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Valorization of Southeast Algerian Dune Sand as a Source to Metallurgical Grade Silicon Production

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ABSTRACT

This work investigates certain physical and structural properties of three categories of sand samples, as natural resource, taken from Three deposits of El-Oued region in southeast Algeria. X-ray fluorescence (XRF), X-ray diffraction (XRD) and infrared spectroscopy (FTIR) have been used. The X'Pert High Score program was used in the analysis of XRD data. The chemical analysis reveals a relative purity of El-Oued sand, with 90 % of SiO_2, in addition to the presence of some oxides such as Iron and Aluminum oxides. The mineralogical analysis confirms the presence of a-quartz with a high crystalline nature, calcite and feldspar minerals. Furthermore, the micrograph observations revealed the presence of different shapes and sizes of sand grains. The shapes of Mih Ouensa, Reguiba and Taleb Larbi sand grain samples ranged from rounded to subangular to irregular. However, the construction sands of Mih Ouensa have shapes ranging from elongate to subrounded. The obtained results affirm that the three regions could be important sources of quartz and gypsum which are primary materials for many industrial applications such as construction materials, microelectronics, and semiconductors

Keywords: Sand dunes, Silica, physico-chemical characteristic, El Oued.

1. Introduction

The use of dunes sand (DS) in the field of engineering and technology has developed rapidly in recent decades. Considerable research has been carried out into the physical and chemical properties of these sands [1]. Renewable energies are gaining in importance worldwide, with solar energy being the most promising clean, renewable energy [2]. Today, silicon photovoltaic cells account for around 90% of all solar cells manufactured, installed and used worldwide. Crystalline silicon is the most widely used semiconductor for solar applications, due to its low production cost and relatively high conversion efficiency [1,2]. Quartz is one of the many crystalline forms of silica (SiO2). It is found in various metamorphic rocks, including granite and pegmatite, as well as in sand dunes [3]. It should be noted that extracting quartz and silicon from sand requires in-depth knowledge of the physical and chemical properties of the quartz contained in the sand. Sand dune is very abundant in Algeria and very rich in quartz [4], but is not exploited in practice, due to the scarcity of studies on its physico-chemical characteristics. The composition of dune sands is highly variable, depending on local rock sources and conditions. They are composed mainly of SiO2 quartz grains, small quantities of impurities and heavy minerals, in particular high levels of Fe2O3 ferric trioxide and CaCO3 calcium carbonates, and higher levels of Al2O3 aluminum oxide [1, 4]. The present work aims to determine the physico-chemical properties of dune sands from the El-Oued region, a region in the northeastern Algerian Sahara, and to determine its potential use in the production of metallurgical-grade silicon, and thus as a source of silicon for photovoltaic applications.

2. Experimental

The three dune sand deposits sites in the El-Oued region are located in the three communes of Mih Ouensa, Reguiba and Taleb Larbi (Fig 1).

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a- b- c-

Figure 1: Sand dune deposits of El Oued, a)-Mih Ouensa, b)-Reguiba and c)-Taleb Larbi

The region's dune sand concentration zones lie to the north of the Grand Erg Oriental. Samples were taken from different sides of the dune, from top to bottom and at different depths, then equal weights of each sample were thoroughly mixed to obtain a homogenized sample.

3. Results and Discussion

According to the results, the most important finding is the presence of a high percentage of silica in the three (03) DS samples analyzed (85 to 90 %). The presence of limestone and traces of various oxides is also noteworthy. Indeed, CaO content is limited, ranging from 3 to 6 %. These results confirm that Ouargla sand dunes consist mainly of quartz with minor calcite and very low quantities of Fe_2O_3, Al_2O_3, Na2O, SO_3, MgO and TiO_2. In addition, the spectra of x-ray diffraction (XRD) analysis reveals that the three DS samples are composed of two (02) phases. A primary phase of silicon oxide (α-SiO_2). A secondary phase of calcium carbonate (Calcite) $Ca(CO_3)$. The grain size of El Oued sands is fine grain of light brown color, (Fig. 2). Because of their small size and rounded shape, the grains are ovoid. In addition, whatever the nature of the sand grains, it is essentially noticeable that they present a blunt matte appearance with few edges and faces. This appearance is most probably due to both the phenomenon of rock disintegration due to thermal shocks linked to the local climate, and the action of the wind on the material through wind erosion.

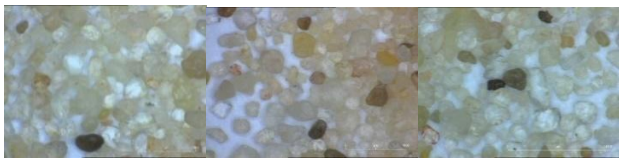

Figure 2: Microscopic observation of El Oued DS samples

4. Conclusions

This study deals with physico-chemical characterization of dune sand from El Oued, Algerian desert. The sand from El Oued has a high SiO_2 concentration but not sufficient for direct use for solar-grade silicon production. It needs enrichment by acid leaching for the best result in the briquetting process for producing silicon for photovoltaic applications. XRF analyses show maximum silica contents on the order of 85–90%, with presence of others oxides in small quantities. By using X Ray Diffraction analysis; we determinate that EL Oued silica sand reveal a high crystallinity with specific crystallographic parameters.

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