Pakistan J. Sci. Ind. Res., Vol. 29, No. 4, August 1986

GEOLOGY, EXPOLORATION AND EVALUATION OF THE COMMERCIAL FEASIBLE GLASS SAND DEPOSITS OF SURGHAR RANGE (TRANS INDUS SALT RANGE) DISTRICT MIANWALI*

Ahmad Din, Shahbaz Ali and F.A. Faruqi

PCSIR Laboratories, Lahore-16

(Received March 5, 1985; revised November 27, 1985)

Various glass sand deposits of the Datta Formation (Lower Jurassic age) were studied for their suitability for the manufacture different types of glass and ceramic products. Samples No. G.S. 1, G.S. 2 and G.S. 3 shown in the location map can be used for the production of container glasses while samples No. G.S. 4, G.S. 5, G.S. 6 and G.S. 7 are suitable for amber, green and low quality tableware glasses. Samples No. G.S. 6 and G.S. 7 are feasible for casting industries.

INTRODUCTION

This work is an extended part of the programme of the PCSIR Laboratories, Lahore for surveying, evaluation and utilization of indigenous glass raw materials. Silica sand is incorporated into glass [1-2] batches to the extent of 70-75% of the total glass composition. According to an estimate the daily consumption of silica sand in the country is 682 tons. The hitherto known resources of Daud Khel, Musa Khel, Kamar Mashani, Kutki Chopri and Thana Bullah Khan (Sind) will not last long. This necessitates the exploration evaluation of the new glass sand deposits available in the country.

A number of silica sand deposits of the Surghar Range, lying between Makerwal and Malla Khel, were surveyed by one of the authers to assess their lithology, stratigraphy and nature of the reserves. The belt of silica sand has disturbed by tectonic activities and exposed in gorges and at the foot of mountains which can be approached directly by jeepable tracks. None of the beds of silica sand is associated with ferruginous material to contaminate the entire rock. Since these glass sand deposits are not far from the Makerwal railway station, their commercial exploitation is easy and feasible.

SCOPE OF INVESTIGATIONS

Representative bulk samples of sand collected from different sources, on preliminary studies, were found to contain very fine grains and containing impurities in three distinct forms.

(i) Ferruginous clay
(ii) Surface stains
(iii) Black speaks of limonite, hematite, etc. [3]

In the light of the above facts the following operations were included in the present study for the evaluation of the present deposits:

1. Geology of the deposits to determine the nature of the country rocks.
2. Grain size distribution
3. Beneficiation
4. Chemical analysis

EXPERIMENTAL

Field study. Seven typical samples [4] of glass sands G.S. 1 to G.S. 7 were collected from different deposits of the silica sand of said area. Topo sheet No. 38 P/1 of the Survey of Pakistan was used in the field to mark their location. Dip and strike readings of the deposits were recorded by the Burnton compass while the measurement of outcrops was undertaken by a measuring tape. Lithology and startigraphic sequences of the deposits were also studied in the field. The location map attached shows the site of the deposits.

Grading of sand. Raw and water washed sands (100 g) were passed through 10 to 120 Tyler screens. The relative amount of sands retained on various mesh sieves were

*The paper was presented in the 2nd National Seminar on Development of Mineral Resources held in Peshawar 1983.

weighed and recorded in Table No. G.S. 1 to G.S. 7 and graphic representation is given in Fig. 1.

Water washing. 700 g of the sand were stirred with 1 litre of water in a 2 litre beaker and allowed to settle for 30-40 sec. The dirty water was decanted off. Washing of the sand was continued with 1 litre water every time until there was no change in colour on the freshly added water on subsequent stirring. The washed sand was dried at 110° and then graded and analysed (Tables 8-9 and Fig. 1).

CHEMICAL ANALYSIS

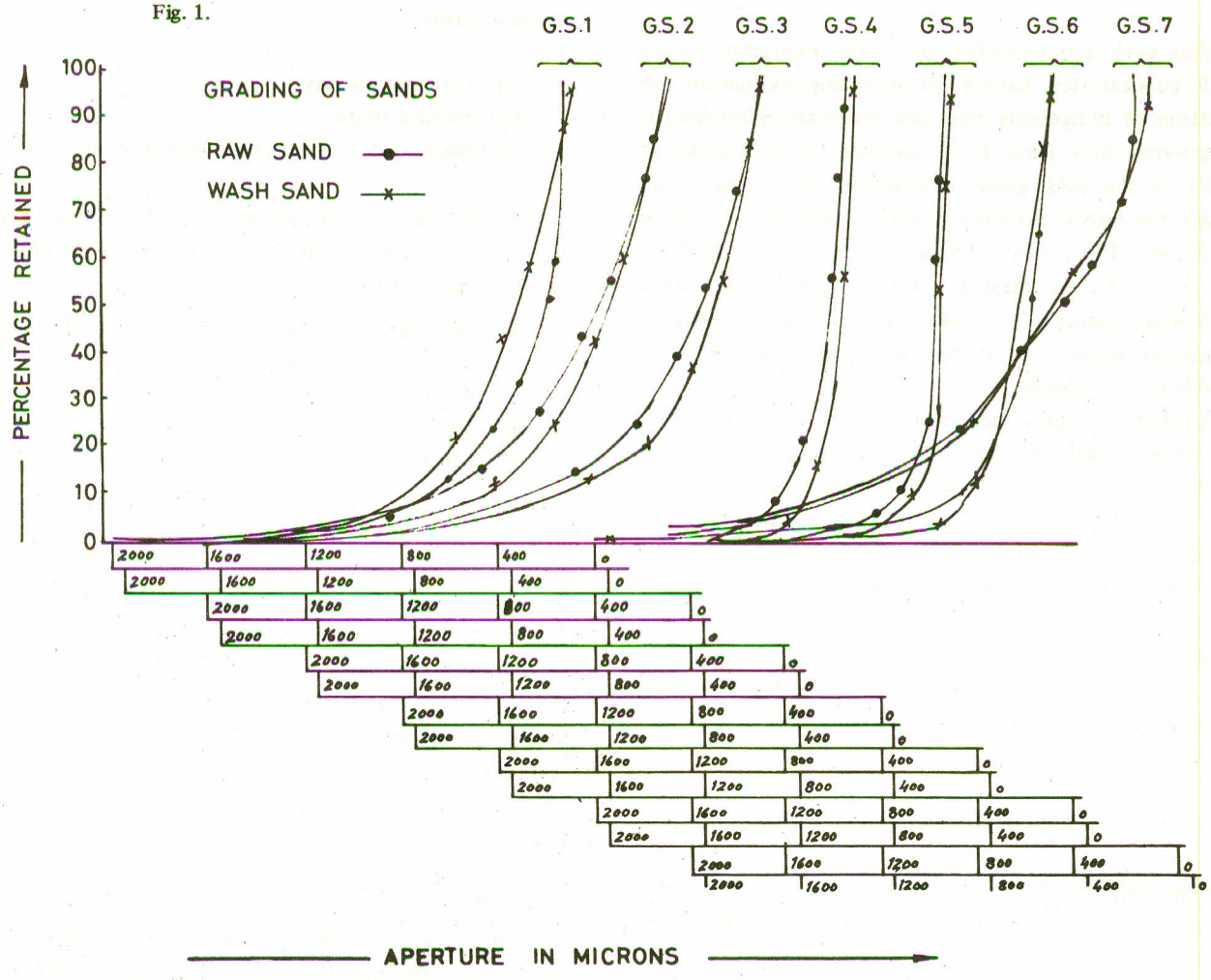
100 g of the sand were ground to a fine powder (– 10 + 120) and analysed using standard methods of chemical analysis (British Standards-1958) [5]. The constituents determined were SiO_2 Fe_2O_3, Al_2O_3, CaO, MgO etc. The results of the chemical analysis of the water-washed and graded; and original samples and improvement of the Fe_2O_3 content, after water washing and grading are given in Tables 8-9 respectively.

Melting of glasses. Based on 1000 g of G.S. 1, G.S. 2 an G.S. 3/7 sands typical glass composition of container and sheet glasses [6-7], were melted in glass melting pots at about 1430° The samples were taken from time to time until the batch was almost free from seeds. The temperature was then lowered to 1260° and maintained for further 3 hr to dissolve the occluded gases in the glass. The melt was then cooled to room temperature and was examined visually. The results are given in Tables 10-a and 10-b.

GEOLOGY OF GLASS SANDS

A preliminary geological survey of a number of glass sand deposits of Surghar Range (Makerwal-Malakhel Area) reveals that these belong to Datta Formation (Lower Jurassic age [8]) which is of Continental origin. The beds

Fig. 1.



of glass sand are associated with silt stone, sand stone, calcareous dolomite, gypsiferous clay gypsum and coal.

The belt of silica sand has closely related three outcrops (at 7th mile from Makerwal Railway Station in North) in Nala Paronga These form the limbs of asymmetrical anticline whose axial portion has been eroded. The beds (g.s. 1 and 2) are at the mouth of the gorge and separated by a nala. The sand deposit (G.S. 1) is about 20 ft thick and has 100 ft extension in North-south (at coordinates 230550 of 38/P/1). This bed dips 60° E. lying over ferruginous silt stone. The sand is medium to fine grained. The colour of fresh surface is white while the weathered surface displays dull black colour. Small nodules of silica are also found profoundly in the bed. Speaks of yellow silica sand are sporadically distributed throughout the rock. The bed of the sand is covered towards south by gypsiferrous clay bed (10 ft) and exposed on the easter side quarry.

The glass sand deposit (G.S. 2) is an extended part of G.S. 1 deposit and has the same lithological capacity and dip-strike readings, It is located at one furlong in the gorge on the other side of the nala (coordinates at 225544). This deposit has coarser sand and a number of yellow speaks of silica snad as compared to that of G.S. 1 deposit.

The third exposure (G.S. 3) of the suit of deposits in about one mile in the gorge (at coordinates 21550) forming the western limb of the anticline, dipping gently in the west. It is comprising three beds of silica sand (10-30 ft) intercalated with sandstone and silt-stone ascending upto the skyline with some break.

The yellow sand of this deposit is more coarse grained than the white. The sandy beds are greyish white to light yellow to dark yellow in fresh colour while the weathered outcrop shows dull black colour.

Silica sand deposit G.S. 4 has two exposures (15 ft approx. separated by Nala Kerai (coordinates at 223486 and 225485). The sand is white to greyish white and has a considerably less number of (heavy minerals) black particles. The sand of (coordinate at 223484) is found more promising for glass industry due to its lesser clay content (G.S. 4).

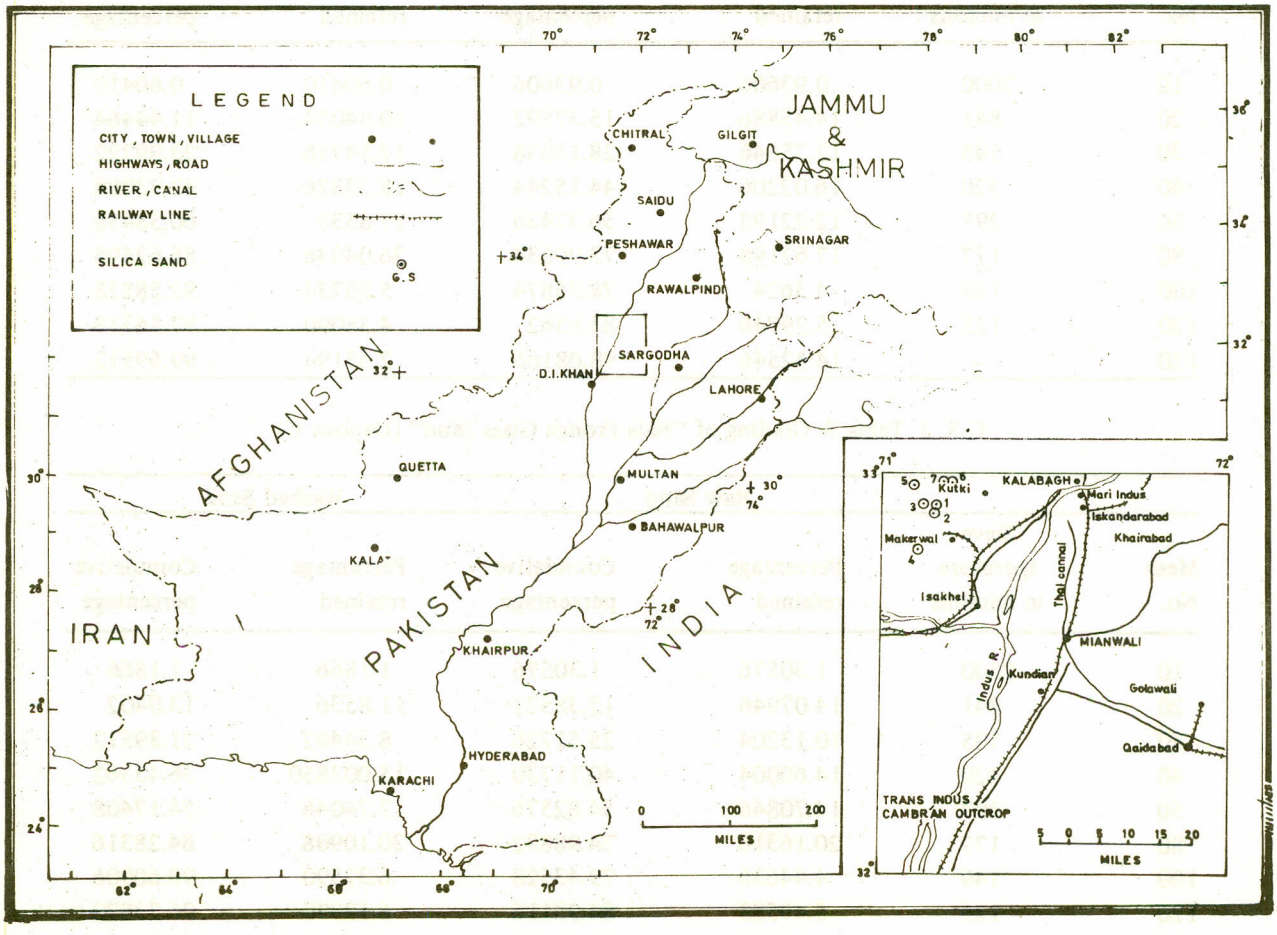


Fig. 2. Location map

G.S. 1. Table 1. Grading of Nala paronga glass sand (deposit (A)

		Raw Sand		Washed Sand	
Mesh No.	Sieve aperature in microns	Percentage retained	Comulative percentage	Percentage retained	Comulative percentage
10	2000	0.3952	0.3952	0.98762	0.98762
20	841	5.46752	5.86272	8.74158	9.72920
30	595	7.49912	13.36184	14.62670	24.35590
40	420	10.82772	24.18956	19.22322	43.57912
50	297	9.74682	33.93638	14.81682	58.39594
80	177	17.58676	51.52314	23.47788	81.87382
100	149	8.4383	59.96154	6.75856	88.63238
120	125	9.70068	69.66222	6.64306	95.27544
120	–	28.99186	98.65408	3.57718	98.85262

G.S. 2. Table 2. Grading of Paronga Nala Glass Sand (Deposit B)

		Raw Sand		Washed Sand	
Mesh No.	Sieve aperature in microns	Percentage retained	Comulative percentage	Percentage retained	Comulative percentage
10	2000	0.93606	0.93606	0.60410	0.60410
20	841	14.43886	15.37592	10.84054	11.44464
30	595	12.75546	28.13038	12.54758	23.99222
40	420	16.02206	44.15244	18.73876	42.73098
50	297	12.22192	56.37436	17.8536	60.58458
80	177	17.62198	73.99634	26.04036	86.62494
100	149	4.3624	78.35874	5.95734	92.58228
120	125	5.29746	83.6562	4.58090	97.16318
120	–	14.42546	98.08166	2.53194	99.69512

G.S. 3. Table 3. Grading of "Nala Pronga Glass Sand" (Deposit C)

		Raw Sand		Washed Sand	
Mesh No.	Sieve aperature in microns	Percentage retained	Comulative percentage	Percentage retained	Comulative percentage
10	2000	1.30576	1.30576	1.1866	1.1866
20	841	14.07946	15.38522	11.8536	13.0402
30	595	10.13204	25.51726	8.34492	21.39512
40	420	14.60004	40.11730	15.003850	36.43362
50	297	14.70846	54.82576	17.74046	54.17408
80	177	20.16316	74.98892	30.10908	84.28316
100	149	4.44636	79.43528	6.32590	90.60906
120	125	5.49588	84.93116	6.12970	96.73870
120	–	14.87656	99.80772	2.88342	99.62212

G.S. 4. Table 4. Grading of the Glass Sand of Kerat

		Raw Sand		Washed Sand	
Mesh No.	Sieve aperature in microns	Percentage retained	Comulative percentage	Percentage retained	Comulative percentage
10	2000	–	–	–	–
20	841	0.9385	0.9385	–	–
30	595	1.64742	2.58592	0.83028	0.83028
40	420	5.56688	8.1528	3.09804	3.92832
50	297	13.13488	21.28768	11.61606	15.54438
80	177	35.02506	56.31274	41.0116	56.55598
100	149	21.30108	77.61382	21.13324	77.68922
120	125	14.53266	92.14648	17.58688	95.2761
120	–	7.35344	99.49992	3.59498	98.87108

G.S. 5. Table 5. Grading of Sand of Nala Broch

		Raw Sand		Washed Sand	
Mesh No.	Sieve aperature in microns	Percentage retained	Comulative percentage	Percentage retained	Comulative percentage
10	2000	0.83458	–	–	–
20	841	1.65084	0.83458	0.3396	0.3396
30	595	3.09454	2.48542	1.84484	1.38444
40	420	5.90024	5.57996	2.46528	3.84972
50	297	33.95194	11.4802	6.02236	9.87208
80	177	14.42344	45.43214	44.00986	53.88194
100	149	17.79324	59.85558	22.0168	75.89874
120	125	21.35286	77.64882	17.5135	93.41224
120	–	–	99.00168	6.4032	99.81544

G.S. 6. Table 6. Grading of Malla Khel Sand A

		Raw Sand		Washed Sand	
Mesh No.	Sieve aperature in microns	Percentage retained	Comulative percentage	Percentage retained	Comulative percentage
10	2000	0.47106	0.47106	0.17524	0.17524
20	841	2.99906	3.47012	1.39778	1.57302
30	595	2.40156	5.87168	1.72228	3.2953
40	420	5.7999	11.67158	10.27246	13.56776
50	297	10.4496	22.12118	22.48546	36.05322
80	177	19.8864	42.00758	38.01082	74.06404
100	149	10.19786	52.20544	10.42918	84.49322
120	125	13.5918	65.79724	10.0023	94.49552
120	–	32.4296	98.22684	5.2276	99.72312

G.S. 7. Table 7. Grading of Malla Khel Sand B

Mesh No.	Sieve aperature in microns	Raw Sand Percentage retained	Raw Sand Comulative percentage	Washed Sand Percentage retained	Washed Sand Comulative percentage
10	2000	2.45498	2.45498	3.59578	3.59578
20	841	21.32558	23.78056	21.76886	25.36464
30	595	16.52324	40.3038	19.07092	44.43556
40	420	11.36	51.6638	13.66122	58.09678
50	297	7.0896	58.7534	7.65576	65.75254
80	177	13.56786	72.32226	15.72594	81.47848
100	149	5.75394	78.0752	6.59928	88.07776
120	125	7.37472	85.44992	4.98536	93.06312
120	–	12.61626	98.06618	6.61418	99.6773

Table 8. Chemical analysis of original water washed and graded sands (0 + 10 + 120) sands

Sample No.	L/I	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Total
G.S. 1							
Original	0.59	97.44	0.21	N.T.	0.26	2.03	99.94
Washed and graded	0.52	98.41	0.07	N.T.	0.20	1.31	99.99
G.S. 2							
Original	0.84	99.44	0.07	N.T.	1.60	2.91	100.02
Washed and graded	0.91	98.61	0.05	N.T.	1.10	1.18	99.97
G.S. 3							
Original	0.79	96.89	0.07	Traces	0.30	2.79	100.05
Washed and graded	0.20	99.22	0.06	0.72	Traces	Traces	99.94
G.S. 4							
Original	1.40	96.20	0.43	1.48	0.36	1.63	100.10
Washed and graded	1.07	98.19	0.36	Traces	0.14	1.22	99.91
G.S. 5							
Original	0.68	95.82	0.28	N.T.	0.25	3.74	100.09
Washed	0.79	96.97	0.22	N.T.	0.09	8.73	100.01
G.S. 6							
Original	1.21	93.29	0.57	N.T.	0.21	5.92	99.99
Washed and graded	0.59	96.94	0.36	N.T.	Traces	2.72	100.02
G.S. 7							
Original	0.72	95.45	0.50	Traces	Traces	4.03	99.98
Washed and graded	0.63	95.33	0.28	3.03	1.36	Traces	100.00

*No traces

There are two exposures of silica sand beds in Nala Borch. The first comprises two beds (16 ft and 3 ft) coordinates at 223554N). The colour of sand on fresh surface is light greyish white with a very small proportion of yellowish, redsish and black particles. The sands of these beds are fine to very fine grained and have an excessive clay content, and are not selected for further study. These may however, prove useful for sodium silicate and earthenware industry.

The second exposure of silica sand (G.S. 5) is 1 to 10 ft thick bed, 1000 ft above bed of Nala, two miles in the gorge near coal Mine. No. 4 of PMDC (at coordinates. 216586). The sand of this outcrop (1 furlong) is good for glass industry in vicinity of limestone and free of any visual impurity.

Near Mallahkel the silica sand belt has two outcrops, about one furlong in the gorge, separated by a ridge (G.S. 6-7). A seem (15 ft) of silica sand (G.S. 6) ascends vertically upto skyline and treanding E-W (at coordinates 233566). The sand is fine grained and of greyish white colour, associated with beds of Fuller's earth and coal.

The second outcrop is a bed of silica sand (100 ft thick trending E.W. and associated with beds of coal, gypsiferrous clay and gypsum. The glass sand (G.S. 7) is fine grained and of pure white colour having a small porportion of clay material. These deposits are near the outlet of gorge and can be easily exploited.

RESULTS AND DISCUSSIONS

According to ASTM (1961) the useful fraction (– 10 + 100) of a good quality sand for glass making should exceed 94%. In the case of the sand studied in the present investigation, only sand No. G.S. 2 after water washing approaches this standard. Sands No. G.S. 1, G.S. 3 and G.S. 7 contain useful sand fractions from 88 to 90% and the rest of the samples i.e. G.S. 4, G.S. 5, G.S. 6 have useful sand fractions from 75-84%. This means that only samples having useful sand fractions above 88% are commercially viable. The rest of the samples (fine grained) are uncommercial for the glass industry. However these can be exploited for the manufacture of sodium silicates and amber glasses/earthenware industries (G.S. 4, 5 and 6).

As can be seen from Table 8, the Fe_2O_3 content of the original (unwashed) sands, i.e. G.S. 1, G.S. 2 and G.S. 3 ranges from 0.07 to 0.2%. G.S. 1 after water washing

Table 9. Improvement in the iron contents of glass sands after washing and grading

Sample No.	% of Fe_2O_3 in original sand	% of Fe_2O_3 in the graded (– 10 + 120) & water washed sands	% reduction in Fe_2O_3 content
G.S. 1	0.21	0.07	66.60
G.S. 2	0.07	0.05	28.57
G.S. 3	0.07	0.06	14.28
G.S. 4	0.43	0.36	16.28
G.S. 5	0.28	0.22	21.43
G.S. 6	0.57	0.36	36.84
G.S. 7	0.50	0.28	44.00

Table 10a. Typical container glass composition

Batch ingredients (g)	G.S. 1	G.S. 2	G.S. 3
Sand	1000	4000	1000
Soda ash	3.40	3.40	340
Limestone	275	275	275
Feldspar	140	140	140
Salt cake	10	10	10
Nitre	2	2	2
Arsenic	1	1	1
Decolouriser (cobalt oxide)	0.009	0.009	0.009
Decolouriser (selenium)	0.06	0.06	0.06
Visual examination:	Coloured glass	Almost colourless	Greywish white

Table 10b. Typical fourcault sheet glass composition

	Batch ingredients (gms)		
Sand	G.S. 1	G.S. 2	G.S. 3
Sand	1000	1000	1000
Soda ash	300	300	300
Limestone	133	133	133
Dolomite	156	156	156
Salt cake	102	102	102
Feldspar	40	40	40
Arsenic	4½	4½	4½
Coal	3½	3½	3½
Visual examination	Light blue	Slightly greenish	Slightly greenish blue

and grading shows that most of the Fe_2O_3 present in it is in form of ferruginous clay (Table 1). Sands G.S. 2 and G.S. 3 also show a remarkable reduction in Fe_2O_3 contents.

This reduction indicates the presence of ferruginous matter in them. The rest of the sands even after grading etc. have still too high a percentage of Fe_2O_3 to be used in the container glasses. However, these can be exploited for making amber and green glasses. Water glasses and earthenware industries where there is little restriction of Fe_2O_3 contents.

Some melts of the container and sheet glass etc. were prepared and the results are given in Tables 10a and 10b. The melting tendency of the G.S. 1, G.S. 2 and G.S. 3 sands is very normal and we obtained bubble free melts evenafter four hours of melting at 1430°. The selected container glass compositions, after proper adjustment of the decolourisers are colourless.

The sheet glass, due to the presence of FeO and Fe_2O_3 without oxidation, exhibits a slightly blusih green tinge [2]. This colour is not complemental because the iron oxide present in the ferrous form absorbs infra-red rays. Therefore the use of all the three compositions G.S. 1, G.S. 2 and G.S. 3 is recommended in the container glass industries while the rest of the sands can be used in amber glass, green glass and water glass manufacture where higher percentage of Fe_2O_3 is permissible.

REFERENCES

1. F.A. Faruqi, Sci. Ind., 5, 335 (1967).
2. F.A. Faruqi, A. Din and S. Sindhu, Pakistan J. Sci. Res., 14, 63 (1962).
3. S. Rashid, A. Din and M.R. Ariff, Pakistan J. Sci., 43, 16 (1964).
4. Specifications for and recommended procedure for the testing and analysis of glass making sands (1978).
5. A. Din, G. Rasul and M.A. Rana, Pakistan J. Sci. Res., 15, 20 (1963).
6. British Standard methods for chemical anaysis (1958).
7. American Ceramic Batches (1970).
8. F.V. Tooley, *The Hand Book of Glass Manufacture*, (Inc. Glass Industry Magazine, Division of Magazines for Industry Inc. 777 Third Avenue, New York) Vol. 2, p. 1088.
9. A. Zaki, Directory of Mineral Deposits of Pakistan, Geological Survey of Pakistan, Quetta (1969).