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A STUDY OF GLASS SAND DEPOSITS FROM KURD, KARAK DISTRICT, NWFP

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In continuation of these authors' earlier work on the evaluation and utilization of raw materials of NWFP and FATA areas [1,2], the silica sand deposits of Kurd village, Karak District, NWFP were surveyed. The deposits are large, occur in Datta formation of Jurassic age and are exposed over a wide area in the Surghar range. The samples of this area were collected for evaluation and beneficiation. The chemical composition, grain-size distribution and physical characteristics were determined. Beneficiation by physical and chemical methods were undertaken to reduce iron contents. The objective of the work was to investigate whether the silica sand deposits of Kurd are suitable for the rapidly expanding glass industries of Pakistan.

Key words: Glass sand, Kurd silica sand, (Karak district), Evaluation.

INTRODUCTION

Silica sand is quartz sand of such purity that it is essentially monomineralic Quartz is the most common mineral of silica. It is essentially a constituent of sand, sandstone and quartzite considered suitable for glass making if free from impurities. The harder silicious material is crushed, screened and sometimes chemically treated before materials of suitable compositional and textural characteristics can be successfully prepared [3]. Such processing is difficult and expensive. Therefore, silica sand of desirable specification is always preferred to sandstone and quartzite.

In general specifications of all grades of glass sands are quite similar except for iron oxide content, which is quite rigid but varies for different applications. Sand used for making clear container glass[4] should contain less than 0.06% Fe_2O_3; for flat glass, less than 0.10% Fe_2O_3; and for amber container glass, less than 0.25% Fe_2O_3. Other oxides such as Al_2O_3, CaO,MgO, Na_2O and K_2O do not have rigid limits since they are the normal constituents of glass. However, the content of these oxides should be kept within certain limits. The major uses of glass sand are for glass making, abrasive, metallurgical and refractory purpose.

The field survey indicates[5] the presence of several million tons of silica sand in the area. Open pits are developed throughout the length of lower bed of the silica sand deposit. Of these the Kurd area falling within Karak District, NWFP, produces more than 30,000 tons of silica sand annually. Mining is generally selective and operates mostly along road and nala cuts[5].

Geology of the area. Stratigraphically, the silica sand in the Surghar Range occurs at two different stratigraphic horizons within the Datta formation. The lower horizon is located in the middle of the continental part of the formation, while the upper horizon is located just below the shallow marine sediments. The two horizons are separated from each other by a 115 meter thick assemblage of shale.

The upper silica sand horizon has a thickness of about 15 meters and is interbeded with clay and sandstone. It is discontinuous and changes to quartzose sandstone laterally forming lenticular bodies of silica sand. The lower horizon is about 30 meters thick and persistently runs along the general trend of the range between the Chichali pass and Mallakhel to a distance of more than 10 kilometers. It thins out towards Mallakhel and pinches down along the axial plunge of the anticline. To the west of Chichali pass, it again thins out and merges into quartzose sandstone.

The colour of the silica sand beds are whether brown to rusty brown mottled with dirty white specks. This colour characteristics helps in differentiating silica sand from other rock units in the area. The white specks are erosional features developed due to the fall of the float from the upper units. On fresh surface, it is chalky white, pale yellow

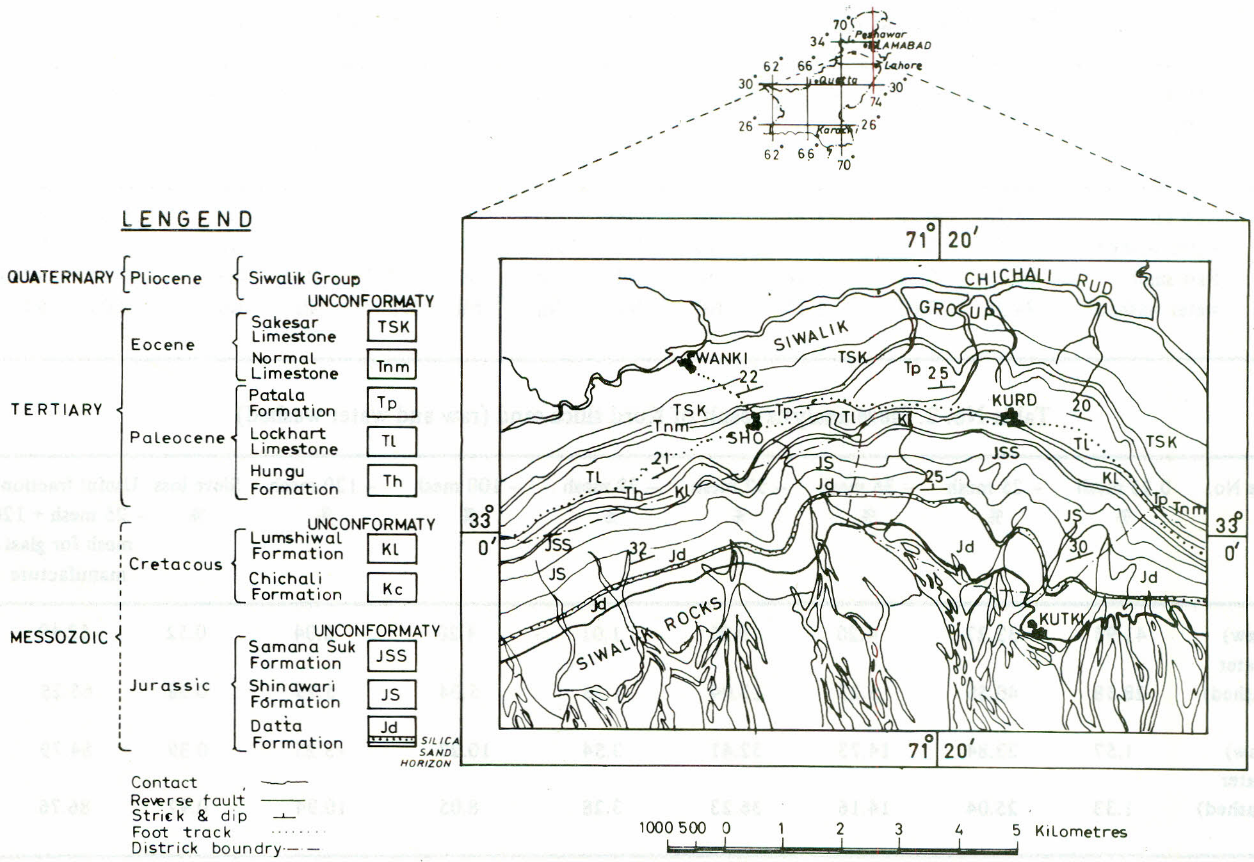

Fig. 1.Geological map of Kurd silica sand Karak District, NWFP, Pakistan.

to reddish brown. It is fine to medium grained, ferruginous and highly jointed sedimentary features such as current bedding, ripple marks and cross bedding are very common. The pale yellow silica sand bodies are harder and medium to coarse grained. A prominent marker bed of 5 meters thick maroon splintery shale overlies the silica snad be [5].

EXPERIMENTAL

Two representative samples were collected from two different deposits namley A (coarse and yellowish) and B (fine and greyish white). R & D work was carried out on these two samples. The work was classified into the following main groups:

(1) Chemical analysis (2) Water washing for removing ferruginous clay matter. (3) Grading to remove unwanted, coarse and fine sand fraction and impurities included therein. (4) Magnetic separation to remove ferromagnetic particles. (5) Beneficiation by chemical treatment.

Chemical analysis. 100 g of the sand were ground to a fine powder (–10 + 120) and analysed using standard methods of chemical analysis (British Standards, 1958) [6]. The constitutents determined were SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO etc. The results of the chemical analysis of the original and water washed silica sand samples are given in Table 1.

Water washing. The clay fraction was removed by washing the sand with water for this purpose. Sand and water were taken in a 3 litre beaker and stirred with a glass rod. The resulting dirty liquid carrying ferrugenous clay particles were decanted after 1½ min. The process was repeated till the washings were free from any dirty liquid. Effect of water washings on the improvement of Fe_2O_3 was done and incorporated in the chemical analysis table (Table. 1) In sample A and B 21.73% and 41.66% Fe_2O_3 was removed by water washing respectively.

Grading. 100 g each of the original and water washed samples were taken and the sieving was done by means of ASTM standard sieves of 25, 36, 52, 72, 100 and 120 meshes. Each sample was shaken for 5 min. in a mechanical shaking machine and the amount retained on every mesh was weighed. From these the percentage retention on a particular sieve and the useful fraction for glass industries were found out and given in Table. .2. Fe_2O_3 in the useful fraction (–25 + 120) was 0.15% and 0.06% in samples A and B respectively.

Table 1. Chemical analysis of Kurd (Karak) silica sand (raw and water washed)

Sample No.	Raw sand or water washed	SiO_2 %	FO_2O_3 %	Al_2O_3 %	TiO_2	MnO %	P_2O %	CaO %	MgO %	Na_2O %	K_2O %	Loss on ignition %	Total
A	Raw sand	98.20	0.23	1.27	Nil	Trace	Trace	Nil	0.11	Nill	Nil	0.35	100.16
	water washed	98.44	0.18	1.08	Nil	Nil	Nil	Nil	0.10	Nil	Nil	0.15	99.15
B	Raw sand	97.15	0.12	2.08	Nil	Nil	Nil	Nil	0.087	0.025	Nil	0.20	99.687
	water washed	98.28	0.07	1.17	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.03	99.55

Table No. 2. Sieve analysis result of Kurd silica sand (raw and water washed)

Sample No.	0.25 mesh %	– 25 mesh %	– 36 mesh %	– 52 mesh %	– 72 mesh %	– 100 mesh %	– 120 mesh %	Sieve loss %	Useful fraction – 25 mesh + 120 mesh for glass manufacture
A (Raw)	41.95	33.27	4.20	9.81	1.01	4.20	5.04	0.52	52.49
A (Water washed)	28.58	40.59	5.23	13.04	1.35	5.04	5.79	0.38	65.25
B (Raw)	1.57	23.84	14.73	32.41	3.54	10.27	13.25	0.39	84.79
B (Water washed)	1.33	25.04	14.16	36.23	3.28	8.05	10.94	0.97	86.76

Name of locality = Kurd (Karak area)
Weight of sample = 100 gms
Method of analysis = 5 minutes shaking in mechanical sieve shaker.

Magnetic separation. In order to remove the ferro-magnetic particles, the washed and raw silica sand were subjected to manual magnetic separation. A strong permanent magnet was passed over a sand bed in a glazed paper. No particles were attracted by the magnet in any one of the two silica sand samples. Both sands were found free from ferro-magnetic particles.

Beneficiation by chemical treatment

(i) *Hydrochloric acid treatment.* 100 g of silica sand were boiled with 200 ml commercial hydrochloric acid [7]. The sand was then boiled with distilled water for ½ hr to wash out chloride completely. It was dried and Fe_2O_3 was determined spectrophotometrically. The above experiment was repeated with 1:1 and 1:4 HCl and iron was determined as above. The reuslts are given in the table below:

(ii) *Oxalate process (Adam's process).* Adam removed the iron coating of sand grain by treating the samples with a solution of sodium acid oxalate containing some $FeSO_4 . 7H_2O$. This method has been commercially exploited for a long time in many countries [8]. The reaction was undertaken at 65 + 5°C. The supernatent liquid was decanted off. The sand was further washed with distilled water till the washings give no indication of iron and the washed sand was dried at 110°C. Iron was then determined spectrophotometrically. The results are incorporated in Table 4 along with the results of sulphite process described below:

(iii) *Sulphite process.* The sand was mixed thoroughly with 0.4% sodium sulphite and the mixture transferred to a 600 ml polythelene beaker, to which water containing hydrofluoric acid (pH 2.7) was added [7]. The amount of water being sufficient to cover the mass completely. The slurry was stirred with a wooden rod for 5 minutes. The resulting turbid liquor was decanted off. The sand was further washed with water and dried at 110°C. Iron oxide was determined spectrophotometrically. Comparison of the improvement of Fe_2O_3 by Adam's process and sulphite process are given in Table. 4.

DISUCUSSION

Table 1 shows that the original sand sample A contains 0.23% Fe_2O_3 and sample B contains 0.12% Fe_2O_3. Water

Table 3. Beneficiation with hydrochloric acid

Sample No.	$\%Fe_2O_3$ in raw silica sand	Strength of HCl for leaching	$\% Fe_2O_3$ retained after treatment with hydrochloric acid	$\% Fe_2O_3$ removal
A	0.23	Conc.	0.033	85.66
B	0.12	Conc.	0.033	72.50
A	0.23	1:1	0.041	82.17
B	0.12	!:1	0.042	65.00
A	0.23	1:4	0.057	72.21
B	0.12	1:4	0.051	57.50

Table 4. Improvement of Fe_2O_3 content by Adam's and sulphite process

Sample No.	$\%Fe_2O_3$ in original sample.	$\%Fe_2O_3$ after oxalate treat.	$\%Fe_2O_3$ after sulphite process	$\%Fe_2O_3$ removal by oxalate	$\%Fe_2O_3$ by sulphite process
Sample A	0.23	0.11	0.05	52.17	78.26
Sample B	0.12	0.041	0.032	65.83	73.33

washing reduced the iron content to 0.18% and 0.07% which means a removal of 21.73% and 41.66% of iron in samples A and B respectively. The more effective water washing in sample B implies that it contains a large part of ferrogenous clay minerals which were removed by water washing leaving behind a comparatively good quality of silica sand. Table 2 indicates that 41.95% of the sand (sample A) is retained by B.S. Sieve No. 25 and 5.04% sand passed out through B.S. Sieve No. 120. This means that the useful sand fraction (the fraction between –25 and + 120 sieves) is 53.01% only. In other words about 47% of the sand (sample A) is wasted which makes it highly uneconomical, while for the sample B the useful fraction is 85.18% and only 14.82% of the original sand goes waste. It is, therefore, advisable to separate this fraction at the site of the deposit so that freight charges are reduced. By proper grading the coarse iron bearing material i.e. +25 mesh and fine clay fraction was removed and the iron content in the sample A was reduced to 0.15% and that of B to 0.06% (Table 5) i.e. half of the iron content can be removed by proper grading.

The lowering of iron content by grading is more or less in accordance with that of water washing, which indicates that the Kurd sand (specially sample B) contains a large quantity of iron bearing clay.

In order to improve the quality of the sand samples they were subjected to magnetic separation and chemical treatment. It was observed that there was no reduction in the iron content after magnetic separation, which means that the iron-rich fraction of the sample is non-magnetic.

It is clear from Table 3 that sand sample A contains much of the iron as coating and by leaching with HCl of different concentrations it is lowered to 0.033%, 0.041% and 0.057% Fe_2O_3. It amounts to total reduction of 85.66%; 82.17% and 72.21% respectively. While similarly treated sample B gives 72.5%, 65.0% and 57.5% reduction in the iron content by retaining 0.033%, 0.042% and 0.05% Fe_2O_3 instead of 0.12% Fe_2O_3 of the original sample.

The results of HCl leaching can be of some importance in laboratory scale but cannot be economically exploited on a commercial scale [7,8].

The results of beneficiation by Adam's process (Table 4) are quite encouraging with a concentrated solution. The iron content of sample A is reduced from 0.23% to 0.11% (52%) and that of sample B from 0.12% to 0.04% (65.83). The results of beneficiation with dilute Adam's solution are however of not much significance. Although this process is suitable [7] for sand beneficiation because of an easy and economical recovery and reuse of the reagents, it is not suitable for the production of high quality iron-free sand samples for manufacturing optical glasses. Treatment of sand with the sulphite process gives a remarkable reduction (Table 4) in the iron content of the two samples. The iron content of the samples A and B are reduced by 78.26 and 73.33% respectively by this process and is suitable for the manufacture of colourless glass.

CONCLUSION

Silica sand sample A because of having lower percentage of useful fraction is uneconomical for glass manufacturing. Also grading and water washing are not much effective in reducing the iron content of sample A. However it is advisable for using it in pottery and abrasive industries.

Silica sand sample B is, however, suitable for use in glass industries. The useful fraction (–25 +120) in this sample is 85.15%. By grading and water washing the iron contents were appreciably reduced by eliminating the fine ferrogenous clay and coarse fraction. The iron content by these two process was reduced to 0.06% which is within permissible limits. The cost of the sand and the freight charges can be lowered by separating the useful fraction at the mining site. The waste material of this silica sand can be used in pottery and abrasive industries. Sample B meets the specification of container glass industires. By exploiting the silica sand mine at Kurd the demand for the local glass industries, for supply of standard silica sand, can be modestly fulfilled. This effort will be greatly enhanced if an access road is constructed to the mine site.

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