) . VI inter. Cong. On

(iii) Respiration : $CO_2 + H_2O \Leftarrow\Rightarrow H + HCO_3 \Rightarrow 2H + CO_3$

(iv) Metabolites : acids , chelatons and oxidants : Gluconic Acid : CH2OH(CHOH)4 COOH - Oxalic Acid HOOCCOOH -Citric Acid HOOCCH2C(OH) (COOH) CH2 COOH.H2O -Salicylic Acid . C6H4(OH0 (COOH) – Tartaric Acid HOOC(CHOH)2 COOH.

(v) Extraction of Minerals Grains

(vi) Digestion of Mineral Substrate

(vii) Staining.

4.1.6.2 Algae ([26])

summarized symptoms on granite of Osireion :

(i) adheres to change the appearance of the granite surface.

(ii) Form gelatin film keeps moisture, expands and contract with wetness and dryness.

(iii) Exude acids such as acetic , carbonic , Oxalic , and sulphuric acids in addition to another weak acids which react with minerals of granite([27]) .

Deterioration and Conservation of Stone, Turin, Italy , 1988 ; Ollier , C D , Weathering , Longman Group , London , 1979 ..

([26]) It is a group of plants that includes the seaweeds Freshwater forms, particularly green algae,
readily colonize stonework that remains damp for sufficiently long periods of time. Because they
contain chlorophyll, they are able to manufacture most of the food they require by photosynthesis and, under the right conditions, they can multiply rapidly. The green appearance imparted to the stone is often considered to be disfiguring makes the point that, while the algae alone might not be
considered to be too unsightly, their appearance is made much worse in an urban environment when
dirt readily becomes entrapped in the algal mass. See : Bravery, A.F. 'Preservation in the Construction Industry', in Principles and Practice of Disinfection, Sterilisation and Preservation (eds Hugo, Aycliffe and Russell), Blackwell Scientific Publications, Oxford, 1980.

([27]) Feilden , M. B. , Conservation of Historic Building , Butter Worth Scientific , London , 1982 , p. 138

(iv) Respiration : CO2 + H2O < => H +HCO3 >=> 2H +CO3 .

(v) Metabolites : acids , chelatons and oxidants

Aspartic Acid HOOCCH2 CH(NH2) COOH - Glumatic Acid, HOOCC(CH2)2CH(NH2)COOH -Glycollic Acid HOOCCOH - Oxalic Acid HOOCCOOH -Citric Acid HOOCCH2C(OH) (COOH) CH2 COOH.H2O -Glucuronic Acid HOOC(CHOH)4CHO .

(vi) Digestion of Mineral Substrate

(vii) Staining

(viii)Penetrates the surface rarely but deteriorates it and pits it with converging pits.

(ix) Regarding the plenty and long time of their growth on surface led to peeling and separation of it ([28]) .

SEM Micrographs and photos of algae and lichens in granite of Osireion display algae in form of parallel stripes inter-granular of the rock , algae green and blue green growth on the ground and lower parts of pillars led to peeling and separation of it (figs.7 A,C,D and 9 C)

4.1.6.3 Plants

The growth of higher plants over and around monuments and archaeological buildings and sites is one of the deterioration problems in Egypt, where cause physical and chemical deterioration, beside affecting its aesthetics , where they widen of gaps between the adjoining blocks or increasing the dimensions of the cracks already present on the surface, increase load on the surface and ome cases may even threaten the stability of the whole structure ([29])

Also Plant roots widen the cleavages of rocks and minerals as they grow, thus participating in the physical weathering of

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([28]) Richardson . B.A. , Defects and Deterioration in Building , E.F.N. Spon ,London , 1990 , p. 122 ; Veloccia , M. L. , Conservation Problems of Mosaic in Situ , in : Mosaics , No. 1 , 1977 , p. 44 .

([29]) Mishr. A.K., Jain , K. K., Garg, K.L. , Role of higher plants in the deterioration of historic Buildings , he Science of the Total Environment 167 ,1995, pp. 375-392.

rocks. The root pressure applied by plants on soils or stones is about 1–1.5MPa which accelerates the mechanical weathering of rocks. Also, there are extremely acidic secretions at the ends of plant roots which give rise to strong chemical weathering that corrode the rocks. The respiration and evaporation process of plants also play an important role on chemical weathering ([30])

Phragmites australis (Gramineae) has been growing in the stranger soil in the channels of the central hall of Osireion causing deterioration and damage stones (its stems reached) 2 meters , and its rhizomes about 3 meters – where its thickening increase the pressure on the surrounding areas of the masonry(Biophysical deterioration) , also rhizomes through its tips and/or the acidic and chelating capabilities of the various root exudates ([31]), the acidic plant root secretions stimulate rock weathering ([32])(fig. 8 A, B, C and 19 E) , these roots also provide channels through weathered material for the circulation of water and air and add carbon dioxide to the soil, air and water, increasing the production of carbonic acid which lowers the pH of circulating water, thereby giving it increased power to dissolve minerals, the weathering begins with the attack of H+ ions on silicate (of

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([30]) Brooks, R.R. (1972) Geobotany and biogeochemistry in mineral exploration, Harper and Row, New York, 290p ; Billings, W.D. (1950) Vegetation and plant growth as affected by chemically altered rocks in the western Great Basin, Ecology 31, 62–74; ;LEE, C. H. ,et.al. , 2003 , p.69,.

([31]) Caneva, G. and A. Altieri, 1988. Biochemical mechanisms of stone weathering induced by plant growth. In: Proceedings of the VIth International Congress on Deterioration and Conservation of Stone, Torun, pp. 32-44 ; Mishr, A.K., Jain , K. K., Garg, K.L. ,op.cit. ,1995, pp. 380-382.

([32]) Carroll, D., 1970. Rock Weathering. Plenum, New York.Crafts, AS., 1975. Modern Weed Control. University CaliforniaPress, Berkeley, CA.;.Mishr, A.K., Jain , K. K., Garg, K.L. ,op.cit. ,1995, pp. 380-382.

granite) ([33])in the substrate and is dependent upon the concentration of H+ ions surrounding the root , silicate minerals may be weathered by the polarizing effect of H+ ions on the oxygen atom and a mass exchange action ([34]) , the transformation of biotite to vermiculite through oxidation of iron in the biotite and release of potassium is aided by plant roots ([35]) The results obtained by Boyle et al. (1974) also confirmed the release of potassium and other ions because of the action of the roots ([36]) .. Once the break up process starts, it is strongly accelerated by the action of carbonic acid, humic acid and various other complex organic acids which are produced from the organic remains ([37]).

also there are man-made destruction representing in an intentional cutting of the blocks of the ceiling and architraves (fig. 9 A, B, C) .

([33]) Williams, D.E. and N.T. Coleman, 1950. Cation exchange properties of plant root surfaces. Plant Soil, 2: 243-256 ; Keller. N.D. and A.F. Frederickson, 1952. The role of plants and colloid acids in the mechanism of weathering. Am. J.Sci., 250: 594-608..;.Mishr, A.K., Jain , K. K., Garg, K.L. ,op.cit. ,1995, pp. 380-382.
([34]) Caneva, G. and A. Altieri, 1988, op. cit., pp. 32-44 ; Mishr, A.K., Jain , K. K.. Garg, K.L. ,op.cit. ,1995, pp. 380-382.
([35]) Mortland, M.M., K. Lawton and G. Uehara, 1956. Alteration of biotite to vermiculite by plant growth. Soil Sci., 82:477-481. ; Mishr, A.K., 'ain , K. K., Garg, K.L. ,op.cit. ,1995, pp. 380-382.
([36])Boyle, J.R., G.K. Voigt and B.L. Sawhney, 1974. Chemical weathering of biotite by organic acids. Soil Sci., 117: 42-45 ; Mishr, A.K., Jain , K. K., Garg, K.L. ,op.cit. ,1995, pp. 380-382.
([37])Winkler, E.M., 1975. Stone decay by plants and animals. In: Stone Properties, Durabilities in Man's Environment ,Springer, New York, pp. 154-164.; Jain, K.K., V.K Saxena and T. Singh, 1991. Studies on the effect of biogenic acids on stone materials. In: O.P. Agrawal, and S. Dhawan (Eds.), Biodeterioration of Cultural Property. Macmillan, New Delhi, India, pp. 240-248; Jain, K.K., A.K. Mishra and T. Singh. 1993. Biodeterioration of stone: a review of mechanisms involved. In: K.L. Garg , K.G. Mukerji and N. Garg (Eds.), Recent Advances in Biodeterioration and Biodegradation, Vol. 1. Naya Prokash.Calcutta, pp. 323-354. ; Mishr, A.K., Jain , K. K., Garg. K.L. ,op.cit. ,1995, pp. 380-382.

4.2 Medamud temple & site

The temple of Medamud & site lies on the Holocene alluvium sediments of the Nile , also is surrounded by recent cultivation and urban areas which assist much in the deterioration and damage. Granite exfoliation is very common as a result of destructive effect of the salts crusts intrusions on the some granitic masses of the temple , Salt marshes and crusts are very dominant and occupying the floor of the temple as well as the sanctuary which partially to completely destroyed by salt and the granite base of the sanctuary ([38]) has affected much by salt encrustation and show obliteration and decay by salt destruction, decay and alteration of the feldspar and mica minerals to clay and partially weathering of quartz mineral and development of salts along cleavage and crystal boundaries are very common in the pegmatitic types of the studied granite (fig.10 a-d) , plus lichens and algae. .

The granite of the temple is subjected to intensive investigation include petrography, geochemistry and mineralogy , A number granitic samples were selected from the weathered granite and salty crust from the sanctuary area of the temple to complete geochemical study using XRD, XRF, petrography and SEM techniques.

The granite samples were chosen for this study from the sanctuary area of the temple (fig.10 a-d).

The samples show high obliteration and weathering by salt and algae .

The granite masses are partially to completely alter to clay materials of kaolinite and salt minerals especially those

([38]) The stromatolitic sanctuary areas that developed by action of capillary water mechanism as well as the water run -off and bad irrigation, fertilizers and past flooding seasons in ancient time before Aswan Dam left its finger prints on the weathering of the different granites masses of the temple .

buried in the accumulation of soil , salts and moisture at the east of the temple (fig.10 a and 17).

. Some of the granite masses lies on the pavement are partially altered and disintegrated. It is obvious clear that the Sanctuary part of The Medamud temple showing severe deterioration by salt as a result of polluted wetness development with white color which is formed of different forms and composition of salt types plus mineral alteration and bio-deterioration .

Decay can occur by; alteration of minerals, break- down of those mineral phases which undergo hydrolysis action of soluble salt in pores and fractures. Water and soluble salt movement through the stone is of primary importance in all these mechanisms. Mortar joints, limestone are particularly potential source of soluble salts.

Identification of Unaltered Granite

The different varieties of granites were identified in the investigated Medamud Temple - Petrography of studied granite - are composed of quartz, microcline, sodium plagioclase, muscovite and biotite.

They are pink granite (variety 1) and biotite tonalities and subordinate granodiorite type.

Pink Granites - as mentioned before - are coarse to fine-grained and consist of quartz, microcline K-feldspar, plagioclase, muscovite and biotite and less frequent pyroxene (Fig. 3a). Apatite and zircon are accessories , for Identification of granite of Medamud , see upon the whole : (fig. 11 A-F . 12 A-B and 13 A-B. 14 and15).

Pegmatitic biotite tonalites are coarse grained rock and formed of parallel alignment of biotite, quartz, amphibole and plagioclase. Plagioclase porphyrocrysts occur in fine-grained matrix consisting of plagioclase, biotite and quartz (fig.11 b). The porphyrocrysts are characterized by strongly serecitized cores and comprise two varieties: dark and light. The dark tonalite is rich in hornblende, apatite .

Also the XRD analysis shows the presence of microcline, quartz, biotite, albite of the original composition of the granite beside the deterioration products (figs.12 , 13) .

4.2.1 Composing minerals transformation and alteration to clay minerals

Petrography studied samples display kaolinite on the vicinity of feldspars and biotite (Figs 11 c-f) where is replacing k-feldspar minerals , in addition to other clay minerals such as sericite a result of alternative cycles of wetting and drying and saline ground water which dominants the site :

also kaolinite minerals associate microbial algae or most Na retains in the carbonate phase in surface soils as trona and thenardite or (Figs. 11 ,14 , 15 and 17) .

for alteration to clay minerals upon the whole see : (Figs. 11 c-f , 14 , 15 and 17) .

Generally in Medamud temple & site the alteration is less naked than in Osireion probably due to the shorter time of ageing and deterioration , less subjection to alternative cycles of wetting and drying . and saline ground particularly with existence of wetness sources since short time (the beginning of the 20th centaury)

4.2.2 Exfoliation

The mineralogical composition, petrophysical characteristics and petrography investigation revealed that all types of granite were already partially or completely weathered. where petrography studied samples display the cleavage plane of the biotite crystals, amphiboles and altered feldspar are dissected by trona and thenardite minerals. the microcline and plagioclase are completely altered to sericite and kaolinite which were identified by means of X-ray diffraction (Fig.12, 13).

The deteriorated granite petrographical study shows development of thenardite, trona ,rock salt and floating texture which is very common due severe alteration by rock salt and trona. , while quartz forming floating textures due to chemical weathering of feldspar. Development of prismatic and acicular crystals of thenardite and trona within the exfoliated granite are restricted in the sanctuary area and close to the lower parts of the granite that immersed on the sanctuary area soil of the temple (Fig.11) .

4.2.3 Granular Disintegration

Granular disintegration is the most important deterioration in Medamud temple & site and associated with another deterioration symptoms (Fig.18 A-B).

Generally the Granular Disintegration is more naked in Medamud temple & site than in Osireion probably due to that the latter is more exposed to the direct variations of temperatures& relative humidity and inadequate sun exposure , because of its normal ground level relatively Osireion and because of the semi-complete loss of walls that meant more exposing to direct solar radiation , see : (Figs.19 E , 20A-B , 21 , 22and 23) .

4.2.4 Salts Efflorescence and Crypto-florescence (An Acute case)

The XRD study of the salty granite revealed the recognition of multi salts of different composition include: trona, halite, polyhalite, thenardite, and burkalite (Fig.12. 13) where the identiried salt minerals that include:

Trona is sodium carbonate mineral that form in non-marine evaporite deposits. Trona is probably the most common and well known of these minerals. Trona gets its name from a discarded Arabic word for native salt, "tron", which is derived from the word "natrun".

Halite is the mineral form of sodium chloride, NaCl, commonly known as rock salt. Halite forms isometric crystals. the mineral is typically colorless or white.

Thenardite is an anhydrous sodium sulfate mineral, Na_2SO_4 which occurs in arid evaporite environments. Thenardite crystallizes in the orthorhombic system and often forms yellowish, reddish to grey white prismatic crystals although usually in massive crust deposits. Thenardite samples will gradually absorb water and convert to the mineral mirabilite, $Na_2SO_4 \cdot 10H_2O$.

Polyhalite is an evaporite mineral, a hydrated sulfate of potassium, calcium and magnesium with formula: $K_2Ca_2Mg(SO_4)_4 \cdot 2(H_2O)$. Polyhalite crystallizes in the triclinic system although crystals are very rare. The normal habit is massive to fibrous.

Mirabilite is a soft hydrous sodium sulphate mineral; it is vitreous, colorless and white monoclinic mineral. Always present in sanctuary area and playa environment associating to thenardite, trona and rock salt. It is unstable and quickly dehydrates in dry air and turning into thenardite white powder which are common in the temple.

Burkeite is a double sulfate and carbonate of sodium, $Na_2SO_4 . Na_2CO_4$

For XRF analysis, four altered salty granite samples were analyzed by XRF techniques in order to know the chemical characteristics of the deteriorated granitic rock.

The analysis is included in (table 1) the chemical results of the salty altered granite samples show different composition in most chemical elements. Ti and Fe, Na oxides are more or less constant in the studied samples while other elements i.e. Al, Si, and K are varied.

Anions of Cl, Na, and S are very dominant and may represent the composition of halite, thenardite and trona

The increase in Ca ratio cation may indicate the structure of gypsum or calcite minerals and may be added to the system from the alteration of limestone bodies or mortars of the temple while S could be attributed to the used fertilizers in the adjacent agricultural areas. The fluctuations in Cl anions reflect in general evaporative regime with different level far or close from water ponds and sanctuary area within the compass of the temple.

For SEM several minerals of soluble salts were identified by SEM in deteriorated stones of the granite in Medamud temple, namely halite (NaCl), gypsum ($CaSO_4 \cdot 2H_2O$), calcite ($CaCO_3$), and thenardite (NaNO3). Gypsum was identified by XRD in four of the four samples analyzed. The SEM photographs are included in (Figs. 14 , 15).

Table (1): XRF Chemical analysis of selected salt crust developed on granite of Medamud

Element	A	B	C	D
Na	12.16	12.36	4.72	11.76
Al	2.20	1.84	7.01	5.09
Si	8.70	6.46	32.77	20.81
S	9.62	14.29	6.54	3.14
Cl	35.90	47.32	18.29	ND
K	12.20	5.79	20.30	12.38
Ca	12.75	7.53	6.88	12.23
Ti	0.95	0.67	0.58	0.98
Fe	5.52	3.73	0.58	5.31

Halite appears as cubic crystals, cubic+octahedral crystals, euhedral crystals, and dendritic aggregates as well as partially dissolved subhedral crystals, partially dissolved anhedral crystals and very minute anhedral crystals

Most Na retains in the carbonate phase in surface soils as tror^ and thenardite associating microbial algae or kaolinite minerals (Figs. 14 , 15). The skeletal single crystal shown in Fig. 6a-c exemplifies hollow crystals of euhedral thenardite crystallites in a growth mode associating algal filamentous structure and prismatic crystals of thenardite with small halite hopper crystals. Hopper structure of halite intergrown with stubby, twinned gypsum and white thenardite coatings. A rosette arrangement of a cluster of trona crystals of radiating arrangement associated with thenardite and white mirabilite are commonly exist (Fig.6d-f). Association of trona with quartz is quite common in these soils as corroded anhedral quartz crystal associated with radiated skeletal crystals of thenardite.

Exfoliation of granite affected much by the crystallization power of gypsum and other salt minerals (Fig. 15a-f). Many of the identified salts are either intercalated the altered exfoliated granitic particles or expanded within the fractures of the granite as well as the cleavage planes of the mica minerals or the cavernous forms that resulted from normal corrosion of iron oxides within the original granites.

Occurrence of such skeletal crystals is important because they represent growth that follows the reverse pattern of normal growth (Alena et al., 1990). Hollow crystals of trona were reported in the work of Jones et al. (1996). So the assemblage of trona and thermonatrite with minor calcite is important for this soil behavior.

The morphology of thenardite that formed under conditions of subaerial exposure has been reported for a number of sites. Thenardite occurrences are most commonly observed to consist of clusters of elongated prismatic, Driessen and Schoorl et al., 2000. Thenardite can also occur as crystals with a bipyramidal habit, Gore et al., 2000.

The present morphology of thenardite throughout the profiles has at least partly developed during the redistribution of salts. However, the thenardite coatings that consist of large single crystals or smaller subhedral crystals will mainly have developed during the initial period of salt enrichment. Thenardite occurrences and soil microstructure can therefore well have remained unchanged since the time when the coatings were formed.

The common habits of the minerals of soluble salts in the porous granite are prisms, acicular and hair-like crystals without any visible relation to their characteristic crystal forms. The crystallization of the minerals of soluble salts in the porous network of the stones causes most part of the deteriorations. The more soluble and/or hygroscopic these minerals are the more damaging they potentially are. The higher the crystallization force of the mineral, the higher the destruction on the stone. When the crystallization forces of the minerals of soluble salts are higher than the tensile strength of the rock, new cracks are formed, the previous fissures become wider and longer and porosity increases. Salts in porous building materials exist as aqueous solutions or crystallized in the pores or fissures and on the surface. They are strongly connected with water migration in walls, becoming concentrated where water moves in one direction and evaporates such as the upper zone of rising damp, laterally to water running along the surface and evaporates after percolating through stones. In areas where salt solutions evaporate as for instance the zones submitted to the capillary rise of soluble solutions from the ground, concentration gradients are developed. The different solutes precipitate at different places as the solution moves further on. The more soluble the salts, the more hygroscopic they tend to be. Thus, the precipitation depends greatly on the relative humidity of the surrounding atmosphere. Therefore, the crystalline phases are deposited in sequences according to their respective solubility. The least soluble and hygroscopic salts such as the carbonates and sulphates precipitate in the lower zones of rising damp while the most soluble and hygroscopic salts such as the chlorides and nitrates precipitate in the higher areas of rising damp.

Crystallization of salts in pores can occur due to changes in temperature or evaporation of water from the solution. Crys...llization will occur from the surface of the stone is greater than the rate of water supply from the interior by capillary action. Salts crystallize out at a depth into the stone determined by the pore characteristics, ambient relative humidity and the chemical composition of the solutions. Crystallization of salts from supersaturated solutions can generate sufficient energy to overcome the compressive strength of stone. Where there are lines of weakness such as micro fractures, the energy required is less. Crystallization of salts can thus lead to increases in porosity and can enlarge pre-existing fractures. Hydration pressure is developed when a salt hydrates from one state to another under the influence of temperature and relative humidity. Differential thermal expansion occurs where a salt increases in volume at a significantly greater rate than the constituents of the stone.

The studied granite is affected by granular disintegration, plates, flakes and biological colonization. Granular disintegration is the dominant deterioration and is associated with capillary rise of salt solutions from the ground in sanctuary area environment remaining for long periods of time wetted but not subjected to run-off.

4.2.4.1 Discussion of the Acute case of Salts Efflorescence and Crypto-florescence in Medamud temple & site

The crystallization of the pure salts from a multi-component salt mixture system starts at a lower relative humidity than in the single salt solutions. Actually, highly soluble minerals as halite and trona crystallize in the same areas where minerals of much lesser solubility such as calcite and gypsum crystallize both in the lower and higher areas of rising damp. Granular disintegration is the most important deterioration in Medamud temple & site and associated with the crystallization of very soluble salts specially halite, trona and thenardite. Consequently, the fluctuation in the local groundwater level of the area of the temple due to seasonal irrigation, evapotranspiration and water seepages led to water becomes enriched in these soluble ions and subsequently through the deteriorated and/or open joints.

As reported by Eugster (1971) and Eugster and Jones (1979), the mineral trona alone can be responsible for the pH of a solution above 9 because of the presence of necessary concentration of the carbonate ions. The high solubility of trona (Monnin et al.1984; Given, 1985) contributes toward most of the alkaline properties of the soil. Two conditions must be satisfied to produce extensive trona formation: one is the existence of a closed basin and the other is sufficient perennial inflow to allow solutes necessary to form a salty lake/deposit (Eugster, 1971). At the end of the irrigation period, fast evaporation is very characteristics for this part of Upper Egypt that leads to drying, and trona precipitating during the drying process. Crystallization of sodium carbonates and bicarbonates from natural waters is controlled by dissolved CO_2 and temperature (Fig. 16).

The kinetic effects, especially those governing equilibration between dissolved and atmospheric CO_2, are extremely important in determining the final form of the carbonates (Eugster, 1971; Whittig et al., 1982). At higher temperatures, natron is replaced by thenardite (Fig. 16). Evaporative concentrations under conditions of equilibrium with atmospheric CO_2 will follow path AB in Fig. 8. At B, trona will begin to crystallize.

Crystallization of trona together with further evaporation should result in the solution composition moving towards C.

4.2.4.2 conclusion of the Acute case of Salts Efflorescence and Crypto-florescence in Medamud temple & site

In conclusion, trona alone or possibly a mixture of trona and thenardite, which crystallize as a surface efflorescence on flood plains, represent the end product of evaporative concentration of seasonal flood waters mixed with the local groundwater drawn up within the soils by capillary action or the splashed water a result of seepage or from the bad irrigation system in the area. In the process of evaporation, calcite precipitation occurs below the surface, whereas trona and thermonatrite form on the surface.

Crystallization of salts raises the pH of near-surface soil to 10.5 which assist much in silicate weathering and processes of desilisication and pulverization of the granite.

The crystallization of the minerals of soluble salts in the porous network of the granites applied Medamud temple & site is the major cause of stone decay.

The weathered granitic stones used in the temple are characterized by a porous network essentially composed by very thin and very well interconnected fissures that propitiated the fast rising damp of the soluble solutions, the fast capillary transfer of rain water, fast evaporation kinetics, humidity and, ultimately, the damage originated by successive cycles of crystallization, dissolution and crystallization/deliquescence of the minerals of soluble salts.

For photos , investigations , analysis of salt crystallizations Efflorescence and Crypto-florescence in Medamud temple & site , see : (Figs. 10 -16 , 19E and 23).

Generally in Medamud temple & site the Salts Efflorescence and Crypto-florescence - the same as in granular Disintegration - is less naked than in Osireion probably due to that the latter is less exposed to the direct variations of temperatures& relative humidity and inadequate sun exposure , because of its abnormal ground level and because of the semi-relatively existence of walls that meant less exposing to direct solar radiation .

For the Salts Efflorescence and Crypto-florescence in Medamud temple & site see upon the whole (Figs. 10 A- D , 11 A-F , 12 A, B , 13 A , B , 14 , 15 , 16 , 19E and 23) .

4.2.5 Bio-Deterioration Effects :

SEM micrograph shows growth mode of microbial algae (filamentous structure) associating Euhedral Thenardite crystallites (Figs. 14A).

4.2.5.1 Plants

Imperata cylindrica ، Alhagi maurorum ، Tamarix nilotica and Phragmites australis , plus some trees and seedlings has been growing in soil , in , inside and around the remains of the temple and the site of Medamud causing deterioration and damage stones, where exude acidic excretion particularly at the ends of plant roots where give rise to strong chemical weathering (in addition to respiration and evaporation process of plants) , corrode , deteriorate and damage components of stone . cause accumulation of soluble salts inside stones , Plant roots and stems penetrate and widen the joints , cleavages, fissures and cracks of stones (the gap between these cracks and fissures may be increased further on account of the increase in the volume of the roots and root tip pressure), accelerates the mechanical weathering of granite, sometimes splits the blocks either horizontally or vertically (Figs. 19 and 20 A).

4.2.5 Tort, Inexactitude, Inaccurate and erroneous Restorations Portland cement mortar (Man-made faults) (restoration

There are a part of deteriorated granitic semi-pillar in Medamud temple site - which was joined and cemented with a part of relative good preserved granitic engraved inscribed pillar surface (probably there is not rapport or affinity between the two parts)- and partially compensated with Portland cement and was erected in wrong position (Figs. 24)

So there are three faults in this granitic element restoration : (a) its two parts were attached - probably - without original relation . (b) partially compensated with Portland cement .(c) was mislocated in wrong position , and for the negative of this partial compensation are.:

(i) applied without any art , skill or sensation resulting in incompatible compensation with construction of the pillar , in addition to its color (from faint to dark grey) , its texture (slick and satiny) are incongruous with the color , texture and appearance of granite .

(ii) its irreversibility does not enable conservators to remove its damage and unsightly , also its impermeability and low porosity seal , keep moisture and blockage the evaporation.

(iii) its shrinkage during and after setting resulting in cracks which in turn allow entering moisture and its impermeability prevent getting it out easily , also generates soluble salts which in turn deteriorates granitic pillar particularly engraved inscribed surface .

The Second Theme

5. Deterioration Causes of granite of the two case study

5.1 Cause of Composing minerals transformation and alteration to clay minerals

5.1.1 Endogenous cause : Regarding to the feldspars in granite are Xenoliths which magma had picked up from surrounding silt rocks , then were subjected to abnormal conditions of pressure and temperature , so they have had low durability and resistance against deterioration causes .

5.1.2 Exogenous cause : Incurring to alternative cycles of wetting and drying and saline ground water which stamp the sites of two case study : Osireion and Medamud .

the combined reactions of hydration, hydrolysis (regarding wetness throughout the year on the ground and the lower parts of the granite pillars of the central hall and a high level table of ground water in temple &site of Medamud) combined with inadequate sun exposure (due to complete loss of the covering ceiling of the central hall over the granitic pillars and architraves , and the smashup of temple of Medamud , which are open up to sun light) (Figs.18 A , B) .

in addition to variation of air temperature and relative humidity ([39]).

5.2 Cause of Exfoliation

Exfoliation occurs as a result of mineral alteration in granite to clay minerals , where

([39]) (in : Arabic) El-Derby , A. A.O.D. , The Architectural Conservation and Maintenance of Some Ancient Egyptian Temples in Upper Egypt , An Analytical Study of Deterioration factors & Symptoms and The Strategy for Treatment , with Application on Selected Case Study , Archaeology Conservation Department , Faculty of Archaeology , Cairo University , 2007 , pp . 518 – 524 ; (in : Arabic) El-Derby . A. A. O.D. , op.cit., pp. 350 -355.

the kaolinite - which occurs at the boundary between quartz and feldspar - and formed membranes on the surface of orthoclase and plagioclase gives rise to exfoliation, also the zygotes of smectite, kaolinite and sericite grown into euhedral habits can be observed on the plagioclase surface, and the non-crystallized sericite particles form a membrane ([40]).

5.3 Cause of Fracturing

Fracturing - which has been a result of exposure to hydrothermal processes of varying intensity - as mentioned before - and leads and indicates to weathering in quartz and potassium (K) feldspar crystals .

Also in addition to variation of air temperature and relative humidity.

5.4 Cause of Granular Disintegration

Due to variations of temperatures& relative humidity and raising of ground water tables , combined with inadequate sun exposure , **see :** (Figs.19 E . 20A-B . 21 , 22and 23) .

General deterioration Causes

5.5 Incurring to sun light radiation and variations of air temperature and relative humidity

Regarding to lying the two case study in arid climate of upper Egypt due to poverty of plant coverage , poverty of clouds , descent of relative humidity and desert besiege , there are a big variation in air temperature daily and seasonally particularly the middle of upper Egypt – where the two case study lie because of distance away from nautical and astronomical influences .

The same for relative humidity , **see :** (Figs.19 E . 20A-B . 21 , 22and 23) for more details see : (in : Arabic) El-Derby ,

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([40]) Taboada , T., et.al . op. cit., 1999 p. 281.

A. A.O.D. , 2007 . and (in : Arabic) El-Derby , A. A. O.D. 2005.

5.5 Agricultural , Housing ,Urban trespasses and Man-made destruction

5.5.1 Osireion

In addition to the general Man-made destruction of granite in Osireion such as agricultural , reclamation , housing and urban trespasses, consequently leads to raising of ground water tables , Bio-Deterioration Effects , Salts Efflorescence and Crypto-florescence , neglecting , monuments plunder and robbery and reusing (Fig.21) .

There is some evidences of intentional cutting the blocks of the ceiling and architraves , probably for reusing or because of religion contest (as a symbolism of heathen or pagan) revise (Fig.20 A) run over and revise (figs. 9 A, B, C).

5.5.2 Medamud temple & site

Resembling Osireion the same such as agricultural , housing and urban trespasses (there is no reclamation activities) , and the same complications and consequents which leads to raising of ground water tables , Bio-Deterioration Effects , Salts Efflorescence and Crypto-florescence , neglecting , monuments plunder and robbery and reusing (fig. 22).

5.6 Ground Water raised tables

5.6.1 Osireion

The studies show that the aquifer beneath Osireion site is prenile sand , and presence of two water levels : the static - artesian which is below the ground of the central hall about twenty cm. where it has raised more than the original designed level of structure founder

(fig.21 A , B) due to several causes :

a- as a result of elevated ground water in the Nile silts and gravels underlying the structure and its ambience b- increasing the ground water tables after storage of the Nile water behind the High dam about 7 km south Aswan which started 1964 locally in Aswan district and

c- through construction of the High dam which started since from 1959 till 1969 ,

and locally appeared in Abydos since 1980 ([41]).

d- The general direction of ground water - which differs in its speed and direction from region to another – of the centre of Nile valley regions and around the river Nile generally - is from south to north , and from east to west in the west bank of the Nile, and from east to west in the east bank of the Nile , where move from the higher level topographically where the Eocene plateau , Scarps , Terraces and Sand Dunes & sand Drifts to the lower level topographically where the Nile valley , so in general ground water movement in Osireion compass is from east to west .

e- according to brooks et.al 1993 and Abdel Moneim 1999 ([42]) ground water flows from east to west , in contrary of the latter studies which indicates to inclination and flowing it from east to west (probably for local topographic conditions) .

f Where ground water are flowing from west to east – converting its trajectory from south – after impinging to Eocene calcareous impermeable projection which lying at the west of Abydos between the two bays lying to west of both Abydos and Nag Hammadi -

([41]) Abdel Moneim , A. A. , Ground Water Studies in and around Abydos Temples , El-Baliana, Sohag, Egypt ,Annals Geol. Surv. Egypt , vol. XXII ,1999 , p. 357 .

([42]) Brooks J. B. , and Issawi B . , Ground Water in Abydos Area , Egypt . proc. Inter. Conf. 30 Years Cooper , Geol. Surv. Egypt .p 303 ; ; Abdel Moneim , A. A. , Ground Water Studies in and around Abydos Temples , El-Baliana, Sohag, Egypt ,Annals Geol. Surv. Egypt , vol. XXII .1999 , pp .357-368 and turn to east direction to pass by Osireion leading to raise of ground water level continuously([43]) .

The other level is the free main water level which lies on depth about 3meters between Osireion and the cultivated lands to the east and increase wherever trending to west to reach beneath the reclaimed land to about 27 meters .

This free level due mainly to irrigation and drainage along water east - north- east in inflowing amount about 508.64 m 3 / d ,where the raised ground water below Osireion due to :

a- converting the irrigation system from basin once a year throughout the Nile inundation before 1964 to perennial- minimum three crops- all over the year after 1964, either in old cultivated to the east and south east or new reclaimed lands to the west and north west , with using overflow irrigation type .

b- infiltrated water from old damaged pipes of drinking water plus excess of using water by the villagers .

c- the sewage waste water coming from the primitive trenches drainage system coming from random growing housing compounds - lying on a higher level - surrounding the context of Osireion , and it was deuced from drying of sewage trenches of the housing after pumping of water from Osireion . and before pumping it had been drained two times per month at least . and analysis of water sample from Osireion showed that it mixed with sewage water drainage ([44])(fig.21 A , B)

Resulting in raising the level of the free main water table to override the level of the ground of island of the central hall with about 120 cm. (fig.21 A . B) .

d- the infiltrated water from floor beds of unlined and uncovered channels and drains to east of Osireion .

([43]) Abdel Moneim , A. A. ,op. cit. ,1999 , pp .357-368

([44]) El Khedr . M., op. cit.. 1997. p. 132.

e- the infiltrated water from deep aquifers through fractures, fissures and faults lying to west of Abydos

f- a local movement of ground water from west to east – regarding to the new reclaimed lands to the west and north west .

g- falling the bottom of Osireion island to its close surrounding by about 18 meters , so flooding of water increase inside it .

h- There are special religion reason are related of design of Osireion for representing everlasting ocean , it had been constructed in an excavation as subterranean structure on an ancient well and connected to pipes supplying it with more water coming from the east side beneath the Seti I temple ([45]) .

i- The main direction of the free level is from east- north – east to west – south – west

There is no hydrological correlation between the river Nile ground water level table below Osireion because of the distance between them about 12 km , whereas the correlation between fluctuation of the Nile and ground water occurs through distance less than 2 km ([46]).

The quantity of the ground water which inflows the ambient beneath and around Osireion - via applying the equation Qd (inflow m3/ day) = TIL (T = coefficient of transmissivity

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([45]) (in : Arabic) El-Derby , A. A. O.D. , op. cit., 2005 , pp. 212 – 224 ; Rostom , O . R. ; The Scheme planned by The Late Abdel Salam Mohamed Husein for The protection of The Monuments of Seti I at Abydos , Le Caire , Imprimerie de L , Institut Francais d , Archeologie Orientale , MGML , p. 70 .

([46])Ahmed Aziz Abdel Moneim El Sherif ، Hydrology of The Nile Basin in Sohag Province , A Master of Science Thesis , Department of Geology , Faculty of Science , Assiut. University, Egypt, 1987, pp. 187-88 ; El Khedr , M., Salvage of Egyptian Antiquities from Ground Water in Abydos Area, Sohag, A.R.Egypt. A Master of Science Thesis, Department of Geology, Faculty of Science ،Cairo University, 1997, pp. 121-122 . ; Abdel Moneim , A. A. ,op. cit. ,1999 . pp .357-368 m2/ day , L = hydraulic gradient = 0. 476 , So Qd = TIL = 3630.59 × 0. 476 × 0.3 = 508.64 m3/ day ([47]) .

The studies indicate to Meteoric Origin of the ground water in Abydos

The free main water level is the main cause of deterioration of Osireion particularly Salts Efflorescence and Crypto-florescence .

Note :

For the symptoms of wet infiltration in the lower parts of granitic pillars of the central hall of Osireion , upon the whole revise (figs. 1, 3 C,D , 4 B, C , 5 bB,C,D , 7 B, C , D and 9 C) .

5.6.2 Medamud temple & site

Incurring to raised ground water table levels for the most of reason's of Abydos (Osireion) belonging to either the static – artesian level or the free main water level except the local and special ones related the topography and the nature of Osireion structure design and its religion function ,with no existence of reclamation drainage water .

With important note : that the free main water level (resulting in cultivation & irrigation drainage water , infiltrated water from old damaged pipes of drinking water , the infiltrated water from floor beds of unlined channels and drains to east of Medamud site and the sewage waste water coming from the primitive trenches drainage system coming from random growing housing compounds which surround the site particularly in the south and the south eat of the site) effects are visible clearly in the south and the south eat of the site as result of concentration of population activities , run over and revise (fig.22) and see (fig.23).

Note :

([47]) (in : Arabic) El-Derby , A. A. O.D. , op. cit. , 2005 , pp. 212 – 224 ; El Khedr , M., op. cit., 1997, p. 121.

For the symptoms of wet infiltration in the southe and south east parts of of Medamud temple & site, upon the whole revise (figs. 19 D , E, 20 B , 22 , an see particularly 23.

5.7 Pollution and infection of ground water beneath the two case study

5.7.1 Osireion

a- the irrigation water it self in Abydos includes 0.3 gram / liter , then feddan which is irrigated with 5000 m3 per a year obtain in its soil about 1500 kg. of salts , plants absorbs a portion of them and the residue accumulates in soil beneath the Osireion and the other archaeological buildings .

b- agricultural drainage water contain nitrate salts due to using fertilizers .

c- sewage water drainage contains sodium chloride – which used in primitive sewage trenches , beside nitrate salts (due to urea and proteins compounds) which are liquefiable and alter to nitric acid which in turn can form calcium and magnesium nitrate (liquefiable saline) .

c- analysis of water samples of Osireion showed the main cations and anions are :

k + Na then Mg then Ca , SO3 , Cl and HCO3 alternatively , leading to hypothetical deduct of salt compounds are : sodium chloride , sodium sulphate , magnesium sulphate , calcium sulphate or magnesium bicarbonate and calcium bicarbonate

and in another analysis of water samples of Osireion showed the dominant anions are in order : HCO3- > SO4 -- > Cl- , and the dominant cations are in order : (Na+ + k +) > Mg++ > Ca++ .

d- the total dissolved salts (T.D.S) of water of Osireion is 619 ppm and the Ph values vary from slight alkaline (7.7) to alkaline (8.1) ([48]) .

run over and revise (fig.21)

5.7.2 Medamud temple & site

([48]) El Khedr , M.. op. cit., 1997, p. 132.

The chemical analysis of water of the sacred lake showed the presence of some elements (gram / liter) : chloride (7.82) , calcium (112) , sulphate (178) , nitrate (172) , phosphate (119) , soluble total solid elements (2120) and the Ph value is 7.72 (slight alkaline) .

The bacteriological analysis of water of the sacred lake showed the presence of a high percentage of Coliform (capped the climax and the maximum which 2400 cells per 100 ml. of water according to M.P.N method) (the allowed number in drinking water is less than 10 cells) . that indicates also to presence the Faecal Coliform , run over and revise (fig.22and 23) .

The Third Theme

6 . Conservation Strategy thoughts of the two case study

6.1 Dealing with Deterioration Causes

6.1.1 Inspiring and stimulating Archaeological and cultural Awareness of the two Case Study:

Whereas Osireion is an unique construction all over the ancient Egyptian architecture and Medamud temple & site is one of the important complexes in Luxor (Thebes) context , these cultural values of them have not been corresponded and retaliated with care and conservation starting from arresting and staying the causes of failure and pot till opening up to visitation and tour .

Then the abstract and moral of the cultural values of the two case study will impel and inspire to removing neglecting before removing causes and symptoms of deterioration .

6.1.2 Removal , Exile and Transportation of Agricultural , Housing , Urban Trespasses and Man-made Destruction :

Thereby we prevent Osireion and Medamud temple & site from causes of :

raising of ground water tables . Bio-Deterioration Effects , Salts Efflorescence and Crypto-florescence , neglecting , monuments plunder and robbery and reusing .

6.1.3 Control measures for Ground Water in the Two Case Study

After Removal , Exile and Transportation of Agricultural , Housing , Urban Trespasses and Man-made Destruction ,

thereupon we lower raising of the ground water tables and take out
Sewage drainage water , we follow the following procedures :
(i) the regional insulation of presuppose context of each site ([49]).
(ii)the local insulation of the two structures and their close context .
(iii)Converting the unlined and uncovered channels and drains -to the covered subsurface drain system .
Converting the soaking perennial irrigation system the to spray and dropping system .

6.1.4 Bio-deterioration control thoughts

6.1.4.1 Osireion

6.1.4.1.1 Control measures for higher plants growing in the central hall

(i)pumping the high level ground water , regional isolation to prevent raising it any more .

(ii)removal the strange soil - due to about fault connotation and concept led to balk , stalk and fill the wells of island of the hall with accumulation of soil and sand , beside accumulating of falling soil - in which the plants (Phragmites australis) growed , so Hand pulling with Hand hoeing of plants with strange bearing soil was used (figs.8 B. C) (formerly the plants were removed with Mowing. repeated cutting and defoliation resulting in more activation of growth) .

6.1.4.2 Medamud temple & site

It is suggested the chemical methods (herbicides) such as Glyphosate (commercial nom is Round Up). it is derived

([49]) see : (in : Arabic) El-Derby , A. A. O.D. ,op. cit. 2005 and (in : Arabic) El-Derby , A. A. O.D. , op. cit. , 2007).

from Glycine acid and Fuluazifop-p-buty commercial nom is Fusilade) (see : (in : Arabic) El-Derby , A. A. O.D. , 2007)..

with making provision and having care with harming the stones physically or aesthetically , Methods of application of herbicides .

With accomplishing prevention procedures , such as continuous cleaning , compensation , repairing of cracks , joints , crevices and cavities , regular removal of soil deposits , controlling the dampness and moisture in buildings and sites of the two case study and controlling the birds and animals movement in and around of the two case study ([50]) .

For microorganisms the mechanical cleaning and biochemical treatments are required for the elimination of vegetation on the surface .

6.1.5 Upgrading , Development , Renovation and presentation of the two case study

With preparation of the two sites in term of cultural , administration , tourism services

6.2 Dealing with Deterioration Symptoms

6.2.1 Removal of tort , inexactitude and inaccurate restorations

(Restorations Portland cement mortar)

The fault repair by cement mortar of the granitic part of pillar in the Medamud temple site had to be removed for suggesting compensation with the original (pink granite) or mortars of the following components with portions in brackets : granite grit (6) + granite powder(6) + red sand (2)

([50]) Mishr. A.K., Jain . K. K.. Garg. K.L. . Role of higher plants in the deterioration of historic Buildings . he Science of the Total Environment 167 .1995. p. 390.

+ white sand (2) + Esna shale (1)+ lime (1) + transparent araldite () (5) , where gave a suitable color and texture and exhibit durable physical and mechanical properties

Removal Restorations Portland cement mortar

Small accurate sharp instruments and tools is suggested to detach the fault-attached two parts and remove the cement mortars , then it is suggested to store these parts away from weathering till executing a compatible conservation of the site , and on conservation it is suggested all parts that required compensation will be cleaned of dirt , clay and soiling by using a weak air compressor and suitable brushes and then washed with distilled water, The surfaces of the pillar were already so weakened by deterioration processes that stone grains were crumbling and disintegrated .

6.2.2 Removal of efflorescence and cryptoflorescence salts from Granite of the Two Case Study :

It is suggested to use sepiolite formulation The ability to remove salts efflorescence and cryptoflorescence particularly the absorbed and adsorbed in the altered granites ([51]) , it is suitable to salty altered granite of the two study case , in addition to be a cheap, non-aggressive, easy and effective way to remove salts from the surface and subsurface of built in granite .

The extracting agent was Supermold, a composition based mainly on sepiolite clay, cellulose fibre , where the surfaces of granite were first gently brushed to remove salts precipitated on their external faces, and then the sepiolite paste was applied to the surface , and were left for drying at room temperature, then the paste was removed gently and the process repeated till the analysis became free of salts .

([51]) Trujillano R., Garcia-Talegon . J., Ifiigo, C. A., Vicente , M. A., Rives , V., Molina , E., Removal of salts from granite by sepiolite , Applied Clay Science 9 ,1995, pp. 459-463.

6.2.3 Consolidation of Granite of the Two Case Study :

It is suggested to the following consolidates Paraloid B 72 , polyvinyl butural , Wacker H Wacker OH , for Consolidating the deteriorated granite surfaces .

6.2.4 Compensation and partial reconstruction

These **Compensation and partial reconstruction** (restoration) aim to recover , structural stability and the esthetical appearance of the granitic deteriorated elements , with using reversible materials and methods to minimize surface damage and in preparation for further conservation treatment .

It is suggested the original pink granite , and in case of presence of financial or or crafsmenpower , It is suggested mortars of the following components with portions in brackets : granite grit (6) + granite powder(6) + red sand (2)+ white sand (2)+ Esna shale (1)+ lime (1)+ transparent araldite (5) (araldite AY 106 and HY 953U (a hardener), a epoxy type resin with high viscosity that was mixed in the weight proportion of 100:80 (volume ratio1:1) and adding granite powder) . where gave a suitable color and texture and exhibit durable physical and mechanical properties (see : (in : Arabic) El-Derby , A. A. O.D. , 2005, p.528 and (in : Arabic) El-Derby , A. A. O.D. , 2007).

In the end of it is suggested for matching the texture and color of the granite , it will be added to the surface touches of granite powder and talc plus finishing with natural and acrylic pigments .

6.2.5 Partial reconstruction for some elements

6.2.6 Complete reconstruction for some elements .

6.2.7 Partial reconstruction for some units .

6.2.8 Complete reconstruction for some units .

according to each case condition , and we have to cite that these compensations and reconstructions fulfill conservation of esthetical , structural , constructional and functional requirements . plus prevention from animal , birds

, insects , plants and Incurring to sun light radiation and variations of air temperature and relative humidity particularly in arid environment of the two case study .

6.2.9 Recompositin , fitting, attaching , joining and uniting

It is suggested bonding with stainless steel which is fixed (with lining with sleeve method which eases reversibility ([52])with 20% Polaroid NAD-10 resin , and using araldite AY 103 and HY 956 U of low viscosity that were mixed in weight proportion of 100:20 (volume ratio 1:1) with the addition of glass fibers .

And for crack and gap in are suggested to filled with slaked lime and granitic grits(5:1) . Later after accomplishing a comprehensive conservation project for the site , may the remained elements - which we can not resembles and match with another remains –may need a suitable bases in their adjusting original locations .

([52]) see : (in : Arabic) El-Derby . A. A. O.D. ,op. cit. 2005 , p.542 . fig.273 .

7. Results Discussion and Conclusion

7.1 Table 2 Comparing analysis in deterioration Causes , Symptoms and Conservation Strategy thoughts of Wetted Monumental Granite of the two case study (Osireion and Medamud temple & site)

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
1	Identification of granite			
1.1		Monumental Red or Pink Coarse Granite of Egypt (Variety 1)	Monumental Red or Pink Coarse Granite of Egypt (Variety1)	For Osireion see Identification of granite upon the whole : (figs. 3 E, G and 6). For Medamud temple and site see upon the whole : (figs. 11 A-F , 12 A, B , 13 A , B , 14 , 15)
2	Deterioration Symptoms of granite of the two case study			
2.1	The age of deterioration (since quarrying , constructing granite in its building up till now)			
2.1.1	Natural aging , deterioration and weathering	(the 4th Dynasty period)(Khaefr a rule time .	may be dated from Amenhotpe II	It is expected of course the granite of Osireion have been subjected to more deterioration .

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
			rule time !!!!.	
2.2	The wetness deterioration			
2.2.1	infiltration	present	present	For Osireion : In the lower parts of granitic pillars of the central hall , revise upon the whole (figs. 1, 3 C,D , 4 B, C , 5 bB,C,D , 7 B, C , D and 9 C) . For Medamud temple & site in the southe and south east parts, totally revise upon the whole (figs. 19 D , E, 20 B , 22 , an see particularly 23) .
2.2.2	Sunken (awash)	present	absent	Present in Osireion due to : 2.2.1 The island ground of Osireion have been sunken in raising the level of the free main water table which with about 120 cm. falling the bottom of Osireion island to its close surrounding by about 18 meters , so flooding of water increase inside it . 2.2.2 There are special religion reason are related of design of Osireion for representing everlasting ocean , it had been constructed in an excavation as subterranean structure on an ancient well and connected to pipes supplying it with more water coming from the east side beneath the Seti I temple . revise upon the whole (figs. 1, 3 C,D , 4 B, C , 5 B,C,D ,

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
				7 B, C , D and 9 C) .
2.3	Composing minerals transformation and alteration to clay minerals			
2.3.1		present	present	For Osireion Granite composing minerals were subjected to transformation and alteration of feldspar to clay minerals (kaolinite) (kaolinization) particularly on the surface where seem in SEM micrographs in form of chips , plys and scales surrounding quartz grains , also exhibits a crystal of pyrite or iron sulphide . for alteration to clay minerals in Osireion upon the whole see : (Figs. 3 A-G , 4 A-c and 5 B-D) . For Medamud temple & site the kaolinite replacing k-feldspar minerals , in addition to other clay minerals such as sericite . for alteration to clay minerals upon the whole see : (Figs. 11 c-f , 14 , 15 and 17) . Generally in Osireion the alteration is more naked than in Medamud temple & site probably due to the longer time of ageing , deterioration , more subjection to alternative cycles of wetting , drying and saline ground particularly with existence of wetness sources since structure construction promotion .

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
2.4	**Exfoliation**			
2.4 1		present	present	in Osireion planes , where the kaolinite existed and occurred in the splits planes and at the boundary between quartz and feldspar forming membranes on the surface resulting in exfoliation, for exfoliation in Osireion to clay minerals upon the whole see : (Figs. 3 A-G , 4 A-c and 5 B-D) . for exfoliation in Medamud temple & site upon the whole see : (Figs. 11 c-f , 14 , 15 and 17) .
2.5	**Fracturing**			
2.5.1		present	not clear	present in Osireion and absent in Medâmud temple & site probably due to the longer time of ageing , deterioration , more subjection to alternative cycles of wetting , drying and saline ground in Osireion particularly with existence of wetness sources since structure construction promotion For fracturing in Osireion see upon the whole (figs. 3 E and 4 A, B, C)

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
2.6	**Granular Disintegration**			
2.6.1	In form of grus	present	present	In Osireion the Granular Disintegration is less naked than in Medamud temple & site probably due to that the latter is more exposed to the direct variations of temperatures& relative humidity and inadequate sun exposure , because of its normal ground level relatively Osireion and because of the semi-complete loss of walls that meant more exposing to direct solar radiation , see : (Figs.19 E , 20A-B , 21 , 22and 23) .
2.7	**Salts Efflorescence and Crypto-florescence**			
2.7.1	In forms of Efflorescence and Crypto-florescence	present	present	In Osireion ther exhibition of salts of anhydrite $CaSo4$, Halite NaCl ,Calcite $CaCo3$, in addition to existing the following components : sodium chloride halite NaCl , sodium sulphate Na2 SO4 thenardite, magnesium sulphate , calcium sulphate or magnesium bicarbonate and calcium bicarbonate . In Medamud temple & site trona alone or possibly a mixture of trona and thenardite, which crystallize as a surface efflorescence on flood plains, represent the end product of evaporative concentration of seasonal flood waters mixed with the local groundwater drawn up within

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
				the soils by capillary action or the splashed water a result of seepage or from the bad irrigation system in the area. In the process of evaporation, calcite precipitation occurs below the surface, whereas trona and thermonatrite form on the surface , for halite its existence is always expected normally . In Osireion the Salts Efflorescence and Crypto-florescence - the same as in granular Disintegration cleared above - is less naked than in Medamud temple & site probably due to that the latter is more exposed to the direct variations of temperatures& relative humidity and inadequate sun exposure , because of its normal ground level relatively Osireion and because of the semi-complete loss of walls that meant more exposing to direct solar radiation , For the Salts Efflorescence and Crypto-florescence in Osireion see upon the whole (figs. 3 A-G , 5 A - D , 6 , 7 A and 9 C) And for Medamud temple & site see upon the whole (Figs. 10 A-D , 11 A-F , 12 A, B , 13 A , B , 14 , 15 , 16 ,, 19E and 23) .

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
2.8	Bio-Deterioration Effects			
2.8.1	Lichens			
2.8.1.1		Not clear	present	For summarized symptoms on granite of Osireion revise the text and (fig.7 B and 9 C)
2.8.2	Algae			
2.8.2.1		present	absent	For summarized symptoms on granite of Osireion revise the text and (figs.7 A,C,D and 9 C)
2.8.3	Plants			
2.8.3.1		present	present	For Osireion <u>Phragmites</u> <u>australis</u> (Gramineae) has been growing in the stranger soil in the channels of the central hall of Osireion causing deterioration and damage stones. (fig. 8 A, B, C and 19 F) . for Medamud ، Alhagi maurorum ، Imperata cylindrica temple & site Tamarix nilotica and Phragmites australis , plus some trees and seedlings has been growing in soil , in , inside and around the remains of the temple and the site

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osircion	Medamud Temple & site	N.B.
				of Medamud causing deterioration and damage stones, revise (Figs. 19 and 20 A) .
2.9	**Tort, Inexactitude , Inaccurate and erroneous Restorations Portland cement mortar (Man-made faults)**			
2.9.1		absent	present	revise (Fig. 24) .
3	**Deterioration Causes of granite of the two case study**			
3.1	**Cause of Composing minerals transformation and alteration to clay minerals**			
3.1.1		present	present	**Endogenous and Exogenous causes**
3.2	**Causes of Exfoliation**			
3.2.1		present	present	the kaolinite formed membranes on the surface of orthoclase and plagioclase gives rise to exfoliation , also the zygotes of smectite, kaolinite and sericite grown into euhedral habits can be observed on the plagioclase surface, and the non-crystallized sericite particles form a membrane .
3.3	**Cause of Fracturing**			

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
3.3.1		absent	present	Fracturing is present in Osireion as a result of exposure to hydrothermal processes of varying intensityand leads and indicates to weathering in quartz and potassium (K) feldspar crystals . Revise - above - the causes of its absence in Medamud and revise (figs. 3 E and 4 A, B, C)
3.4	Cause of Granular Disintegration			
3.4.1		absent	present	Due to variations of temperatures& relative humidity and raising of ground water tables , combined with inadequate sun exposure Revise - above - the causes of its absence in Medamud and revise (Figs.19 E , 20A-B , 21 , 22and 23) .
	General deterioration Causes			
3.5	Incurring to sun light radiation and variations of air temperature and relative humidity			
3.5.1		present	present	There are a big variation in air temperature and relative humidity daily and seasonally particularly the middle of upper Egypt – where the two case study lie, see :(Figs.19 E , 20A-B , 21 , 22and 23)

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
3.6	Agricultural , Housing ,Urban trespasses and Man-made destruction			
		present	present	For Osireion agricultural , reclamation , housing and urban trespasses, consequently leads to raising of ground water tables , Bio-Deterioration Effects , Salts Efflorescence and Crypto-florescence , neglecting , monuments plunder and robbery and reusing , revise (Fig.21) . For Medamud temple & site Resembling Osireion the same (there is no reclamation activities), and the same complications and consequents, revise (fig. 22) .
3.7	Ground Water raised tables			
3.7.1		present	present	For two case study there are two water levels : the static - artesian and , the other level is the free main water level due to agricultural , reclamation , housing and urban trespasses, consequently leads to raising of ground water tables , but Osireion is characterized with specific ancient topographical , religious and functional causes . For Osireion revise upon the whole (figs. 1, 3 C,D , 4 B, C , 5 bB,C,D , 7 B, C , D and 9 C) , and for

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
				Medamud temple & site in the southe and south east parts, revise upon the whole (figs. 19 D , E, 20 B , 22 , an see particularly 23) .
3.8	Pollution and infection of ground water beneath the two case study			
3.8.1		present	present	a- the irrigation water it self in Abydos For Osireion liter , , plus nitrate salts due to using / includes 0.3 gram fertilizers in agricultural drainage water , sodium chloride , nitrate salts from sewage water drainage , the investigations and analysis of Osireion showed the presence of anhydrite $CaSo_4$, Halite NaCl ,Calcite $CaCo_3$, in addition to existing the following components : sodium chloride halite NaCl , sodium sulphate Na_2SO_4 thenardite, magnesium sulphate , calcium sulphate or magnesium bicarbonate and calcium bicarbonate , plus polluting with sewage drainage water . the total dissolved salts (T D.S) of water of Osireion is 619 ppm and the Ph values vary from slight alkaline (7.7) to alkaline (8.1) . For Medamud temple & site the chemical analysis of water of the sacred lake showed the presence of some

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
				elements (gram / liter) : chloride (7.82) , calcium (112) , sulphate (178) , nitrate (172) , phosphate (119) , soluble total solid elements (2120) and the Ph value is 7.72 (slight alkaline) . and the bacteriological analysis of water of the sacred lake showed the presence of a high percentage of Coliform. which indicates also to presence the Faecal Coliform .
4	**Conservation Strategy thoughts of the two case study**			
4.1	**Dealing with Deterioration Causes**			
4.1.1	Inspiring and stimulating Archaeological and cultural Awareness of the two Case Study			
		wanted	**wanted**	
4.1.2	**Removal , Exile and Transportation of Agricultural , Housing , Urban Trespasses and Man-made Destruction**			
4.1.2.1		**wanted**	**wanted**	to prevent the two case study from causes of : raising of ground water tables , Bio-Deterioration Effects , Salts Efflorescence and Crypto-florescence , neglecting , monuments plunder and robbery and reusing
4.1.3	**Control measures for Ground Water**			

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
4.1.3.1		wanted	wanted	After Removal , Exile and Transportation of Agricultural , Housing , Urban Trespasses and Man-made Destruction , thereupon we lower raising of the ground water tables and take out Sewage drainage water , we follow the following procedures : (i) the regional insulation of presuppose context of each site . (ii)the local insulation of the two structures and their close context (iii)Converting the unlined and uncovered channels and drains -to the covered subsurface drain system . and lastly converting the soaking perennial irrigation system the to spray and dropping system .
4.1.4	**Bio-deterioration control thoughts**			
4.1.4.1	**Control measures for higher plants growing in two case study**			
		wanted	wanted	For Osireion in the central hall , afterpumping the high level ground water , regional isolation to prevent raising it any more , removal the strange soil in which the plants (Phragmites australis) growed , so Hand pulling with Hand hoeing of plants with strange bearing soil was used (figs.8 B, C) . For Medamud temple .. site It is suggested the chemical methods (herbicides) such as Glyphosate (commercial nom is Round Up), it is derived from Glycine acid and Fuluazifop-p-buty commercial nom is Fusilade) , with

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osircion	Medamud Temple & site	N.B.
				making provision and having care with harming the stones physically or aesthetically ,'Methods of application of herbicides .with accomplishing prevention procedures , such as continuous cleaning , compensation , repairing of cracks , joints , crevices and cavities , regular removal of soil deposits , controlling the dampness and moisture in buildings and sites of the two case study and controlling the birds and animals movement in and around of the two case study . For microorganisms the mechanical cleaning and biochemical treatments are required for the elimination of vegetation on the surface .
4.1.4	**Upgrading , Development , Renovation and presentation of the two case study**			
4.1.4.5		wanted	wanted	With preparation of the two sites in term of cultural , administration , tourism services
5	**Dealing with Deterioration Symptoms**			
5.1	**Removal of tort , inexactitude and inaccurate restorations**			

Serial No.	deterioration Symptoms , Causes and Conservation Strategy thoughts	Osireion	Medamud Temple & site	N.B.
5.1.1		-	wanted	
5.2	Removal of efflorescence and cryptoflorescence salts from Granite of the Two Case Study			
5.2.1		wanted	wanted	It is suggested to use sepiolite formulation because of its ability to remove salts efflorescence and cryptoflorescence particularly the absorbed and adsorbed in the altered granites , it is suitable to salty altered granite of the two study case , in addition to be a cheap, non-aggressive, easy and effective way to remove salts from the surface and subsurface of built in granite .
5.3	Consolidation of Granite of the Two Case Study			
5.3.1		wanted	wanted	It is suggested to the following consolidates Paraloid B 72 , polyvinyl butural , Wacker H Wacker OH , for Consolidating the deteriorated granite surface
5.4	Compensation and partial reconstruction .			
5.5	Partial reconstruction for some elements .			
5.6	Complete reconstruction for some elements .			
5.7	Partial reconstruction for some units .			
5.8	Complete reconstruction for some units .			

Appendixes

Appendix 1

An Archaeological and Architectural study Revision of Osireion

Osireion is an unique ancient Egyptian subterranean structure (temple or tomb) of Osiris (so it has been so called Osireion), and Some suppose that had been functioned as a symbolic tomb or cenotaph of Osiris , see: Kemp , B .J. , The Osiris Temple at Abydos , Mitteilungen des Deutches Archaeologisches Institute Kairo 23, 1968 , pp.138-155 ; Wilkinson R.H.,The Complete Temples of Ancient Egypt , Thames & Hudson , London , 2001 , p. 143-144) lies to the west , next and on the same axis of to the Temple of Seti I at Abydos (It is built on the same axis as the Temple of Seti. Or, as some believe, the Temple of Seti was built on the axis of the much earlier cenotaph) , it had been built in an excavation in the Esna shale - under Thebes formation - with vertical sides , it has been protected with two retaining limestone walls run over the eastern room (sarcophagus room) of structure to the sand bed upon which the temple of Seti I was built (revise figs. 1 and 20 A) (see : Frankfort H . , The Cenotaph of Seti at Abydos. Egypt Exploration Society Memoirs, no. 39. London, 1933 , pp 9-22 , pls.I-II. ; Badawy , A . , History of Egyptian Architecture , The Empire (The New Kingdom) , Vol. 3 , Berkeley and Los Angeles , 1968, p. 218; Omm Sety and El Zeini , H. ,op. Cit ., p. 10) was completely covered in sand in the early part of the century. When it was uncovered primarily by Margaret Murray who was working with W.M. Flenders Petrie in 1902-1903 (see: Murray , M. , The Osireion at Abydos, London , 1904) the excavation were resumed by Naville in 1911-1914 , and were completed by Henri

Frankfort under sponsor of The Egypt Exploration Society and published his works in three vols. in 1926 , , the central chamber (hall) Arnold , D. The Encyclopedia of Ancient Egyptian Architecture , Translated by Sabine H. Gardiner and Helen Strudwick , English Language ed. I.B.Tauris&Co Ltd. , AUC Press , 2003 ; Redford , B.R., The Oxford Encyclopedia of Ancient Egypt , AUC Press , 2001, pp.351-353 .the doorway of this building is in the north west through a shaft outside the temenos wall of the precincts a long vaulted ramp extends from north to south in length of 32 meters and consists of 5 courses thick alternating in their inclination from the vertical built of a special curved bricks , the surfaces of the limestone walls of the passage are inscribed with scenes from funerary books , this slopping passage (51°) opens into a transverse room (its dimensions 27.15 × 5.25 × 4.65 high) roofed with a corbel roof cut in the shape of a pent roof underneath and is symmetrical with the sarcophagus chamber lies on the other side of the main chamber , see : Badawy , A . , History of Egyptian Architecture , The Empire (The New Kingdom) , Vol. 3 , Berkeley and Los Angeles , 196? pp.218- 222 . There is some question as to whether Sety himself built the temple, or some earlier or later pharaoh. Stylistically, it is so different from the temples of the New Kingdom that it is almost an aberration. If Sety built this, he was breaking with the common architectural plans of his time. ; this structure is so stylistically different from the other ruins on the site that it was quite controversial. It looks strikingly like the simple valley temple of Chephren at Giza simple, square Monolithic columns , totally devoid of decoration (Monolithic Architecture of the 4th Dynasty , see : Wegner , J . W ., op. Cit . , 2001 , p. 10) , but they are bigger (its dimensions 4 × 2.38 2.13 , dimensions temple of Chephren are (4.30 × 1.10 × 1.10 , El-Derby exhibited eleven proofs and evidences support attribution the structure to the Old kingdom (the 4th Dynasty period), see : (in : Arabic) El-Derby ; A. A. O.D. , The Architectural Conservation and Maintenance of Some Ancient Egyptian Temples in Upper Egypt , An Analytical Study of Deterioration factors & Symptoms and The Strategy for Treatment , with Application on Selected Case Study , Archaeology Conservation Department , Faculty of Archaeology , Cairo University , 2005 , pp. 212 – 224 . The whole structure is built below ground level; no other temple has ever been built like this. It is possible that the temple was built very early, on top of what was ground level then and the inundation of the Nile laid down layer after layer of silt that buried the temple to its existing depth. Some believe that it may predate the Egyptian dynasties entirely. , the main central hall (or chamber) which represents the main part of the structure includes a central platform (island) and ten monolithic granitic piers (pillars) and was may be a burial structure for Osiris , this central platform which is a raised area, which is barely seen underneath the water - is surrounded by water channels represents the primeval mound of creation surrounded by the waters of Nun , is a raised area, which is barely seen underneath the water. It is surrounded by a moat that was apparently mean to be filled with water, bordered with unfinished cells , two stairways lead from the western and eastern small sides to the bottom of the channels between the island and the opposite walls there are other chambers and passages attaching this central chamber , where the west room set transversely and similar to the entrance hall built of limestone with a corbelled roof of sandstone cut in the shape of a bent roof had inscriptions on its plasters , see : Zayed , A. , Abydos , General Organization of Government Printing Offices , Cairo , 1963 , pp. 102-107 .

An Archaeological and Architectural study Revision of Medamud & Site

Medamud temple and site Locates five kilometers north of Karnak , and to NE of Karnak temple and dedicated to month and was attached to its temple at Karnak via a canal . The temple is bounded by latitude 25° 44′ 08′′ N to the North and latitude 25° 43′ 54′′ N to the south, and longitude 32 .42 44 E due East and 32°42′ 24′′ due west. , is one of the important complexes in Luxor context It had been excavated by French excavators Fernand Bisson de la Roque, Alexandre Varille and Clement Robichon from 1925-1930 who discovered various parts of temple complex, works continued till 1933 ,, studies continued till 1939 and most of works ended before the Second world war , The oldest part of temple complex is a double primitive sanctuary dated to before 11th Dynasty or the 1st intermediate period were surrounded with (strange structure) trapezoidal (or polygonal) bricks enclosure within which courtyard with two pylons preceded two primitive deep sanctuaries (there were two winding corridors inside lead to these subterranean chambers or sanctuaries) each of them was covered with a shallow mound surrounded with gardens were planted with trees , the architectural plans remain only (whither its remains were smashed by the flooding of the Nile of the high dam In 1970) , above this sanctuary the temple of middle Kingdom was constructed by Senwosret III (measuring 100 × 60 m.) which was built of bricks and its columns and gateways of limestone , and its stones were reused later in foundations so the French excavators re-erected and reconstructed some portal (one of them was erected in the Egyptian museum at Cairo and one of them was erected in the open museum at Karnak).and the brick wall base and remains enabled them to draft reach a hypothetical plan of the temple which consists of remained a thick wall (5.5 m.) enclosed a cult building with royal statue pillars , magazines , six priests houses and grain stores , foundations deposits indicate to a north south axis with a n unknown edifice , the temple of New Kingdom - which has not a drawn plan - was constructed to westward on a foundation platform that contained a deposit from Thutmose III above the location of the western mound , and the granitic gateway which dating from Amenhotpe II stands on the site (so probably the most granitic remains date from Amenhotpe II rule) , the New Kingdom temple was replaced by the older Ptolemaic temple due to Ptolemy III which measured 32 × 21 m.. and the youngest temple dated - a long time - from Ptolemy V to Diocletian in Roman period , its plan is quite original depending on the oldest directional orientations with the principal axis west-east for the main temple , it includes also at the entrance three kiosks , a hall of justice which opens into a big , columned courtyard (the court of Antoninus Pius : where a portal still standing ; a hypostyle and a sanctuary surrounded by chapels , ther is a rear temple lying on the secondary axis north-south which has a passage which approaches from the courtyard where the house of the god month or Montu the grat venerable bull which was mentioned as early as the 11^{th} dynasty (it is supposed that were connected with the holy cities of Thebes , Tod and Armant) , the farthest enclosure opens westward to the Dromos; the monumental gateway of Tiberius , an avenue of sphinxes leads from the main gate to a platform with obelisks , there is a sacred lake in the south - west corner next to which the remains of a destroyed temple of the early Ptolemaic period , an Coptic church reoccupied the site at the end of the 4th centaury , see : Bisson de la Roque , Fernard, et. al. Report preliminaire des fouilles de Medamoud , 1925, 1932, fouilles de l Institut francais d archeologie orientale du Caire, 3-9 Cairo , 1926-1933Seton-Williams , Ptolemaic Temples , 1978 .p. 28; - Arnold , D. The Encyclopedia of Ancient Egyptian Architecture , Translated by Sabine H. Gardiner and Helen Strudwick , English Language ed. I.B.Tauris&Co Ltd. , AUC Press , 2003 ;Redford , B.R., The Oxford Encyclopedia of Ancient Egypt , AUC Press , 2001, pp.351-353 .

For granitic elements remains may be –as mentioned above – dated from Amenhotpe II time .

Appendix 3

Identification of granitoids

Granite

It is The most prominent group and a variety of rich pink to reddish-pink, coarse- grained, porphyric granite, well known as rose-granite and the best known quarries of ancient Egypt lie south of Aswan. where cover an area of about 4 - 5 km. Here, almost all varieties of granitoids used during the ancient Egyptian periods in , , see:- (Klemm , D . and Klemm , R . , The building stones of ancient Egypt - a gift of its geology , African Earth Sciences 33 , 2001,p. 635).It is a hard stone used in ancient Egyptian buildings and Sites from 1st dynasty onwards , had been quarried mainly from the cataract region in Aswan , it is a deep granular stone consists of quartz ,alkali feldspar (microcline or orthoclase), mica (muscovite or biotite), hornblende amphibole , sodic to intermediate plagioclase (oligoclase or andesine) , pyroxene and small amounts of various secondary minerals , see ☹ Aston , B.G. , Harrell . J. and Shaw , I. , Stone in :Ancient Egyptian Materials and Technology , Edited By Paul T. Nicholson and Ian Shaw , Cambridge University Press , 2000, p. 35.) of specific gravity (kg/l) 2.6- 3.2, hardness 6-8 , compressive strength (kg /qcm) 1600-1400 and stroke until destruction.(DIN 52107).

Monumental Red or Pink Coarse Granite of Egypt (Variety 1)

Rose-granite (Pink to reddish) has well-known appearance not only in Egypt but also all over the world in addition to its different local varieties ; the characteristic feature of this granite is the dominant texture of intensely etched, 2–5 cm long (very coarse to mainly coarse-grained granite with quartz , microcline , oligoclase , biotite , minor hornblende and secondary minerals (apatite , sphene , zircon and iron oxides)) .

It is commonly porphyric K-feldspar grains, set in a medium-grained granitic matrix. under the polarizing microscope the intensive microclinal texture of the K-feldspars – phenocrysts up to 4 cm. across and the ubiquitous presence of allanite are characteristic.

In case of presence minor amount of mica (biotite) it has pinkish or reddish appearance , but In case of presence major amount of it darker with a black and pink flecks .

This variety most common used in the ancient Egyptian buildings and sites after limestone and sandstone (where used in construction purposes in the 1st dynasty for pavement in Den's tomb at Abydos, see Petrie, W. M. F., the Royal Tombs of the Earliest Dynasties, 1900-1901, 3 Vols, Egypt Exploration Society Memoirs, nos. 18, 21, 21 suppi. London 1900-1901, 9. , used widely from the 3rd to 12th dynasty in pyramids (especially in Khufu and Menkaure regions) for lining burial chambers and passages (such as Djoser –Saqqara , Khufu - Giza , Khafra - Giza and Menkaure - Giza) See Reisner, G. A., Mycerinus, p. 71., for exterior or outer facing or coverings (such as Khafra and Menkaure pyramids at Giza) (about 45 thousands cubic meters must had been quarried from Aswan during the Old Kingdom period), for capstones (such as pyramids of Amenemhat II – Dahshur and Khendjer – Saqqara of the Middle Kingdom ,and in early Christian churches. see :

Aston , B.G. , Harrell , J. and Shaw , I. , Stone in :Ancient Egyptian Materials and Technology , Edited By Paul T. Nicholson and Ian Shaw , Cambridge University Press , 2000, p. 36.) perhaps due to its greater abundance at Aswan than other granitoids in addition to sculptures purposes (For sculptures purposes it had been used from the Early Dynastic period to the Roman period for statuary either private , royal , statuettes or colossi , sarcophagi (of kings, nobles and acrificed animals), stelae , naoi , the uncountable columns distributed all over the Roman Empire, obelisks (only in the New Kingdom)(fthe well-known example is Unfinished obelisk, 42m in length, in a quarry of red-pink granite south of Aswan) and vessels . sarcophagi of kings, nobles and sacrificed animals , see Aston , B.G. , Harrell . J. and Shaw , I., op.cit. pp. 35-36 ; Klemm, D.D. and Klemm R. , The building stones of ancient Egypt - a gift of its geologyAfrican Earth Sciences , 33 (2001) 631- 642; Arnold , D., , Ancient Egyptian Architecture ,translated by Sabine H. Gardiner and Helen Strudwick , edited by Nigel and Helen Strudwick , AUC press, 2001, pp. 100-101.) the amount of rose-granite mined in this region is hard to estimate but is likely to be in the range of some million tons had been quarried from locations from Aswan city and El-Shallal district and the district between Aswan city and El-Shallal island along the east bank of the Nile plus islands of Elephantine , Saluja , Sehel and other islands which also had been used from the early Dynastic period to the Roman period , see : (Aston , B.G. , Harrell . J. and Shaw , I. , op.cit. , p. 35.) .

The texture of this variety granites varies from amorphous to almost gneissic, but always preserving its porphyric character and the phenocrysts themselves comprise 40–60 vol. % of the rock , see (Klemm, D.D. and Klemm R. , The building stones of ancient Egypt - a gift of its geology African Earth Sciences , 33 (2001) 631- 642) it exhibits – such as all varieties of granite – a patent parallel or sub parallel arrangement of grains of feldspar and biotite (so-called gneissoid granite or granite gneiss , see : (Aston , B.G. , Harrell .. J. and Shaw , I. , op.cit. , p. 35.)

Granite (Fine granite) (Variety 2)

For the variety 2 there had been a rare uses in ancient times - it is the less used in ancient Egyptian buildings and Sites - because of difficulty of obtainment of large and devoid of fracture blocks from its veins , it is generally medium to mainly fine-grained , its composition is similar to of variety 1 with absence of phenocrysts , it varies from light grey to pinkish to reddish color according to the amount and color of microcline, it exhibits foliation (parallel alignment of biotite flakes variety 1and granodiorite so it contains fragments of them its principle outcrops are on the east bank of the Nile on Saluja , Sehel islands , there are not ancient quarries are reported , see : (Aston , B.G. , Harrell . J. and Shaw , I. , op.cit. , p. 35.) .

Granodiorite (Aswan) Monumental Black or Grey Granite

Consists also of same compositions but with less alkali feldspar , it is coarse to mainly medium-grained granodiorite with quartz , alkali feldspar(microcline and minor orthoclase), biotite, hornblende and secondary minerals (mostly apatite , sphene , zircon and ilmenite and magnetite)) .

It is incorrectly known as Synite (Syne equal to Aswan , see:Arnold , D. ; Ancient Egyptian Architecture ,translated by Sabine H. Gardiner and Helen Strudwick , edited by Nigel and Helen Strudwick , AUC press, 2001,p. 100.) because of its similarity to granite with much less quartz , see :(Aston , B.G. , Harrell . J. and Shaw , I. , op.cit. , pp. 35- 36.) .

it had been used in ancient Egypt from the Pharaonic periods onwards as widely as the rose granite and for the same range of purposes of building and sculpture , but in small quantities , not for large obelisks or columns, due to their smaller joint distances (The most prominent examples are the many bull sarcophagi in the Serpaeum in Sakkara, the lion-headed Sahmet-statues of Amenhotep III and also the Rosetta-stone, which gave the key to Champollion's (1822) deciphering of the hieroglyphic symbols , see: Klemm, D.D. and Klemm R. , op. cit. (2001) 631- 642..) , its quarries lie mainly around Gebel Ibrahim Pasha and Gebel Togok from the early dynastic to the Roman periods , see :(Aston , B.G. , Harrell . J. and Shaw , I. , op.cit. , p. 37.)(for more , see : Ball, J 1907 A Description of the first or Aswan Cataract of the Nile . Cairo : GSEGeography and Geology of South-eastern Egypt . Cairo : GSE ; Gindy ، A,R.I956.the igneous and metamorphic rocks of the aswan area , Egypt : their description , origin and age relations BIE, 37/2:83-I3I ; . Lucas , A ,Ancient Egyptian Materials and Industries . 4th ed., rev J.R. Harris . London : Edward Arnold . 1962 ; Attia,M1 ,1955 Topography , Geology and Iron-ore Deposits of the District East of Aswan . Cairo :GSE ; Gindy ، A,R.I956.the igneous and metamorphic rocks of the aswan area , Egypt : their description , origin and age relations BIE, 37/2:83-I3I ; Ragab , A. I. Meneisy . M.Y. and Taher , R.M. 1978. Contributions to the petrogenesis and age of Aswan granite rocks , Egypt. Neues Jahrbuch fur Mineralogie Abhandlungen , 133/1-71-87; Roder , J.1965. Zur Steinbruchgeschichte des Rosengranits von Assuan . Archaologischer Anzeiger , 467-552; Meneisy , M.Y., Ragab , A.i. and Taher , R.M. 1979. Contributions to the Petrography , Petrochemistry and classification of Aswan granitic rocks , Egypt .

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Figures

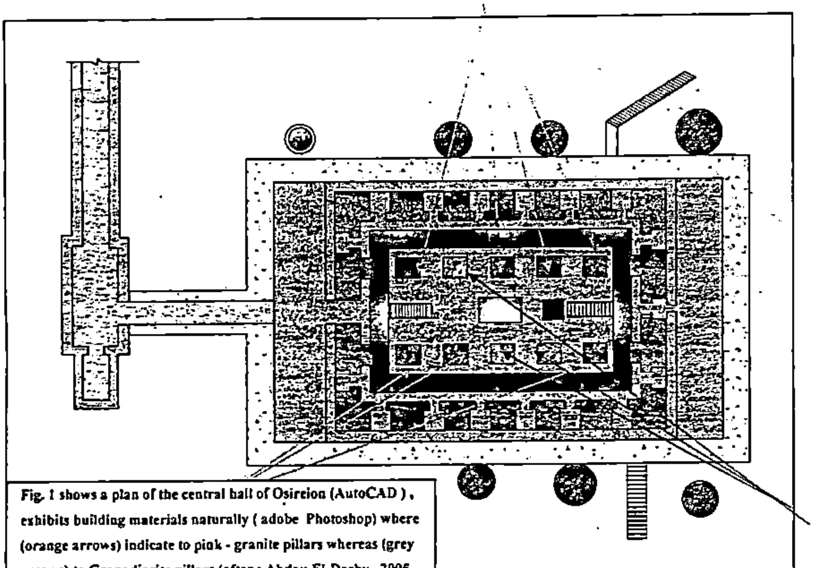


Fig. 1 shows a plan of the central hall of Osireion (AutoCAD), exhibits building materials naturally (adobe Photoshop) where (orange arrows) indicate to pink - granite pillars whereas (grey arrows) to Granodiorite pillars (after : Abdou El-Derby , 2005 , fig.144) (with an amendment) .

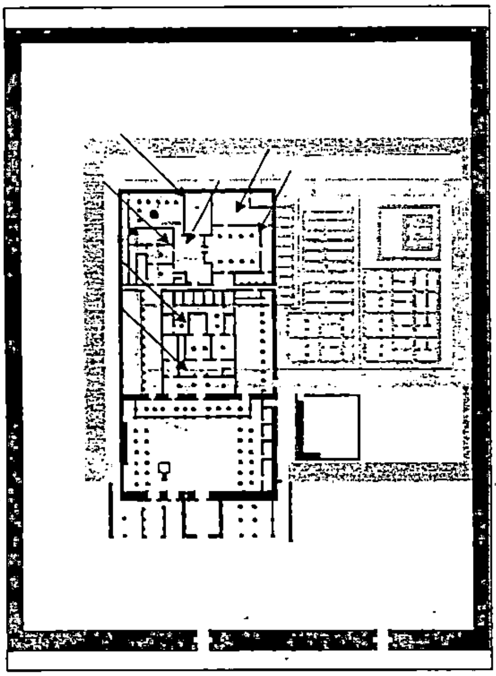


Fig. 2 shows a an overlapped the temporal alternative three plans of Medamud temple AutoCAD) and(adobe Photoshop) , where (blue arrows) indicate to locations of remains of granitic elements in the temple

(after : El-Derby, A.,2007 and Arnold , D., 2003 ,p. 143) (with an amendment) .

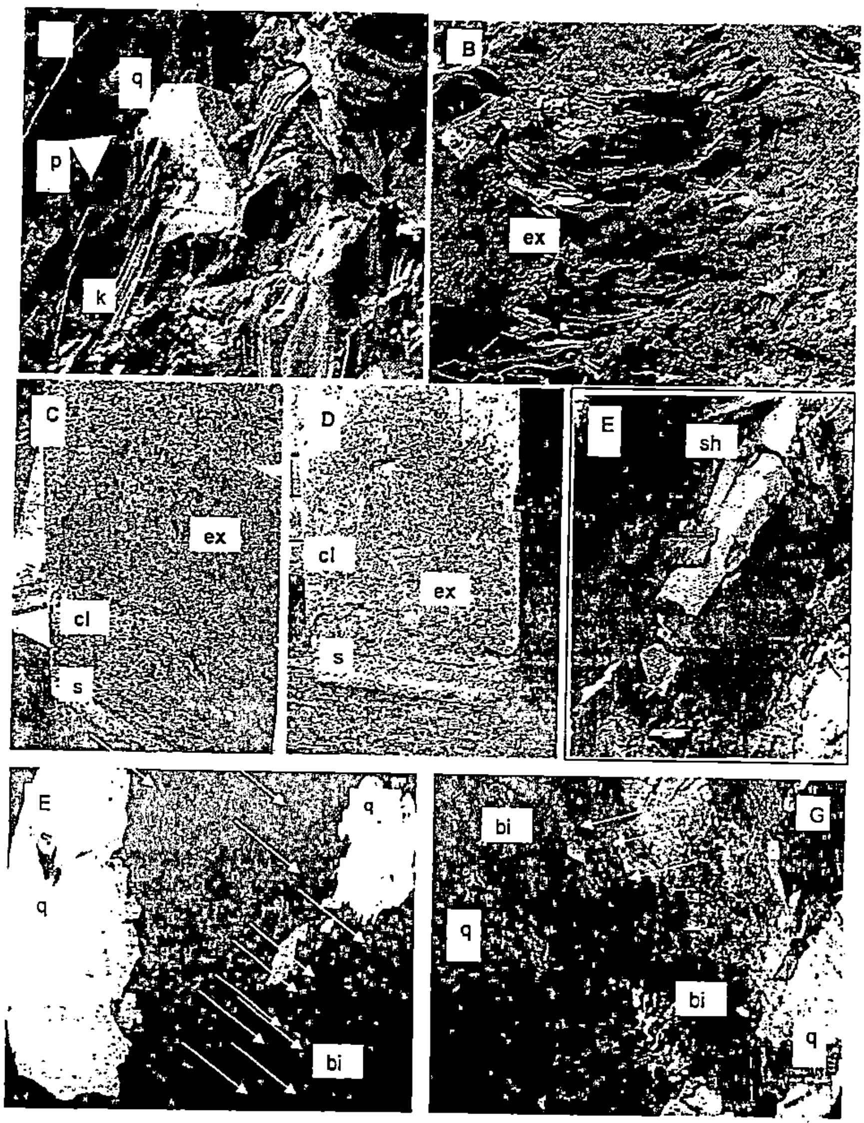
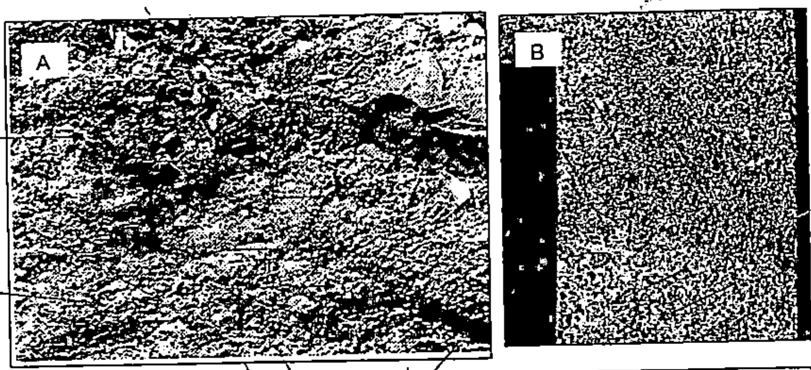


Fig. 3 showing investigations and photos of deterioration symptoms of granite of Osireion : (A) SEM Micrographs X650 showing transformation and alteration of feldspar - in granite of Osireion to clay minerals (kaolinite) on the surface where seem in form of chips, plys and scales surrounding quartz grains - of rhombic crystals (q), also exhibits a crystal of pyrite (p)(iron sulphide). (B) SEM Micrographs X90 showing exfoliation (ex) in feldspar (orthoclase) and lamelliform mica . (C) and (D) Photos display alteration into clay minerals (cl), exfoliation (ex) and salt fluorescence (f). (E) SEM Micrographs X300 showing shuttering in quartz grains. (F) and (G) display thin sections of granite of Osireion (cross sections) (cross Nichol) (x 4) display the presence of quartz grains (q) , biotite (bi) , sphene and splits planes (white borrows) where exfoliation occurs as a result of mineral alteration in granite to clay minerals , where the kaolinite existed and occurred in these planes and at the boundary between quartz and feldspar forming membranes on the surface (of orthoclase and plagioclase) resulting in exfoliation



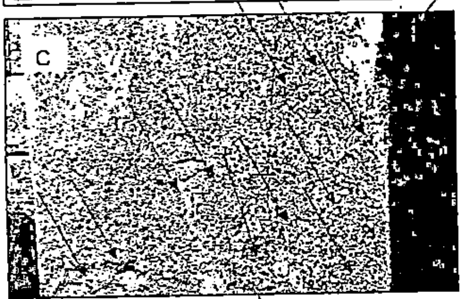


Fig. 4 includes investigations and photos of deterioration symptoms of granite of Osireion: (A), (B) and (C) SEM micrographs X100 and photos showing loss of smooth finished surface, Pulverization, granular disintegration (into grus) and Minute cracks, become the moisture path giving rise to acceleration in chem.. and mecha. weathering and produce new micro-cracks or open cracks that are already in existence in granite, (orange borrow), plus a loss of sharpness on corners (blue borrow)

Fig. 5 includes investigations and photos of deterioration symptoms of granite of Osireion: (A) SEM micrographs X650 showing sulphate (.anhydrite CaSo4 or calcium sulphate) salts (orange borrow), and photos (B). (C) and (D) display Salts efflorescence and crypto-florescence in the lower parts of granite pillars of the central hall of Osireion (blue borrow), also exhibits mineral alteration in granite to clay minerals and exfoliation.

جدول افقى

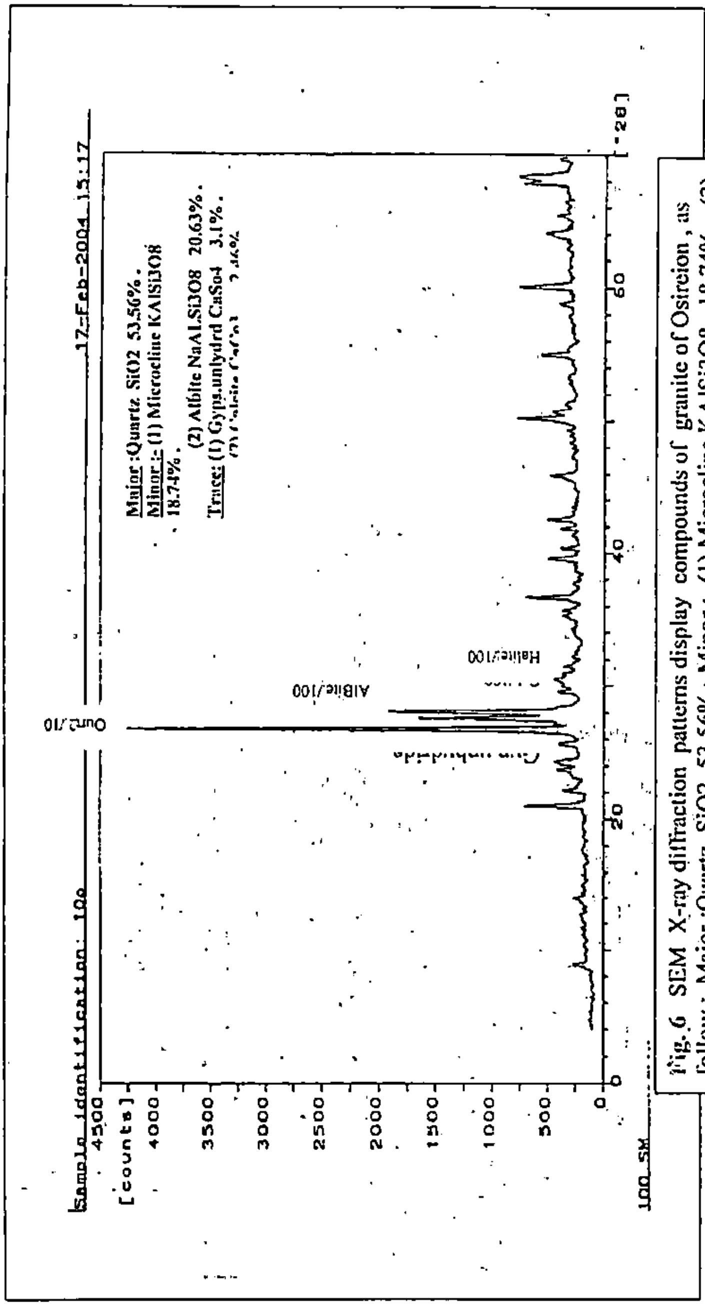


Fig.6 SEM X-ray diffraction patterns display compounds of granite of Osireion , as follow : Major :Quartz SiO_2 53.56% ; Minor :-(1) Microcline $KAlSi_3O_8$ 18.74% . (2) Albite $NaALSi_3O_8$ 20.63% . (in addition to salts of) : Trace: (1).anhydrite $CaSo_4$ 3.1% . (2) Calcite $CaCo_3$ 2.46% . (3) Halite NaCl 2.08% .

Fig. 7 includes investigations and photos of deterioration symptoms of algae and lichens in granite of Osireion :

(A) SEM Micrographs X650 showing algae in form of parallel stripes inter-granular of the rock .

(B) lichens growth layers on the wetted , light . moderate temperature and high RH exposed surfaces

(blue arrows) .

(C) and (D) algae green and blue green growth on the ground and lower parts of pillars (red arrows) led to peeling and separation of it

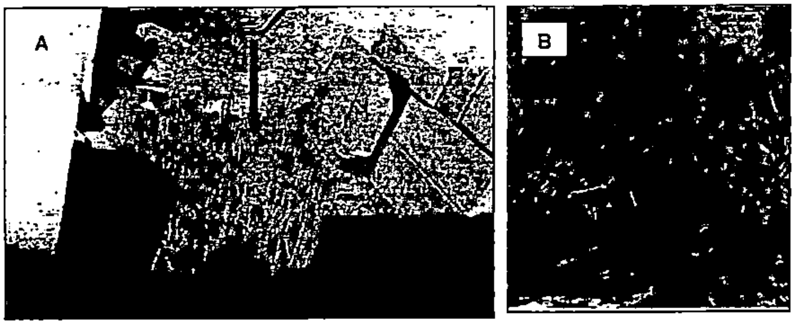
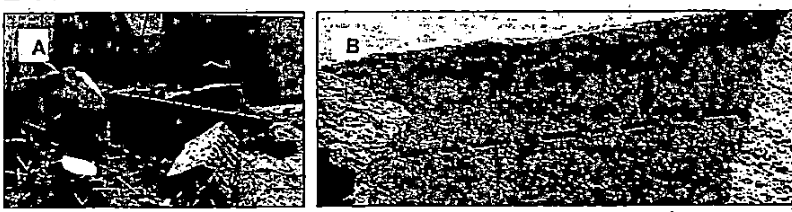


Fig. 8 (A) displays Phragmites australis (Gramineae) which has been growing in the stranger soil in the channels of the central hall of Osireion (its stems reached 2 m (red bouncing arrow).

(B) and (C) Display Phragmites australis (Gramineae) rhizomes which its length reached about 3 m. after Hand pulling) (blue bouncing arrows), causing deterioration and damage stones



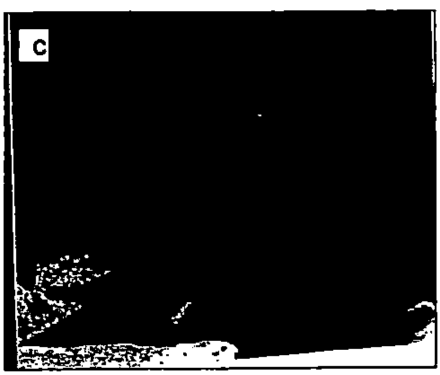


Fig. 9 displays there is some evidences of intentional cutting the blocks of the ceiling and architraves of Osireion , (A) transverse hall (B) the ceiling (C) the central hall , probably for reusing or because of religion contest (as a symbolism of heathen or pagan) ,salt efflorescence , lichen and algal effects are clear in 9 (C) (red arrows)

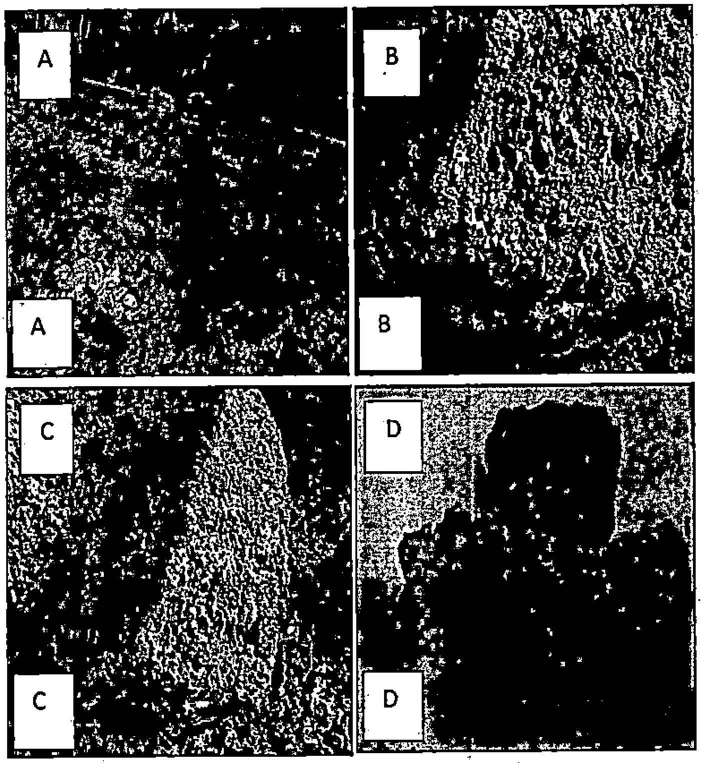


Fig. 10 : Field Photographs and megascopic textures of the granite of the Madomud Temple:

Fig. 2A: Field photograph of the Shrine part of The Madamud temple Showing the severe deterioration by salt as a result of sabkha development with white color which is formed of different forms and composition of salt types. The photo shows the concurrent existence of the temple and its surroundings by cultivation and urban areas.

Figs. 2B &C: Close up views show the destructive effect of the salts crusts and exfoliation on the some granitic masses of the temple. Notice the development of cracks which represents an advanced stage of deep deterioration.

Fig. D: Close up photo for the megascopic deterioration of the granite in the temple showing the severe obliteration by salt and weathering. Notice the destruction and decay and alteration of the feldspar and mica minerals to clay and partially weathering of quartz mineral and development of salts along cleavage and crystal boundries.

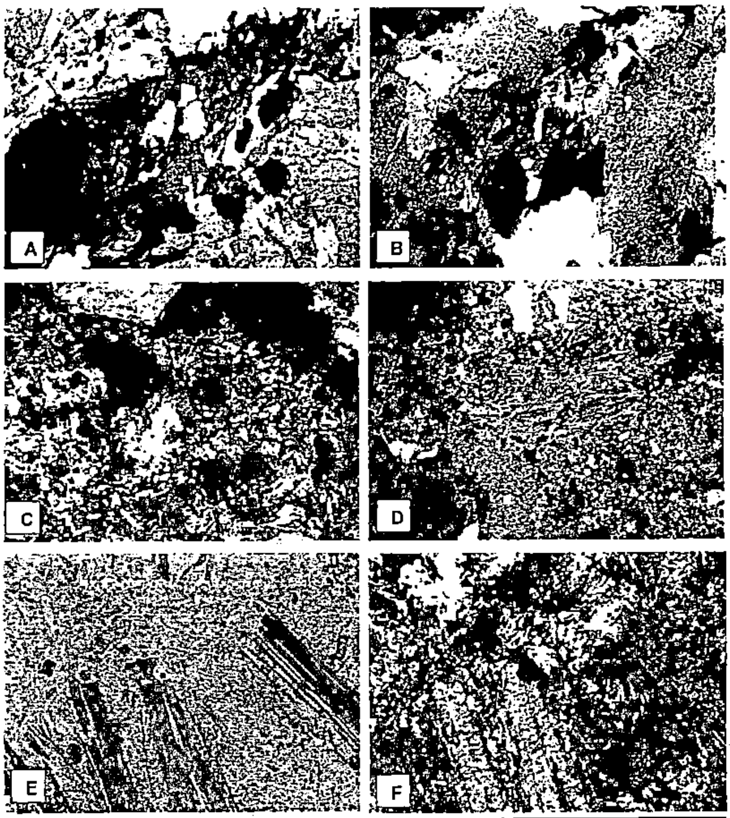


Fig. 11: Representative photomicrographs graphs of textural features of the deteriorated granite of Medamud temple

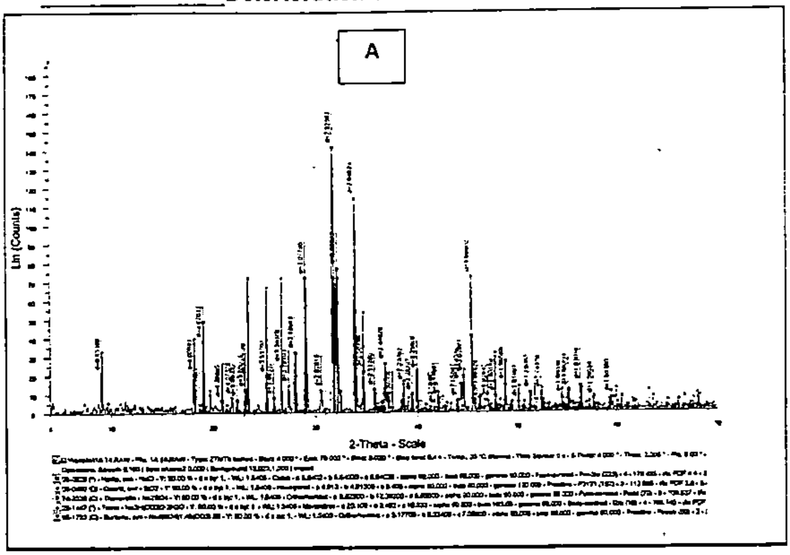
(A) Crossed Nicols photomicrograph of granite consists of fine-grained quartz, microcline K-feldspar, plagioclase, muscovite and biotite and less abundant pyroxene. Apatite and zircon are accessories.

(B) Crossed Nicols photomicrograph of course grained rock consists off parallel alignment of biotite, quartz, amphibole and plagioclase.

(C) Development of thenardite, trona and kaolinite on the vicinity of feldspars of the granite.

(D) Highly altered pink granite with rock salt (Halite). Kaolinite is replacing k-feldspar minerals while quartz forming floating textures due to chemical weathering.

(E&F) Polarized and Crossed Nicols photomicrographs of highly deteriorated biotite granite with prismatic and acicular crystals of thenardite and trona. The deterioration penetrated the cleavage plane of the biotite crystals. The microcline and plagioclase are completely altered to sericite and kaolinite



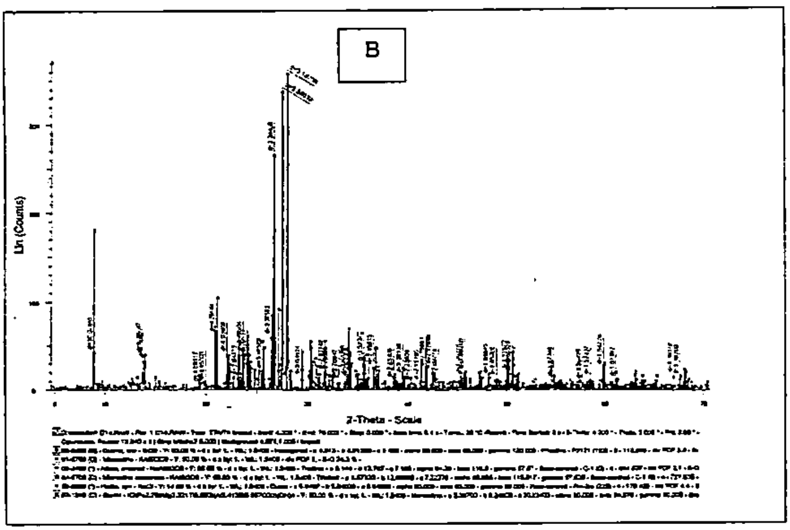
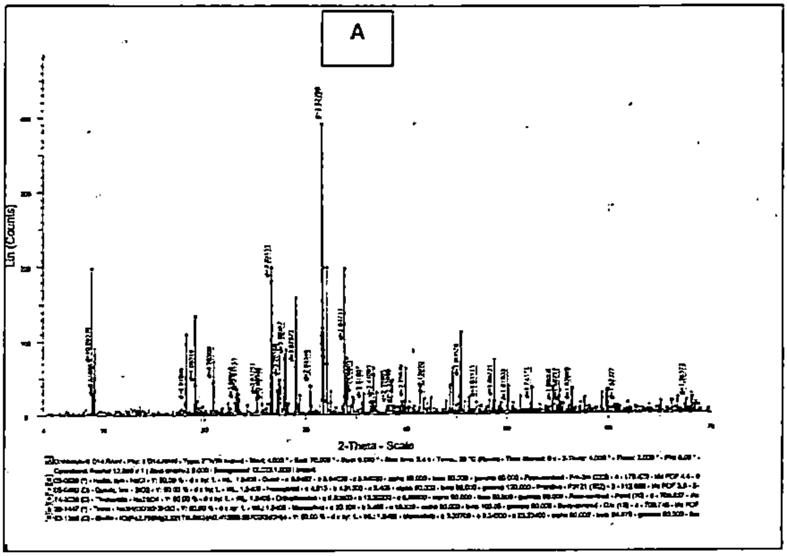


Fig. 12 X-ray diffraction patterns of deteriorated granite minerals with salt crust of Medamud temple sanctuary to the east of the site where show in (A) halite NaCl , quartz SiO_2 ,thenardite Na_2SO_4 , trona $Na_2(CO_3)_2.2H_2O$ and burkeite $Na_4(SO_4)$ 1.45(CO_3) .55 . and in (B) quartz SiO_2 , microcline $KAlSi_2O_8$, albite $NaAlSi_2O_8$, microcline maximum $KAlSi_2O_8$, halite NaCl, and biotite .



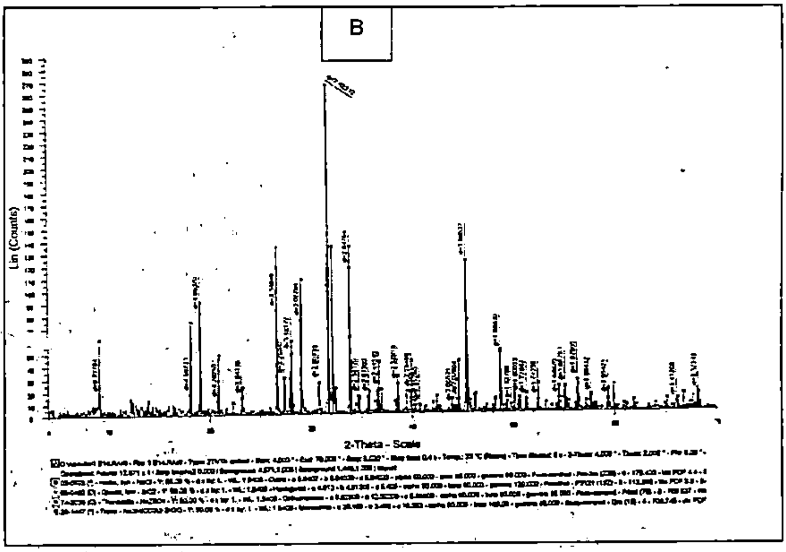


Fig. 13 X-ray diffraction patterns of deteriorated granite minerals with salt crust of Medamud temple sanctuary to the east of the site where show in (A) .halite NaCl , quartz low SiO_2 ,thenardite Na_2SO_4 , trona $Na_2(CO_3)_2.2H_2O$ and burkeite $Na_4(SO_4)_{1.45}(CO_3)_{.55}$. and in (B) halite syn-NaCl, quartz low SiO_2 thenardite Na_2SO_4 , trona $Na_3H(CO_3)_2.2H_2O$.

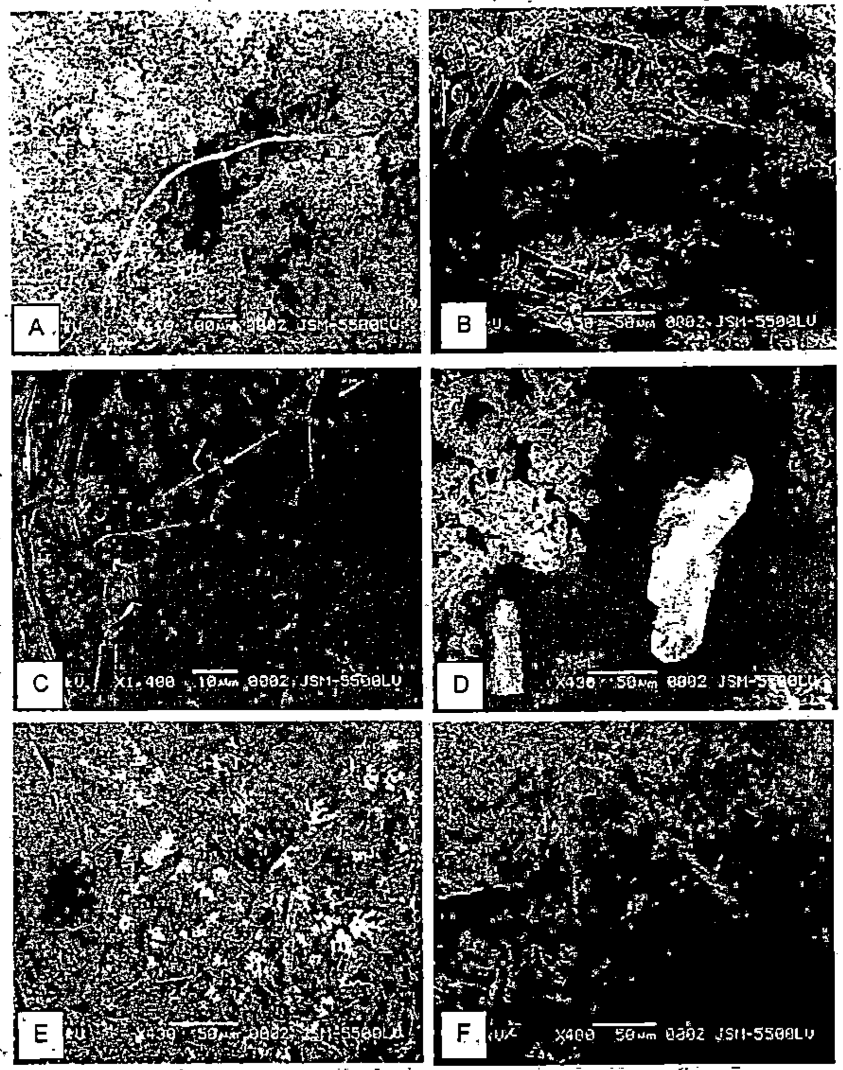


Fig. 14:.Scanning electron micrographs of salt minerals:

A) Euhedral Thenardite crystallites in a growth mode associating algal filamentous structure.
B) Kaolinite and Thenardite
C) Prismatic crystals of Thenardite with small halite hopper crystals
D) Hopper structure of halite intergrown with stubby, twinned gypsum and white thenardite coatings.
E) A rosette arrangement of a cluster of trona crystals (radiating arrangement). Thenardite and white mirabilite . Association of trona with quartz is quite common in these soils.
F) Anhedral quartz crystal associated with kaolinite flakes and abundant radiated skeletal crystals of thenardite

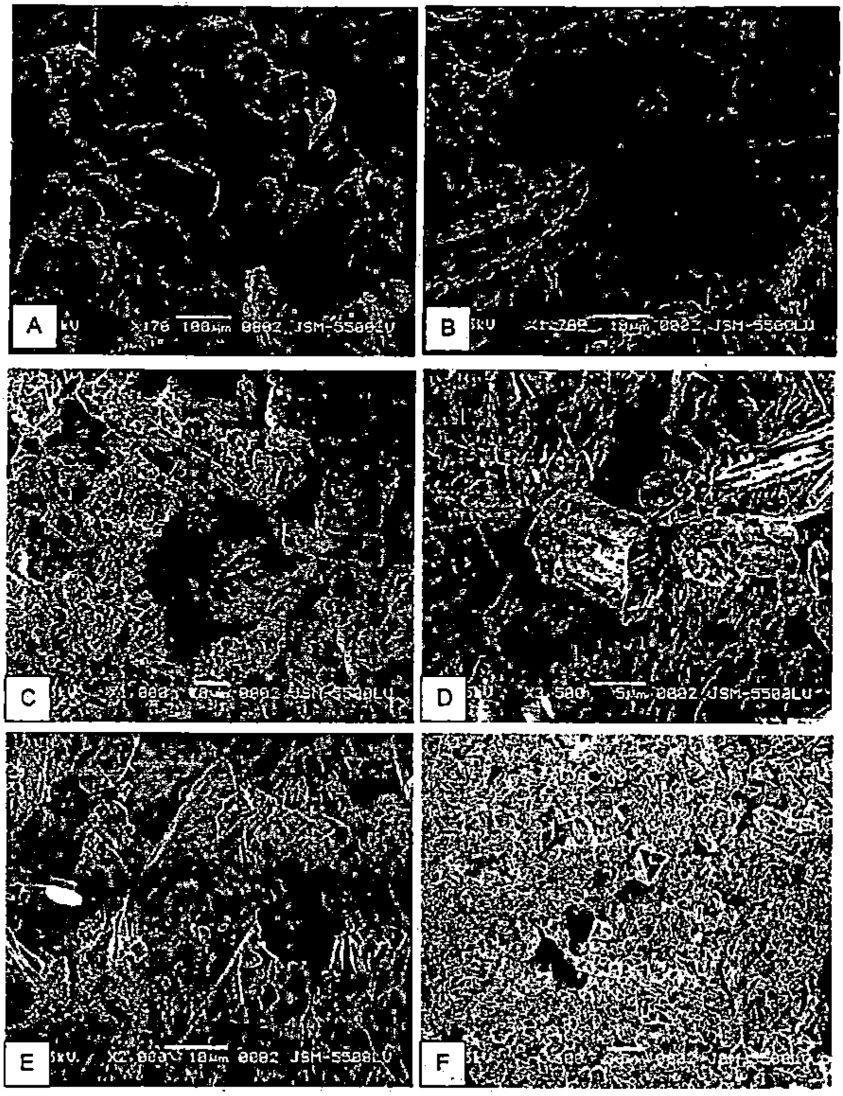


Fig. 15 : Scanning electron micrographs of salt minerals:

A) Altered granite show kaolinite and porous structure due corrosion by salt and exfoliation due to gypsum crystallization.
B) Exfoliated structure of altered granite showing gypsum and salt interlayres
C) Trona associating with white mirabilite and dominant of voids.
D) Gypsum crystals and hopper structure of halite interfering the granite exfoliation
E) Flaky and tabular habit of kaolinite and dissolved halite crystals
F) Salt crust entirely show intergrown of gypsum and trona, thenardite and mirabilite

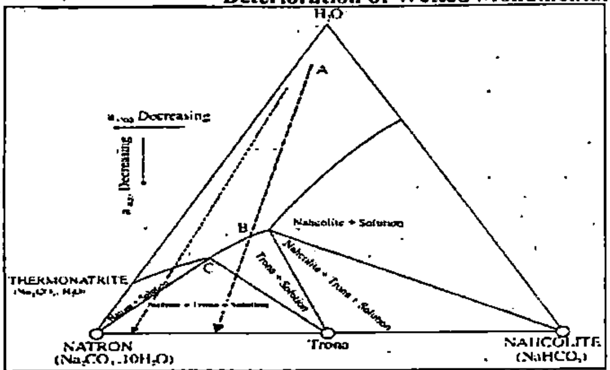


Fig. 16'. Phase diagram of the portion of the sodium carbonate, sodium bicarbonate, water system at 25° C. Trona saturation occurs at B (after Eugster, 1971).

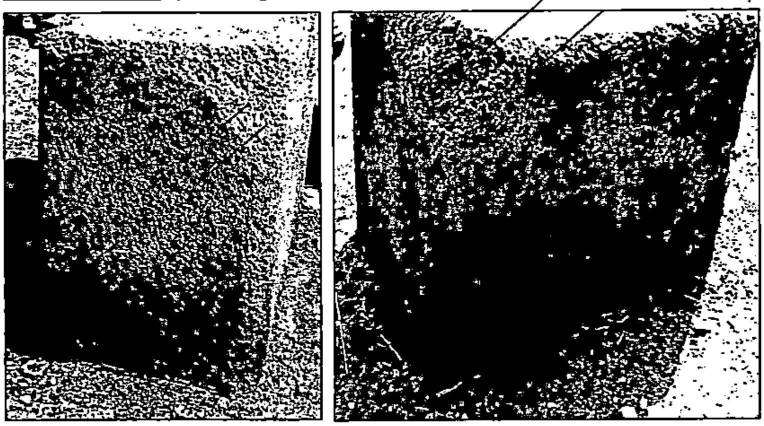


Fig. 17 displays clay minerals in granite of Medamud (red arrows) , also displays dogs stale effects and marks (blue arrows) .

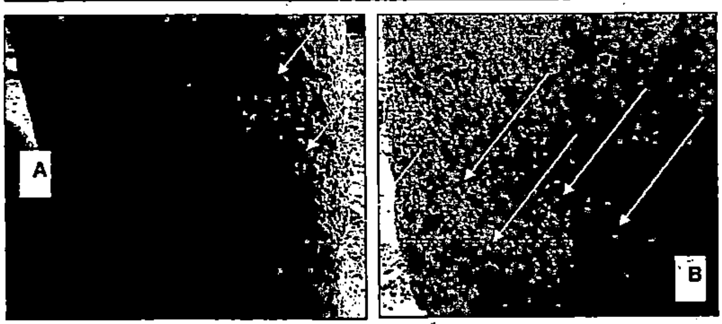
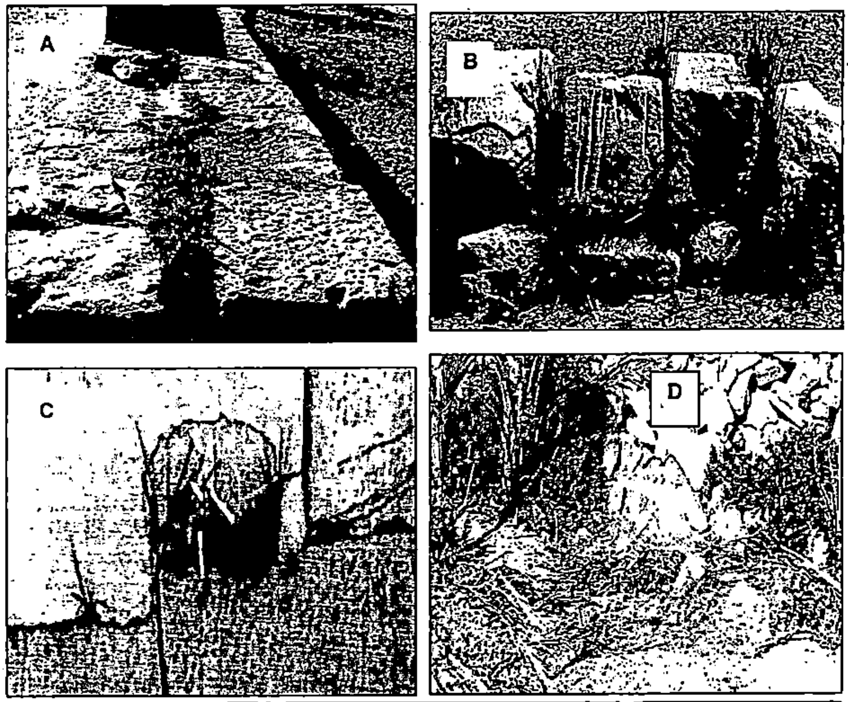


Fig. 18 (A) and (B) shows granular disintegrating into grus in remains of an granitic architectural element of Medamud temple & site (blue bouncing arrow).



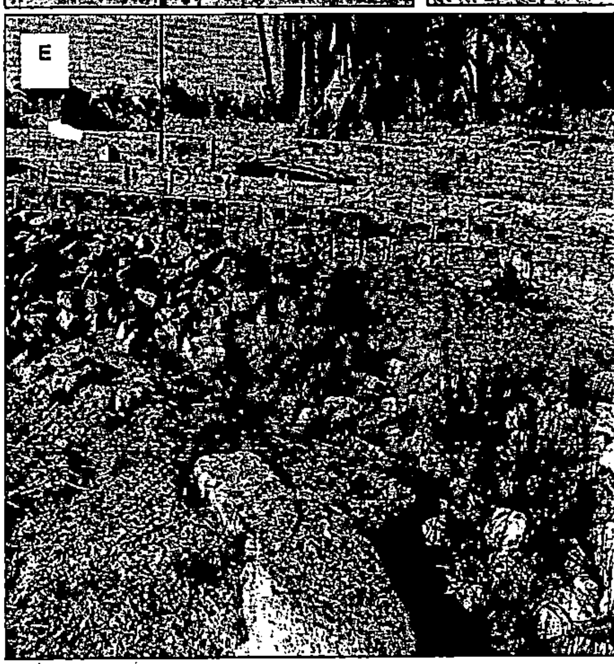


Fig.19 (A), (B), (C), (D)and (E) displays Imperata cylindrica، Alhagi maurorum ، Tamarix nilotica and Phragmites australis , plus some trees and seedlings has been growing in soil , in , inside and around the remains of the temple and the site of Medamud causing deterioration and damage stones, where exude acidic excretion which deteriorate and damage components of stone, , cause accumulation of soluble salts inside stones , penetrate widen the joints and cracks of stones , and sometimes splits the blocks either horizontally or vertically (salt efflorescence are clear in the last photo (E) on the surface of stones .

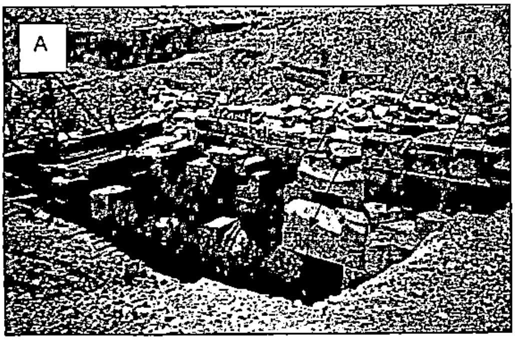


Fig. 20 (A) the central hall of Osireion showing complete loss of the covering ceiling over the granitic pillars and architraves (red arrows) (also shows the growing plants of Phragmites australis).

And 20 (B) a part of Medamud temple showing the smashup of temple of Medamud .

resulting in Incurring to alternative cycles of wetting and drying and a combined reactions of hydration. hydrolysis combined with inadequate sun exposure . plus saline ground water which stamp the sites of two case study : Osireion and Medamud .

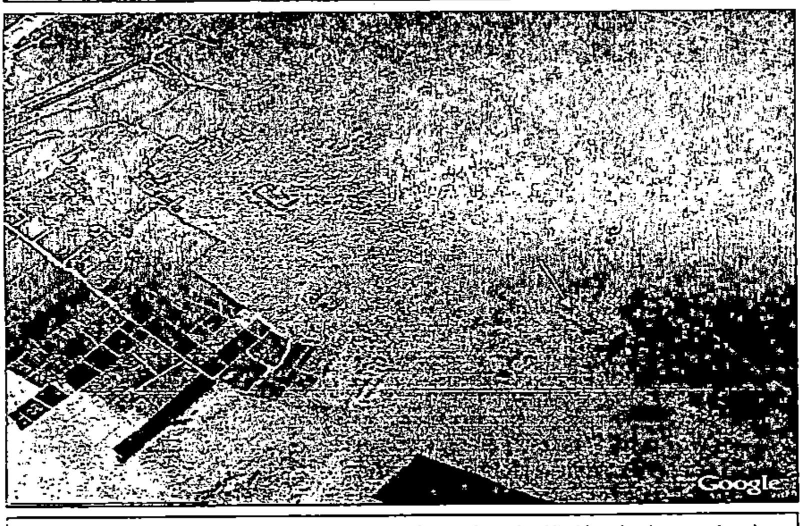


Fig. 21 an aerial view photo (by Google Earth - land sat image) shows the old cultivated to the east and south east (flowery arrows) of Osireion (turquoise arrow) , new reclaimed lands to the west and north west (red arrows) the source of irrigation and drainage water and housing compounds surrounding the context of Osireion (blue arrows) the source of the sewage waste coming from the primitive trenches drainage system .

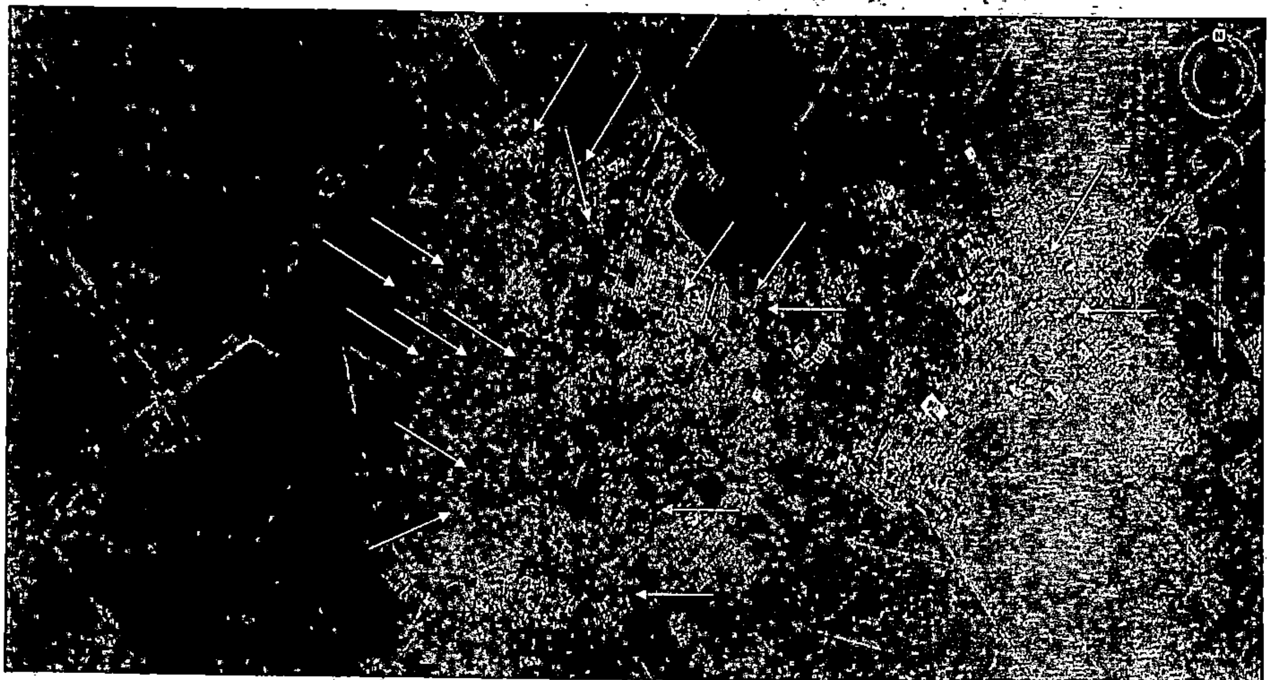


Fig. 22 an aerial view photo (by Google Earth - land sat image) shows the old cultivated surrounding Medamud temple & site (flowery arrows), the source of irrigation and drainage water and random growing housing compounds and url an surrounding the temple & site (turquoise arrow) the source of the sewage waste coming from the primitive trenches drainage system, the wild higher plants, plus some trees and seedlings has been growing in soil, in, inside and around the remains of the temple and the site (yellow arrows), with visibility of influences of the free main water level in the south and south east of the site (red arrows).

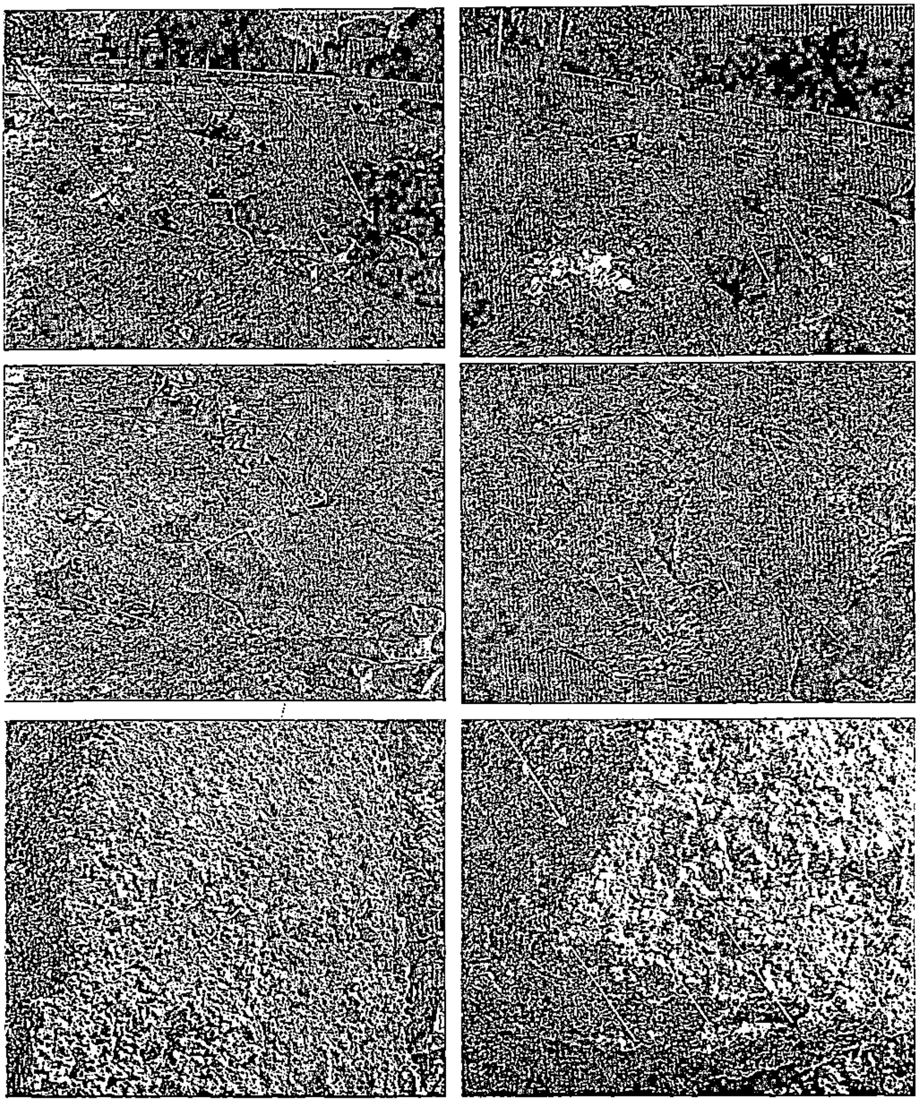


Fig. 23 displays the south and the south eat of the site of Medamud where the effects of infiltration of the free main water level (red arrows) due to cultivation & irrigation drainage water . infiltrated water from old damaged pipes of drinking water . the infiltrated water from floor beds of unlined channels and drains and the sewage waste water coming from the primitive trenches drainage system coming from random growing housing compounds which surround the site are visible clearly effects as result of concentration of population activities . resulting in salt efflorescence and cryptoflorescence (turquoise arrows) .

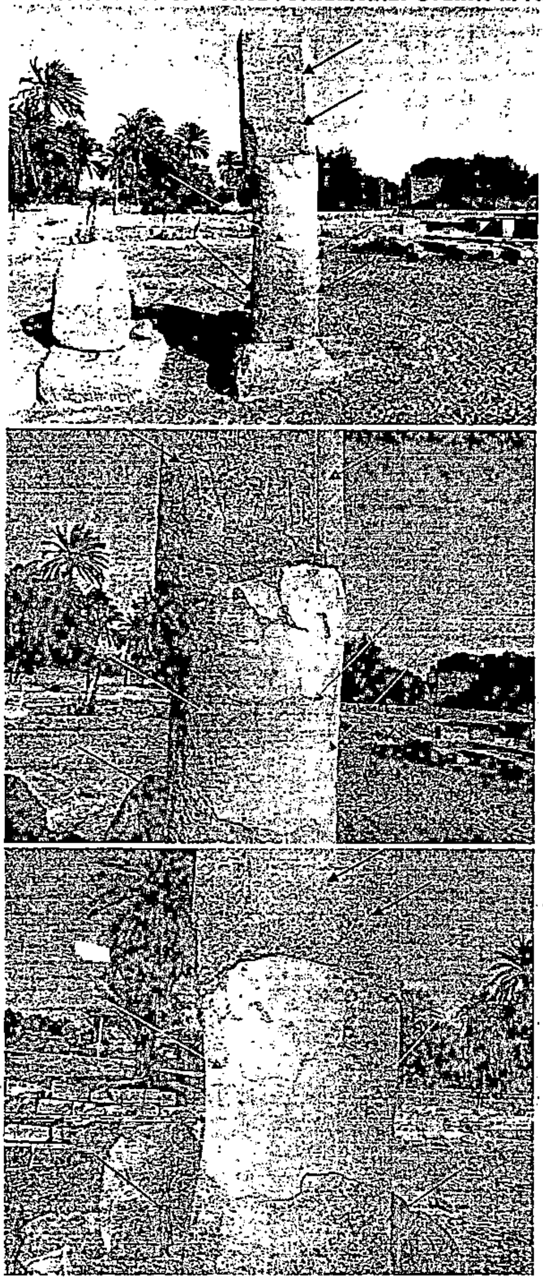


Fig. 24 displays a part of deteriorated granitic semi-pillar (red arrows) , in Medamud temple site - which was joined and cemented with a part of relative good preserved granitic engraved inscribed pillar surface (blue arrows) (probably there is not rapport or affinity between the two parts)- and partially compensated with Portland cement mortar (turquoise arrows) and was erected in wrong position.