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EVALUATION OF WHITE SAND DEPOSITS FOR INDUSTRIAL APPLICATIONS: A CASE STUDY FROM ABU ZENIMA AREA, SINAI, EGYPT

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ABSTRACT : White sands in Sinai are friable; they represent a valuable source of silica for glass and ceramics, and of silicon for semiconductors. To evaluate the present white sandstone; twenty four samples are gathered from six localities. The samples analyzed physically, petrographically and chemically. Preliminary investigation on the white sand deposits of Abu Zenima area shows that they are of medium to fine in particle size grained, moderately well- sorted grain, fine skewed and leptokurtic. They have a considerable purity and high grade (97%). Petrographically sandstones are classified as quartz arenite and chemically the most studied sandstones samples are composed of SiO2 (98.54-99.80%), Fe2O3 (0.010-0.11%), TiO2 (0.01 – 0.24) and Al2O3 (0.11-1.05 %). Characterization of the Abu Zenima silica sand deposits have been accomplished with a view to find its industrial application. They might be suitable for manufacturing of industrial purposes such as solar cells, sheet glass, oil production process (catalyst ceramic and in building materials). According to American standard specification U. S, white sand deposits of Abu Zenima area shows that they are of well-sorted grain size, high purity, with quality ranges compatible with 1st , 2nd, ,4th ,6th and 8th grade according to U.S standard and grade (A, B and C) as a British Standard. They are suitable for high quality glass industries. As well as chemical analysis of Abu Zenima white sands meet the American standards for all industrial glass uses.

KEYWORDS: **Silica sand, Industrial glass, Abu Zenima area, Sinai, Egypt.**

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I. INTRODUCTION

Silica sand is a general term that is used used to portray washed, graded, dried and cooled clay free sands, that are found in many sectors worldwide. They generally contain 90% to 100% silica but vary generally in chemical composition.

In Egypt, there are two main sites of high-quality silica sand: 1st, Zaafrana –Red Sea, and the 2nd, north and south Sinai, the reserves in the mentioned areas are more than thousands million ton of high-quality silica sand. The production of the glass industries in Egypt are till now below the domestic needs. Much of glass components (deposits) are still imported. Increase in productive capacity will result in the certain wealth and drastically reduce the unemployment problem in Egypt.

Accordingly, comprehensive investigation to look for these deposits in Sinai took place in last few years. Kamel et al., 1997 showed that the Egyptian glass industries need more than 1500 tons per year of silica sands.

The chemical, mechanical and physical properties of the white sand attract the attention of many authors for industrial applications (e.g. Khalid, 1993, El-Fawal, 1994, Kamel et al., 1997, Howard, 2008, Alnawafleh 2009, Awadh, 2010,Alnawafleh 2009, Awadh, 2010, R.A. Osman,2021.,Ramadan, F. S. 2014.,Said, R., 1971., Shata, A.A., 1992., Ibrahim, S. S., Selim, A. Q., & Hagrass, A. A. 2013., Ismaiel, H. A., Askalany, M. M., & Ali, A. I. 2017., EL-Bayaa, A. A., Badawy, N. A., Gamal, A. M., Zidan, I. H., & Mowafy, A. R. 2011., Abdel-Rahman, I. F., and El Shennawy, A. A. 2012., Akarish, A.I.M. and A.M. El-Gohary, 2008.).

The main objective of this study is to investigate the physicochemical characteristics of the white sand deposits at Abu Zenima area, west central Sinai and to give a brief description of their grain size distribution, petrography and chemical composition to determine the suitability of white sands for industrial applications.

II. LOCATION AND GEOLOGICAL SETTING

The area under investigation is located in south west Sinai Peninsula about 20 km. east Gulf of Suez and about 40 km. southeast of Abu Zenima city; where Sinai Manganese Company located. It covers an area of approximately about 191 km2 and extends from latitude 28° 57' 00" to 29° 07' 00" N and longitude 33° 18' 00" to 33° 27' 00" E (Fig. 1). The studied white sand deposits belong to the Abu Thora Formation of Late Paleozoic age (Lower Carboniferous). In the study area the Precambrian basement rocks are overlain by Paleozoic sedimentary rocks. The Cambrian succession (Sarabit El Khadim, Abu Hamata, Nasib, and Adedia formations) comprises continental to shallow marine clastic rocks (e.g., ElAgami, 1996). These rocks are unconformably overlain by Carboniferous shallow marine facies of the Um Bogma Formation and deltaic to fluviomarine facies of the Abu Thora Formation (Fig. 2). Basaltic sills (Late Triassic-Early Jurassic) cut the top of the Abu Thora Formation. Abu Thora Formation is easily identified and this is attributed to the marked differences in lithology between its sandstone and the dolostone of Um Bogma Formation.

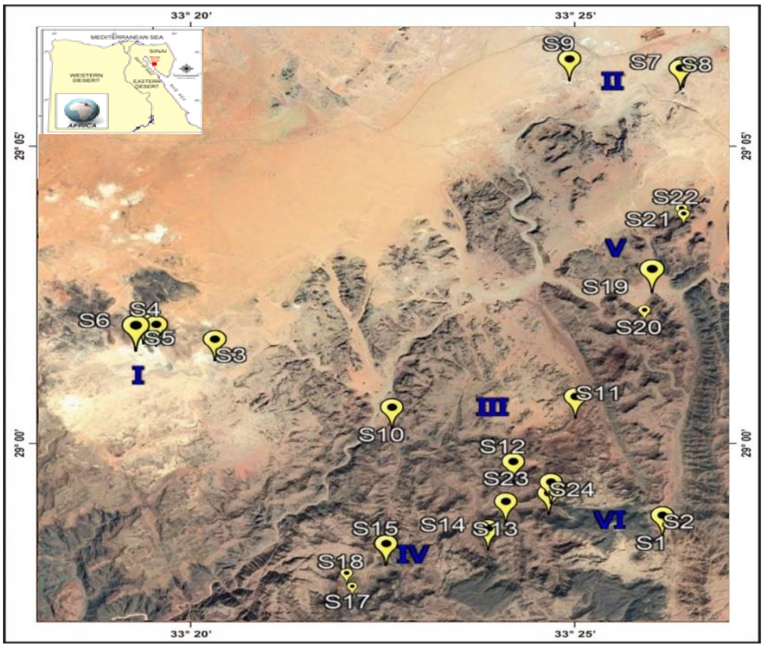


Fig.1: Location map of study area showing sites of samples and sections (I,II,III,IV,V and IV)

Abu Thora Formation is composed of yellowish to pinkish white sandstone with siltstone and mudstone interbeds. It consists of brownish cross- laminated sandstones intercalated with thin shale and siltstone. Ripple marks, trough, and tabular planar cross stratification are observed in the lower part of this formation. In the middle part; it is composed of shale, siltstone, sandstone, kaolin, claystone and semi-friable sandstones (glass sand) with siltstones and shale. Also, some sandstone beds of this formation wedge out, (Al Shami 2003).

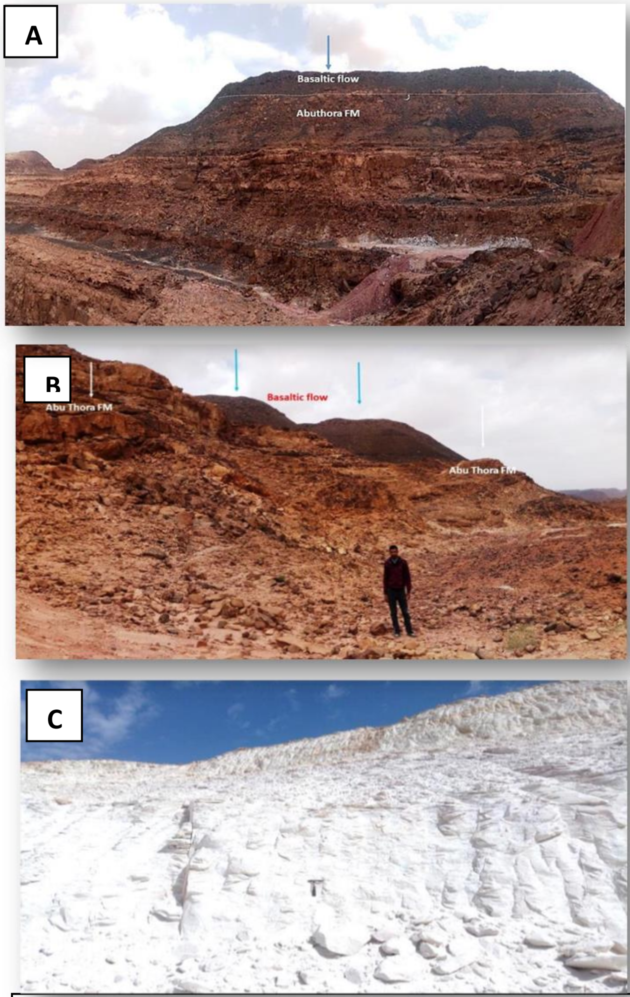
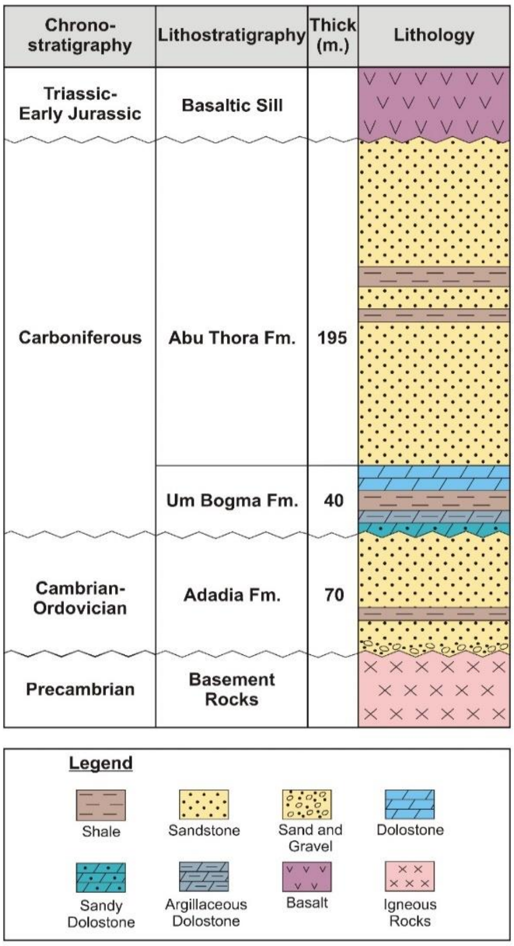


Fig.2: Field photographs showing; A& B (section V) Abu Thora Formation unconformably overlain by Basaltic Flow and, C. Glass white sand of Abu

Table 1: General lithostratigraphy of the Paleozoic succession study area, southwestern Sinai, after Kora (1984) or El-Shami (2003).



III. SAMPLING AND METHODOLOGY

Six lithostratigraphic sections were measured and described in the field (Fig. 1). Twenty-four samples from six sections were collected (four samples from section I at Al-Qoor area, three samples from section II at Al-Badaa Area, three samples from section III at Abu-Thora Area, six samples from section IV at Um-Bogma Area, four samples from section V at Al-Zobeir Area and four samples from section VI at Abu-Zarab Area (Table 2). The collected samples were analyzed physically, petrographically, and chemically.

Table2: The geographic coordination of sampling sites and in the study area

Section no	No of samples	locality	Sample no	Latitude	longitude
I	4	Al-Qoor area	S3	29° 02' 56.10"	33° 19' 7.10"
			S4	29° 03' 9.80"	33° 18' 21.90"
			S5	29° 03' 12.00"	33° 18' 11.70"
			S6	29° 03' 5.30"	33° 18' 5.56"
II	3	Al-Badaa area	S7	29° 07' 11.70"	33° 25' 10.80"
			S8	29° 07' 9.40"	33° 25' 8.70"
			S9	29° 07' 18.10"	33° 23' 42.20"
III	3	Abu-Thora area	S10	29° 01' 52.34"	33° 23' 23.72"
			S11	29° 02' 2.70"	33° 23' 46.80"
			S12	29° 01' 1.95"	33° 22' 58.64"
IV	6	Um- Bogma area	S13	29° 00 ' 24.60"	33° 22' 52.80"
			S14	28° 59 ' 59.83"	33° 22' 39.43"
			S15	28° 59' 46.20"	33° 21' 21.60"
			S16	28° 59' 46.20"	33° 21' 20.70"
			S17	28° 59' 18.00"	33° 20' 56.00"
			S18	28° 59' 28.50"	33° 20' 51.60"
V	4	Al-Zobeir area	S19	29° 04' 0.20"	33° 24' 46.30"
			S20	29° 03' 32.90"	33° 24' 41.10"
			S21	29° 05' 2.70"	33° 25' 11.40"
			S22	29° 05' 7.80"	33° 25' 9.70"
VI	4	Abu -Zarab area	S23	29° 00' 43.00"	33° 23' 28.30"
			S24	29° 00' 32.90"	33° 23' 26.70"
			S1	29° 00' 12.50"	33° 24' 55.10"
			S2	29° 00' 12.50"	33° 24' 55.10"

3.2 Methodology

3.2.1. Grain size analysis

A representative of the dry sample of 200 gm was transferred into the top sieve of the arranged set of sieves, the weighted amount is sieved for 15 minutes through a set of sieves with opening diameters of 2.00mm,1,00mm,0.5 mm,0.250mm,0.125 and 0.063mm; using Raw Tap Shaker sieve. Each sieve (one after the other) was carefully removed and the quantity of the sand grains retained in each was calculated after pouring it on a clean white paper (with known weight). A brush was used to remove all sand particles retained in each sieve. The weight was determined using digital balance and was tabulated. The average values of studied samples in each section are plotted on histograms and cumulative curves.

3.2.2. Petrography analysis

Eight selected samples were chosen from all collected samples and were sent to the Egyptian mineral resources authority(EMRA) laboratories in cairo to prepare eight thin sections and they were examined under the transmitted light polarizing microscope attached by digital camera to achieve their mineralogical composition,texture,sorting,roundness and other petrographic parameters .The results of the petrographical studies are shown below in (Table 5).

3.2.3. Chemical analysis

Twenty-four samples representing the white sandstone of the investigated six sections of study area at Abu Zenima area were chemically analyzed using both XRF and weight analysis technique for determination of the chemical composition of studied samples. Chemical analysis for silica sand samples was performed both at Sinai Factory Company laboratories and at the Laboratory of Nuclear Materials Authority (Qatameia), Cairo. Major oxides of selected samples were performed using different wet chemical analytical techniques.

IV. TEXTURE AND COMPOSITION OF THE SANDSTONES

4.1. Grain size distribution of white silica sands

4.1.1 Grain size Distribution (Sieve Analysis):

The grains of the silica sands of our study area at Abu Zenima are well-sorted. More than 95% of the grains fall in the range of 0.125 to 1.00 mm; (fine to coarse sand). More than 70% of the grains fall in the range of 0.25 to 1.00 mm; (medium to coarse sand, Table 3). Average results of twenty-four samples from the study area represents six different sections are listed in the tables and charts below (Figs. 3& 4):

Table 3: Average white sand grain size for study sections

Section no./ Sieve diameter	section I Al-Qoor (n= 4)	section II Al-Badaa (n= 3)	Section III Abu-Thora (n= 3)	Section IV Um- Bogma (n= 6)	Section V Al-Zobeir (n= 4)	Section VI Abu-Zarab (n= 4)
2-1 mm	0.25	0.39	0.55	0.68	0.38	0.47
1-½ mm	3.93	6.64	5.28	11.83	8.22	6.92
½-¼ mm	74.10	58.51	66.30	60.95	59.41	64.97
¼-1/8 mm	18.35	31.26	24.81	23.66	29.27	24.52
1/8-1/16 mm	3.01	2.77	2.89	2.38	2.09	2.76
-1/16 mm	0.36	0.44	0.40	0.50	0.63	0.43
Total	100.00	100.00	100.00	100.00	100.00	100.00

4.1.1.1. Histograms

Histograms are used to measure how frequently values or value ranges appear in a set of data. The vertical axis typically displays the weight percentage of particle size. The horizontal axis shows the grade size. The results of Histograms showed homogeneity in particle size, the study samples in all sections are unimodal graphs (Fig. 3).

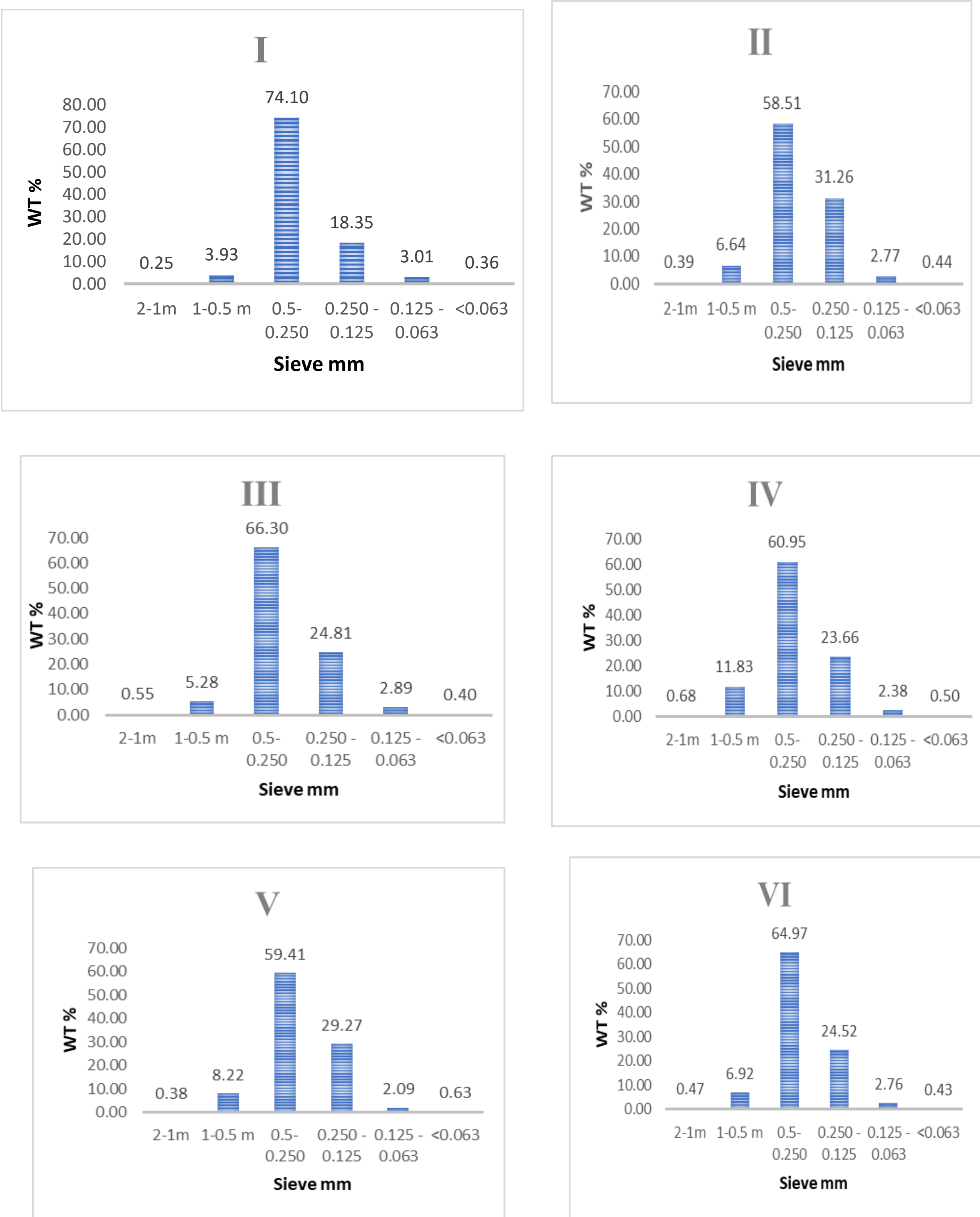


Fig.3: Histograms of average Grain size distribution in study sections at Abu-Zenima area

4.1.1.2. Cumulative frequency curves

The cumulative values of the grain-size analysis were graphically drawn in the form of cumulative curves and detecting the values of main percentiles. The weighted fractions of each sample obtained from the mechanical analysis used and average were cumulated to draw the cumulative frequency curves, using ϕ scale (Krumbein, 1934). The cumulative frequency curves were presented in figure (4) for the studied sections. The percentiles which corresponding to the ϕ5, ϕ16, ϕ25, ϕ50, ϕ75, ϕ84 and ϕ95 were obtained from the curves and then calculating textural parameters (Table 4). Cumulative curves consist of a number of different line segments, each one clears categories of particles (populations), which was transported in different modes of transportation. The cumulative frequency curve is obtained by plotting grain size (in phi scale) versus cumulative percent on the Probability paper. The cumulative curves drawn of the studied sediments appear as wide slopes with gentle angles as shown in figure (4). They are indicating that, it is well sorted sands.

Table.4: Average percentiles values and textural parameters of the study sections (Folk and Ward, 1957)

Percentiles /Textural parameters	I	II	III	IV	V	VI	Average
ϕ5 =	1.05	0.63	0.75	0.35	0.53	0.65	0.66
ϕ16 =	1.20	1.15	1.15	1.10	1.13	1.15	1.15
ϕ25 =	1.32	1.35	1.33	1.30	1.30	1.27	1.31
ϕ50 =	1.65	1.75	1.67	1.60	1.70	1.65	1.67
ϕ75 =	1.98	2.35	2.10	2.05	2.30	2.12	2.15
ϕ84 =	2.32	2.55	2.50	2.45	2.55	2.53	2.48
ϕ95	2.93	2.93	2.95	2.93	2.95	2.95	2.94
Mean grain size (Mz)	1.723	1.817	1.773	1.717	1.793	1.777	1.77 (Medium sand)
Inclusive standard deviation (δI)	0.564	0.698	0.671	0.728	0.722	0.693	0.68 (Moderately well sorted)
Inclusive graphic skewness (Sk1)	0.278	0.083	0.197	0.145	0.115	0.203	0.17 (Fine skewed)
Kurtosis (KG)	1.164	0.941	1.171	1.410	0.992	1.109	1.13 (Leptokurtic)

According to the equations suggested by Folk and Ward (1957) the four statistical sedimentological parameters which are Graphic Mean (Mz), Inclusive Graphic Standard Deviation (σI), Inclusive Graphic Skewness (SkI) and Graphic Kurtosis (KG); these statistical parameters should indicate the characteristics of grain size distribution, and the sediments are classified according to the limits given by Folk and Ward (1957) and was discussed in the following paragraph. The average values of grain size, sorting, skeweness and kurtosis each section in study area have been determined and represented in table (4) .

$$M_z = \frac{\phi_{16}+\phi_{50}+\phi_{84}}{3} \qquad (1)$$

$$\sigma_1 = \frac{\phi 84-\phi 16}{4} + \frac{\phi 95-\phi 5}{6.6} \qquad (2)$$

$$sk_1 = \frac{\phi_{16}+\phi_{84}-(2\phi_{50})}{2(\phi_{84}-\phi_{16})} + \frac{\phi_5+\phi_{95}-(2\phi_{50})}{2(\phi_{95}-\phi_5)} \qquad (3)$$

$$k_g = \frac{\phi_{95}-\phi_5}{2.44(\phi_{75}-\phi_{25})} \qquad (4)$$

4.2. Petrography and Textural analysis:

The obtained sand fractions were examined under the polarizing microscope to achieve their mineralogical composition (Table 5).The fractions are composed essentially of monocrystalline quartz grains, with few polycrystalline grains and small amounts of heavy minerals. Samples are texturally classified to sandstone (medium to fine grained) and petrographically, they indicate that the studied sandstone are formed mainly of very well sorted well rounded to sub rounded, coarse grains (0.5 mm) are usually rounded to sub-round, whereas the finer-grains (0.125 mm) are rounded to sub- rounded.

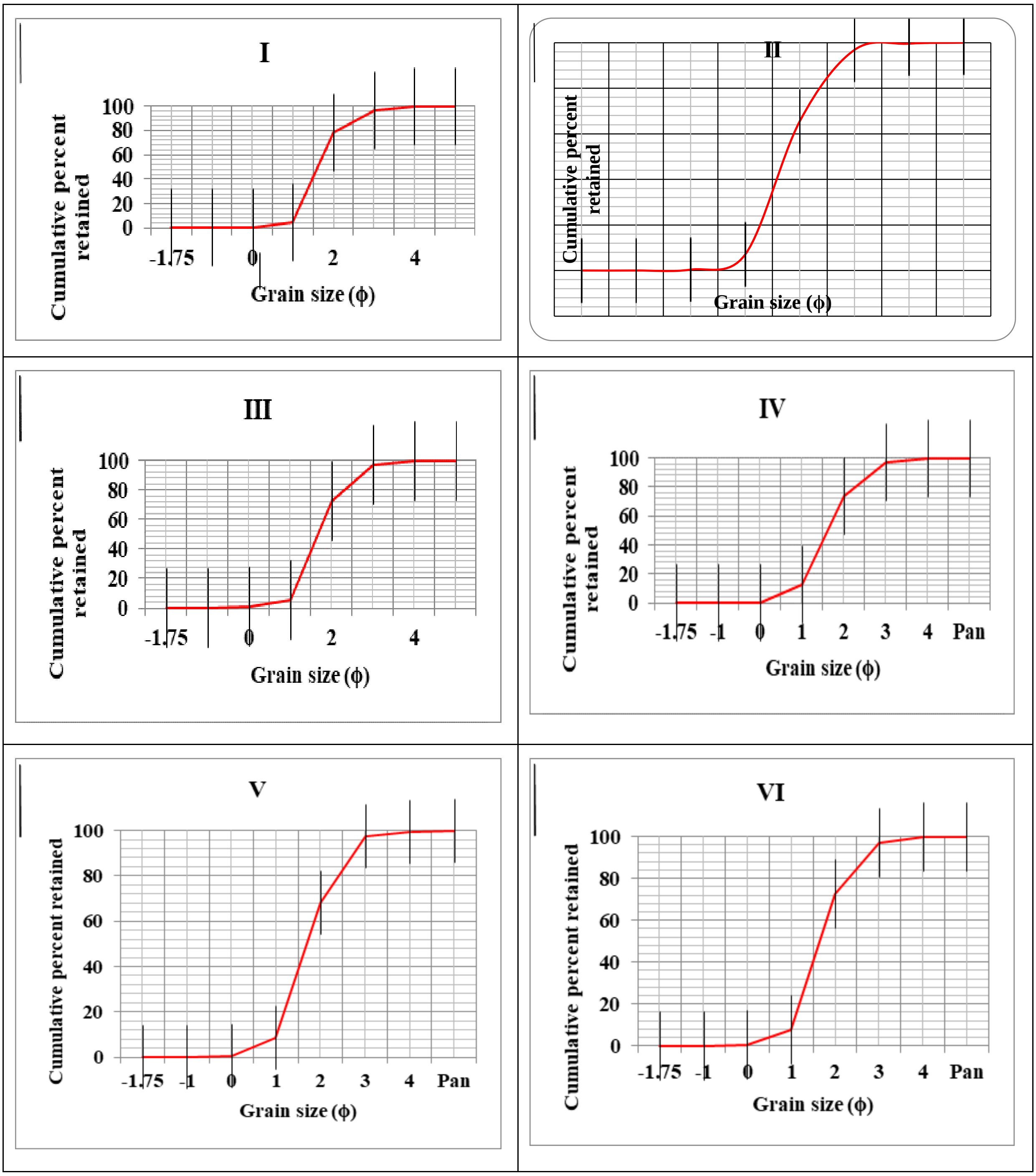


Fig.4: Cumulative curves of silica sand in studied sections..

Table. 5: Physical and petrographic properties of the studied sand fractions

Section/ Sieve	I	II	III	IV	V	VI	Description
2-1 mm V.C	0.25	0.39	0.55	0.68	0.38	0.47	White, well-rounded to rounded quartz grains Mainly monocrystalline grains.
1-1/2 mm C.S	3.93	6.64	5.28	11.83	8.22	6.92	White, well-rounded to rounded quartz grains,Monocrystalline quartz grains.
1/2-1/4 mm M.S	74.10	58.51	66.30	60.95	59.41	64.97	White, well-rounded to rounded quartz grains, Monocrystalline quartz grains.
1/4-1/8 mm F.S	18.35	31.26	24.81	23.66	29.27	24.52	White, grains rounded to sub-rounded quartz, a few Grains white yellowish in color.
1/8-1/16 mm V.F.S	3.01	2.77	2.89	2.38	2.09	2.76	White, grains rounded to sub-rounded quartz, White yellowish in color and patches of iron oxides.
< 1/ 16 mm Silt and clay	0.36	0.44	0.40	0.50	0.63	0.43	Yellowish sub-rounded quartz grains and some iron oxides spotes.

V.MAJOR ELEMENT CHEMISTRY OF WHITE SANDS AND COMMAND ON SUITABILITY IN GLASS INDUSTRY SMALL

5.1. Chemical Analysis:

The sandstones of Abo-Thora Formation are commonly termed as the silica sand deposits (white sand) of southern Sinai (Abdel Rahman , 2002). Detail chemical analysis of these sands was necessary to compare with the known composition of standared sand used glassmaking. Normally, the glass sands have mineralogical and textural composition which depends largely upon the nature of depositional regime and the source area. Therefore, twenty-four samples representing the white sandstone of the investigated six sections were chemically analyzed for their major oxides (Table 6) then compared with the composition standards of glass sands to define the systems and grades having the sand suitable for this purpose.

Concentrations of SiO_2, Fe_2O_3, Al_2O_3, and MgO were determined by XRF analysis technique (Table.5 and figure.5). The studied Southwest Sinai white sands are nearly pure silica, with mean concentrations SiO_2 (weight %) of 99.72, 99.69, 98.93, 98.89, and 98.98 for section (I, II.III, IV, V and VI respectively). Impurity concentrations are Fe_2O_3 = 0.010%-0.110%, Al_2O_3 = 0.11% – 1.05%, TiO_2= 0.012% - 0.242% and MgO = 0.0001%- 0.0085%.

The glass sands must have silica content (95%-99.85 %,) according to Kuzvart, 1984. The glass sands must have silica content (95%-99.85 %,), the Al_2O_3 should be less than 4 % for ordinary glass and less than 1%for optical glass (Jensen and Bateman, 1979). Fe_2O_3 generally, undesired. For ordinary glass it must not exceed 0.04% but for colorless glass should not exceed 0.013% and 0.008% for optical glass (Srivastava, 1978). Traces of lime, magnesia and alkalis are desired for all common types. The glass sands should lie well sorted and their grain sizes range between 0.25 to 2.75 (20-100 mesh); Srivastava, 1978; Jensen and Bateman; 1979).

The chemical analysis (Table 5) shows that the white silica sands of the studied six sections attain average percentages of silica (99.72, 99.69, 98.93, 98.89, and 98.98% respectively), iron oxide with mean weight percentage of (0.019, 0.024, 0.081, 0.078, 0.076 and 0.073 respectively) and alumina (0.185, 0.220, 0.803, 0.817, 0.833 and 0.698 respectively), contents that are suitable for glass manufacture. They are generally pure white, less consolidated medium to fine fine grain in size, well - sorted. Generally Aeolian deposition results in clean, well-sorted arenite with high quartz content relative to any other environment (Folk, 1980).

Standards for minimum SiO_2 concentration and maximum impurity oxide concentrations in white sand for optical, transparent, and colored glasses have been circulated by the British Standards Institute (2975/1985) and by the American Ceramic Society (Norton, 1957) . Chemical criteria for optical glass are the most restrictive and the analyzed sample (5) meet the requirements of optical glass (BSI: $SiO_2 > 99.7\%$, $Fe_2O_3 < 0.012$ by the weight, ACS: $SiO_2 > 99.8\%$, $Fe_2O_3 < 0.020$ by the weight). If we consider that iron oxides are the critical oxides for the determination sands quality, the studied white silica sand samples of Abu Zenima meet the optical glass, quality flint containers and table ware, quality sheet and plate glass, quality green containers &windows glass and quality Amber glass containers requirements. The observed Al_2O_3 concentrations in Sinai white sands are below the maximum allowed for glass manufacture and MgO concentrations in all samples are below the maximum allowed. For colorless glass, the concentration of Fe_2O_3 must be less than 0.06 % by weight. None of samples from Abu Zenima Sections (III, IV, V and VI) are suitable for colorless glass. All white silica sand samples from Abu Zenima sections (I and II) meet the criteria for colorless glass.

Table.5: Results of chemical analysis of the studied silica sand samples

Section no	locality	Const. / Sample	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	MgO	Cr_2O_3	CaO	Total
I	Al-Qoor area	S3	99.65	0.020	0.22	0.022	0.0002	0.003	0.021	99.94
		S4	99.50	0.020	0.20	0.025	0.0003	0.004	0.022	99.77
		S5	99.20	0.010	0.11	0.012	0.0001	0.012	0.050	99.39
		S6	99.50	0.025	0.21	0.025	0.0002	0.005	0.022	99.79
Avg.			99.72	0.019	0.185	0.021	0.0002	0.006	0.029	99.98
II	Al-Badaa area	S7	99.50	0.020	0.22	0.025	0.0004	0.006	0.019	99.79
		S8	99.48	0.028	0.24	0.024	0.0003	0.005	0.010	99.79
		S9	99.49	0.023	0.20	0.020	0.0002	0.003	0.020	99.76
Avg.			99.69	0.0237	0.22	0.023	0.0003	0.0047	0.016	99.98
III	Abu-Thora area	S10	99.12	0.062	0.66	0.055	0.0050	0.015	0.055	99.97
		S11	98.73	0.072	0.80	0.061	0.0050	0.008	0.050	99.73
		S12	98.65	0.110	0.95	0.120	0.0085	0.018	0.090	99.95
Avg.			98.93	0.081	0.803	0.079	0.006	0.014	0.065	99.98
IV	Um- Bogma area	S13	98.78	0.076	0.82	0.067	0.0050	0.015	0.050	99.81
		S14	99.22	0.052	0.55	0.048	0.0042	0.005	0.062	99.94
		S15	98.52	0.094	1.05	0.082	0.0040	0.014	0.070	99.83
		S16	98.67	0.081	0.87	0.100	0.0040	0.009	0.060	99.79
		S17	98.32	0.100	0.96	0.242	0.0050	0.009	0.095	99.73
		S18	98.66	0.063	0.65	0.104	0.0060	0.008	0.090	99.58
Avg.			98.89	0.078	0.817	0.107	0.005	0.010	0.071	99.98
V	Al-Zobeir area	S19	98.57	0.067	0.75	0.227	0.0040	0.008	0.084	99.71
		S20	98.64	0.057	0.68	0.060	0.0040	0.017	0.090	99.55
		S21	98.62	0.085	0.90	0.220	0.0040	0.009	0.098	99.94
		S22	98.54	0.095	1.00	0.210	0.0005	0.004	0.088	99.94
Avg.			98.77	0.076	0.833	0.179	0.003	0.010	0.09	99.98
VI	Abu-Zarab area	S23	98.80	0.066	0.65	0.078	0.0040	0.018	0.070	99.69
		S24	98.70	0.068	0.72	0.100	0.0040	0.009	0.060	99.66
		S1	98.65	0.100	0.82	0.225	0.0054	0.050	0.090	99.94
		S2	99.10	0.056	0.60	0.055	0.0045	0.008	0.050	99.87

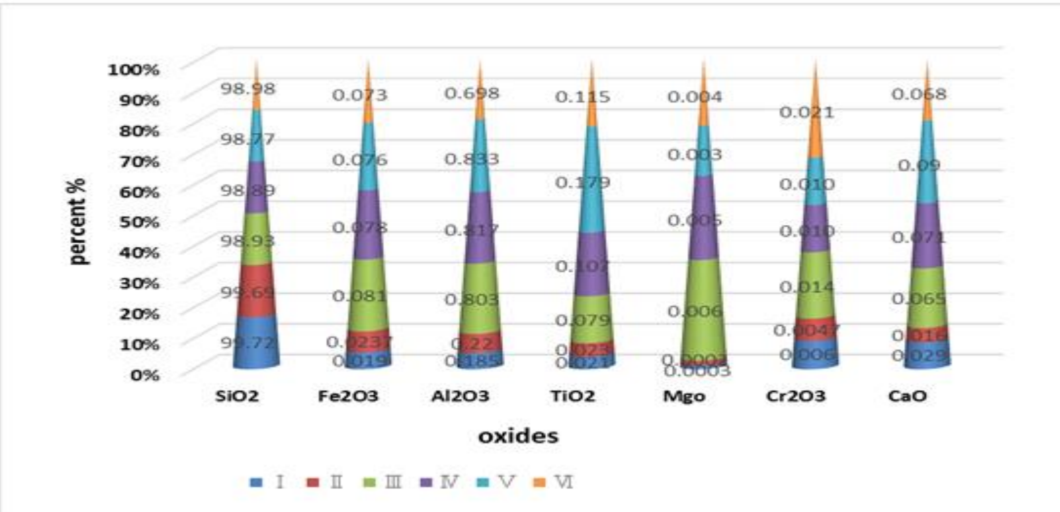


Fig.5: Histograms of chemical analysis for studied sections at Abu-Zenima area

5.2. Types and grades of silica sand used for glassmaking:

5.2.1 Types of silica sand:

For an exacting source of sand to be appropriate for glassmaking, it must not only hold a very high amount of silica but also other components may include alumina, feldspar and iron bearing minerals. Silica sand is also normally required to be well sorted, having grains of an approximately uniform size.

5.2.2 Grades of silica sand:

The glass industry has established different standard specifications for the silica sand intended for seven types of glass. The requirements for these grades of silica sand are set out in BS 2975:1988, British standard methods for sampling and analysis of glassmaking sand (BS 2975) which cover the following applications:

- Optical and ophthalmic glass Grade A
- Tableware and lead crystal glass Grade B
- Borosilicate glass Grade C
- Colourless (or clear) container glass Grade D
- Clear flat glass Grade E
- Coloured container glass Grade F
- Glass for insulating fibres Grade G

Three levels of purity are specified, A,B, and C. Grade A sand, suitable for manufacture of high grade optical ware,should contain no more than 0.008%Fe_2O_3, 0.030% $Ti0_2$ and 2 ppm Cr_2O_3. Grade B sand, suitable for high grade domestic and decorative glassware, should contain no more than 0.013% Fe_20_3 and 2ppm Cr_2O_3. Grades A and B should contain a minimum of 99-5% SiO_2. Grade C sand, suitable for the manufacture of colour less containers e.t.c, should have a maximum Fe_2 O_3 content of 0.030% and not more than 6 ppm Cr_2O_3. There is a proviso that the Fe_2O_3 specification can be relaxed to 0.035% maximum if the sand contains less than 2 ppm Cr_2O_3. A minimum SiO_2 content of 98.5% is specified (Doyle, 1978) . This specification refers only to sand used in the manufacture of colourless glass and many thousands of tons of sand (with contents of colouring elements well outside the limits specified) are used in the manufacture of flat glass and coloured containers.

The general specifications and the standards for glass sand are graded according to the silica and the alumina contents. The percentage contents of lime, magnesia may also take into consideration. Specifications of chemical composition for glass sand vary within certain limits from one glass manufactures to another as showen in tables (6 & 7).

Table.6: Specification of chemical composition for glass sand (Recommended by the American Ceramic Society and National Bureau of standard (Norton, 1957)

System / Number	**Product (glass)**	**SiO2% (Min)**	**Al2O3% (Max)**	**Fe2O3% (Max)**	**CaO+ MgO %(Max)**
1	Quality Optical glass	99.8	01	0.02	0.1
2	Quality Flint containers and table ware	98.5	0.5	0.035	0.5
3	Quality flint Glass	95.0	0.4	0.035	0.5
4	Quality sheet and plate glass	98.5	0.5	0.06	0.5
5	Quality sheet and plate glass	95.0	0.4	0.06	0.5
6	Quality green containers and windows glass	98.0	0.5	0.3	0.5
7	Quality green glass	95.0	0.4	0.3	0.5
8	Quality Amber glass containers	98.0	0.5	1.0	0.5
9	Quality Amber glass	95.0	0.4	1.0	0.5

Table 7. Iron Oxide Standards set by Glass Manufacturer (Ceramic Industry Magazine , 1966 in Art 186 Introductions to Ceramics, 2011)

Product	**Maximum Fe2O3(%)**
Optical Glass	**0.015 – 0.016**
Containers (Colourless)	**0.03 – 0.04**
Containers (Amber)	**0.05 – 0.08**
Plate Glass (General)	**0.15**
Plate Glass (window)	**0.08**

To meet these tight specifications, the sand often has to be subjected to extensive physical and chemical processing. This involves crushing, screening and further adjusting the grain-size distribution, together with removing the contaminated impurities in the sand and from the surface of the individual quartz grains.

Presence of metallic oxides in the glassmaking sands usually produce colored glass. If iron is present, the resulting glass is colored green or brown. The iron level is consequently the most critical parameter in determining whether particular sand can be used to make clear glass. Sands used to manufacture colorless glass are therefore likely to be processed further by certain methods such as acid leaching, froth flotation or gravity separation. Figure (6) illustrates the range of iron level permitted in each of the grades of silica sand.

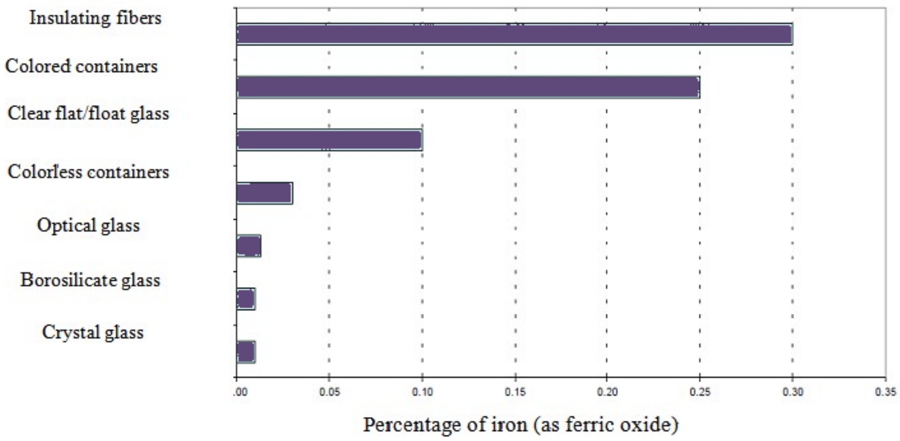


Fig.6: Ranges of acceptable iron content in silica sand (BS 2957).

VI. RESULTS AND CONCLUSION:

The results of the grain size analysis, petrography and microstructure studies and chemical composition of the studied white silica sands indicate that:

1. The studied Carboniferous white sand of southwest Sinai (Abo Zenima) are medium to fine grained in size more than 97% of the grains fall in the range of 0.125 to 1.00 mm, well sorted, well rounded to rounded grains and mainly pure crystals of quartz .

2. According to the American Ceramic Society (Norton, 1957), Abu Zenima (S5) from section (I) is of first grade and meet the requirements of optical glass. From iron oxides percentages point of view all the samples of Abu Zenima are compatible with 1st, 2nd, 4th, 6th and 8th grade which meets almost all glass making requirements.

3. According to British standards BS 2975:1988 the glass sand of Abu Zenima meets the specification of grade (A, B and C) they are suitable for high quality glass industries especially samples from section (I and II) of SiO2 content 99.7% and 99.69%) and iron content (0.019% and 0.024%).

Most of the silica sand deposits of Abu Zenima area southwest Sinai correlated well with system no of 1st -2nd, 4th, 6th and 8th according to the American Ceramic Society and National Bureau of standard (Norton, 1957) S/N System /Number and meets grade (A,B and C) according to British standards(BS 2975:1988). They can be suitable for the making Optical and ophthalmic glass, Table ware and lead crystal glass, Borosilicate glass, Colourless (or clear) container glass, clear flat glass, green glass and amber glass, colored container glass and insulating fibers.

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