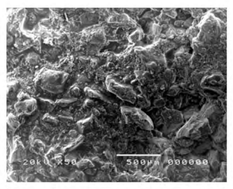
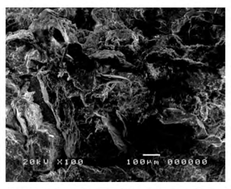
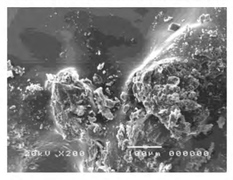
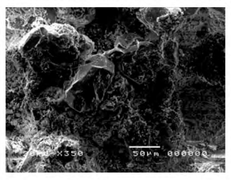
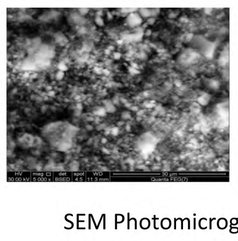
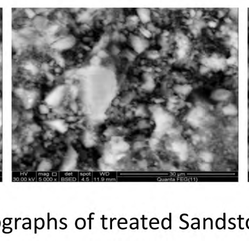
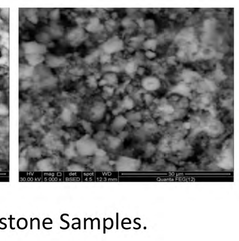
A Comparative Study between using of Nanomaterials and Silicon Based Polymers in Consolidation of Archaeological Nubian Sandstone

Dr. Ezz A. Orabi, Dr. Mohamed K. Khallaf

Introduction

Horemheb was the last king of Dynasty XVIII and he carved a much larger rock-chapel, or speos, out of the hillside at the northern end of the site. The chapel was dedicated to Amun-Re as well as other deities that were connected to the River Nile. All the walls are covered in reliefs and inscriptions, in some places quite damaged, but in others there are some very fine high quality reliefs.

Deterioration Phenomena in the Archaeological Sandstone Blocks of King Horemoheb Speos.

SEM Photomicrographs of treated Sandstone Samples.

Treatment of Sandstone Samples

The sandstone samples were treated, then physical and mechanical properties were measured and SEM examination were carried out before and after artificial weathering.

Artificial aging of Sandstone Samples

The following conditions of artificial aging aimed at simulate the actual cause of environmental deterioration and at quantify the durability of the treatments.

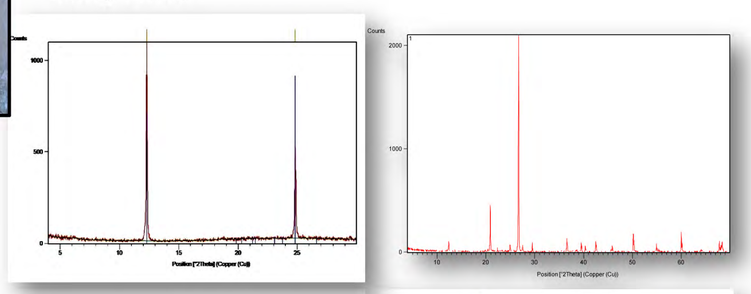
- Wet-dry cycles. - Salt crystallization weathering. - Acid water weathering.

Petrography Study

Examination using a Leitz polarizing microscope shows that, quartz grains had fine cracks. The sandstone includes white grains of crystalline silica in addition to clay minerals such as kaolinite and feldspars . The presence of potassium feldspars, orthoclase and plagioclases was detected. Decomposition of potassium feldspars into sericite and kaolinite minerals was inferred. The section also showed inclusions of muscovite and rutile crystals.

Scanning electron microscopy (SEM)

SEM photomicrographs of the sandstone samples show erosion and disintegration between mineral grains and with presence of voids because of dissolving and lose of binding materials.



X-Ray Diffraction patterns (XRD) of Sandstone Samples.

X-ray diffraction analysis

XRD data of sandstone samples showed that it consists essentially of quartz SiO_2 (00-033-1161), with trace amounts of the following minerals: kaolinite $Al_2 Si_2 O_5 (O H)_4$ (00-058-2006) and orthoclase $K (Al, Fe) Si_2 O_8$ (00-008-0048).XRD analysis of clay minerals in the sand stone sample was carried out and results show that kaolinite was found.

Mechanical Properties of Sandstone Sampels After Treatment and Artificial Aging .

No.	Consolidant	Compressive Strength, psi	Tensile Strength, psi
1	Ethylsilicate [TEOS]	2248.7	302.6
2	Mthoxy tri- methoxy Silane [MMOS]	1110.5	156.4
3	SiO_2 / [TEOS] nanocomposities	2982.6	346.3
4	SiO_2 / [MMOS] nanocomposities	1834.8	218.7

Static Contact Angle of Sandstone Sampels After Treatment and Artificial Aging .

No.	Consolidant	After Treatment	After Artificial Aging
1	Ethylsilicate [TEOS]	115	114
2	Mthoxy tri- methoxy Silane [MMOS]	123	122
3	SiO2 / [TEOS] nanocomposities	136	134
4	SiO2 / [MMOS] nanocomposities	162	161

Physical Properties of Sandstone Sampels After Treatment and Artificial Aging .

No.	Consolidant	Porosity %			Grain Density gm / cm³			Water Absorption %		
		B.C.	A.A.	Ch. %	B.C.	A.A.	Ch. %	B.C.	A.A.	Ch. %
1	Ethylsilicate [TEOS]	30.4	25.2	17.1	2.63	2.76	4.7	13.24	5.2	60.7
2	Mthoxy tri-methoxy Silane [MMOS]	29.9	12.4	58.5	2.62	2.74	4.4	12.98	2.44	81.2
3	SiO_2 / [TEOS] nanocomposities	30.8	19.3	37.3	2.61	2.85	8.4	12.52	4.21	66.4
4	SiO_2 / [MMOS] nanocomposities	30.5	8.6	71.8	2.62	2.78	5.8	12.14	1.97	83.8

Conclusion

The Temple is suffering from weathering and deterioration of sandstone blocks. The surface treatment with polymers is one of the possible treatment techniques that have been tried to overcome the aging problem. The aim of this work was the investigation of consolidation and protective water repellent coatings. Static contact angle measurements, show high values in SiO_2 / [MMOS] nanocomposities treatment as a superhydrophobic effect. Treatment with SiO_2 / Silicon Nanocomposities improved physical and mechanical properties of treated sandstone samples and were more effect than treatment with silicon polymers.