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Physico-chemical characterization of Bechar sand- Valorization for silicon production

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Abstract - *In order to widen the industrial uses of Taghit sand (Bechar) different investigations have been performed to characterize the natural raw material using several techniques. Mineralogical and physic chemical characterizations of the natural raw material indicate that pure Bechar sand can be yield a very interesting for silicon production for photovoltaic application.*

Résumé **-** *Dans le but d'élargir les utilisations industrielles du sable de Taghit (Bechar), différentes investigations ont été réalisées pour caractériser la matière première naturelle en utilisant différentes techniques. Des caractérisations minéralogiques et physico chimiques ont indiqué que le sable pur de Bechar pourrait être d'un grand intérêt pour la production de silicium pour des applications photovoltaïques.*

Keywords: Dune sand - Silica - Silicon - Photovoltaic.

1. INTRODUCTION

Algeria is firmly committed to the promotion of renewable energy in order to provide comprehensive and sustainable solutions to environmental challenges and to the problems regarding the conservation of the energy resources of fossil origin.

The strategic choice is motivated by the huge potential in solar energy. This energy is the major focus of the programme of which solar power and photovoltaic systems constitute an essential part. Solar should achieve by 2030 more than 37 % of national electricity production. [1]

Photovoltaic solar energy refers to the energy recovered from sunlight and transformed directly into electricity through photovoltaic panels. It results from direct photon-to-electron conversion in a semiconductor. The solar grade silicon for photovoltaic systems does not exist in the nature, where silicon is always oxidized as silica (sand, quartz, sandstone,...).

Silica (SiO_2) is one of the ubiquitous materials in the earth's crust. Quartz, quartzite, silica sand and sandstone are all grouped together under one genetic name "Silica minerals". Sand is one of the products of geological weathering of the surface of the earth; this weathering is continuously going on everyday so silica sand is an extremely common and abundant material in nature. [2]

Silicon and its ferroalloys are produced by reducing silica-rich raw materials with carbon materials. [3]

A composite briquette fulfilling the purity targets was developed. The composite contains several carbon materials with different levels of reactivity's and quartz sand.

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The raw materials aspects, the paste and briquette preparation, as well as the final carbonization step are commented. The finished briquettes are free of volatiles and are mechanically and thermally very stable, thus ensuring stable arc furnace charges with minimum losses of dust and SiO gas. [4]

Fig. 1: Location of Bechar in Algeria

Fig. 2: Bechar (Taghit) sand dune

2. MATERIALS AND METHODS

The silica sand used for this research was obtained from Taghit silica sand deposit (Bechar). Taghit is a town and commune in Taghit District, Bechar Province, in western Algeria. The town is an oasis watered by the underground Oued Zousfana, which runs along beside the dunes of the Grand Erg Occidental.

2.1 Chemical characterization of Taghit dune silica sand

A chemical analysis of Taghit dune silica sand was carried out to determine the % oxide composition of the sample. The oxides include: SiO_2, $CaCO_3$, Fe_2O_3, MgO, Al_2O_3, TiO_2 …

The oxides were determined using X Ray Fluorescence (ORGM, Boumerdes).

2.2 Sieve analysis test

The standard grain size analysis test determines the relative proportions of different grain sizes as they are distributed among certain size ranges.

We take a representative oven dried sample of sand that weighs about 50 g.

The sieves were arranged in descending order of mesh number with collector at the bottom to collect the finest particles. The set of sieves with the sample in it cover with lid (pan) was properly fixed on the sieve shaker and the shaker was switched on to vibrate for 15 minutes.

Each sieve (one after the other) was carefully removed and the quantity of sand grains retained in each was measured by pouring it on a clean white paper (with pre-determined weight). [5]

Brush was used to remove all sand particles retained in each sieve by brushing it on to the paper. The weight were determined by *using* chemical balance and presented in tabular form. The sieves test was establish in the laboratory of SNVI (Rouiba).

2.3 XRD of Taghit silica sand

Powder X-ray diffraction (XRD) analysis was carried out using an X-ray diffractometer (Siemens D500 analyzer, Biskra Algeria) with $Cu K\alpha_1$ radiation and a 6 h scanning range between 5° and 100°. The XRD scans were run at 0.02° per step with a counting time of 4 s. [6]

2.4 Microscopy observations of Taghit dune silica sand

In order to determinate the shape of the sand grain, scanning electron micrographs of the sand samples were obtained by using JSM-5500LV/JSM-5500 in the Department of Materials Science of the University of Biskra, Algeria.

Optical micrographs of the sand samples were obtained by using Nikon Eclipse E600 at the metallurgy laboratory of the national company of the industrial vehicles (SNVI) in Rouiba (Algiers, Algeria).

2.5 Determination of clay content

Two (02) kg of sand sample was weighed into head pan and water was added; the mixture was rubbed and stirred carefully with hand and the brown water was decanted from the mixture. This process was repeated continuously until clean water was obtained on the sand sample. The water was decanted and the sample (sand) was loaded into drying cabinet for two hours at temperature of 110°C. It was removed and reweighed to determine the loss in weight which will reflect the percentage clay content of the silica sand.

2.6 Physical appearance of Taghit dune silica sand (color)

The color of the Taghit dune silica sand was observed.

2.7 Determination of moisture content

Two (02) kg of the sand was pulverized and placed inside a drying cabinet for 02 hours at temperature of 110°C. The sand sample was removed from the cabinet and weighed. Their process was repeated until there was no change in the weight of the dry sand sample again. The different in weight was determined and presented in percentage.

3. RESULTS AND DISCUSSION

3.1 Chemical characterization of Taghit dune silica sand

Table 1: Result of chemical analysis of Taghit silica dune sand

Components	Concentration (%)
SiO_2	98.70
Al_2O_3	0.14
Fe_2O_3	0.12
CaO	0.76
Na_2O	0.006
MgO	0.006
TiO_2	<0.05
K_2O	0.006
MnO	00
Cr_2O_3	0.004

3.2 Sieve analysis test

Table 2: Granulometric analysis of Taghit silica dune sand

Opening mesh sieves (mm)	Refusal (%)
1.4	0
1	0
0.71	0.018
0.5	0.7
0.355	5.1
0.25	32.68
0.18	47.08
0.125	11.54
0.09	1.4
0.063	0.44
F < 0.06	0.42
A	0.542

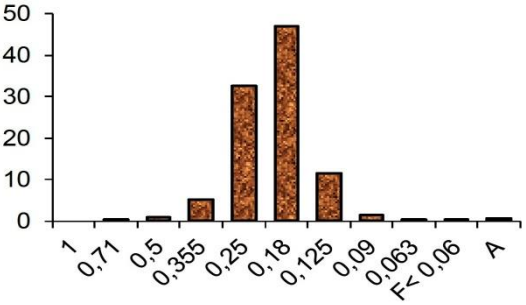

Fig. 3: Histogram representation of granulometric analysis of Taghit sand

After the results obtained, we notice that the size distribution of Taghit sand prevails in the class 0.25 sieve and 0.18. It respectively represented almost 32.68 to 47.08 % of the overall mass of sand.

In the particle size sieve 0.125, we find that almost 11.5 %, 5.1 % in the size sieve 0.355, while the concentration is insignificant in the sieve remains.

3.3 XRD of Taghit silica sand

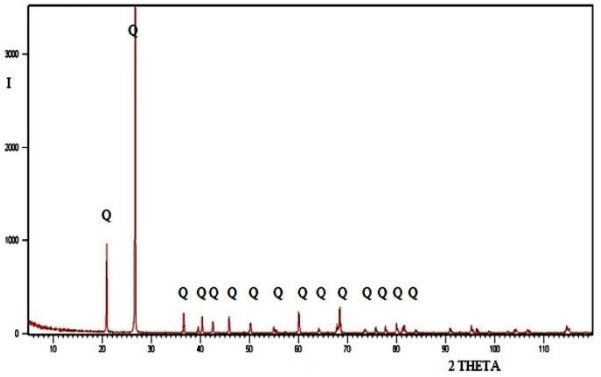

Fig. 4: The XRD spectrum of Taghit sand

In the figure 4, we observe the appearance of all peaks relating to the presence of alpha-quartz in our sand sample, confirming the increased crystallinity.

According to these results, we attest the absence of other phases than quartz (minor quantities), which confirmed the results found by XRF.

3.4 Microscopy observations of Taghit dune silica sand

Optical microscopy observation

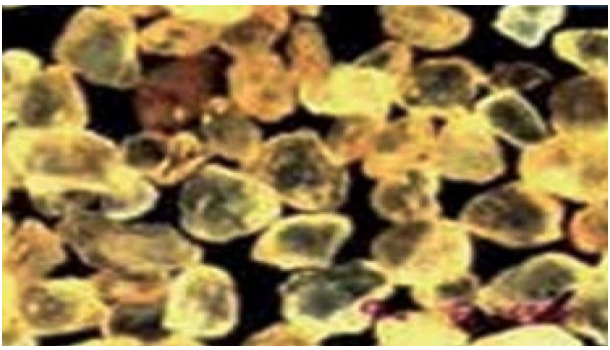

Fig. 5: Micrograph of Taghit sand (lower magnitude)

The micrographs at lower magnifications reveal the presence of somewhat rounded, angular edged, elongated and irregular grain.

Scanning electron microscopy observation

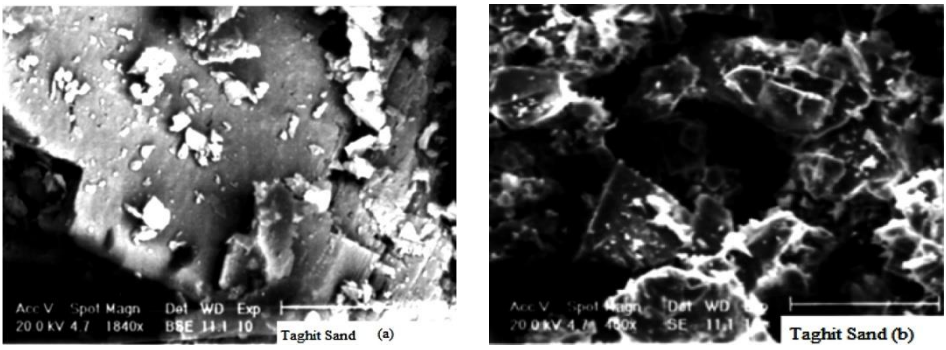

Fig. 6: The Scanning electron micrograph of Taghit sand (higher magnitude)

In order to observe the internal micro morphology of the studied sand, the Scanning Electron Microscopy (SEM) was carried out using the "retro diffused electrons" technique, since it gives a better vision rather than the "secondary electrons technique".

Figure 6 shows that the Taghit sand is constituted by well crystallized lamellar - quartz. The size of the sand crystals range from 5 to 50 µm roughly. We note that intragranular pore spaces correspond to the black cavities. However, their lower number can be indicates a poorly internal porosity of the studied material.

3.5 Determination of clay, moisture content and color of Taghit sand

Table 3: Result of physical analysis of Taghit silica sand

Property	Biskra silica dune sand
% moisture content	0.7
% clay content	2.3
Appearance (color)	List brown to gray coloration

3. CONCLUSIONS

The chemical composition by XRF indicate that Taghit silica sand deposit has a high concentration of quartz (98.7% silica) with low concentration of others oxides. The result of the grain size distribution shows that the Taghit silica sand deposit has relatively high percentage of medium to fine.

The sand has percentage moisture content of 0.7% and percentage clay content of 2.3 % with grey to light brown coloration. The microscopic observations reveals several morphologies of sand, some are elongated, rounded and angular with presence of pores.

We conclude that Taghit sand has got good proprieties for preparing metallurgical grade silicon destined for photovoltaic application, however it need a prior enrichment for it suitable use.

ACKNOWLEDGMENT

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