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Исследования обогатимости руд кварцевого месторождения Вади Мубарак в восточной пустыне Египта с целью выявления возможности извлечения концентрата особо чистого кварца

Настоящее исследование связано с геохимической и технической квалификацией месторождения кварца Вади Мубарак в Восточной пустыне Египта, а также процессами обогащения, необходимыми для этих месторождений для достижения высокой классификации особочистого кварца (ОЧК), для использования их в качестве сырья материалов и в некоторых высокотехнологичных отраслях.

А. М. Заед Мохаммед

Айрықша таза кварц концентратын алудың мүмкіндігін көрсету мақсатында мысырдың шығыс даласындағы Вади Мубарак кварцты кен орнында руданың байытылуын зерттеу

Бұл зерттеулер Мысыр аймағындағы шөл даланың Шығыс бөлігіндегі Вади Мубарак кварцты кен орнын геохимиялық және техникалық квалификациялаумен (бағалаумен), сонымен қатар кейбір жоғары технологиялық салаларда материалдық шикізат ретінде пайдалану үшін, айрықша таза кварцтың жоғары деңгейіне жету үшін осы кен орнына қажетті байыту үрдістерімен байланысты.

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PROSPECTS OF USING THE QUARTZ DEPOSITS OF MARWAT ALIMIKAN AREA, EASTERN DESERT, EGYPT IN HI-TECH INDUSTRIES

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The present study deals with the geologic description, geochemical characteristics, thermal behavior and some petrophysical properties of the quartz deposits of Marwat Alimikan area, Eastern Desert, Egypt.

Introduction

Quartz is one of the most common minerals in nature. According to silicate tetrahedron, it belongs to silicate varieties- the most widespread mineral group in the earth's crust. Quartz – the main source of silicon, which is the second most common element in the earth's crust.

High-purity quartz is common quartz that is characterized by exceptionally low concentrations of elements other than silicon and oxygen. Untreated, naturally occurring quartz with less than 50 ppm of impurities qualifies as high-purity quartz; however, quartz with as much as

500 ppm total impurities may suffice if industrially feasible dressing techniques succeed in lowering the impurity level to less than 50 ppm /1/.

The demand for the quartz raw material is increasing worldwide, in particular, the demand for high-purity quartz (HPQ; e.g. /2, 3/). The forecasts of the solid growth of the high-purity quartz demand in the world market is about 5–20% per annum, as a result of continued expansion in the production of silicon oxide wafers for semi-conductor technology.

Quartz deposits, which are the raw materials for the reception of silicon, are basically concentrated in the Eastern Desert of Egypt. All these quartz deposits, unfortunately, have not been studied in detail for their suitability for solar energy purposes and other hi-tech industries. Therefore, based on the quartz deposits of Marwat Alimikan, a revision of mineralogical and geochemical studies to determine their compatibility for high-purity quartz had been carried out.

Methods and Techniques

The methods and techniques that have been applied on the quartz deposits of Marwat Alimikan area are field work and laboratory work. The field work was carried out to study the relationship between the quartz deposits and their host rocks, as well as collecting representative samples of quartz for laboratory work. The laboratory work that carried out on the quartz deposits of Marwat Alimikan area are: 1) Thermal and petrophysical measurements (thermal stability, loss on ignition, water absorption and mechanical resistance) and 2) Geochemical composition by using the XRF technique.

All the laboratory works were carried out in the labs of the Egyptian geological survey.

Geology of Marwat Alimikan quartz deposits

Marwat Alimikan area is situated at Bernice-Aswan district in the southern part of the Eastern Desert. The quartz deposits of Marwat Alimikan area appear as intrusive bodies within the granodiorite rocks. Three quartz bodies occur as conspicuous high cones surrounded by flat surface of wadi deposit forming triangle feature. The three quartz bodies of Marwat Alimikan area are delineated by latitudes 23°52'48"–23°53'30" N and longitudes 35°06'09"–35°08'48" E (Fig.1). Quartz in the three bodies is milky white in color, jointed, fractured and stained by iron oxides along the fissures and cracks, while the entire quartz bodies are iron free. The quartz bodies vary in their height from 30 to more than 50 m and diameter from 100 to 120 m. The dimensions of the first quartz body (M_1) are 60m×60m×150m, which give about 1,400,000 tons. The dimensions of the second quartz body (M_2) are 30m×80m×120m, which give about 750,000 tons. The dimensions of the third quartz body (M_3) are 60m×60m×100m, which give about 950,000 tons. In general the geological resources of the three quartz bodies are about 3 million tons. Two of these quartz bodies of the area were quarried, while the third is not quarried until now.

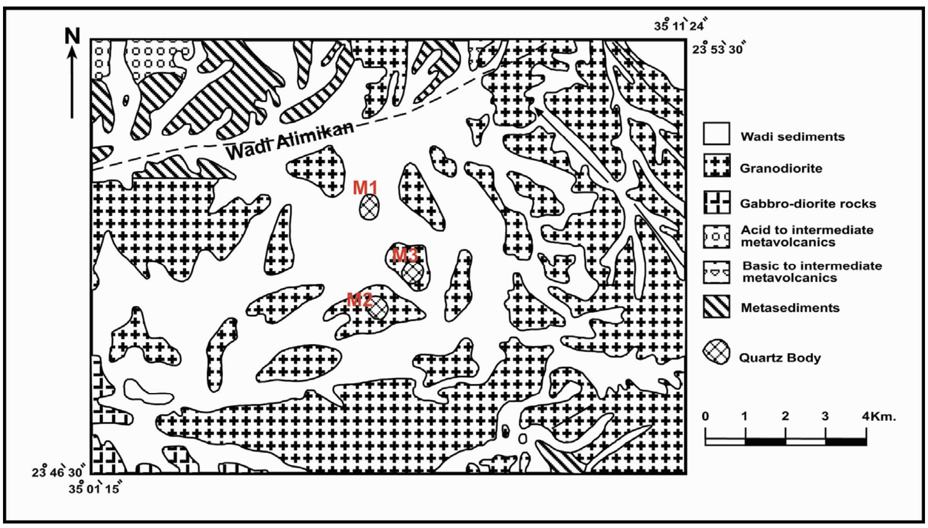

Figure 1. Geologic map of Marwat Alimikan quartz deposits, Bernice area, South Eastern Desert, Egypt /4/

Geochemical, thermal and petrophysical characteristics of Marwat Alimikan quartz deposits

The chemical composition, thermal, and petrophysical properties of raw quartz are the most important starting investigations serving as bases for assessing both the quality of a deposit and the potential uses of the raw materials contained therein. It provides valuable results to the probable processing steps required and the potential product grades achievable. The success assessment of each individual processing step is verified by chemical analyses. The chemical analysis is the bases on which all further approaches are decided. Mineralogical examinations are required even during the course of processing, and are needed for developing target-oriented procedures to remove mineral or liquid inclusions, thereby ensuring increased purity of the product.

a) Chemical analyses

Seven representative quartz samples from Marwat Alimikan area were chemically analyzed (Table 1).

From Table 1, the SiO_2 content ranges between 99.25 and 99.60% with an average content 99.46%, TiO_2 content is < 0.01%, Al_2O_3 content ranges between 0.15 and 0.28% with an average 0.20%, Fe_2O_3 content ranges between 0.01 and 0.04% with an average 0.02%, CaO content ranges between 0.08 and < 0.01 with an average 0.05%. Therefore these composite quartz materials, without treatments, match well the requirements of the following industries: Aluminum alloy industry (Si minimum 98 wt%, Fe maximum 0.02–0.05 wt% and Ca from 0.015–0.3 wt % /5/) and Ferrosilicon alloy industry (SiO_2 > 98%, Al_2O_3 < 0.4%, Fe_2O_3, CaO and MgO ≤ 0.2% /6/).

From the above chemical results it is clear that the quartz deposits of Marawat Alimikan are compared to those that are classified as pure (SiO_2 99% to < 99.5%) to very pure (SiO_2 ≥ 99.5%) quartz /7/as the result of SiO_2 content which ranges between 9925 to 99.60%.

The analyzed quartz samples also show abnormal contents of Zr, Cr, Cu and Ni. This content has a negative effect on the process of transferred efficiency of quartz into solar cells /8/. This negative has to be treated during quartz processing.

b) Thermal behavior

Four quartz samples were subjected to differential thermal analysis to detect their thermal behavior versus thermal gradient (Table 2).

The given analyses show that the mineral constituent of the analyzed samples is quartz with total loss of ignition due to heating up to 1000°C ranging between 0.089 and 0.412%. The DTA curve of the studied samples indicates that the quartz is of α -type, where the endothermic peaks on the curve show that the temperature ranges between 572.78° C to 575.03° C (Fig. 2).

c) Petrophysical measurements

Four quartz samples representing the different quartz bodies of Marawat Alimikan were measured to determine some of their petrophysical properties such as water absorption, stress and mechanical resistance (Table 3).

The petrophysical properties results of the analyzed quartz deposits of Marwit Alimikan area indicate their suitability for the manufacture of artificial ornamental stone /7/. Also the high mechanical resistance with low water absorption is suitable for using this quartz for manufacturing solar silicon /8/.

Conclusion

Geochemical studies revealed that Marwat Alimikan quartz deposits exhibit high degree of purity ranging from pure to very pure owning to the silica ratio which ranges between 99.25 and 99.60% with an average content 99.46%.

The differential thermal analyses of Marwat Alimikan quartz deposits, clarify that they are of α -quartz type. Also their petrophysical measurements (high mechanical resistance and low water absorption values) are suitable for the silicon solar cell production after suitable beneficiations.

The high degree of purity of the quartz deposits of Marwat Alimikan area, their remarkable petrophysical characteristic (high mechanical resistance and low water absorption values) and thermal behavior have nominated and qualified these deposits, even without beneficiation, to be used in hi-tech industries such as Aluminum alloy and Ferrosilicon alloy industries.

Table 1

Results of XRF analyses of seven quartz samples, Marwat Alimikan area

Sample No.	*Marwa (1)*		*Marwa (2)*			*Marwa (3)*		*Av.*
	1	*3*	*5*	*8*	*9*	*11*	*12*	
Major oxides wt %								
SiO_2	99.56	99.27	99.25	99.50	99.52	99.60	99.52	99.46
TiO_2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Al_2O_3	0.21	0.27	0.28	0.16	0.25	0.15	0.15	0.2
Fe_2O_3	0.03	0.02	0.04	0.02	0.02	0.02	0.01	0.02
MnO	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MgO	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
CaO	0.07	0.05	0.05	0.08	0.05	0.05	< 0.01	0.05
Na_2O	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
K_2O	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
P_2O_s	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
SO_3	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
L.O.I	0.01	0.30	0.30	0.02	0.09	0.01	0.01	0.11
Trace elements (ppm)								
V	2	<1	<1	<1	<1	<1	<1	1
Cr	29	15	40	17	19	12	4	20
Co	<1	<1	<1	<1	<1	<1	5	2
Ni	8	6	9	6	8	3	1	9
Cu	5	6	5	4	5	6	< 1	4
Zn	<1	<1	<1	<1	<1	5	6	2
Ga	<1	<1	<1	<1	<1	3	< 1	1
As	<1	<1	<1	<1	<1	<1	< 1	<1
Rb	<1	1	<1	<1	<1	<1	2	<1
Sr	23	23	23	24	23	23	< 1	20
Y	3	2	3	3	3	3	< 1	3
Zr	3	3	3	4	4	3	5	3
Nb	<1	<1	<1	<1	<1	<1	< 1	< 1
Mo	3	4	4	2	5	3	4	4
Sn	1	1	1	1	1	1	2	1
Sb	1	<1	<1	<1	1	<1	1	<1
Ba	44	57	42	52	46	63	< 1	44
La	<1	<1	<1	<1	7	3	< 1	2
Ce	<1	<1	<1	<1	<1	<1	1	< 1
Pr	<1	<1	5	3	<1	3	6	3
Nd	<1	16	<1	30	<1	<1	13	9
Vb	3	4	5	1	1	3	5	3
Hf	2	2	2	3	1	<1	< 1	2
Ta	<1	2	<1	4	<1	5	< 1	2
Pb	3	<1	<1	<1	2	<1	< 1	1
Th	<1	<1	<1	<1	<1	3	< 1	< 1
U	4	3	3	3	3	<1	4	4

Table 2

Results of thermal analyses of four quartz samples of Marwat Alimikan area

Occurrence No.	Sample No.	Mineral constituents %		Total loss Wt. due to heating up to 1000° C
		Major	Minor	
Marwa (1)	1	Quartz	…..	0.133 %
Marwa (2)	5	Quartz	…..	0.412%
Marwa (3)	9	Quartz	…..	0.089 %
	12	Quartz	…..	0.107%

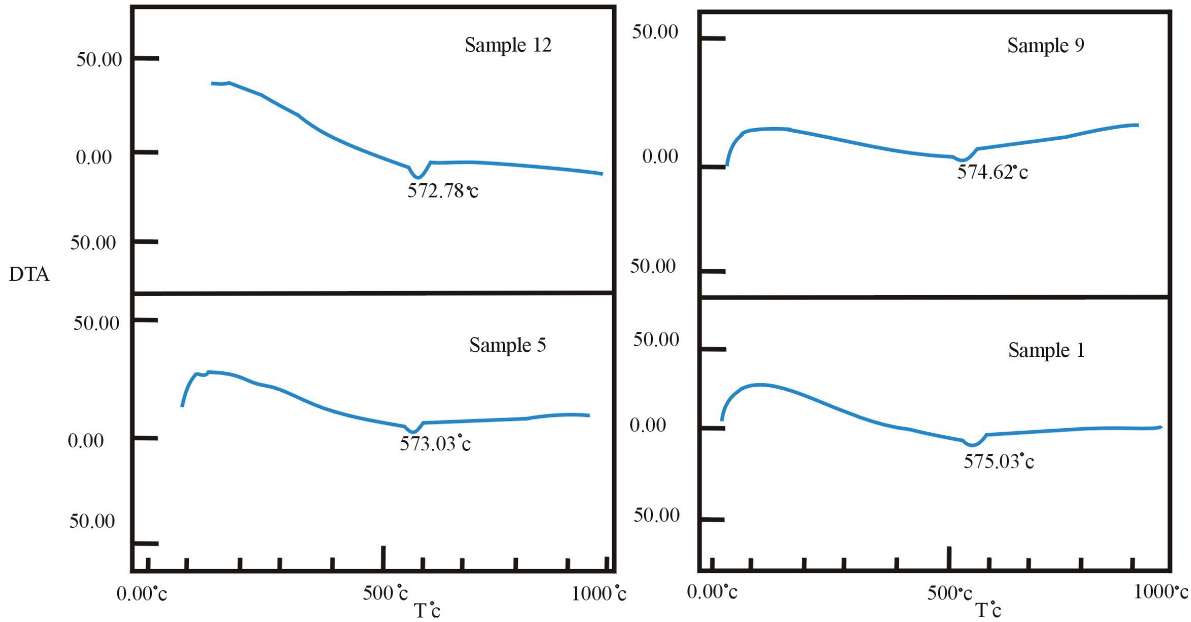

Figure 2. Differential thermal analyses (DTA) curves showing the thermal behavior of α- quartz samples and change of α-quartz to β-quartz at Marwat Alimikan area

Table 3

The results of petrophysical properties (water absorption, stress and mechanical resistance) of four analyzed quartz samples of Marwit Alimikan area

Occurrence №.	*Sample №.*	*Water absorption wt %*	*Stress kg/cm^2*	*Mechanical resistance kg /cm^2*
Marwa (1)	1	0.020	71.50	1398.8
Marwa (2)	5	0.050	70.60	1398.8
Marwa (3)	9	0.049	71.49	1415.7
	12	0.050	72.00	1428.6

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