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## Mineralogy of Abu Rowash pyramid. Egypt

### Abstract

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### Abstract

Field, microscopic and X-ray investigation of blocks of pyramid constructed Abu Rowash were performed. Investigation showed the pyramid is constructed on specially prepared hill where slopes are cut in form of steeps and blocks constitute only the cover. Mineralogy and petrography as well as X-ray examination confirmed the use of gypsum mortar for fixation of blocks. Moreover examination document that blocks used for pyramid construction are of other structure and texture than limestones constituting the core of pyramid.

**Key words:** Egypt, pyramid, Abu Rowash, mineralogy

### Introduction

Abu Rowash pyramid of Djediefre (IVth dynasty) is located 8 km to the North from pyramids in Giza on the western ridge of Nile valley – continuation of Gebel (hill) el-Ghigiga (Smith, Hawass, Lehner, 2006, Lehner 2008). Pyramid constitutes the center of monument structures consisted was not finished (Fig. 1).

### Methods and material

After field works documentation and sampling microscopic as well as X-ray investigations of natural rocks, tests on stone blocks of pyramid were performed. Moreover substance cementing stone blocks have been tested.

The examination was done using polarizing light microscopy Polmi A with semi-quantitative counter Eltinor and X-ray powder diffractometry.

Material for investigation was collected from natural layers of limestones (core of pyramid) blocks cover of pyramid, blocks covering walls of tomb as well as from mortar cementing blocks.

The list of samples is enclosed below

## **List of tested samples and place of location**

Samples from North wall of pyramid

Sample no      place of sampling

- 1- Natural limestone present under the pyramid
- 2- Natural limestone just under the first layer of blocks
- 3- Block of base of pyramid
- 4- Substance cementing blocks of pyramid
- 5- Block of pyramid located 1.5 m above the base
- 6- Block of pyramid located 3.5 m above the base
- 7- Block of pyramid located 6.0 m above the base
- 8- Block of pyramid located 3 m below the top
- 9- Block of pyramid located 1,5 m below the top
- 10- Block located at the top of pyramid
- 11- Natural limestone – bottom of the tomb
- 12- Limestone block located 2 m above bottom of the tomb

Samples Fromm South wall of pyramid

- 13 –Block of pyramid. Surface coated with patina
- 14 - Block of pyramid. Surface coated with patina

## **Results**

Field observations peforemd in Abu Rowash showed that the pyramid was constructed on a natural, but specially prepared hill (Photo 1). Slopes of this hill were cut in the form of steps. Then steps were used for location of stone blocks. Walls of tomb and corridor present at pyramid as well as corridor were also cut in the hill and next covered with stone blocks fixed with gypsum mortar (Photo 2, 3).

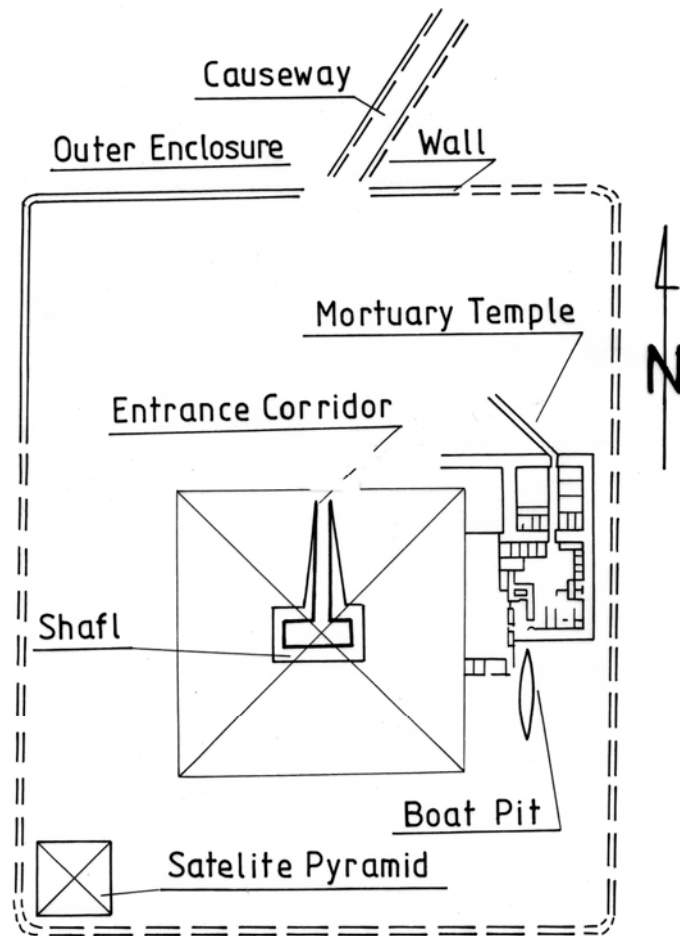


Fig. 1 Scheme of area near pyramid At Abu Rowash



Photo 1 Light, layers of natural limestones cut in form of steps at the core of Abu Rowash pyramid.



Photo 2 Corridor leading to the tomb at the pyramid of Abu Rowash. One can see walls cut in natural limestone and coated with blocks of not local limestones.



Photo 3 Bottom of the tomb at pyramid of Abu Rowash. Blocks of limestones used for construction of architecture at the tomb. One can see rests of plasters at the surface of limestone used for fixing of blocks with wall cut in limestones





Photo 4 Light, fine crystallized gypsum at species between blocks used as material cementing blocks of Abu Rowash Pyramid

### **Microscopic analyses**

Obtained data documents that blocks of the pyramid represent limestone and ankerite (izostructural with dolomites). Studies with the use of polarizing light microscopy show also admixture of quartz, calcitic skeleton of mollusk, foraminifer etc., opaque minerals (sulphides) and others. Porous structure of stone blocks suggests that at the deposit rock was wet, soft and easy to cut. This phenomenon was the reason of relatively easy production of numerous blocks at a short time

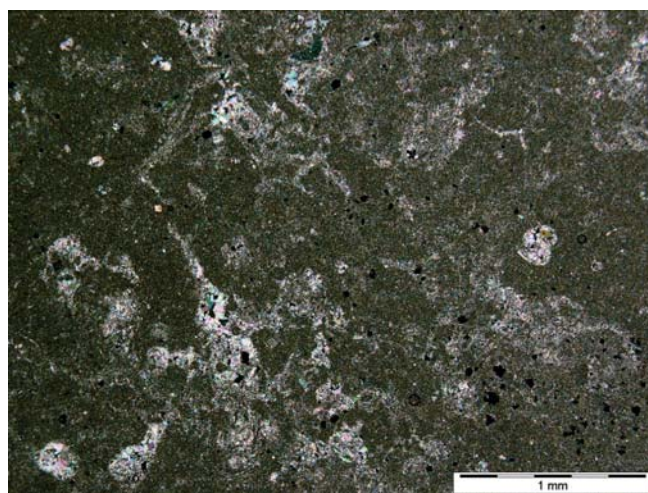
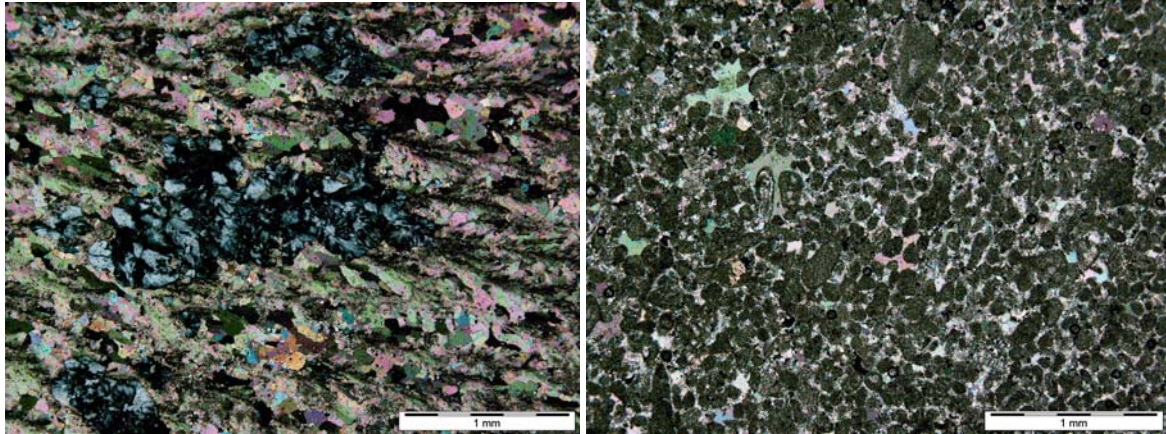


Photo 5 Sample 1. Example of micritic limestone containing skeletons of organisms. Layer just under the pyramid Abu Rowash. Polarizing light microscopy, polaroides X.

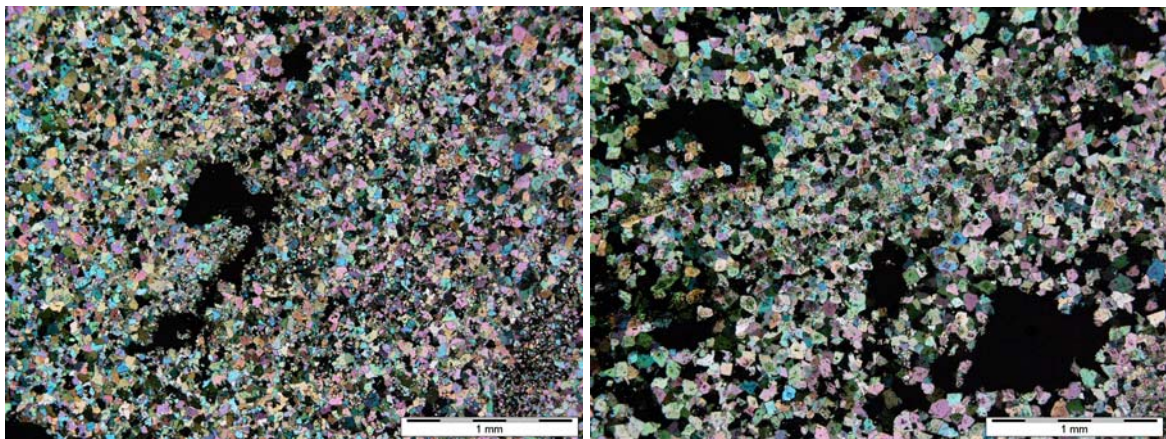




A

B

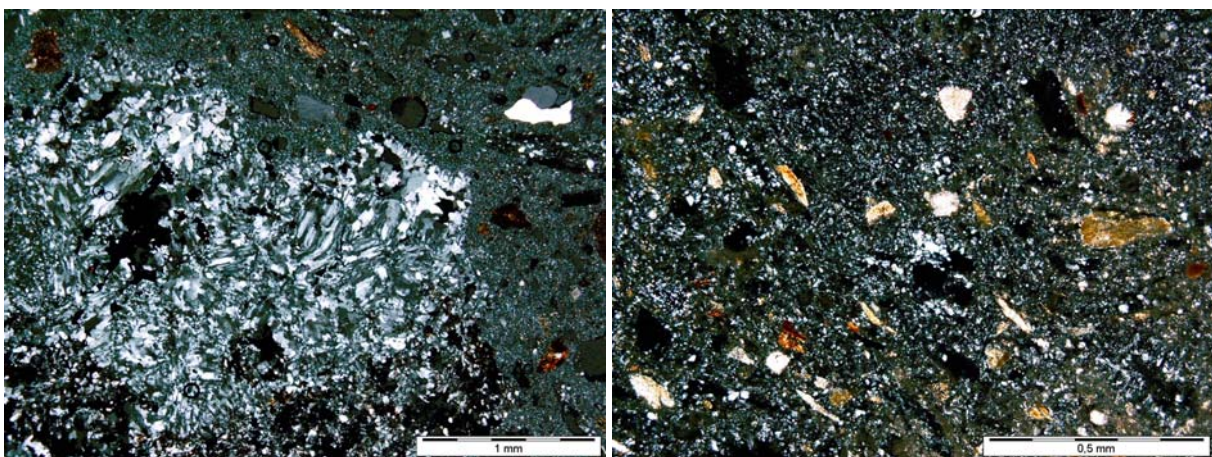
Photo. 6 A – Block of pyramid. Organic limestone containing inclusions of fine crystalline gypsum. B – Block of limestone. Pseudoolitic limestone. Polarizing light microscopy, polaroides X.



A

B

Photo7 Blocks of pyramid. Various porosity of dolomites seen under microscope as black spots. Polarizing light microscopy, polaroides X.



A

B

Photo 8 Substance cementing blocks of pyramid. A- Fine gypsum with bigger grains of not grinded medium crystalline gypsum. B – Fine gypsum with small organic inclusions (brownish grains). Polarizing light microscopy, polaroides X.

Table 1A

Mineral composition of blocks from Abu Rowash pyramid (vol. %)

**Mineral composition of blocks (Vol. %)**

component	sample no				
	1	2	3	4	5
calcite	96	75,5	94,6	19,7	64,4
quartz	2,4	0,2			0,3
skeletons	0,9		0,1	1,8	0,1
opaque min.	0,1	0,1	0,1	0,1	0,2
dolomite	0,6	2,2	3,2		5,3
gypsum		22	2	79,4	16,1
ankerite					13,6

Table 1B

Mineral composition of blocks from Abu Rowash pyramid (vol. %)

**Abu Rowash Pyramid**

**Mineral composition of blocks (Vol. %)**

component	sample no				
	6	7	8	9	10
calcite	99,3	84,3	94,2	86,3	88,2
quartz		0,3		1,8	0,7
skeletons		3,3		0,5	0,8
opaque min.		0,2	0,2	0,2	0,3
dolomite			5,3	10,1	10
gypsum	0,7	22,7	0,3	1,1	
ankerite					

Table 1C

Mineral composition of blocks from Abu Rowash pyramid (vol. %)

**Abu Rowash Pyramid**

**Mineral composition of blocks (Vol. %)**

component	sample no			
	11	12	13	14

<b>calcite</b>	<b>77,9</b>	<b>12,6</b>	<b>67,3</b>	<b>68</b>
<b>quartz</b>	<b>0,3</b>	<b>0,1</b>	<b>2,2</b>	<b>2,3</b>
<b>skeletons</b>	<b>0,3</b>			
<b>opaque min.</b>	<b>0,2</b>	<b>0,1</b>	<b>0,3</b>	<b>0,1</b>
<b>dolomite</b>	<b>1,8</b>	<b>0,3</b>	<b>10,2</b>	<b>8,7</b>
<b>gypsum</b>	<b>3,7</b>		<b>20,1</b>	<b>20,9</b>
<b>ankerite</b>	<b>6,8</b>	<b>76,9</b>		

Microscopic data documents that blocks of pyramid represent various types of limestones and dolomites containing admixture of quartz, calcitic skeleton of moluscas, foraminifer etc. and opaque minerals (sulphides) and other. Porous structure of stone blocks suggests that at the deposit rock was weat, soft and easy for cutting. This phenomenon was the reason of relatively easy production of numerous blocks at short time.

Natural rock present just under the pyramid represents pure limestones of other type than blocks used for pyramid construction. This means that blocks used for pyramid construction are not of local origin.

Microscopic examination confirmed that the substance cementing blocks of pyramid is gypsum with various admixture of fine calcite. The use of this material confirms that the Egyptians knew (at time of 3th dynasty) the technology of gypsum production as well as the way of use of this material for construction of architectonic objects.

### **Results of X-ray examination from North wall of pyramid**

Obtained data documents that blocks of the pyramid represent limestone and ankerite (isostructural with dolomites). Studies with the use of polarizing light microscopy show also admixture of quartz, calcitic skeleton of mollusk, foraminifer etc., opaque minerals (sulphides) and others. Porous structure of stone blocks suggests that at the deposit rock was wet, soft and easy for cutting. This phenomenon was the reason of relatively easy production of numerous blocks at a short time.

Natural rock present just under the pyramid represents pure limestone [PDF 81-2027], whereas the base of the pyramid construction is built of ankerite [PDF 84-2066]. It means that blocks used for the base of the pyramid construction were not of local origin.

X-ray powder diffraction examination confirmed that gypsum [PDF 70-0982] with some admixture of fine calcite is the substance which joins the blocks of the pyramid. The use of this material by Egyptians (at time of 3th dynasty) shows that they knew the technology of gypsum production as well as the way of using it for construction of architectonic objects.

<b>Sample no</b>	<b>Mein component</b>	<b>admixtures</b>
1.	calcite - $\text{CaCO}_3$	
2.	ankerite- $\text{Ca}_{1,01}\text{Mg}_{0,45}\text{Fe}_{0,54}(\text{CO}_3)_2$	gypsum – $\text{CaSO}_4 \cdot (\text{H}_2\text{O})_2$
3.	calcite - $\text{CaCO}_3$	



- |     |   |   |
|-----|---|---|
| 4.  | gypsum - $\text{CaSO}_4 \cdot (\text{H}_2\text{O})_2$                       |   |
| 5.  | calcite - $\text{CaCO}_3$   | ankerite- $\text{Ca}_{1.01}\text{Mg}_{0.45}\text{Fe}_{0.54}(\text{CO}_3)_2$ |
| 6.  | calcite - $\text{CaCO}_3$   |   |
| 7.  | calcite - $\text{CaCO}_3$   |   |
| 8.  | calcite - $\text{CaCO}_3$   |   |
| 9.  | calcite - $\text{CaCO}_3$   |   |
| 10. | calcite - $\text{CaCO}_3$   |   |
| 11. | calcite - $\text{CaCO}_3$   |   |
| 12. | ankerite- $\text{Ca}_{1.01}\text{Mg}_{0.45}\text{Fe}_{0.54}(\text{CO}_3)_2$ |   |

### **Samples from South wall of pyramid**

- |     |                           |   |
|-----|---------------------------|---|
| 13. | calcite - $\text{CaCO}_3$ | gypsum – $\text{CaSO}_4 \cdot (\text{H}_2\text{O})_2$ |
| 14. | calcite - $\text{CaCO}_3$ | gypsum – $\text{CaSO}_4 \cdot (\text{H}_2\text{O})_2$ |

### **Conclusions**

Performed investigation suggests that other Egyptian pyramids are of similar construction and may contain natural core in form of small specially prepared hill. The slopes of hill were probably similarly as at Abu Rowash cut in form of steps used later for deposition of blocks. It is possible that even these small hills (cores) were artificially prepared by exploration of part of natural layers. This way was easier for construction of all pyramid than building with the use of blocks.

Obtained data suggests that other pyramids are not in all volume constructed only of stone blocks. Probably, similarly as pyramid at Abu Rowash they are constructed on natural hill (core) covered with stone blocks. This hypothesis concerning other pyramids have to be confirmed by future detailed examination.

### **Literature**

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