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Research Article

Evaluation of Quartz Sand Deposit from Abu Dalam Area, Bara Locality, Sudan

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I N F O

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A B S T R A C T

The study area is mainly composed of granitic gneisses, migmatites, quartzites, and schists in some parts. Regional and small scales exploration was carried out in the sand dunes of Abu Dalam El Ama, Bara Locality to find quartz sands occurrences to cover most of the geologically favorable areas. During the field visits, quartz sand samples were collected from 12 points of the area. Ten representative samples were collected from the Abu Dalam area and were tested for their suitability to be used as raw materials for different industrial uses. The suitability of quartz sand deposits from the Abu Dalam area, Bara Locality for commercial glass production were assessed based on the chemical and physical properties. Tests were carried out at the University of Kordofan, Sudan, and the Geological Research Authority of Sudan (GRAS). The chemical analysis was carried using Atomic Absorption Spectroscopy (AAS). The particle size was carried out using a mechanical shaker (sieving method). The quartz sand from the study area had the highest SiO_2 content of 91.01%, which were found to be within the acceptable limits for glass making. The percentage of Fe_2O_3 , MgO, CaO, Al_2O_3 Na_2O, and K=O in the quartz sand samples were very low and can be suitable industrial glass making. The physical satisfy the standard requirements for glass making.

Keywords: Chemical and Physical Characteristics, Quartz Sand, Glass Making, Bara Locality

Introduction

Quartz sand or silica sand is a type of sand that has a high concentration of Silica (SiO_2) and represents one of the most important industrial minerals used for the most important raw material in the world. The quartz sand was defined as "sand used for the industrial applications relative to building materials and which are valued for their chemical and physical characteristics" (the British Geological Survey (BGS; September 2011)). The quartz sand is the final weathering product of quartz-bearing igneous, sedimentary, or metamorphic rocks which are an important part of the rock cycle (Shaffer, 2006). The weathered grains are transported generally by water and the weak minerals are separated and resistant grains become more rounded in shape, smaller in size, and their surfaces are modified by constant abrasion or chemical reaction (Platias et al., 2014). Very mature sands produce the most chemically pure, mainly preferably round, and optimum sorted silica sand deposits. Quartz sand deposits

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are generally mature or super-mature. Super-mature quartz sands often are more than 95% quartz with some natural deposits containing 98% quartz. These high-purity sands have a variety of economic applications and are vital for ceramics, chemical industries and for water filtration purposes as well as the glass and foundry casting industries (BGS; September 2011).

The quartz sand is found in many localities in Sudan and the more important field is in North Kordofan State, around Bara Locality. Some scattered investigations were conducted around Bara Locality to evaluate the quality and extensions of the silica sand deposits to be used for different applications. The surface area of the quartz sand deposits around Bara Locality is largely undulated by inactive or mobile sand dunes of different time origin. Most of these dunes are extended E-W direction, as the dominant wind direction is generally N-S. No clear drainage occur, but large silty inter-dunes depressions are found, and usually, they utilized by gardener activities.

This study aimed to establish the chemical and physical properties of quartz sand that are required for the different industrial applications.

Geology of the Study Area

According to Geotichnika, (1985), the geological units in the study area include basement complex, Um Ruwaba Formation and Superficial Deposits.

Basement Complex

It is the oldest rock unit in the area. It's mainly composed of granitic gneisses, migmatites, quartzites and schists in some parts. The depth to the Basement Complex in the area is variable.

Um Ruwaba Formation

The Um Ruwaba Formation overlies the Basement Complex and consists of unconsolidated grave sands, sandy clays, and clays with vertically and horizontally rapid facies changes. The thickness of Um Rauwaba Formation is highly variable as the formation rests uncomfortably upon the uneven surface of the Basement Complex.

Superficial Deposits

According to Strojexsport, (1976) this area formed mainly by sand dunes (Qoz sands), it is the product of the erosion processes of the older deposits. These deposits are typical Aeolian sediments, forming gently-rolling sheets and fixed dunes. They are composed of well-rounded, fine to medium quartz grains. The area of West Bara is generally characterized by sand sheets and dunes. The sand dunes are of few meters high, of moderate size and stable shape. On the other hand, the sand sheets spread for several square meters, some of them are covered with low dense plants and shrubs. In some places low lands and depressions are found, the isolated villages and the irrigated area were located in these low lands.

Specifications of Quartz Sand

Quartz sands are used for the essential raw material for a great variety of commercial purposes (Bayat et al., 2007; Duvuna and A. Ayuba, 2015), which can be divided into two types: (1) glass making uses (2) Nono glass uses.

Table 1.Specified grades of glass making sand according to BS2975 (1988)

Grade	Type of glass	SiO_2%	Fe_2O_3%	Al_2O_3%
A	Optical glass	99.70	0.013	0.20
B	Tableware glass	99.60	0.01	0.20
C	Borosilicate glass	99.60	0.01	0.20
D	Colourless container	98.80	0.03	0.10
E	Flat glass	99.00	0.10	0.50
F	Coloured container	97.00	0.25	0.10
G	Insulating fibres	94.50	0.30	3.00

Glassmaking uses

Quartz sand is used for the glass industry such as cameras, optical instruments, microscopes, and optical fibres for telecommunications (BGS; September 2011). The glass industry has documented different standard specifications for the quartz sand according to the requirements for the British standard (BS2975, 1988). In general, the specifications of the quartz sand as the raw materials depend on the glass type and the purity level of quartz sands. The British Standard BS2975 has recommended limits composition of quartz sand for the different grades of glass (Table 1). Although the SiO_2 content of quartz sand usually exceeds 97–98%, the presence of metallic oxides in quartz sands usually results in coloured glass. There are several requirements that quartz sand deposits must meet to be considered as potential sources for different industrial applications. The initial iron content of the quartz sand must be approximately 0.13% Fe_2O_3. The iron level is consequently the most critical parameter in determining whether quartz sand can be used to make clear or coloured glass (David, 2011). According to Waudby (2011), quartz sand used for windows glass may contain 0.1–0.5% iron oxide (Fe_2O_3) and dark green bottle glass as much as 2–3% iron oxide. Aluminum, magnesium, calcium and potassium levels affect the melting properties and have to be kept at low levels.

None-glass uses

Quartz sand is used in a variety industry includes foundry casting industries, as well as in other industries such as ceramics industry (quartz sand constitutes about 40% of the ceramic body), plastic industry, manufacturing of metal casting moulds, drilling of oil and gas and water treatment, fiberglass, metallurgical industry, blasting sand, filter sand and chemical manufacture (BGS; September 2011).

Field Work and Experimental Testing

Regional and small scales exploration was carried out in the sand dunes of Abu Dalam El Ama, Bara Locality to find quartz sands occurrences to cover most of the geologically favorable areas. Because the quality of the quartz sand deposit is more significant at first approach than the size of the deposit, the first step in each case was bench-scale quality testing. Six field visits to the Abu Dalam area had been taken for sampling. The collected quartz sand samples were subjected to some laboratory tests including grain size and chemical characteristics to assess the quality of quartz sand in the study area.

Sampling

During the field visits, quartz sand samples were collected from 12 points of the area. The coordinates of the points were taking by using GPS. Representative samples from the surface and subsurface were selected for physical and chemical analyses. Representative samples and quality characterization of quartz sands resulted to view the evaluation and discovery of quartz sands deposits.

Chemical Analysis

Ten representative samples were collected from the Abu Dalam area and were tested for their suitability to be used as raw materials for different industrial uses. The samples were analyzed through Atomic Absorption Spectroscopy (AAS) at the Geological Research Authority of Sudan (GRAS). It was proved that the samples from Abu Dalam area gave initial promising results, even though further research work is needed.

Grain Size and Shape Analysis

Ten samples were selected for the sieve analysis to determine the grain size of the quartz sands. Test on grain size analysis of the quartz sand samples was carried out at the University of Kordofan. The dry sieving method was adopted and the represented quartz sand samples were obtained from the quartered quartz sand samples. The samples were first dried and from each sample; 500 g was weighed and grain size distribution was determined by a mechanical shaker with the coarsest on top. The machine was operated for 10 minutes. After sieving the samples, the cumulative percentage by weight of the particles passing each sieve was calculated and recorded. Wet sieving was carried out in tune with the requirements for glass making sand and hence the sieves selected were 0.28 and 0.15 µm.

The quartz sand samples were studied by binocular microscope to determine the grain shape of the samples and their suitability for different uses.

Result and Discussion

Chemical Characteristics

The chemical analysis is a very important part because it helps to determine the percentage of SiO2 and other elements which is one of the main factors for estimating the quality of the silica sands. The results in Table 2 show, the chemical contents analyzed for the quartz sand samples obtained from the Abu Dalam area. In the average, the percentage of SiO_2 in the quartz sand from the study area is 91.01%, which is high and adequate for glass making **(**BGMC, 2011**)**. Generally, the specifications of the raw materials depend on the glass produced, and the purity intensity of the quartz sand is dominated by the Fe_2O_3 content. The percentage of Fe_2O_3 obtained is low which results in naturally white quartz sands and can be suitable industrial applications. This is because the iron content is lower than 1%. The percentage of the entire main ingredient (MgO, CaO and Al_2O_3) available in the silica sand samples as shown in Table 2, were very low for glass making when compared with the standard percentage composition requirements. For example between 4–5% of CaO and MgO are required for soda-lime and lead glasses manufacturing. The percentage of Na_2O and K_2O is also very low which fall within the range of 2–9% by weight of Na_2O and K_2O and therefore, can be used for borosilicate, fibre glasses and to some extent alumina silicate glasses.

Physical Characteristics

Grain Size

The testing of physical properties such as grain size is a very important factor in the determination of the quality of quartz sand for industrial purposes. The grain size must lie in a range size limit and should be consistent. Finer grains are more likely to carry iron oxide and refractory mineral grains, whereas larger grains will melt slower than smaller grains and will remain un-melted causing inclusions in the final product.

According to BS2975 (2011), the grain size range processed for industrial is from 0.10–0.50 mm in diameter (BSS number) and it is required that 75% of the grain should fall within this range (David, 2011). The nearest available sieves used for testing samples of the Abu Dalam area is ranging between 0.15 mm and 0.28 mm (Table 3).

The obtained results indicate that approximately 90% of quartz sand in the study area falls within the grain size range and is suitable for industrial uses.

Table 2.Major element contents for quartz sands from Abu Dalam area, Bara Locality

Sample	19A2	19A3	19A6	19A10	19A15	19A18	19A30	19A32	19A35	19A39
SiO_2	90.73	90.13	92.21	92.70	91.74	90.42	92.75	89.00	90.84	89.61
Al_2O_3	6.34	5.54	6.67	3.90	2.47	4.62	3.69	3.027	4.60	4.34
Fe_2O_3	0.32	0.38	0.30	0.29	0.70	0.27	0.27	0.33	0.21	0.31
MnO	0.05	0.04	0.05	0.04	0.06	0.04	0.05	0.06	0.06	0.07
MgO	0.37	0.58	0.55	0.43	0.62	0.62	0.47	0.51	0.58	0.66
CaO	0.53	0.41	0.29	0.31	0.20	0.64	0.21	0.52	0.22	0.76
Na_2O	0.44	0.34	0.30	0.33	0.40	0.42	0.36	0.43	0.32	0.32
K_2O	1.99	1.53	1.25	1.40	1.66	1.63	1.55	1.72	1.62	1.42

Table 3.Grain size for quartz sands from Abu Dalam area, Bara Locality

Sample No.	Size (mm)	Weight (gm.)	Weight %	C. Weight %
19A1	0.28	75.9	15.18	15.18
	0.149	368,2	73,64	88.82
	pan	55.7	11.14	99.96
19A4	0.28	20.2	4.04	4.04
	0.149	423.7	84.74	88.78
	pan	42.7	8.54	97.32
19A11	0.28	47.7	9,54	9,54
	0.149	389.3	77.86	87.4
	pan	62.3	12.46	99.86
19A21	0.28	24.4	4.88	4.88
	0.149	426.9	83.38	88.26
	pan	48.6	9.72	97.98
19A22	0.28	40.7	8.14	8.14
	0.149	412.8	82.56	90.7
	pan	45.6	9.12	99.62
19A23	0.28	84.8	16.96	16.96
	0.149	367.3	73.46	90,42
	pan	46.4	9.28	99.70
19A24	0.28	16.1	3.22	3.22
	0.149	438.2	87.64	90.86
	pan	45,6	9.12	99,98

Grain shape

The grain shape of the quartz sand is another physical property that determines the suitability of the quartz sand sample for glass making. The roundness of the grain must be slightly angular than rounded (Powers, 1983; Waudby, 2011). Physical tests of the quartz sand from Bara Locality indicate that most of the grains are rounded to sub-ground with a fewer sub-angular grains.

Conclusion

Quartz sands generally have a high concentration of silica (SiO_2) and represent one of the most important industrial minerals used for the most important raw material in the

world. Quartz sands are used for the essential raw material for a great variety of commercial purposes. They are found in many localities in Sudan and the more two important field is in North Kordofan State, around Bara Locality. This area formed mainly by sand dunes (Qoz sands), it is the product of the erosion processes of the older deposits. They are composed of well-rounded, fine to medium quartz grains.

Geochemical and physical investigations of quartz sands from Abu Dalam area in the Bara locality lead to the following conclusions:

- The quartz sands have high SiO_2 content and thus materialize to be suitable as raw material for industrial applications.
- The percentage of Fe_2O_3, MgO, CaO, Al_2O_3 Na_2O and K_2O obtained are low and can be suitable glass making.
- The quartz sand samples have the physical properties that met the requirements for the industrial uses.

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