

STUDIES ON QUARTZITE DEPOSITS OF NOWSHERA AND SWABI AREA, PESHAWAR DIVISION, PAKISTAN

Fazal A. Siddiqi, M. Alauddin, Hamidullah Khan, Shagufta Nasreen and Ahmad Husain†

PCSIR Laboratories, Peshawar

(Received January 27, 1985; revised March 26, 1986)

Geology, chemical composition, mineralogy, beneficiation and thermal studies of quartzite samples from Misribanda (Nowshera) and Naugram (Swabi) have been discussed. The results of these studies indicate that the Misribanda quartzite may be used in manufacture of semi-silica bricks while the Swabi quartzite is suitable for use as refractories in furnaces and manufacture of sodium silicate and colourless glass.

INTRODUCTION

Quartzites are the source of silica for metallurgical purposes. Silica bricks made from quartzite are extensively used in steel and glass industries. These bricks also find utility in electric furnace roofs, coke oven, open-hearth furnaces, copper refining furnaces, blast furnaces and glass melting furnaces. Pakistan Steel Mills require 25,000 tons of quartzite annually. Quartzite also constitute a basic raw material in fibre-glass and glass and ceramics industries. Quartzite of pure form is very useful in the manufacture of sodium silicate – an important industrial product having a variety of uses.

Extensive deposits of quartzite are found in various parts of North West Frontier Province. The notable occurrences of quartzite are found near Naugram, Misribanda, Charpani-Hisartang, Tarbela, Abbottabad and Sobra Gali areas.

Teichert and Stauffer [1] described the rocks of Misribanda area and Martin *et. al* [2] gave general description of the rocks around Naugram.

The present investigations have been undertaken to evaluate the quartzite deposits of Misribanda near Nowshera and Naugram near Swabi for their possible use in different industries.

Geology of the area

Misribanda deposit. The deposit is located near Misribanda village (lat. 34° 1' 00" N; long. 72° 7' 18" E) at a distance of 10 km to the northwest of Nowshera, district Peshawar. It can be approached by a metalled road of about 10

km from Risalpur which is located on the Nowshera-Mardan road.

The quartzite is light grey to brownish grey and contains dark brown and reddish brown ferruginous patches and encrustations. It is thin to medium bedded, compact and medium to coarse grained. The quartzite trends nearly eastwest and dips at 45-60° to the north. It is well sorted and contains poorly preserved cross beddings which indicate a normal sequence of strata. The quartzite is intercalated with sparsely distributed intercalation of argillites.

The quartzite is mainly composed of quartz grains which are well sorted and well rounded. Some of the grains show corroded margin and are replaced by dolomite.

The quartzite extends for 3000 metres with an average exposed width of 500 metres. Its reserves above the ground surface are estimated at 112 million tons.

The following rock sequence has been established in the Misribanda area:

Formation	Approximate thickness in metres	Lithology	Age
Surficial deposits	± 30	Gravel, sand silt and clayey material	Quaternary
Nowshera formation	75	Limestone and dolomite	Early Devonian
Misribanda quartzite	120	Quartzite with subordinate lenses of argillite and dolomite	Late Silurian
Mian Dheri formation	+ 40	Limestone, dolomite with subordinate argillite	Middle Silurian

Naugram deposit. The quartzite is located at about 1 km to the southeast of Naugram village (lat. $34^{\circ}13'13''N$; long. $72^{\circ}26'8''E$), Tehsil Swabi, District Mardan. It can be approached by a fair weather road of about 7 km from Swabi on Mardan-Swabi road. The quartzite is the part of Tanawal formation which belongs to late Pre-Cambrian age.

The quartzite is white to light grey, hard and fine to medium grained. It is well sorted, compact and contains reddish brown to dark brown ferruginous encrustations along jointed and fractured spaces. The bedding is thin to medium and massive at places. Poorly preserved cross bedding is also found in a few beds. Irregular and cross cutting veinlets of quartz are common. The quartzite beds strike at $N20^{\circ}W$ and dip at $60-70^{\circ}NE$. It contains a few localized intercalations of phyllitic material. The quality of quartzite along these intercalations is poor due to the enrichment of muscovite, sericite and clay minerals along with the quartz grains.

The quartzite extends for 1000 metres in length with an average exposed width of 500 metres. Its reserves above the ground surface are estimated at 62 million tons.

The generalised stratigraphic sequence of the Naugram area is as follows:

Formation	Approximate thickness in metres	Lithology	Age
Surficial deposit	± 13	Gravel, sand, silt and clayey material	Quaternary
Abbottabad formation	75	Limestone, dolomite, argillite and quartzite	Late Pre-Cambrian
Tanawal formation	100	Quartzite with subordinate argillite	Late Pre-Cambrian
Hazara formation	± 120	Phyllite, slate and argillite	Late Pre-Cambrian

The locations of the samples are shown in Fig. 1.

EXPERIMENTAL

Chemical composition. Five representative samples from Misribanda and six from Swabi were analysed. The Misribanda quartzite contains on average 90.38% SiO_2 ; 0.38% Fe_2O_3 ; 3.60% Al_2O_3 ; 0.17% TiO_2 ; 0.16% Na_2O and 3.7% K_2O . The average chemical composition of Swabi quartzite is 95.61% SiO_2 ; 0.12% Fe_2O_3 ; 3.50% Al_2O_3 ; 0.05% TiO_2 ; 0.00 Na_2O and 0.31% K_2O . Chemical analysis indicates that the Misribanda quartzite contains a high percentage of alkalis and iron which renders it soft on heating at high temperature. The percentage of alkalis and iron in Swabi quartzite are within permissible limits. In samples AH-9 and AH-10 the Fe_2O_3 content is 0.05% and 0.085%

respectively. TiO_2 content in Swabi quartzite is less as compared to Misribanda.

Petrography. The quartz grains are medium to fine grained. The minerals other than quartz are feldspars, zircon, tourmaline, dolomite, calcite, magnetite, hematite and muscovite. Carbonates are also present as irregular interlocking crystals. Layering of quartz grains and carbonates are distinct in some thin sections.

Approximate percentage of various constituent minerals estimated by studying the thin sections are presented in Table 2.

Beneficiation. Powdered (-120 mesh) quartzite samples were subjected to water-washing and several chemical treatments [4] such as hydrochloric acid leaching, Adam's process and sulphite process in order to remove the iron which is undesirable constituent in the glass manufacturing raw materials.

The results are given in Table 3.

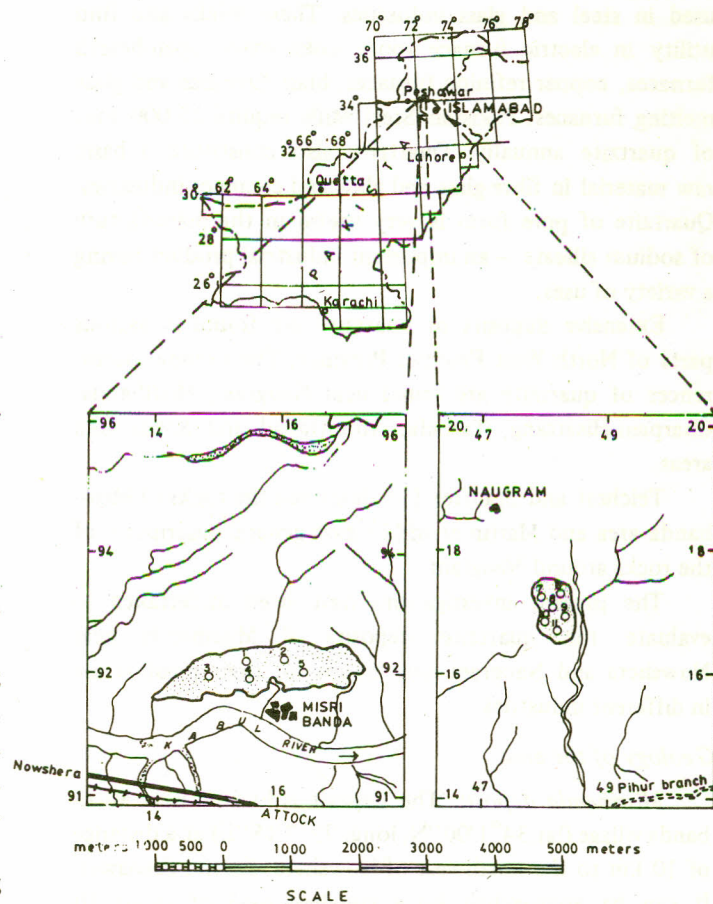


FIG. 1

Table 1. Chemical analysis of quartzite from Misribanda and Naugram

Chemical composition (%)	AH-1	AH-2	AH-3	AH-4	AH-5	AH-6	AH-7	AH-8	AH-9	AH-10	AH-11
SiO ₂	90.10	90.30	89.51	89.70	92.30	97.20	94.86	97.68	95.01	94.20	94.76
Fe ₂ O ₃	0.14	0.44	0.63	0.34	0.38	0.12	0.14	0.11	0.06	0.08	0.24
Al ₂ O ₃	3.24	2.90	3.32	5.21	3.37	2.13	3.93	1.71	4.15	4.53	4.60
TiO ₂	0.05	0.20	0.30	0.10	0.20	0.14	0.05	0.05	0.08	0.01	0.02
MnO	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
P ₂ O ₅	Nil	0.09	0.05	0.05	0.10	Trace	Trace	Trace	Trace	Trace	Trace
CaO	1.23	0.89	1.10	1.45	0.72	Nil	Nil	Nil	Nil	0.39	Trace
MgO	Nil	Nil	Nil	Nil	Nil	Trace	Trace	Trace	Trace	Trace	Trace
Na ₂ O	0.17	0.15	0.17	0.15	0.17	Nil	Nil	Nil	Nil	Nil	Nil
K ₂ O	4.50	4.50	4.50	2.50	2.50	0.25	0.50	0.22	0.25	0.40	0.27
L.O.Ign:	0.20	0.50	0.50	0.50	0.20	0.19	0.45	0.23	0.10	0.29	0.20
Total:	99.63	99.97	100.08	100.00	99.94	100.03	99.93	99.98	99.65	99.90	100.09

*Samples 1-5: Misribanda.

Samples 6-11: Naugram.

Table 2. Approximate mineral percentage

Minerals	AH-1	AH-2	AH-3	AH-4	AH-5	AH-6	AH-7	AH-8	AH-9	AH-10	AH-11
Quartz	90	89	90	87	91	92	91	92	91	90	91
Carbonates	3	2.5	4	5	2.5	3	4	3.5	4	5	3.5
Felspars	4	3.5	3	4	3	2.5	3	3	2	3	4
Muscovite	1.5	1.5	T	2	1	2	1	T	0.5	0.5	0.5
Biotite	T	-	1	1	-	T	-	-	-	-	T
Zircon	1	-	T	-	T	T	T	-	-	-	T
Tourmaline	T	1	T	T	1	1	T	-	1	-	0.5
Magnetite	1	1.5	1	1	0.5	T	0.5	1	1	1.5	0.5
Hematite	T	1	0.5	0.5	1	T	T	0.5	0.5	T	T

*Samples 1-5: Misribanda.

Samples 6-11: Naugram

RESULTS AND DISCUSSIONS

Misribanda quartzite contains silica ranging from 89.51 to 92.30%, alumina content varies from 2.90% to 5.21% and total alkali contents are in the range of 2.70 to 5.00%. Due to the presence of alkali and other impurities the quartzite develops cracks on heating to high temperature, the refractoriness is low and is not suitable for high class silica bricks. TiO₂ content in Misribanda quartzite ranges

from 0.05 to .30%. According to Baron [6] about 2% TiO₂ lowers the refractoriness upto 0.5 cone as compared to 0.5-1.5% Al₂O₃ to 1-2 cones. The deformation temperature is not affected by the presence of TiO₂ even upto 3%. P₂O₅ content in Misribanda quartzite is negligible while the alumina content varies from 2.5 to 5.21%. The presence of alumina also has a lowering effect on the refractoriness of quartzite. The Misribanda quartzite is, therefore, not suitable for manufacturing quality silica bricks. However,

Table 3. Beneficiation of quartzite by chemical processes

Sample No.	Fe ₂ O ₃ in raw sample (%)	Fe ₂ O ₃ after Adam's process (%)	Fe ₂ O ₃ after HCl leaching (%)	Fe ₂ O ₃ after Sulphite process (%)
AH-1	0.14	0.014	0.25	0.057
AH-2	0.44	0.014	0.23	0.042
AH-3	0.63	0.110	0.28	0.140
AH-4	0.34	Nil	0.12	0.028
AH-5	0.38	0.040	0.19	0.055
AH-6	0.12	0.070	0.05	0.028
AH-7	0.14	0.012	0.04	0.028
AH-8	0.11	0.060	0.01	0.052
AH-9	0.06	Nil	Nil	0.022
AH-10	0.08	0.065	0.03	0.040
AH-11	0.24	0.085	0.02	0.014

* Samples 1-5: Misribanda.

Samples 6-11: Naugram.

it may be used for manufacturing semi-silica bricks or low-grade silica bricks.

Quartzite samples from Swabi contain as high as 97.68% silica. The lowest percentage of silica is 94.10%. The percentage of iron oxide is very low between 0.05 to 0.24%. The TiO₂ content is negligible while K₂O is also present in minor quantity.

Swabi quartzite which contains less amount of Na₂O, K₂O, TiO₂ and Al₂O₃ has excellent refractoriness and degeneration at high temperature is low and no deformation or cracks appear on heating at high temperature like 1750°. Swabi quartzite appears to be highly suitable for manufacturing different types of furnaces for metallurgical and glass melting purposes. As the quality of quartzite is very good it can be supplied to Pakistan Steel Mills but it may be uneconomical due to heavy transportation cost.

The water absorption capacity of the Swabi quartzite is below 0.7%. Quartzite having water absorption capacity less than 1.5% can be used for good quality silica bricks. Refractoriness is an important property of quartzite as it determines its suitability for making good bricks. For this purpose the Swabi Quartzite is very suitable.

Efforts were made to beneficiate the powdered quartzite samples for removing iron and other undesirable material keeping in view the requirements of glass industry. Though percentage of iron was appreciably reduced by water washing, the quantity of Fe₂O₃ retained by the

samples was too high to be of any commercial value. HCl leaching, Adam's process and sulphite process were attempted to reduce the iron content. While hydrochloric acid leaching did not yield significant success, Adam's process and sulphite process showed varying degree of success for removing iron.

CONCLUSION AND RECOMMENDATION

The present investigations have spotlighted the presence of some good-quality quartzite deposits in N.W.F.P. The Swabi quartzite is suitable for use as refractories in furnace and the powdered and water-washed samples meet the requirements of glass industries for their low iron and high silica content. The cost will be on the higher side due to the process of heating, quenching and grinding involved, but the improved quality of raw material may have a balancing effect on the cost of production. The Swabi quartzite is also suitable for the manufacture of sodium silicate because of its purity which finds a variety of industrial uses. The Misribanda quartzite may be used as low quality silica bricks.

The Swabi quartzite is also suitable for use in steel mills where it is used as a raw material to control basicity in the blast furnace.

Acknowledgement. The authors are thankful to Dr. S.A. Qureshi, Director, PCSIR Laboratories, Peshawar for his keen interest and encouragement during the work.

REFERENCES

1. C. Teichert, K.W. Stauffer, "Siluro-Devonian Reef Complex near Nowshera, Pakistan", Geol. Soc. Am., Bull, 79 (1965)..
2. N.R. Martin, S.F.A. Siddiqi and B.H. King, "Geological Reconnaissance of the Region between Lower Swat and Indus River of Pakistan", Geol. Bull. Punjab University, 2, 1 (1962).
3. M. Ashraf, M. Hanif Qureshi, and F.A. Faruqi, "Studies on quartzite and ganister- Raw materials for refractories from N.W.F.P. and Punjab", Geol. Bull., Peshawar University, 7-8, pp. 89-100 (1975).
4. Din Ahmad, Ghulam Rasul and M.A. Rana, Pakistan J. Sci. Res., 15, 21 (1963).
5. R.G. Davis and R. Ahmad, Geol. Bull, Punjab University, 3, 1 (1963).
6. V.A. Baron, Ogneupary, 8, 210 (1940).

EXPERIMENTAL

Reagents and apparatus. Analytical grade chemicals and doubly distilled water were used throughout the work. Nitric acid of purity not less than 99.8% was washed successively with 2% nitric acid, water and ethanol and dried.

A Varian-AA 1225 atomic absorption spectrophotometer equipped with a digital read out system and mercury hollow cathode lamp was used. The absorbance of mercury was measured at 253.7 nm.

Standard procedure. A finely ground and dried sample containing 0.1-0.5 mg nitrate was transferred to a 50 ml conical flask with a ground glass neck and a side-arm with gas-purging tubes. For smaller samples a suitable amount of nitrate solution was evaporated to complete dryness. 1 ml of 90% trifluoroacetic acid was added and nitrogen gas was passed to displace air from the flask. 3-3 drops of mercury were added and the flask was shaken for 5-7 min. The liquid phase was decanted into a 100 ml standard flask containing 30-40 ml water. The mercury residue was dried at least three times successively with 10-15 ml portions of water and the washings were added to the flask. The flask contents were diluted to the mark with water and equated into an air-acetylene flame. The absorbance at 253.7 nm was measured against a compensatory blank.

RESULTS AND DISCUSSION

Calibration curve. A linear calibration curve is shown in Fig. 1, was obtained over the concentration range of 0.1-0.5 mg nitrate. Calibration for a further lower range of con-

As compared to the use of metal electrode during anodic reduction potentiometry has been in use employed for the determination of nitrate. For nitrate only one method based on this technique has been extensively used so far [1]. This involves the formation of an ion-associate complex, $[Cu(NH_3)_4]^{2+}NO_3^-$, in the reaction of nitrate with copper (II) in the presence of ammonia. The resulting complex is extracted into an acetylene flame (propyl ketone) and pumped into an air-acetylene flame for measuring copper absorbance. The method is relatively free from interferences as commented by several workers [2,3].

Another indirect method for nitrate determination based on atomic absorption spectrophotometry has been recently developed in the author's laboratory [4]. This procedure involves the transformation of the nitrate into a silver-phenanthroline-nitrate complex. The ternary complex is filtered off and the absorbance of excess silver ion in the filtrate is measured. A different approach has been employed by Hissari in which the nitrate is reduced with cadmium metal in the presence of hydrochloric acid under carbon dioxide atmosphere and the absorbance of oxidized cadmium is measured in an air-acetylene flame [5]. This method is relatively free from interferences but involves the rapid reduction and thus consuming procedure of nitrate reduction.

Literature reveals that mercury in the presence of sulphuric acid quantitatively reduces nitrate to mercuric nitrate [6]. In the present work a new method for nitrate determination based on this reduction is described. The nitrate sample is reduced with a mercuric sulphate acid mixture and the absorbance of oxidized mercurous ion is measured in an air-acetylene flame. The method has been