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STUDIES ON THE ECONOMIC POTENTIAL OF GLASS SAND DEPOSITS OF DAU DAM DISTRICT DADU SINDH FOR GLASS MANUFACTURE

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In the Dau Dam silica sand deposits, the main impurity is iron, present as heavy black particles of magnetic and hornblende and yellow to reddish coatings of limonite on some of the grains. Simple beneficiation methods of water washing, screening and dry magnetic separation render these sands suitable for the manufacture of glass.

Key words: Potential, Sand, Glass.

Introduction

Silica (SiO_2) is an important primary glass forming compound and constitutes about 70% of the total batch material. The chemistry, mineralogy and physical properties [1] are the 3 main attributes to determine whether a particular silica sand is suitable for the manufacture of glass. The chemistry is of prime importance, dictating the minimum acceptable silica level and maximum permissible impurity levels. Mineralogy describes the nature of the undesirable elements that must be removed by physical or chemical means. Grain size distribution [2] also plays an important role in affecting the meltability.

If the glass making factories situated in the Karachi region [3] use locally available sands instead of more distant sands from Punjab or Sarhad, they can compete better in the market. Keeping this requirement in focus, the investigation of the nearby Dau Dam silica sand deposits was undertaken. Pakistan Mineral Development Corporation collected samples from 3 quarries, designated Q-1, Q-2 and Q-3 according to the geological aspects for these studies.

Geology. A number of silica sand deposits of poor to good quality occur in Sindh. The Dau Dam deposit is located in Dadu District about 50 km to the north west of Thana Bullah Khan. The deposits are of tertiary age of Kirthar formation.

The Nari formation in which quite a few deposits of silica sand occur has variegated colours. The colour of this formation are light grey, grey brown, buff, yellow and light orange. The predominant lithologies are sand and shale. However, some lime-stone and conglometrates also occur.

In the immediate vicinity of Dau Dam area, the following rock formations are exposed.

Gaj formation	= Miocene
Nari formation	= Oligocene
Kirthar formation	= Middle and late Eocene

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The silica sand deposit occurs in upper part of Nari formation. Over all the formation is composed of sand, silica sand and clays. The total thickness of this formation varies from 16 to 35m. The silica sand is quite loosely consolidated. It is composed of 96-98% quartz. Clay, organic matter, mica, magnetite, haematite, limosite and rarely goethite occur as accessories. Zircon and tourmaline occur as traces only.

Mineralogy [4]. The sand is composed predominantly of quartz (more than 96%). The accessories are mainly magnetite, haematite and limonite. The heavy mineral particles on further investigation showed paramagnetic behaviour. The microscopic studies revealed the presence of limonite and haematite in the paramagnetic portion.

Experimental

The sampling for the experimental work was done by the useful method of coning and quartering [5].

Grading. 500 Grams of unwashed silica sand samples under study from quarries Q-1, Q-2 and Q-3 were subjected to sieve analysis. B.S. Test sieves No. 22 and 120 [6] were employed in a mechanical sieve shaking machine for 15 mins. The fraction between 22 and 120 mesh sieves is the fraction considered suitable for glass making. The results are given in Table 1.

Water washing. 500 Grams of the raw and the graded i.e.- 22 + 120 fractions were washed with about 3L of tap water in a china dish till the supernatant layer was clear of any suspension. The loss due to washing for the raw sands is 3.50, 3.00 and 2.75% and is 2.50, 2.65 and 2.00% for the -22 + 120 fraction for samples Q-1, Q-2 and Q-3 respectively. The results are given in Table 1.

Magnetic separation. The -120 mesh sieve fraction being too fine and +22 mesh sieve fraction being too coarse to use for glass making were rejected for any further test work. Only the -22 mesh sieve and +120 mesh sieve fraction was subjected to dry magnetic separation. The magnetic particles were separated at various current intensities. The removal of ferromagnetic minerals was done at 0.2 amp. The speed of the rollers of the magnetic separator was adjusted so that the non-magnetic minerals might not be carried away along with the magnetic ones. The optimum speed of the rollers for this purpose was found to be 40 cycles per minute. At 0.5 amp. current intensity, the paramagnetic and the traces of ferromagnetic minerals were separated which still remained after the first run.

After passing the samples at 0.2 amp. and 0.5 amp, the middlings were again circulated at 0.5 amp. to get the end product almost free of ferromagnetic and paramagnetic minerals. The non magnetics recovered were 98.58, 98.20 and 97.92%, the magnetic particles were 0.13, 0.16 and 0.20% and the losses recorded during processing were 1.29, 1.64 and 1.89% from Q-1, Q-2 and Q-3 respectively.

Chemical analysis. The chemical analysis of the raw, water washed, washed and graded, upgraded and black particles were carried out according to B.S.S. No. 2975 [7] for ignition loss, SiO_2 and mixed oxide (R_2O_3) Fe_2O_3, TiO_2 and MnO were determined spectro photometrically [8], CaO and MgO, titrimetrically by EDTA [9] and Na_2O and K_2O by flame photometer. The results are given in Table 2a and 2b.

Petrographic examination of heavy black particles. The thin sections of the heavy black particles collected by gravity separation by bromoform [6] were studied for the identification and determination of magnetite, haematite, limonite, chromite, ilmenite, sphene, tourmaline, muscovite, zircon and biotite. The nominal compositions are given in Table 3.

Melting of glass. The commercial batch compositions of soda-lime-silica glass on the basis of 1000 parts of the upgraded sand, 427 parts of soda ash and 248 parts of lime stone were prepared for glass meltings from sample Q-1, Q-2 and Q-3, respectively. The oxide composition of the resulting glass was SiO_2 72%, Na_2O 18% and CaO 10%. Soda ash and lime stone used in the batches were almost free of iron.

The glass batches of 500 g each from the raw materials mentioned above were melted in a clay pot at 1450°. The samples of the molten glass were taken out time and again till the glass was almost free of seed and bubbles. The temperature of the furnace was then lowered to nearly 1260° and maintained for 3 hrs to dissolve the occluded gases in the glass. The melts were then cooled to room temperature and examined visually. All the 3 glasses were tintfree transparent and free of inclusion. It was also observed that the glass melt from sample Q-2 was of fine quality.

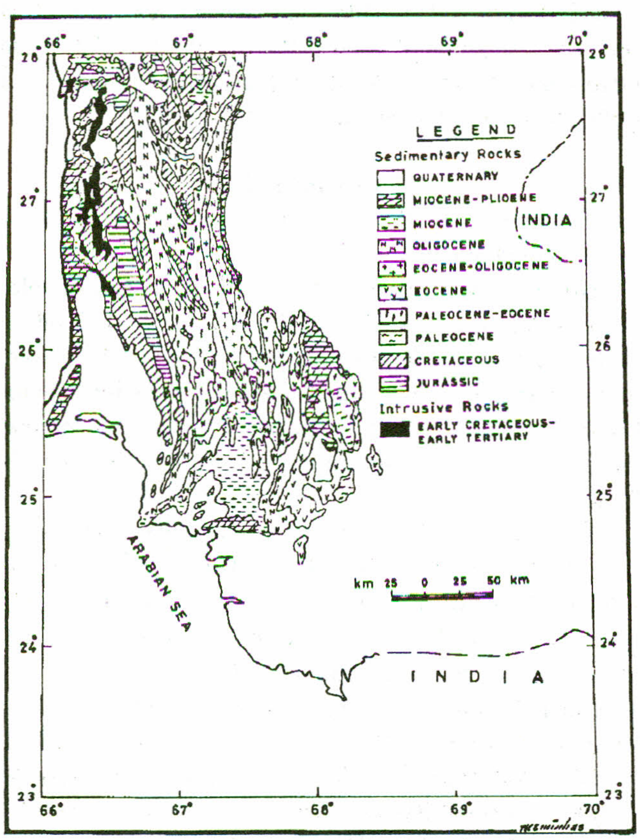

Fig. 1. Geological map of Kirthar sub-basin (After Bakr & Jackson, 1964, simplified).

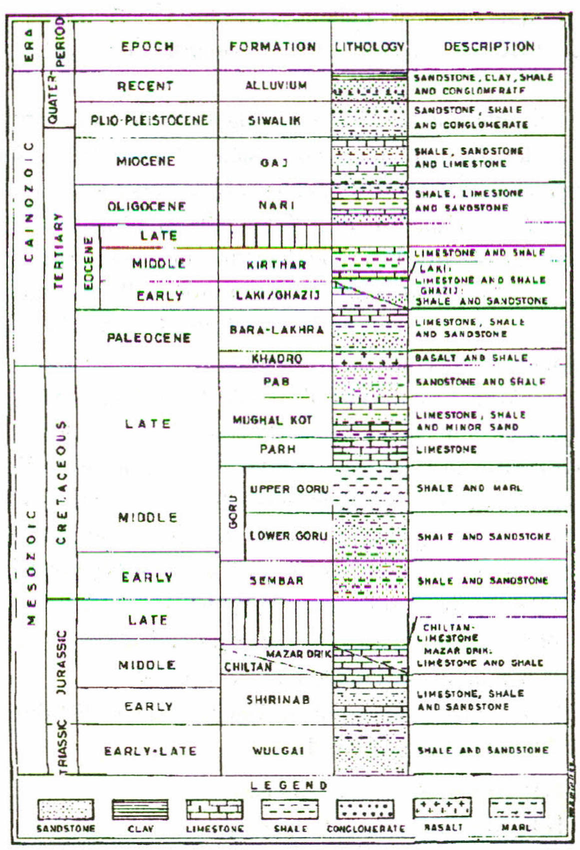

Fig. 2. Generalized stratigraphy of Kirthar sub-basin (After Hilal *et. al.*).

Results and Discussion

The largest amount of glass manufactured is soda-lime silica glass produced by fluxing and melting of pure silica in a glass melting furnace. Silica (SiO_2) is the glass forming oxide, soda ash is the fluxing agent while lime is the stablizing materials to provide chemical durability to the glass. The colour of the glass is imparted by the addition of oxides of chromium iron, titanium, cobalt and nickle etc. Purity requirements depend on the type of glass being melted. Low iron content to melt colourless glass is most critical. The inclusion of heavy black particles are to be avoided being rich with the colouring oxides especially of iron. The sand used for the colourless glass [11] requires a maximum iron oxide content averaging from 0.030 to 0.045%.

The chemistry of these sands reveal that after the most elementry beneficiation, i.e. water washing, grading and magnetic separation, the iron oxide contents of the upgraded samples reduces to 0.061, 0.042 and 0.057% of samples Q-1, Q-2 and Q-3 respectively. Sample Q-2 containing Fe_2O_3 0.042% can be used for the production of fine quality colourless glass such as table ware etc. Samples Q-1 and Q-3, with Fe_2O_3 0.061 and 0.057% respectively are suitable for the manufacture of container and flint quality glasses. The SiO_2 contents are nearly close to the specified range i.e. about 98% as is clear from Table 2a. As far as the grain size distribution is concerned, according to Table 1, the useful fractions i.e. washed -22 + 120 fraction being close to 90% are within feasible limits. The presence of Al_2O_3, Na_2O and CaO which are

TABLE 1. SCREENING AND WASHING.

Smaple No.	Fraction retained on seive No. 22 (-22)%	Fraction passing through sieve No. 120 (-120)%	Fraction rejected (+22-120) %	Suitable fraction (-22+120)%	Loss on water washing of fraction (-22+120)%	Useful fraction %
Q-1	1.83	5.00	6.83	93.17	2.50	90.67
Q-2	2.00	5.13	7.13	92.87	2.65	90.22
Q-3	2.73	5.80	8.53	91.47	2.00	89.47

TABLE 2 (a). CHEMICAL ANALYSES.

Sample No.	Specifications	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	$-H_2O$ (%)	L.O.I. (%)
Q-1	RAW	97.03	0.021	1.79	0.105	–	0.08	0.18	0.04	0.01	0.00	0.56
	Water washed	97.53	0.020	1.60	0.071	–	0.07	0.17	0.04	0.01	0.04	0.42
	Graded–22+120	97.44	0.020	1.72	0.082	–	0.05	0.15	0.03	0.01	0.00	0.46
	Washed and graded	–	–	–	0.070	–	–	–	–	–	–	–
	Up-graded	–	–	–	0.061	–	–	–	–	–	–	–
Q–2	RAW	96.29	0.031	2.55	0.101	–	0.05	0.35	0.02	0.01	0.02	0.52
	Water washed	98.33	0.018	0.75	0.077	–	0.04	0.27	0.02	0.01	0.08	0.45
	Graded–22+120	97.81	0.020	1.33	0.065	–	0.04	0.22	0.02	0.01	0.00	0.48
	Washed and graded	–	–	–	0.060	–	–	–	–	–	–	–
	Up-graded	–	–	–	0.042	–	–	–	–	–	–	–
Q–3	RAW	95.33	0.028	2.96	0.190	–	0.56	0.10	0.04	0.01	0.00	0.78
	Water washed	97.60	0.020	1.63	0.122	–	0.20	0.02	0.03	0.00	0.02	0.36
	Graded–22+120	96.4	0.020	2.46	0.081	–	0.28	0.05	0.03	0.01	0.00	0.63
	Washed and graded	–	–	–	0.080	–	–	–	–	–	–	–
	Up-graded	–	–	–	0.057	–	–	–	–	–	–	

TABLE 2 (b). CHEMICAL ANALYSES OF BLACK PARTICLES.

Sample No.	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	Cr_2O_3 (%)	MnO (%)	MgO (%)	CaO (%)	ZrO_2 (%)	Na_2O (%)	K_2O (%)	$-H_2O$ (%)	L.O-1 (%)
Q–1	39.40	0.06	15.15	40.20	0.006	0.00	0.80	1.06	0.22	0.32	0.21	0.02	2.60
Q–2	38.43	0.07	13.00	42.80	0.008	0.00	1.00	1.20	0.30	0.40	0.25	0.00	2.52
Q–3	36.10	0.06	14.30	44.52	0.005	0.00	0.90	1.08	0.25	0.32	0.20	0.00	2.22

TABLE 3. PETROGRAPHIC COMPOSITIONS OF BLACK PARTICLES.

Sample No.	Limonite (%)	Magnetite (%)	Haematite (%)	Chromite (%)	Ilmenite (%)	Sphene (%)	Tourmalire (%)	Muscovite (%)	Zircon (%)	Biotite (%)
Q–1	16.50	36.00	20.00	0.50	8.00	0.00	11.00	1.00	3.00	4.00
Q–2	17.20	35.30	19.30	0.62	7.80	1.00	10.25	1.50	2.81	4.22
Q–3	17.52	37.48	20.00	0.48	7.20	0.58	10.00	0.80	2.58	3.36

normal constituents of glass batch [12] is not deleterious but advantageous because it contributes to the alumina content of the batch which otherwise must be controlled at the required level by the addition of relatively expensive minerals such as feldspar or nepheline syenite.

Thus through the use of these locally available sands, the glass manufacturers of the Karachi area where about 85% of the glass industry of Pakistan is situated, can not only complete for a quality glass but can also produce glass at low cost.

References

1. Joyee Griffiths, Industrial Minerals, April (1987).
2. Steve Toon, Industrial Mineral, August (1986).
3. M. Rafique, G. Rasul and M.A. Rana, Pak. j. sci. ind. res., **12**, 58 (1969).
4. Majeed A. Khan, Glass Sands of Pakistan, Geological Survey of Pakistan, (1958), Unpublished Report.
5. G. Rasul and F.A. Faruqui, Pak. j. sci. ind. res., **14**, 63 (1971).
6. M. Rafique, M.A. Chaudhry and M.N. Chaudhry, Pak. j. sci. ind. res., **31** (9), 663(1988).
7. Sand for Making Colourless Glass, B.S.S. No. 2975 (1958).
8. G. Svehla, *Comprehensive Analytical Chemistry* (Elsevier, Amsterdam, Oxford, New York, Tokyo, 1985).
9. Frank. J. Welcher, *The Analytical Uses of EDTA* (D. Van Nostrand Company Inc; Princeton, New Jersey, 1958).
10. R. Charan, *Hand Book on Glass Tech.* (1956), 3rd edn.
11. B.S.I. Revised Specifications, J. Soc. Glass Tech., **18**, 41 (1954).
12. H. Segrove, Glass Tech., **17**(1) (1976).