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STUDIES ON MOHMAND AGENCY SILICA SAND

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Geochemical and beneficiation studies were carried out on representative samples of silica sand from Mohmand Agency, NWFP, to examine their suitability for glass industry. The samples were subjected to physical and chemical treatments to remove iron bearing minerals and other impurities.

Final results indicate that the quantity of iron is too high for the manufacture of quality glassware. After beneficiation with sulphite process the iron content in raw samples was reduced by a percentage 72.63 to 90.43.

INTRODUCTION

Silica is a major constituent of all types of glasses and is usually added to batches in the form of sand. Other forms of silica such as sandstone, crushed quartzite or ground flint can also be used but sand is preferred due to its physical nature. It is mainly silica consisting of quartz grains having limits of 0.1 to 1.0 mm, dia.

From the glass making point of view, only pure quartz (SiO_2) is required and other minerals, if present, are to be regarded as impurities. These may occur in the form of free iron oxide, clay, mica, felspar, calcite and dolomite which can be readily identified by examining a few grains of samples under microscope. Pure sand should consist of transparent colourless grains. Sometimes the sand grains are coated with a thin film of clay, felspar and limonite ($2\ Fe_2O_3 . 3H_2O$) which can be removed to a large extent by washing with water or boiling with dilute hydrochloric acid. A good quality silica sand should be free from heavy minerals such as limonite, ilmenite, rutile and tourmaline and should not contain less than 99.50% of SiO_2 after washing. The heavy minerals will give higher values than 2.65 (specific gravity of pure quartz). The presence of organic matter will yield lower values. An appreciable amount of organic matter will show an increase in specific gravity after washing. However, small amounts of Al_2O_3, CaO, MgO and alkalis are not objectionable but should not exceed 1.5%. A significant amount of alumina indicates the presence of felspar, mica and clay usually contain iron oxide.

Iron is the most objectionable impurity present in a sand. Its contents should not exceed by 0.08% Fe_2O_3. The permissible limits of iron oxide in a sand depends upon the type of the glass.

Besides the chemical composition, the suitability of a particular sand for glass manufacture is also determined by grain size and shape of the particles. Therefore, sands with angular grains are preferred, and can be divided into three main groups [1].

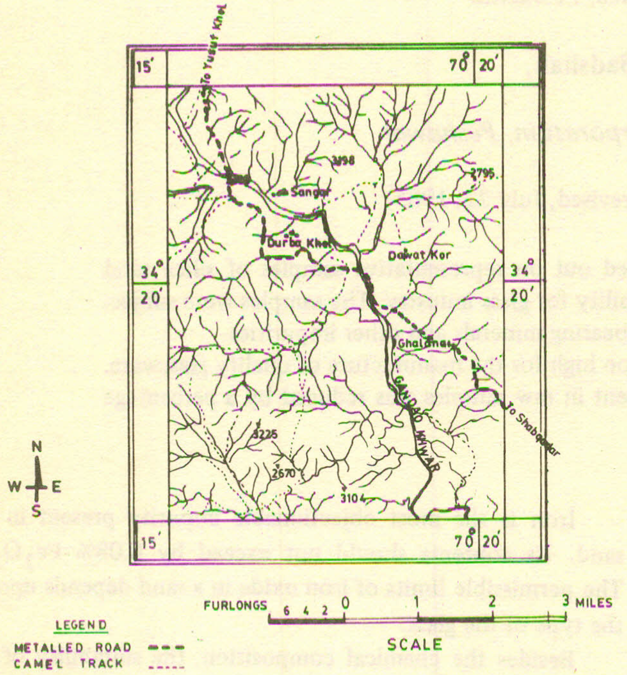
Coarse sand	1.0 to 0.5 mm dia.
Medium sand	0.5 to 0.25 mm dia.
Fine sand	0.25 to 0.10 mm dia.

The grading of sand is determined by sieving or elutriation. Elutriation is used when fine powders are to be investigated. The proportions of grains of different sizes constituting the sample shall fall within 0.5 and 0.15 mm in diameter. If large grains are present, then incomplete fused grains are left in the glass. If the sand is too fine and in a damp state, fine air bubbles are produced which are very difficult to remove during melting process.

GEOLOGY OF THE AREA

Silica sand deposits of Mohmand Agency are of some commercial importance. The silica sand is associated with phyllitic schists. The deposits are exposed at five isolated localities in an area of about 40 sq.km. The area is accessible through the metalled Ekkaghund Yusufkhel Road. Estimated reserves of silica sand are 537.18 million tons up to a depth of 30 meters [2].

The area investigated lies about 60 km north of Peshawar and is delimited by latitudes 34°17′ to 34°22′ and longitudes 71°21′ to 71°25′E covering about 40 km of land in Lower Gandao (Fig. 1).



The area comprises metasedimentary rocks. Metasediments comprise phyllitic slates and phyllitic schists having in general a NW strike and NE dip. The metasediments are greyish to greenish black in colour, highly jointed and comprise quartz, felspars, muscovite, clayey and carbonaceous materials. Sericite and calcite are also present. Pyrite crystals are rarely observed. Sometimes epidote has also been produced at the contact with dolerites.

Silica sand occurs in the form of hard and friable lenticular quartzite bodies engulfed in the metasediments.

Ghalani

Lower quartzite. This bed is about 450 m. long and 150 m. thick. The rocks are medium to coarse grained and show a faint orientation of grains, especially in the case of micaceous minerals. In most cases, quartz is granular to subgranular and makes about 90% of the whole. The rest of the mass is made up of carbonates, felspars, muscovite, biotite, opaque ores and coatings of iron oxide are present as accessories.

Middle quartzite. With nearly a uniform thickness of 10 m. it runs for about 900 m. The unit is dislodged, showing a displacement of about 90 m. in a direction almost perpendicular ot the bedding. The rock is medium grained, loosly cemented and white in colour. It is made up of 92% quartz, 2.5% carbonates, 2% felspars and traces of iron and opaque ores.

Upper quartzite. The formation is about 500 m thick at eastern limits and decreases up to 200 m. in the west. It consists of hard, compact as well as friable bands. Optical observations gave an average composition of 89% quartz, 4-5% carbonates, 4% felspars and opaque ore and mica as accessory minerals.

Dawat Kor. The formation is about 300 m. thick and 140 m. long. Little variation in colour, texture and composition has been observed. It consists of 93% quartz, 3% carbonates, 3% felspares, 1% muscovite and biotite and opaque ore as accessories.

Durba Khel. The formation can be differentiated into a moderately hard to friable, thin to medium bedded, closely jointed and loosely cemented lower unit and hard, compact, medium to thick-bedded, moderately jointed and highly cemented upper unit. The average composition of the rocks is 91% quartz, 4% carbonates, 3% felspars 1.5% muscovite and 0.5% opaque ore.

Sangar. The formation, 150 m. thick and 300 m. long, is medium bedded, friable to moderately hard and shows foliation along trend. The average mineralogical composition is 91% quartz, 4% carbonates, 2% felspars, 1% muscovite and 1.5% opaque ore.

EXPERIMENTAL

Petrographic and chemical analysis. Representative sand samples from Ghalanai, Dawat Kor, Durba Khel and Sangar were analysed.

The approximate percentage of mineral constituents and chemical composition are given in Tables 1 and 2.

Table 1. Approximate percentages of minerals in original silica sand

Minerals	FS-1/A	FS-1/B	FS-1/C	FS-1/D	FS-2
Quartz	90	92	93	91	91
Carbonates	4	2.5	3	4	4
Felspars	3	2	3	3	2
Muscovite	3	Traces	1	1	1
Biotite	0.5	1.0	Traces	0.5	Traces
Magnetite	Traces	1.5	Traces	0.5	1
Hematite	1	Traces	Traces	Traces	0.5

1/A, 1/B, Ghalanai; 1/C, Dawatkor; 1/D, Durbakhel; 2, Sangar

Table 2. Chemical analyses of raw and washed silica sand

Per cent Chemical composition	FS-1/A		FS-1/B		FS-1/C		FS-1/D		FS-2		BULK-1		BULK-2	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
SiO_2	91.40	95.01	95.01	97.17	92.40	96.04	93.60	95.04	93.06	95.10	93.82	94.70	88.24	91.40
Fe_2O_3	0.63	0.30	0.44	0.14	0.50	0.16	0.41	0.22	0.79	0.38	0.63	0.36	0.95	0.18
Al_2O_3	2.29	2.07	0.19	0.17	2.47	1.08	1.03	1.01	1.91	0.89	1.70	1.65	4.98	4.01
TiO_2	0.14	NIL	NIL	NIL	0.03	NIL	0.26	NIL	0.30	NIL	0.14	NIL	0.23	NIL
MnO	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
P_2O_5	0.15	0.02	0.05	NIL	NIL	NIL	0.10	0.01	0.05	0.03	NIL	NIL	0.05	0.03
CaO	1.12	0.45	1.34	0.16	1.33	0.81	1.30	0.71	0.50	0.42	0.39	0.43	0.67	0.67
MgO	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	0.43	0.42	0.65	0.43	0.50	0.67
Na_2O	0.17	0.16	0.05	0.02	0.04	NIL	0.10	NIL	0.05	NIL	0.39	NIL	0.67	NIL
K_2O	3.50	1.50	2.01	1.50	2.25	1.50	2.12	1.50	2.50	2.25	2.25	2.01	3.32	1.50
Loss on ignition	0.74	0.57	0.91	0.84	0.42	0.35	1.14	0.74	0.50	0.31	0.26	0.45	0.52	0.67
Total	100.14	100.08	100.00	100.00	99.44	99.94	100.06	99.23	100.09	99.80	99.87	100.03	99.56	100.13

a, raw silica sand, b, washed silica sand.

Table 3. Sieve analysis results of raw and washed silica sand

	Raw silica sand							Washed silica sand						
Sample No Sieve size	FS-1/A	FS-1/B	FS-1/C	FS-1/D	FS-2	BULK-1	BULK-2	FS-1/A	FS-1/B	FS-1/C	FS-1/D	FS-2	BULK-1	BULK-2
0-25 mesh (%)	18.74	11.73	19.35	17.36	20.54	31.42	6.54	19.44	8.14	14.86	12.64	16.94	35.12	5.36
-25 mesh (%)	3.54	4.14	8.10	5.44	6.08	3.32	3.32	4.87	4.39	7.59	4.92	10.48	6.37	5.46
-36 mesh (%)	4.98	5.44	10.96	7.28	9.86	8.80	4.10	6.98	6.72	12.61	7.53	12.69	2.55	7.18
-52 mesh (%)	7.92	16.40	18.31	14.16	14.00	15.57	13.79	11.06	15.93	23.59	17.09	21.18	30.12	17.43
-72 mesh (%)	16.92	24.52	17.86	18.44	16.28	16.10	12.42	14.82	16.03	18.94	20.28	25.72	11.30	20.45
-100 mesh (%)	10.10	12.00	4.60	13.47	20.82	7.32	38.27	21.70	27.21	9.02	10.46	6.30	6.37	20.49
-120 mesh (%)	37.77	25.75	20.81	23.84	12.42	13.99	21.55	21.13	21.55	13.39	27.08	6.69	8.17	23.83
Weight (%) from -25-120 mesh	43.49	62.52	59.84	58.80	67.04	54.59	71.91	59.43	70.31	71.75	60.28	76.43	56.71	70.81

Beneficiation. Various physical and chemical methods were tried to beneficiate the sand samples to the specifications required for the manufacture of high quality glasswares.

Physical Methods. The raw samples were subjected to water washing, grading (Table 3) and magnetic separation to remove the ferrogenous clayey fraction, undesirable coarse and fine fractions and the paramagnetic particles respectively.

Chemical Methods. Hydrochloric acid Leaching.– The sand samples were treated with hot hydrochloric acid [3] of various concentrations for 1 hr and tested for iron content. The removal of iron content by this process was negligible (Table 4).

Adam's Process.– To remove the iron coatings of sand grains, the samples were treated with a solution containing sodium oxalate sulphuric acid and small amount of ferrous sulphate [4] (Table 5).

Sulphite process.– The sand was mixed with sodium sulphite and the pH was adjusted 2.7 by adding dilute hydrochloric acid [5] (Table 6).

Table 4. Removal of iron in silica sand by hydrochloric acid leaching

Sample No.	Per cent Fe_2O_3 in original sample	Per cent Fe_2O_3 retained after hydrochloric acid leachings		
		0.5 N HCl.	1N HCl.	Conc. HCl.
FS-1/A	0.63	0.57	0.56	0.48
FS-1/B	0.44	0.42	0.41	0.40
FS-1/C	0.50	0.49	0.46	0.42
FS-1/D	0.41	0.40	0.39	0.38
FS-2	0.79	0.76	0.75	0.72
Bulk-1	0.63	0.61	0.60	0.58
Bulk-2	0.95	0.91	0.90	0.88

Table 5. Beneficiation of silica sand by Adam's process

Sample No.	Per cent Fe_2O_3 in Raw Sample	Per cent Fe_2O_3 after Adam's process	Percentage reduction in ferric oxide contents
FS-1/A	0.63	0.30	52.38
FS-1/B	0.44	0.085	80.68
FS-1/C	0.50	0.20	60.00
FS-1/D	0.41	0.18	56.09
FS-2	0.79	0.54	31.64
Bulk-1	0.63	0.22	65.07
Bulk-2	0.95	0.57	40.00

Table 6. Beneficiation of silica sand by sulphite process

Sample No.	Percent Fe_2O_3 in raw samples	Percent Fe_2O_3 after treatment with the sulphite process	Percent reduction* in Fe_2O_3 content
FS-1/A	0.63	0.08	87.30
FS-1/B	0.44	0.05	88.63
FS-1/C	0.50	0.079	84.20
FS-1/D	0.41	0.081	80.24
FS-2	0.79	0.20	74.68
BULK-1	0.63	0.06	90.47
BULK-2	0.95	0.26	72.63

* Calculated on the basis of Fe_2O_3 present in the original sample.

RESULTS AND DISCUSSION

Chemical analyses and physical characteristics reveal that all the samples of silica sand from Mohmand Agency contain small amounts of calcite, biotite, muscovite, felspars etc. Iron oxide is particularly harmful and it should not exceed 0.08%. The iron content in the raw samples of Mohamand Agency silica sand varies from 0.41% to 0.95%.

Glass-making sands should pass through a 25-mesh sieve and a majority should be retained by 100-mesh sieve. The maximum retention of sand samples varies from 43.49 to 71.91%.

With a view to reducing the iron content as well as other impurities, attempts were made to beneficiate the silica sand samples by different physical and chemical methods. Although iron oxide was removed to a considerable extent by water washing, even the quantity of iron oxide retained is too high to render it suitable for colourless glass manufacturing.

The removal of iron content by hot hydrochloric acid leaching was insignificant, whereas by Adam's Process the iron removed in samples FS-1/B was 80.68% and in other samples between 31.64% to 65.07% (Table 5).

The removal of iron oxide in sand samples by the sulphite process was to the extent of 72.63 to 90.43% (Table 6).

It is expected that the silica sand of Mohmand Agency which is available in different forms can find use in finer abrasives, silicate industry and for making green and amber glasses.

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