



MINISTRY OF ENERGY AND MINERAL RESOURCES
Mineral Status and Future Opportunity

SILICA SAND

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2014

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SILICA SAND

1. Introduction

Silica sand is defined as a high purity industrial mineral in which the sand grains are made entirely of quartz. Impurities, if any, are very minor and commonly are clay minerals (kaolinite, illite), titaniferous minerals (rutile, anatase), iron oxides and heavy minerals (zircon, tourmaline). The term silica sand is applied to quartz sand that conforms to the specifications of which the main composition is $\text{SiO}_2 >99\%$, with very little contaminant oxide contents (i.e., Al_2O_3 , TiO_2 , CaO , and Fe_2O_3) and heavy minerals of $< 0.1\%$. And the term glass sand means that silica sand with aspecific size fraction ranges from (- 590) to (+ 105) micron.

The range of silica raw materials occurring in nature is extensive and includes relatively pure forms of the mineral such as rock crystal, quartz in the form of unconsolidated sands, and as consolidated rock such as quartzite and sandstone.

Silica is a basic material in the glass industry, ceramic and refractory industries, and the raw material used in making silicon, silicon alloys, silicon carbide, silicones, soluble silicates, and other silicon-based chemicals. Its specialised applications include such products as piezoelectric crystals, optical products, and vitreous silica.

2. Geological Setting

White silica sand deposits are found exposed on the surface, Disi Sandstone Formation of Early Ordovician age and Kurnub sandstone Formation of Lower Cretaceous age which exposed in south of Jordan.

3. Locations

3.1. Ras En Naqb Area

Huge silica sand resources of Early Ordovician are found in the area south of the Ras En Naqb escarpment (70km north of Aqaba). The exposures are extended over an area of more than 150km^2 with a thickness of about 265-350m.

3.2. Qa'a Ed Disi Area

The area east of Quweira town to the north of Wadi Ram comprises huge reserves of silica sand of Early Ordovician (50km north-east of Aqaba).

3.3. Petra / Ein El Biada Area

White sandstone occurrence of Early Ordovician was found in the area north to Petra town.

3.4. Al Jayoshia Area

A big massive exposure of white, soft friable, and fine sandstone of Lower Cretaceous is located about 6km east-southeast of port of Aqaba. (All locations mentioned above are accessed through the Amman-Aqaba highway).

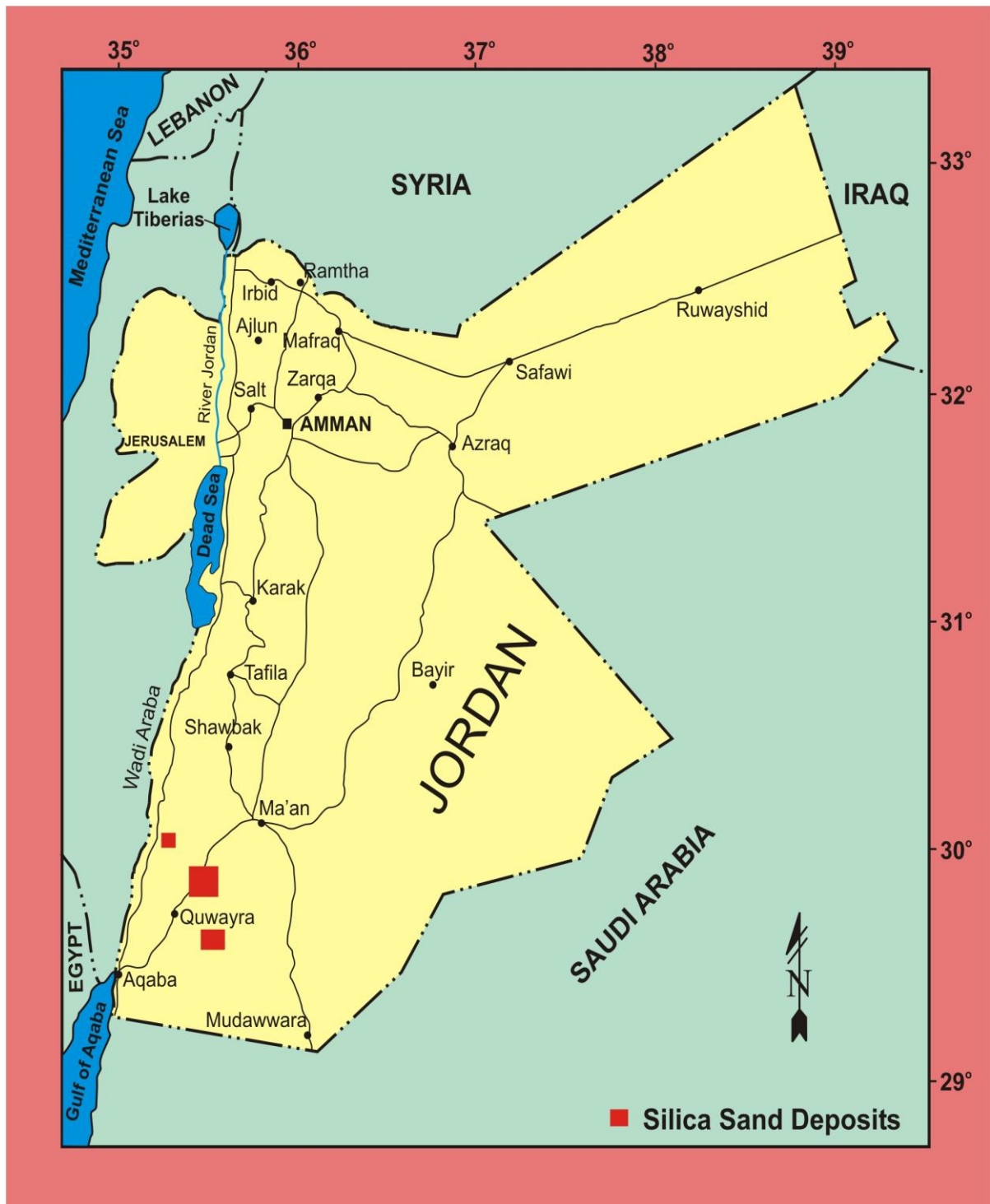


Figure (1): Location map of Silica Sand deposits.

3.5. Wadi Es Siq-Wadi Rakiya Area

Exposures of good potential for silica sand of Lower Cretaceous white sandstone and belong to the Kurnub Sandstone Group were located in the area between and along Wadi Es Siq and Wadi Rakiya in Wadi Araba (65km north of Aqaba). These outcrops are fine to very fine-grained sandstone with kaolinite clay as matrix or thin layer intercalations. Geological reserves are estimated of 120Mt.

4. Mineral Properties

4.1. Chemical Properties

The characterization and beneficiation studies have proved that the four deposits are highly encouraging to produce high quality silica sand.

Table (1): Chemical analysis of Raw, Wet Sieved and Scrubbed glass sand samples from Ras En-Naqab and Wadi Es-Siq areas.

Major Oxides	Raw %		Wet sieved (%)		(% Scrubbed for (500-106µm))		* Grade-A, Glass sand (BS: 2975, 1988)
					8 minutes	6 minutes	
	Ras En Naqb	Wadi Es Siq	Ras En Naqb	Wadi Es Siq	Ras En Naqb	Wadi Es Siq	
SiO ₂	98.72	95.23	99.41	99.36	99.62	99.65	99.70
Al ₂ O ₃	0.52	2.57	0.16	0.22	0.04	0.04	0.20
Fe ₂ O ₃	0.04	0.04	0.03	0.03	0.01	0.01	0.01-0.013
TiO ₂	0.09	0.09	0.04	0.04	0.02	0.02	0.02 (**)
CaO+MgO	0.08	0.22	0.02	0.12	0.01	0.01	0.02 (**)
Na ₂ O+K ₂ O	0.11	0.17	0.09	0.09	0.02	0.02	0.02 (**)

* Grade (A) stands for optical and ophthalmic glass

** Sibelco Company Grade

Table (2): Chemical analysis of Raw and Refined of glass sand samples from Qa'a Disi and Aqaba areas.

Deposit	SiO ₂ %		Al ₂ O ₃ %		Fe ₂ O ₃ %		TiO ₂ %	
	raw	refined	raw	refined	raw	refined	raw	refined
Qa'aDisi	96.59	98.36	1.43	0.24	0.025	0.019	0.13	0.04
Aqaba	95.21	98.93	2.97	0.32	0.028	0.013	0.14	0.04

Table (3): Min. Max. And average of chemical analysis of samples from Ras En-Naqb.

	L.O.I %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	TiO ₂ %	CaO %	MgO %	K ₂ O %	Na ₂ O %
Min	0.30	95.2	0.58	0.19	0.063	0.01	0.01	0.01	0.01
Max	1.13	98.7	2.65	0.059	1.34	0.20	0.02	0.05	0.02
Av.	0.61	97.6	1.31	0.028	0.18	0.06	0.01	0.01	0.01

4.2. Mineralogical Properties

Mineralogical investigation of raw sand and glass size fraction indicated that they consist mainly of quartz as a major mineral with minor amounts of kaoline, Where as mineralogical investigation of fine fraction (<63 micron) reveals that the fine fractions of the glass sand consist mainly of Kaolin and quartz as amajor minerals with traces of heavy minerals such as rutile, illmenite,... etc.

In year 2000, Geindustia Company from Czech Republic in their study, found that pure quartz grains are the predominant component of the most promising Jordan glass sand from the Ras En-Naqb deposit, covers of Fe – Oxides occur on the quartz grain surface or cracks locally only. And they found that the heavy minerals content is very low, represented predominantly by Tourmaline, Leukoxene, Zircon and Titanite in fine fraction. The under sieve fraction is formed by Kaolinite and Silica, Silt mainly.

4.3. Physical Properties

Results of partial size distribution analysis showed that the Disi sandstone in the study area is medium to coarse grained. The Glass size Fraction (GSF%) ranges between 68.85% to 81.75%. And the weight percent of the fine particles less than 63 micron ranges between 2.02% to 6.35%.

5. Reserves

Table (4): Silica Sand Reserves.

Area	Geological reserves (Mt)
Ras En Naqb	>10000
Qa`a Disi	Billions of tones
Wadi Es Siq-Wadi Rakiya	120
Petra/ Ein El Biada area	Not determined
Al Jayoshia area	Not determined

6. Background

Technical studies started in 1970 when Nimry and Haddadin studied the white sandstone outcrops of Ras En Naqb. Swindell Dressler (1974) carried out a study on the properties of these white sands. Hagen et al. (1980) conducted a laboratory investigation on different samples of the silica sand from different localities in south of Jordan. The study concluded that the white sandstone in Ras en Naqb is suitable for glass making. Technostone (1984) investigated the possibility of exploitation of glass sand deposits in the Ras En Naqb area. Barjous (1995) studied silica sand samples of Disi Sandstone formation.

Geological maps at a scale of 1:50,000 covering most of the silica sand outcrops in Ras El Naqb, Qa' Ed Disi and Wadi Gharandal areas were published by the Natural Resources Authority. Previous mineral exploration and the recent drilling activities carried out by Mineral Exploration Division during the time between 1995 and 1998 have delineated huge reserves in Ras En Naqb area/ south of Jordan (Marawan, Ghassan, and Nidal, 1998).

In year 2000, Geindustia Company from Czech Republic carried out technological work program including pilot melting tests on silica sand samples from Ras En Naqb area. The tests resulted in manufacturing glassware products such as green and color decoration glassware, luxury lead crystal and barium crystal products.

Recently, Alali (2001) conducted a detailed characterization and pilot plant beneficiation study on the silica sand of Ras En Naqb and Wadi Siq-Rakiya/ Wadi Araba. The study proved that high quality glass sand could be produced.

7. Mining, Processing and Industrial Applications

The silica sand are exposed on the surface, almost without overburden, so they are easily mineable by open-pit mining.

Technological work program carried out by Geindustia Company from Czech Republic, 2000, was terminated by pilot melting tests resulted in manufacturing of glass ware products qualitatively fully comparable with parameters of adequate Czech Republic standards. The pilot melting tests of batches based on the dressed glass sand from Ras En-Naqb deposit (about 700kg.sample) resulted in manufacturing of the following products :-

- Green decoration glassware
- Glassware colouring decoration products
- Luxury Lead crystal products
- Luxury Barium crystal products

The melting pilot program resulted in the high quality of glassware products, including, Lead crystal and Barium crystal as well, and the percentage of Fe_2O_3 can be decreased to less than 0.018% applying simple dressing process.

From these results it can be concluded that the silica sand can be considerably upgraded through simple beneficiation processes, such as washing and sieving, and can be used in many industrial applications.

8. Mining Companies

There are seven mining companies who have granted mining rights for variable period of time and one for exploration right (one year). Currently, two are producing processed silica flour.

Most of these companies' products are size classification for sand blasting and construction material with little products for other industrial applications, and now Middle East Regional Development Enterprise Co. (MEREN) start produce different types of silica sand such as, Foundry sand, glass sand, silica flour, construction sand (Fracturing sand and Water filtration sand).

Table (5):Total production of Silica Sand (ton) (NRA Mining report, 2012).

Year	2008	2009	2010	2011	2012
Production (m3)	9.337	119.295	69.074	35.379	69.231

Table (6): Treated Silica Sand Production (ton)

Year	2008	2009	2010	2011	2012
Export (ton)	70.149	75.086	53.897	208.376	109.940

Current markets:- Israel, Lebanon, Syria, UAE, Saudi Arabia, Kuwait, Italy.

Silica sand prices January, 2006 (Industrial minerals, January, 2006)

Ex-works, UK

Foundry sand, dry, bulk £ 15.50-16.50

Glass sand, flint, container £15-17

Foundry sand, dry, bulk £14.00-25.00

Table (7): The current Domestic and Export Prices for the Silica Products Produced in Jordan During 2010

Type of Silica Produced	Export price in JD	Domestic Price in JD
Silica Sand (ton)	3.4	3.0
Treated silica sand (ton)	44.0	78.4
Silicate bricks (ton)	No export	25.4

Jordan Market

The local consumption of silica sand around 200,000 mt/year, consumed in White cement, Ceramics, Water filtration and Foundry sand industries. The local consumption figures (30-45,000t) of silica sand mentioned above are not including the consumption in white cement industry.

The glass industry in Jordan started in the early seventies when a glass factory was built 250km south of Amman. Some ten years later, the Boussios and Glaverbel built a modern

three-line Pittsburgh plant for Jordan Glass Industries. The plant started operation in 1984 with a gross capacity of 26,000 tpa. There were basic problems with the design and operations, which continued to the end of 1993. The glass manufacturing has been suspended since that waiting for a decision to rebuild or upgrade.

At the moment, there is no glass production in Jordan and usually glass (container, sheets) is imported from the nearby countries such as Saudi Arabia, Syria and Turkey. However, there are some small glass plants for bottles, which are using the cullets (broken pieces) of the remaining glass factory in south of Jordan (Ma'an city).

9. Investment Opportunities

The easy accessibility and mining, close to the harbour, low content of impurities and low content of heavy minerals are advantages for the exploitation of silica sand. Most of the silica sand produced as a raw material and consumed in the local market with exception few amount for export. There are a lot of quarries in the area of Ras En-Naqb produced silica sand for construction, and two companies produced processed silica sand and silica flour. Deposits are open for investment on the basis of mineral agreement for foreigners investors to produce different types of silica sand, such products should be beneficiated, process and even manufactured in order to be value added to compete prices and to cover transportation cost.

Glass industry:

Glass will be the major issue as no glass production in Jordan since 1994. It should be taken in to consideration that a glass factory should be rebuilt or rehabilitated in an economic and feasible way in order to compete imported glass in quality and price. So it is a good opportunity to produce a high quality silica sand for glass industry (Container and sheets) and also for optics and crystals.

Flour silica:

International Silica Industries Company Produce a range of silica products (Dry or washed sized) ground silica sand (flour) very fine to fine (10-75 μ m) and silica sand grades at cut-off of 100 and 400 μ m. Applications are as filler material (heavy duties paint, silicones, chemicals and ceramic) and as silica sand grains (100-400 μ m) for glass, oil drilling and construction.

Middle East Regional Development Enterprise is planning to produce 500,000 tones/year of three types of products; glass sand, fillers (ground silica) and oil and gas fractionation silica sand. It start production in the middle of 2004. The size of production indicates that it would be a leading company for silica in Jordan.

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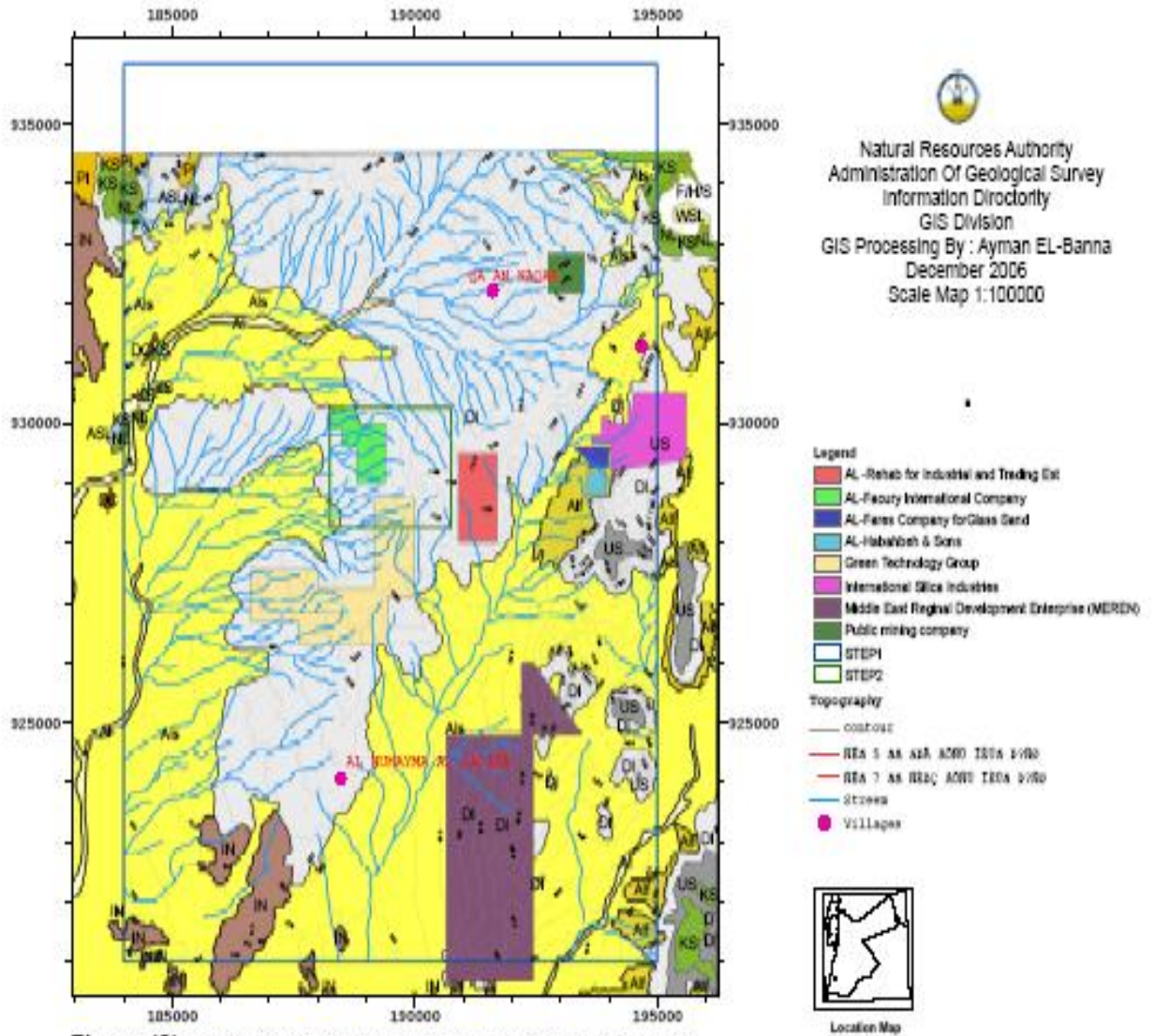


Figure (2): Location Map of The Studu Area & Mining Areas