Weathering damage on Pharaonic sandstone monuments in Upper Egypt

Petrographical properties of the Gebel el-Silsila sandstones

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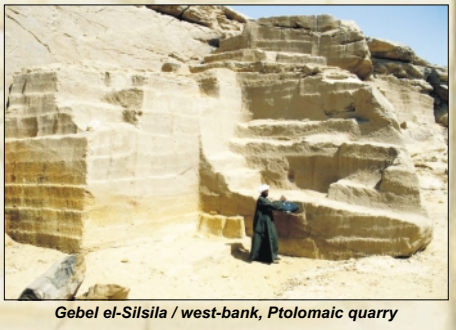
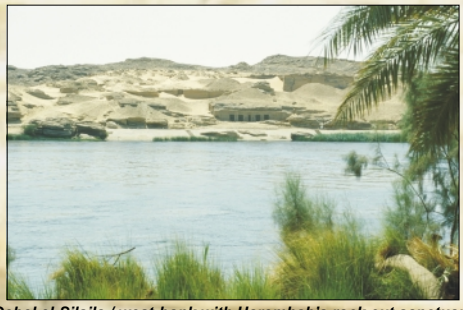
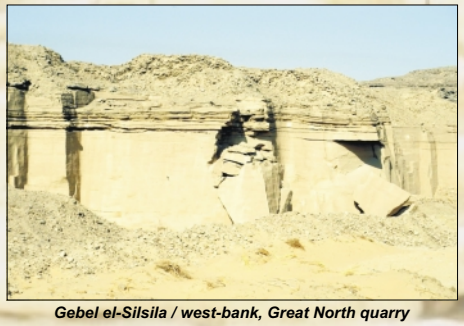
Sandstones from the Gebel el-Silsila region in southern Egypt were used for the construction of most of the Pharaonic monuments in Upper Egypt as well as in the course of past and current restoration works. The ancient sandstone quarries extend over the west and east banks of the Nile. The Gebel el-Silsila sandstones - representing one group of the formerly so-called "Nubian Sandstone" - are stratigraphically attributed to the Qoseir-Formation of the Lower Campanian / Upper Cretaceous.



Gebel el-Silsila / west-bank, Ptolomaic quarry



Gebel el-Silsila / west-bank with Haremhab's rock cut sanctuary



Gebel el-Silsila / west-bank, Great North quarry

GROUPS	I	II				III			IV	V	VI
LITHOTYPES	I - A	II - A	II - B	II - C	II - D	III - A	III - B	III - C	IV - A	V - A	VI- A
STONE COLOUR	white	white	white, spotted	light brown, spotted	yellow	light yellow, brownish-yellow	light gray, spotted	red	brownish-yellow, spotted	light brown	light brown
MINERAL COMPOSITION: Quartz [%]	75 - 100	75 - 100	75 - 100	75 - 100	75 - 100	75 - 100	75 - 100	75 - 100	75 - 100	75 - 100	75 - 100
Rock fragments	50 - 75	50 - 75	50 - 75	50 - 75	50 - 75	50 - 75	50 - 75	50 - 75	50 - 75	50 - 75	50 - 75
Feldspar	25 - 50	25 - 50	25 - 50	25 - 50	25 - 50	25 - 50	25 - 50	25 - 50	25 - 50	25 - 50	25 - 50
Mica	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25	10 - 25
Heavy minerals	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10
Clay minerals	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5
Opaque matter	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Calcite	0	0	0	0	0	0	0	0	0	0	0
Gypsum											
CLASSIFICATION (according to PETTIJOHN et al. 1987)	Subltharenite	Subltharenite	Subltharenite	Subltharenite	Subltharenite	Quartz arenite / Subltharenite	Subltharenite	Subltharenite	Quartzwacke / lithic graywacke	Lithic graywacke	Feldspathic graywacke
TEXTURE: Matrix-grain-ratio	> 0.3	0.2 - 0.3	0.1 - 0.2	< 0.1							
Mean grain size [mm]	0.15 - 0.20	0.10 - 0.15									
Sorting	1.41 - 1.74 moderate	1.23 - 1.41 good									
Grain contacts [Grain contacts per cm³ (thin section analysis)]	5000 - 7500	2500 - 5000	1500 - 2500								
POROSITY PROPERTIES: Bulk density [g / cm³]	1.90 - 2.00	1.80 - 1.90	1.70 - 1.80								
Density [g / cm³]	> 2.70	2.65 - 2.70	< 2.65								
Porosity [Vol.-%]	30 - 35	25 - 30									
Ratio capillary pores / micropores	> 100	50 - 100	< 50								
Median radius of pore entries [µm]	20 - 25	10 - 20	5 - 10	1 - 5							
Pore surface [m² / cm³]	3 - 5	1 - 3	< 1								

Petrographical properties and classification of the Gebel el-Silsila sandstones

Based on a survey of the ancient quarries and the sandstone monuments in Upper Egypt, laboratory studies were carried out aiming at a detailed petrographical differentiation and classification of the Gebel el-Silsila sandstones. The results of the laboratory analyses revealed a considerable variation of the Gebel el-Silsila sandstones with respect to their petrographical properties. Considering all differences in their petrographical properties, the Gebel el-Silsila sandstones were classified into six groups of sandstones, in all including eleven individual lithotypes. As a trend, the content of quartz, the mean grain size, the ratio capillary pores / micropores and the median radius of pore entries decrease from group I to group VI, whereas the contents of feldspar and the clay minerals, the matrix-grain-ratio, the number of grain contacts, the total porosity and the pore surface increase in this order from group I to group VI. According to these results and the observations in the quarries and at the stone monuments, the susceptibility of the sandstones to weathering can be assumed to increase from group I to group VI.

Gebel el-Silsila / east-bank, Ptolomaic-Roman quarry

Gebel el-Silsila / east-bank

Gebel el-Silsila / east-bank, Great Ptolomaic quarry

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