Pak J Sci Ind Res 2000 ***43*** *(3) 195-200*

BENEFICIATION OF HAZARA BARITE AS RAW MATERIAL FOR DIFFERENT BARITE UTILIZING INDUSTRIES

Hamidullah Khan* and Shah Alam Khan

PCSIR Laboratories, Jamrud Road, Peshawar 25120, Pakistan

(Received 24 November 1998; accepted 29 October 1999)

Three barite deposits of economic importance occur near Haripur, Havelian and Kohala in Hazara Division. Beneficiation studies of eighteen representative samples from these deposits were undertaken by chemical method. The objective of this study was to upgrade the quality of barite to acceptable limit for utilization in various industries. Simple treatment for 15 min with commercial hydrochloric acid has been suggested to obtain the required specification for 80% barite utilizing industries.

Key words: Beneficiation, Barite, Hazara.

Introduction

Pakistan is rich in mineral resources particularly industrial minerals like gypsum, rock salt, silica sand, limestone, dolomite, barite, phosphate rock, soap stone and nepheline syenite (Hussain *et al* 1991).

Heavyspar or barite ($BaSO_4$) which is 65.7% barium oxide and 34.3% sulphur trioxide is an important industrial mineral. It has many fold uses. It is used in oil and water well drilling muds, in pharmaceutical industry, for the preparation of several barium chemicals, manufacture of paint, lithophone, glass, artificial ivory and insecticides. Paper, rubber and plastic industries use barite as filler. (Crookshank 1954; Ahmad 1969).

Large stratiform barite deposits occur in Khuzdar and Lasbela districts of Balochistan along the axial belt. Barite deposits of Khuzdar are being mined at the rate of 30.000 tons per annum by Bolan mining company. Barite deposits also occur in various localities of NWFP. A few studies (Marks and Ali 1961; Killinger and Richards 1967; Iqbal and Shah 1980; Afridi 1986) were done covering regional and local geological aspects of some of these barite deposits. Later (Aurangzeb *et al* 1988; Hussain *et al* 1991; Khan *et al* 1994) carried out studies related to petrographic and geochemical characteristics of barite deposits of Haripur and Havelian. Three principal occurrences i. e., Haripur, Havelian and Kohala barite deposits have been reported in Hazara.

Presence of small deposits have also been reported in Swabi, Swat and Salt Range (Shah and Khan 1963; Ali and Aziz 1965).

The present paper deals with the up-gradation of the barite samples, from Hazara deposits, with hydrochloric acid to improve their characteristics for utilization in various industries in the light of international standard specification.

Materials and Methods

Brief description of barite depsoits in Hazara is as follows: Haripur barite deposits that lie around Haripur village have been recorded in 12 localities spreading over an area of about 30 km^2 (Fig 1). The promising barite deposits are Kag, Aluli, Darwaza, Chinjiala, Kachi Bir, etc. All the barite deposits are accessible through Haripur - Bir road. These barite occur in quartzite, quartz-mica and dolomite. In the Kag Aluli under ground mine up to 300 feet deep several feet thick barite veins occur.

Havelian barite deposits lie in the southern area of Hazara Districts. In the thick sequence of limestone with subordinate shale, barite occurs in veins, varying in thickness from few inches to several feet.

In this region Chandomera, Faqir Muhammad and Batagrain are three important barite deposits. In Chandomera, reddish white barite veins occur in grey colour argillaceous limestone and reddish shale (Aurangzeb 1991). The barite veins are irregular throughout the region but have a sharp contact with the host rock.

Kohala deposit is the largest deposit of Hazara district. It is located at about 3 miles to the South West of the Kohala village, near Nithiagali. The barite occurs in large and small dilation veins and is the highest grade of all other barite deposits nearby in Hazara district, and reserves of all catego-

---

* Author for correspondence.

ries have been estimated up to 30,000 tonnes (Ahmad 1969).

Genesis of barite. Field observations have established that Havelian barite occur as veins in shale and limestone in narrow and steeply incline zones. The structural control of mineralization is noticed as barite deposits in Havelian which show linear trends controled by small faults, strongly jointed and sheared zones present throughout the district. Barite veins in the area show pinhing and swelling behaviour and persistance with depth.

The fractures are often seen filled by fine grained recrystallised calcite and goethite. Presence of secondary fine grained are sparry calcite and release of iron oxide solution seen filling the fratures may be the result of diagenesis and low grade regional metamorphism of thick sedimentary sequence exposed in the mineralized area.

The mineralization in faults and joint zone imply outward fluid movements from the structures. Fluids utilizing these structures moved out into potous and permeable sediments

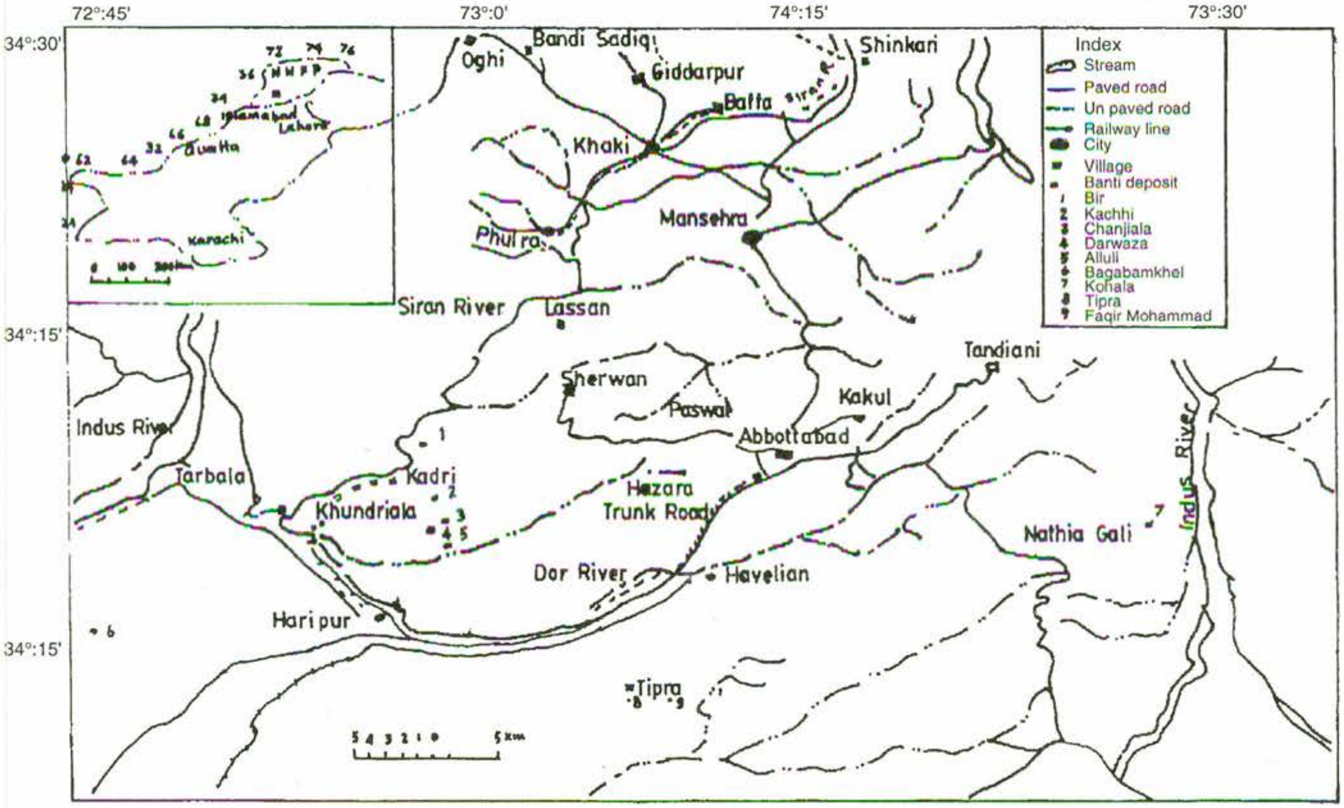

Fig 1 Map showing the location of barite deposits of Hazara NWFP.

Table 1

Chemical composition(%) of Haripur barite in raw state.

Sample No.	SiO_2	BaO	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	LOI	Total	$BaSO_4$	Sp.Gr
Kag	2.62	61.37	1.15	0.80	0.18	0.26	32.34	0.71	99.43	93.71	4.23
Aluli	2.44	59.99	3.65	0.52	0.14	0.51	31.48	1.55	100.28	91.47	4.12
Darwaza	2.87	59.28	1.70	0.86	0.25	0.62	31.26	2.63	99.47	90.54	4.07
Kachi	2.26	58.70	1.68	1.61	0.36	2.19	30.90	1.75	99.45	89.60	4.02
Bir	0.98	60.77	1.48	0.56	0.18	2.20	32.03	1.20	99.40	92.80	4.18
Hil	2.61	60.78	1.26	0.85	0.11	0.14	32.06	1.40	99.21	92.84	4.17
Mean	2.29	60.14	1.82	0.86	0.20	0.98	31.68	1.54	99.51	91.82	4.139

which are widely exposed in Havelian and precipitated barite in the available open space (Charles and William 1997). The oxidation of fluid rich in barium and reduced sulphur would lower the pH and would lead to the dissolution of carbonate host rocks (Plummer 1971). Barite was deposited in pre-existing openspace such as breccice deposits and solution channels (Leach 1980).

Eighteen representative barite samples were collected from Hazara deposits, selecting six each from Haripur, Havelian and Kohala respectively. For chemical analysis each sample was crushed to 150-180 µm after conning and quartering. Percentage composition of silica, iron, aluminium, calcium, magnesium, barium and loss on ignition was determined by conventional methods (Scott and Furman 1962). Iron was also

Table 2

Chemical composition (%) of Haripur barite after HCl treatment

Sample No.	SiO_2	BaO	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	LOI	Total	$BaSO_4$	Sp.Gr
Kag	2.96	62.40	0.63	0.42	0.07	0.12	32.82	0.16	99.58	95.22	4.27
Aluli	2.88	62.36	1.49	0.20	0.05	0.13	32.81	0.23	100.15	95.17	4.27
Darwaza	3.69	62.22	0.33	0.15	0.06	0.18	32.67	0.35	99.64	94.89	4.27
Kachi	3.88	60.55	0.83	0.84	0.09	1.03	31.87	0.32	99.41	92.42	4.16
Bir	2.40	62.37	0.57	0.22	0.06	1.00	32.88	0.20	99.70	95.25	4.29
Hil	2.88	62.52	0.40	0.32	0.04	0.05	32.94	0.28	99.43	95.46	4.29
Mean	3.11	62.07	0.71	0.36	0.06	0.41	32.66	0.36	99.74	94.74	4.26

Table 3

Chemical composition (%) of Havelian barite in raw state

Sample No.	SiO_2	BaO	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	LOI	Total	$BaSO_4$	Sp.Gr
Chandomera 1	4.84	61.01	0.60	0.14	0.08	1.23	32.01	0.31	100.22	93.02	4.18
Chandomera 2	5.30	60.00	1.12	0.38	0.14	1.42	31.48	0.42	100.26	91.48	4.12
Faqir Mohd 1	0.88	55.52	5.56	1.26	0.16	2.11	29.03	5.88	100.40	84.55	3.81
Faqir Mohd 2	0.75	60.67	2.58	0.92	0.15	1.02	31.83	2.54	100.46	92.50	4.15
Batagram 1	6.82	59.04	0.82	0.52	0.09	0.40	30.83	1.66	100.17	89.87	4.04
Batagram 2	6.62	56.83	1.84	1.56	0.12	0.45	29.67	3.57	100.66	86.50	3.89
Mean	4.20	58.84	2.08	0.79	0.12	0.93	30.81	2.39	100.16	89.65	4.31

Table 4

Chemical composition (%) of Havelian barite after HCl treatment

Sample No.	SiO_2	BaO	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	LOI	Total	$BaSO_4$	Sp.Gr
Chandomera 1	5.51	61.44	0.29	0.04	0.03	0.50	32.09	0.11	100.01	93.53	4.21
Chandomera 2	5.83	60.95	0.56	0.27	0.06	0.65	31.89	0.23	100.44	92.84	4.18
Faqir Mohd 1	2.23	62.44	0.75	0.39	0.05	0.83	32.61	0.85	100.15	95.05	4.26
Faqir Mohd 2	1.43	63.34	1.08	0.25	0.04	0.43	33.18	0.58	100.33	96.52	4.34
Batagram 1	7.24	60.50	0.12	0.15	0.02	0.05	31.58	0.42	100.08	92.08	4.14
Batagram 2	6.92	60.65	0.34	0.28	0.03	0.06	31.66	0.65	100.60	92.31	4.14
Mean	4.86	61.55	0.52	0.21	0.04	0.42	32.16	0.47	100.23	93.72	4.21

determined by spectrophotometric method. Chemical analysis of raw samples is given in Table 1, 3 and 5.

Then 50 g of each sample was taken in 500ml beaker, washed two times with distilled water by decantation and 50ml commercial hydrochloric acid was added. Stirring was done with mechanical stirrer. After 15 min reaction, acid was decanted. Sample was washed with distilled water by decantation and then by filtration till the filtrate was free from chloride and iron. Washed sample was dried in the oven at 110°C and chemical analysis was carried out, using the same procedures as were used for the sample in crude form. Results are tabulated in Table 2, 4 and 6 respectively. Specific gravity of all samples was also determined and reported (Table 1-6).

Results and Discussion

Table 1, 3 and 5 show that $BaSO_4$ varies from 89.6% to 93.71% iron from 0.11 to 0.36% and aluminium from 0.14 to 2.2%. in Haripur barite samples. $BaSO_4$ ranges from 84.55 to 93.02% iron from 0.08 to 0.16% and aluminium from 0.4 to 2.11% in Havelian barite while $BaSO_4$ varies from 88.92 to 92.68%, iron from 0.12 to 0.26% and aluminium from 0.28% to 0.82% in Kohala barite.

$BaSO_4$ is up-graded from 92.42 to 95.46% in Haripur barite, from 92.08 to 96.52% in Havelian barite and from 94.32 to 95.90% Kohala barite after hydrochloric acid treatment of the samples. The quantity of iron, aluminium, calcium and magnesium decreased and silica contents increased in all samples after the crude mineral is treated with the acid. HCl reacts only with the impurities of iron, aluminium, calcium and magnesium and has no effect on silica contents and therefore, the silica contents in the treated samples increase with the decrease of other impurities.

Barite contains calcium, magnesium, iron and aluminium as impurities. It is obvious that some iron, aluminium and the part of the calcium and magnesium (present as carbonates) reacts with the hydrochloric acid to form soluble chlorides causing the reduction of these elements. These can be represented by the following reactions:

$$XCO_3 + 2HCl \rightarrow H_2CO_3 + XCl_3$$

where X : Ca, Mg

Table 5

Chemical composition (%) of Kohala barite in raw state

Sample No.	SiO_2	BaO	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	LOI	Total	$BaSO_4$	Sp.Gr
Kohala 1	3.20	58.57	2.58	1.02	0.18	0.28	30.58	3.16	99.57	89.15	4.02
Kohala 2	2.65	58.32	3.23	0.86	0.16	0.45	30.60	2.96	99.23	88.92	4.00
Kohala 3	3.32	60.49	1.48	0.62	0.12	0.32	31.61	1.50	99.46	92.10	4.14
Kohala 4	2.08	59.16	1.95	1.32	0.26	0.82	30.89	3.22	99.70	90.05	4.04
Kohala 5	1.88	60.88	1.83	0.84	0.13	0.63	31.70	2.16	99.79	92.32	4.16
Kohala 6	2.02	60.88	1.47	0.56	0.15	0.52	31.80	1.87	99.27	92.68	4.17
Mean	2.52	59.67	2.09	0.87	0.16	0.50	31.19	2.47	99.47	90.86	4.09

Table 6

Chemical composition (%) of Kohala barite after HCl treatment

Sample No.	SiO_2	BaO	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	LOI	Total	$BaSO_4$	Sp.Gr
Kohala 1	3.54	62.10	0.54	0.32	0.06	0.16	32.43	0.52	99.67	94.53	4.24
Kohala 2	3.00	61.84	0.86	0.34	0.05	0.21	32.48	0.45	99.23	94.32	4.21
Kohala 3	3.57	62.10	0.38	0.29	0.03	0.17	32.58	0.26	99.38	94.68	4.25
Kohala 4	2.73	62.59	0.42	0.43	0.07	0.36	32.68	0.62	99.90	95.27	4.28
Kohala 5	2.34	63.00	0.39	0.30	0.04	0.28	32.90	0.36	99.61	95.90	4.32
Kohala 6	2.40	62.93	0.35	0.21	0.05	0.25	32.87	0.32	99.38	95.80	4.30
Mean	2.93	62.42	0.49	0.31	0.05	0.23	32.65	0.42	99.50	95.09	4.27

Table 7

General specifications of barite

	1 Drill mud barite	2 Filler application	3 Glass grade barite	4 Barite as heavy aggregate	5 Barium chemicals manufacture	6 Paint grade barite
Sp. gravity	4.2	--	--	--	--	--
$BaSO_4$	92% min	95% min	95% min	95% min	92-96% min	95%
SiO_2	--	--	1.5 max	--	--	--
Fe_2O_3	--	--	0.15 max	--	1% max	0.05
Al_2O_3	--	--	0.15 max	--	--	--
Color	--	near white	white	--	--	white
Particle size	95% 45 µm	95% 45max	100%-8.5µm	gravel size	-5.0+0.5 mm	37µm

Ref: Andrew and Collings (1990).

$$Y_2(CO_3)_3 + 6HCl \rightarrow 3H_2CO_3 + 2YCl_3$$

where Y : Al, Fe

This up-gradation of barite has shown that unwanted impurities go along with washings and only minor impurities remain in the acid treated barite. Thus chemical composition of all samples except sample from Kachi, sample no. Chandomera 2 and Batagram 1 and 2 reaches the recommended limit of international standard specification (Table 7) for most of industries. If this beneficiation procedure is undertaken with increasing temperature, or other beneficiating methods are used, the quality of barite could be obtained which can be used for pharmaceutical purposes but that may be uneconomical. By this simple 15 min acid treatment, Hazara barite can be made suitable for 80% industrial applications according to the world standard specification (Endrew and Kollings 1990).

The mean specific gravity of Haripur barite is 4.139, Havelian barite is 4.037 and Kohala barite is 4.092 in the crude form. In the beneficiated samples mean specific gravity changes to 4.463, 4.215 and 4.277 respectively. This increase in specific gravity confirms the increase in the purity of the mineral. The specific gravity of pure barite is 4.5 (Hurlbut 1956).

Conclusion

Though barite produced in Hazara is already utilized in petroleum drilling industry, manufacture of paint and chemical industry, this barite in original form is not suitable for high quality products. The present study show that suitable quality of barite exists in Hazara which after simple acid treatment can be utilised for the international standard production of chemicals, paint and glass, and for application as heavy aggregate and filler in rubber, paper and plastic industries. It can also be used in petroleum drilling industry.

Since commercial hydrochloric acid is abundantly available in Pakistan from the chemical industries, this process can be economically and fruitfully employed to reduce the unwanted constituents.

References

Afridi A K 1986 *Barite deposits of NWFP Pakistan*. Geol Surv Pakistan Information release 134.

Ahmad Z 1969 *Directory of mineral deposits of Pakistan*. Record of Geol Surv Pakistan **15** (3) 55-60.

Ali S M, Aziz S 1965 Studies on the reduction of barite with charcoal. *Pak J Sci Ind Res* **8** 136-140.

Andrewa P R A, Collings R K 1990 Barites in Canada. *Industrial Minerals* 46-47.

Aurangzeb 1991 *Interim Geological Report on Barite Deposits of Hazara Division.* Sarhad Development Authority p 80.

Aurangzeb, Ajmal M, Asif M 1988 Petrology and economic significance of barite deposits of Hazara. M Sc thesis (unpublished), Geology Department, Peshawar University.

Charles J K, William C K 1997 Geologic and geochemical control of mineralization in the Southeast Missori Barite District. *Economic Geology* **82** 719.

Crookshank H 1954 *Directory of the Economic Minerals of Pakistan.* Record of the Geol Surv Pakistan, VII, Part 2.

Hurlbut C S 1956 *Dana's Manual of Mineralogy.* 16th ed, Chapman & Hall Ltd, London.

Hussain V, Khan H, Qureshi K A 1991 Mineralogy and analytical studies of south western Tanol barite district of

Hazara, Pakistan. *Pak J Sci Ind Res* **34** (2-3) 65-69.

Iqbal M W A, Shah S M I 1980 *A Guide to the Stratigraphgy of Pakistan.* Record of the Geol Surv of Pakistan, III.

Khan H, Hussain V, Qureshi K, Pasha K, Ahmad N 1994 Petromineralogical and geochemical studies of Havelian barite, Hazara, NWFP. *Pak J Sci Ind Res* **37** (10) 414-420.

Killanger F L, Richards R L 1967 Baryte in Pakistan. *In: Proceedings of Cento Symposium on Industrial Rocks and Minerals,* Lahore pp 418-428.

Leach D L 1980 Nature of the mineralizing fluid in the barite deposits of central and southern Missuri. *Economic Geology* **75** 1168.

Marks P, Ali C M 1961 *The geology of the Abbotabad area with special reference to Infra Trias*. Geological Bulletin Punjab University 2.

Plummer J N 1971 Barite deposits in central Kentucky. *Economic Geology* **66** 252.

Scott W W, Furman N H 1962 *Standard Method of Chemical Analysis.* D Van Nostrand, 16th ed.

Shah R A, Khan I A 1963 *Preliminary Report on the Reduction of Baryte with Sui Gas I* 165-169.