Pak. j. sci. ind. res., vol. 37, no. 10, October 1994

PETROMINERALOGICAL AND GEOCHEMICAL STUDIES OF HAVELIAN BARITE, HAZARA, NWFP, PAKISTAN

HAMEEDULLAH KHAN, VIQAR HUSAIN, KHALID QURESHI, KAMAL PASHA* AND NISAR AHMAD
PCSIR Laboratories, Jamrud Road, Peshawar, Pakistan

(Received March 7, 1993; revised June 12, 1994)

The epigenetic vein type barite deposits occur at several localities near Havelian in limestone and shale sequence belonging to Eocene age. Barite veins varying in thickness from a few inches to several feet occur in grey coloured argillaceous limestone and shale. Thin bands of barite and galena are also seen in some samples. Important minerals occuring along with barite are calcite, quartz and magnesite. In polished sections, galena, pyrite and goethite were also identified. Petrographically, barite occurs in several textural types: massive, crystalline, lath or platy shaped ranging from fine to coarse in size. The $BaSO_4$ content in Havelian barite samples ranges from 20 to 92%. Major impurities are SiO_2, CaO, MgO, Fe_2O_3 and Al_2O_3. Barite deposits in Havelian are structurally controlled vein and cavity filling type deposits. These barite deposits have not been developed and mined systematically. Barite deposits of this district are good in quality and need detailed investigations for determining mineable reserves. The physical and chemical characteristics of Havelian barite show their suitability for paint, paper, rubber, petroleum drilling and chemical industries with or without processing.

Key words: Barite, Petrochemistry, Industrial uses.

Introduction

Barite is an important industrial mineral being dominantly used as a weighting agent in oil and gas well drilling fluids. The overall production and reserve figures tend to reflect changes in drilling activity. In contrast, the market for barite use as a filler or extender or for chemical purposes, although smaller, is more stable [1]. About 50000 metric tons of barite is produced in Pakistan every year, most of which is consumed as drilling mud but the demand of barite in the country for non-drilling purpose is gradually increasing.

Important barite deposits in the country occur in the axial belt region in a variety of geological environment [2]. About 11 million metric tons of barite–galena deposits occur at Gunga, 16 km South West of Khuzdar which are stratabound, hydrothermal and replacement type hosted in limestone and shale sequence of Jurassic age [3]. A large number of small cavity filling and vein type replacement barite deposits occur in districts Khuzdar and Lasbela [4].

In northern part of the axial belt, important epigenetic vein type barite deposits occur in Hazara division (Fig. 1). These barite deposits occur at about 15 localities near Haripur, Havelian and Kohala (Fig. 2). The barite and quartz veins in Hazara district cut across slate of Precambrian age at Kohala, limestone and shale of Eocene age at Havelian and quartzite-dolomite of Tanawal and Abbottabad formations at Haripur.

The objectives of this study were to compare Havelian barite deposits with those occurring in Hazara region and to speculate on their significance in prospecting for concealed deposits in the area. Specific objectives were: (a) to understand the field relationship of barite veins and comment on the source of mineralising fluids, (b) to determine petrographic, mineralogical and chemical characteristics of barite for their industrial application and (c) to suggest measures for the development of Havelian barite deposits.

* Geological Survey of Pakistan, 16-G, Model Town, Lahore.

Material and Methods

Geological setting. Regionally, the Hazara division lies on the west flank of the Hazara-Kashmir syntaxial bend. The southern part of the area comprising Havelian consists mainly of sedimentary rocks ranging from pre-Triassic to Miocene in age [5].

Havelian barite is mostly covered by Mesozoic and Cenozoic sediments. Oldest exposed rocks in the area are Hazara slate of Precambrian age (Table 1). Hazara formation is overlain by thick sequence of limestone, containing shale and sandstone, ranging in age from Triassic through Eocene. These rocks are complexly faulted and intimately folded with rocks of Hazara formation [5].

Barite deposits. In Havelian district, barite veins occur in thick sequence of limestone with subordinate shale belonging to Margala hill limestone and Chorgali formation of early Eocene age. In Chandomera, reddish white coloured barite vein varying in thickness from few inches to several feet occur in grey coloured argillaceous limestone and reddish shale [7]. In some places barite occurs as irregular veins in intensively weathered rocks. Thin bands of pyrite and galena are also seen in some samples. Barite veins are generally dipping about 45°

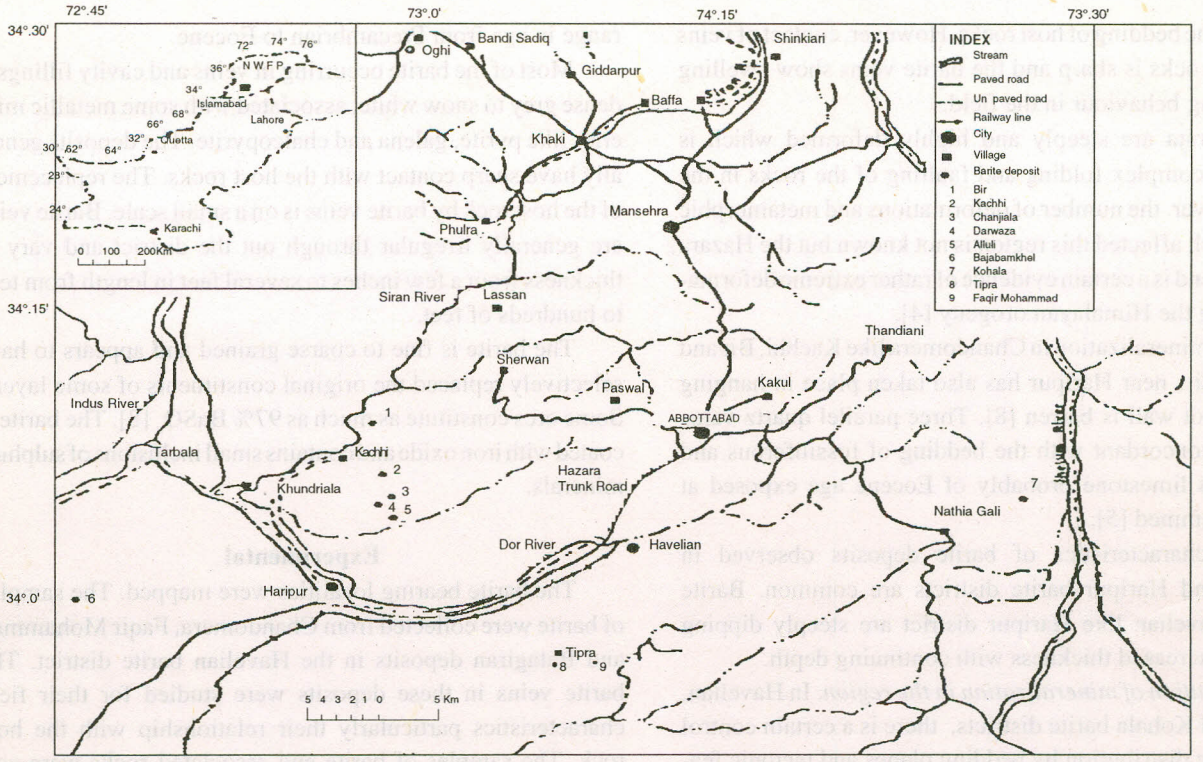
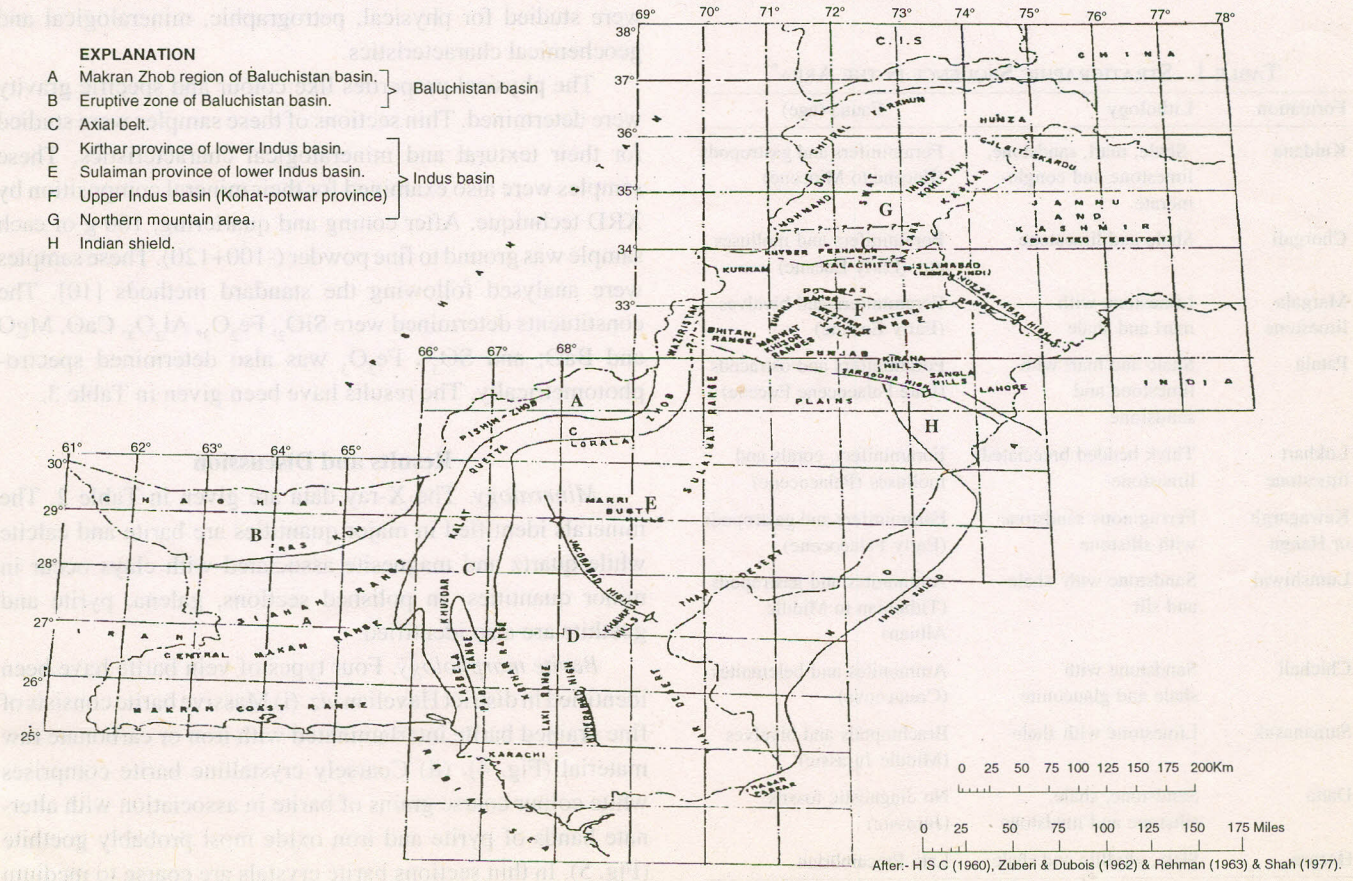


Fig. 1. Map showing the location of barite deposits of Hazara, NWFP.



After:- H S C (1960), Zuberi & Dubois (1962) & Rehman (1963) & Shah (1977).

Fig. 2. Map showing basinal divisions of Pakistan.

parallel to the bedding of host rocks. However, contact of veins with these rocks is sharp and the barite veins show swelling and pinching behaviour in the field.

The strata are steeply and highly deformed which is evident by complex folding and faulting of the rocks in the area. However, the number of deformations and metamorphic events which affected this region is not known but the Hazara syntaxial bend is a certain evidence of rather extreme deformations during the Himalayan orogeny [4].

Barite mineralization in Chandomera like Kachhi, Bir and other deposits near Haripur has also taken place in hanging wall and foot wall is barren [8]. Three parallel quartz veins trend east concordant with the bedding of fossiliferous and argillaceous limestone probably of Eocene age exposed at Faqir Mohammed [5].

Field characteristics of barite deposits observed in Havelian and Haripur barite districts are common. Barite veins at Havelian like Haripur district are steeply dipping and show increased thickness with continuing depth.

Distribution of mineralization in the region. In Havelian, Haripur and Kohala barite districts, there is a certain control on the barite distribution by bedding planes and tectonic features such as faults, joints and breccia zones [9]. The host rocks range in age from Precambrian to Eocene.

TABLE 1. STRATIGRAPHIC SEQUENCE IN THE AREA*.

Formation	Lithology	Fauna (age)
Kuldana	Shale, marl, sandstone, limestone and conglomerate	Foraminifers and gastropods (Eocene to Miocene)
Chorgali	Shale and limestone	Foraminifers and molluscs etc. (Early Eocene)
Margala limestone	Limestone with marl and shale	Foraminifers and bivalves (Early Eocene)
Patala	Shale and marl with limestone and sandstone	Foraminifers and ostracods (Late Palaeocene Eocene)
Lokhart limestone	Thick bedded brecciated limestone	Foraminifers, corals and molluscs (Palaeocene)
Kawagargh or Hangu	Ferruginous sandstone with siltstone	Foraminifers and gastropods (Early Palaeocene)
Lumshiwal	Sandstone with shale and silt	Ammonites and gastropods (Tithonian to Middle Albian)
Chichali	Sandstone with shale and glauconite	Ammonites and belemnites (Cretaceous)
Samanasuk	Limestone with shale	Brachiopods and bivalves (Middle Jurassic)
Datta	Sandstone, shale, siltstone and mudstone	No diagnostic fossils (Jurassic)
Hazara	Slate, phyllite and shale	Late Precambrian

* Iqbal and Shah [6].

Most of the barite occurring in veins and cavity fillings is dense grey to snow white, associated with some metallic minerals like pyrite, galena and chalcopyrite. The deposits generally have sharp contact with the host rocks. The replacement of the host rock by barite veins is on a small scale. Barite veins are generally irregular through out the district and vary in thickness from a few inches to several feet in length from tens to hundreds of feet.

The barite is fine to coarse grained and appears to have selectively replaced the original constituents of some layers. Some ores constitute as much as 97% $BaSO_4$ [8]. The barite is coated with iron oxide and contains small inclusions of sulphide minerals.

Experimental

The barite bearing localities were mapped. The samples of barite were collected from Chandomera, Faqir Mohammad and Batagiran deposits in the Havelian barite district. The barite veins in these deposits were studied for their field characteristics particularly their relationship with the host rock. The samples of barite and associated rocks were collected from important barite deposits in the area. The samples were studied for physical, petrographic, mineralogical and geochemical characteristics.

The physical properties like colour and specific gravity were determined. Thin sections of these samples were studied for their textural and mineralogical characteristics. These samples were also examined for their mineral composition by XRD technique. After coning and quartering, 100 g of each sample was ground to fine powder (-100+120). These samples were analysed following the standard methods [10]. The constituents determined were SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO and BaO; and SO_3 . Fe_2O_3 was also determined spectrophotometrically. The results have been given in Table 3.

Results and Discussion

Mineralogy. The X-ray data are given in Table 2. The minerals identified in major quantities are barite and calcite while quartz and magnesite associated with clays occur in minor quantities. In polished sections, galena, pyrite and goethite are also identified.

Barite morphology. Four types of vein barite have been identified in district Havelian *viz.* (i) Massive barite consists of fine grained barite interlaminated with iron or carbonate raw material (Fig. 4). (ii) Coarsely crystalline barite comprises white colour coarse grains of barite in association with alternate bands of pyrite and iron oxide most probably goethite (Fig. 5). In thin sections barite crystals are coarse to medium grained and occur in association with dark coloured primary

and light coloured re-crystallized fine grained calcite and dolomite. The droplets of iron oxide are also seen randomly distributed throughout particularly on the margins of barite grains (Fig. 6). (iii) Lath shaped barite consists of medium to fine grained barite, replacing primary dark coloured carbonate material (Fig. 7) and (iv) Platy barite occurs as white coloured platy shaped barite with many fractures traversing the whole rock which shows shearing characteristics (Fig. 8). In hand specimen, milky white coloured barite is noticed as replacing the host-rock which is evident from barite bends present (Fig. 9).

TABLE 2. MINERAL COMPOSITION OF BARITE AND HOST ROCK.

Sample No.	Barite	Calcite	Magnesite	Quartz	Other associated clays in very low quantity
CHANDOMERA					
Ba2	+++	-	-	-	K + J
Ba4	+++	-	-	+	K + J + F
Ls5	-	++	-	-	-
Ls7	-	++	+	+	-
BATAGRIAN					
Ba13	+++	-	-	+	-
Ba14	+++	-	-	+	-
Ls15	++	+	+	+	K + D + F
Ls16	-	++	_	+	-
FAQIR MOHAMMAD					
Ls9	-	+	+	+	-
Ls10	+	++	-	+	F

+++ High. ++ Medium. + Low. - Not detectable. K = Kaolinite. J = Illite. F = Feldspar. D = Diaspore.

Important microscopic characteristics of Havelian barite are: (a) various textural types of barite from fine to coarse to platy, (b) primary carbonate occurring both as fine grained material and pellets of various shapes and sizes (Fig. 10), (c) important diagenetic features are re-crystallised fine to coarse grained calcite, replacement of shale and carbonate material by barite, re-crystallized calcite and quartz, fracture filling by iron oxide and sparry calcite, (d) there is a sharp contact of barite with the host rock, (e) the iron oxide (goethite) and iron sulphide (pyrite) are seen randomly distributed through out.

The sequence of barite crystal morphologies observed in Havelian are similar to those precipitated under laboratory conditions which consists of fine grained barite followed by equant, parallel to subparallel and fibrous crystals [11].

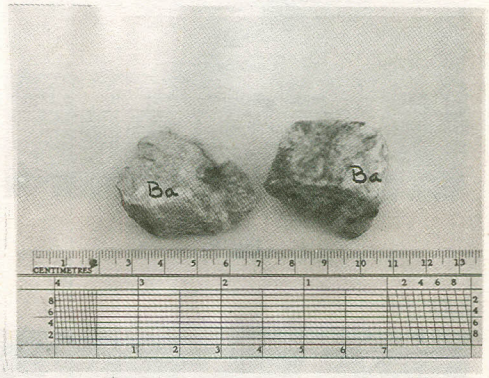


Fig. 4.

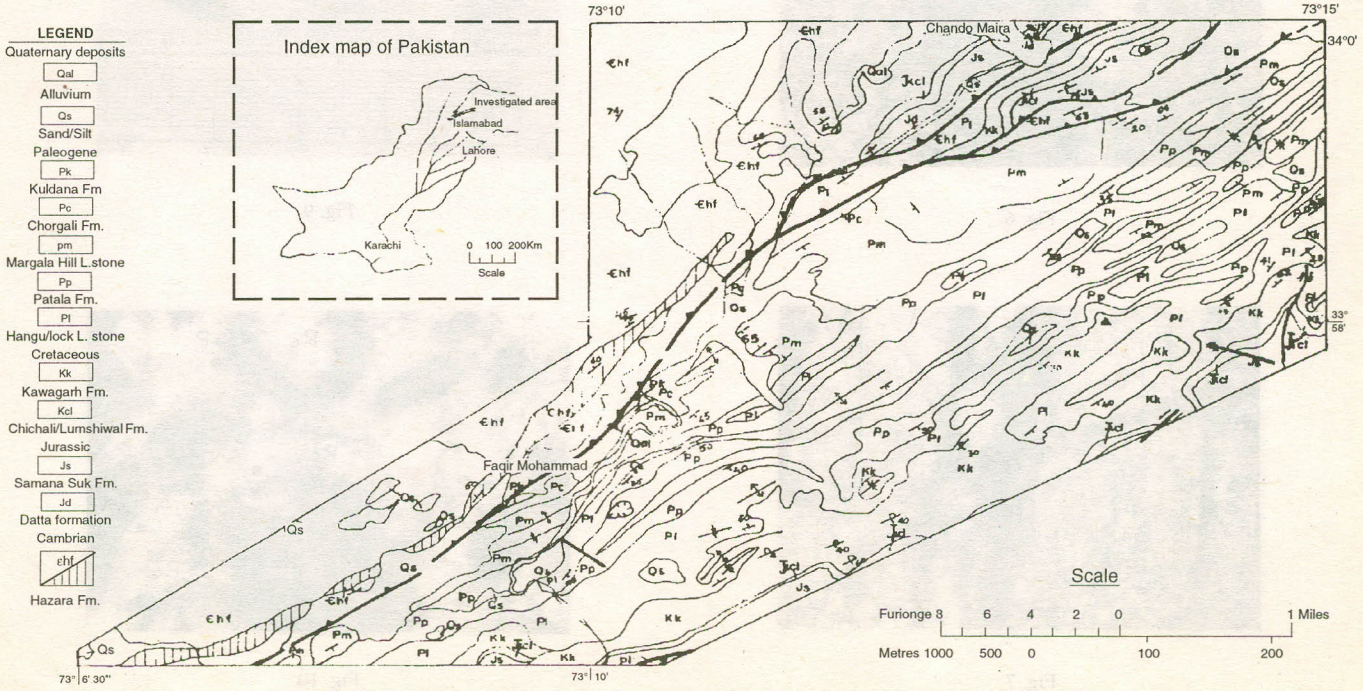


Fig. 3. Geological map of Chando Maira – Faqir Mohammad area Distt. Abbottabad NWFP.

Geochemistry. Major elements of barite and limestone are given in Table 3. The $BaSO_4$ content in Havelian varies from 0.40 to 92.62%. It reflects that Havelian sediments originally contain small amounts of $BaSO_4$. Havelian barite deposits are epigenetic and vein types. The high concentration of $BaSO_4$ in some of the samples given in Table 3 may be due to following factors:

(A) Ground water solution may have leached barium from the carbonate and shale host rocks and re-deposited as epigenetic veins or replacement bodies [12]. (B) In Havelian, thick fossiliferous sequences of limestone and shale are exposed. The studies carried out in Germany also indicate that shales generally contain 50-5000 ppm $BaSO_4$ while fossiliferous shales contain higher amounts of barium [13]. (C) The redistribution of barium in the form of epigenetic barite veins in Havelian may have taken place due to diagenetic processes. Similar studies carried out by Marching *et al.* [14] on diagenetic mobilization of barium element also strengthens this

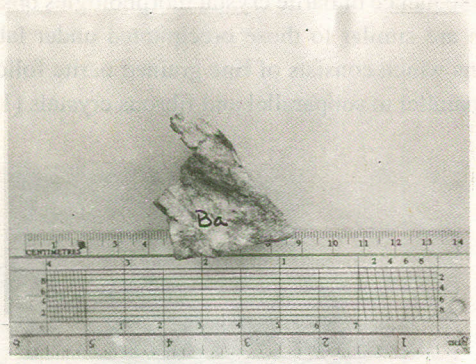


Fig. 5.

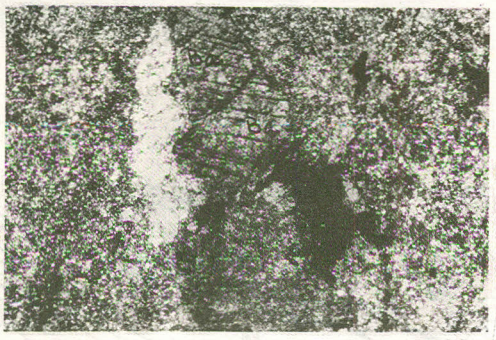


Fig. 6.

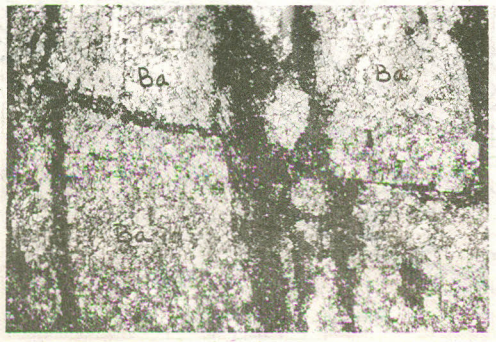


Fig. 7.

Fig. 8.

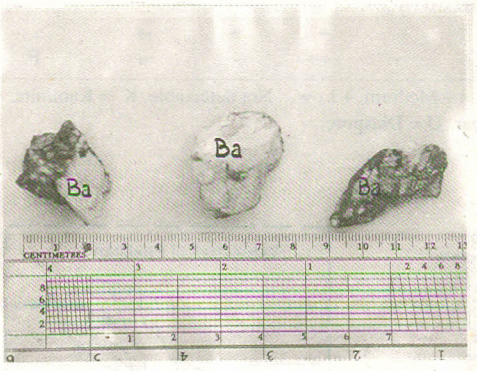


Fig. 9.

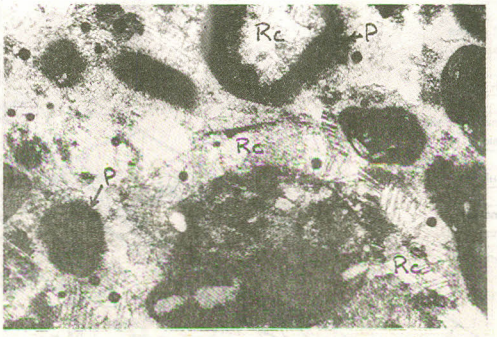


Fig. 10.

TABLE 3. MAJOR ELEMENT CHEMISTRY OF ORES AND HOST ROCKS (WT%).

Sample No.	SiO_2	BaO	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	Moisture	Loss on ignition	Total	Lithology
CHANDOMERA											
Ba1	05.24	60.34	00.63	00.16	00.07	01.25	31.77	-	00.30	99.78	Barite
Ba2	65.27	11.72	01.34	00.43	03.24	10.64	6.16	-	01.15	99.95	Barite
Ba4	06.29	59.34	01.14	00.46	00.17	01.53	31.04	-	00.29	100.26	Barite
Ls5	03.46	0.84	84.40	02.31	00.76	02.50	0.50	-	41.43	100.20	Limestone
Ls7	14.13	0.26	34.18	09.33	01.09	03.16	0.14	-	37.10	99.39	Limestone
FAQIR MOHAMMAD											
Ba8	05.14	52.06	04.45	01.22	00.38	04.29	27.49	00.09	04.93	100.50	Barite
Ls9	17.20	1.38	28.04	10.90	01.33	03.97	Trace	00.19	36.44	99.45	Limestone
Ls10	08.21	0.70	46.03	01.61	0.40	4.44	0.47	00.18	38.26	100.30	Limestone
Ls11	13.83	13.01	21.12	10.08	00.76	06.36	6.95	00.08	27.91	100.10	Barite
BATAGRAIN											
Ba13	07.81	58.25	00.53	00.53	00.08	00.40	30.30	00.01	01.68	100.00	Barite
Ba14	07.72	55.31	01.57	01.88	00.12	00.43	29.35	-	03.87	100.25	Barite
Ls15	09.14	21.63	18.17	10.72	01.12	00.55	11.36	-	26.44	99.13	Limestone
Ls16	11.50	1.16	45.45	01.85	00.46	00.97	0.75	00.03	37.51	99.68	Limestone

mode of genesis for Havelian barite deposits.

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

The mineralization in faults and joint zones imply outward fluid movement from the structures. Fluids utilizing these structures moved out into porous and permeable sediments which are widely exposed in Havelian and precipitated barite in the available open space [15]. The oxidation of fluid rich in barium and reduced sulphure would lower the pH and would lead to the dissolution of carbonate host rocks [16]. Barite was deposited in pre-existing open spaces such as breccica deposits and solution channels [17].

Based on textures present in the deposits, most features suggest an epigenetic (vein and cavity filling) origin. These features include lack of primary bedding, coarse and platy nature of barite grains, random distribution of sulphide minerals and the sharp contact with the host rock [18]. Further, presence of fractures particularly along the margins indicate that the rock was not completely rigid but that stresses generally caused the rocks to part around margins of the grains [19].

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

Mining and processing. Barite deposits occurring in Havelian district have been mined from surface by open pit and crude underground mining methods by small mining groups from time to time. There has been no major technical and financial input in the area in either exploring, developing or mining these deposits by government and private agencies.

Barite occurring in Havelian vary in colour, specific gravity and in $BaSO_4$ content within the same deposit. Generally barite occurring in this district is high in specific gravity, white in colour and has about 90% barium sulphate content.

If systematic exploration and development studies are carried out on the Havelian barite deposits and they are mined by modern methods, barite production from this area would increase considerably. Further, Havelian barites can be upgraded and made more uniform in physical and chemical composition by using processing and concentration techniques such as washing, gravity separation, electrostatic magnetic separation, acid leaching and floatation.

Conclusion

Barites from Havelian deposits have specific gravity about 4.3 which makes them suitable for oil well drilling industry. The Fe_2O_3 content is less than one percent and barium sulphate content is about 90%. If barite from this area is processed it can be utilised for manufacturing barium chemicals. Barite occurring in the area is generally white to snow white in colour which makes it suitable for fillers in paint, paper, rubber and other industries.

The increasing oil and gas exploration activity in parts of Northern Punjab and NWFP expanding chemical industry base in the country, development of Hattar Industrial Estate near Haripur and liberal economic policies of the present government are some of the factors which emphasize the need for attention given to the exploration, development and mining of Havelian vein type barites.

Acknowledgement. Facilities provided by Prof. Dr. Klaus Germann, Director Institute of Mineral Deposits Research, Technical University Berlin, are acknowledged for carrying out XRD and ore microscopic studies of samples from Havelian and other barite deposits samples.

References

1. S. H. B. Clark, M. J. Gallagher and F. G. Poole, World Barite Resources, A Review of Recent Production Patterns and a Genetic Classification, in Remote Sensing, an Operational Technology for the Mining and Petroleum Industries (Institution of Mining and Metallurgy, 1990), pp. 15-33.
2. S. M. Ibrahim Shah, Stratigraphy of Pakistan, Memoire of the Geological Survey of Pakistan (1977), Vol. XII, pp. 138.
3. Report on the Cooperative Mineral Exploration in Khuzdar Area of Balochistan, Phase I (Japan International Cooperation Agency, Metal Mining Agency of Japan 1987), pp. 1-29.
4. S. I. Mohsin, M. A. Farooqui and M. U. Qadri, Distribution and Controls of Barite - Fluorite - Sulphide Mineralization in the Kirthar-Sulaiman Fold Belt, Pakistan, ACTA Universitatis Cavolina-Geologica No. 3 (1983), pp. 237-249.
5. S. Tayyab Ali, James A. Calkins and Terry W. Offield, Mineral Deposits of the Southern Part of the Hazara District, West Pakistan Records of the Geological Survey of Pakistan (1964), Vol. XIII, Part-1, pp. 38.
6. M. W. A. Iqbal and S. M. I. Shah, A Guide to the Stratigraphy of Pakistan, Records of the Geological Survey of Pakistan, (1980), Vol. LIII, pp. 35.
7. Aurangzeb, Interim Geological Report on Barite Deposits of Hazara Division (Sarhad Development Authority, 1991), pp. 80.
8. Viqar Husain, Hamidullah Khan, Khalid Qureshi, Nisar Ahmad and Imtiaz Ali, Pak. j. sci. ind. res., **34** , 65 (1991).
9. H. E. Frimmel and W. Papesch, Isotope Study of the Brixlegg Barite Deposits, Tyrol, Austria, Economic Geology, (1990), Vol. LXXXV, pp. 1162-1171.
10. W. W. Scott and N. H. Furman, *Standard Methods of Chemical Analysis* (D. VanNostrand, 1962), Vol. I, 6th edn.
11. Karen, K. Graber and Henry S. Shafetz, J. Sedimentary Petro., **60** (6) 897.
12. K. R. Dowson, Geology of Barium, Strontium and Fluorine Deposits in Canada, Economic Geology Report 34, Geological Survey Commission Canada (1985), pp. 35-54.
13. F. Leutwein, Geochische Untersuchungen an Alaunund, Kieselschieferum Thuringens, Arch. Lagesttatheforsch, **82,** 1 (1951).
14. V. P. Marching, H. Baker Moeller and P. Dulski, Marine Geology, **62,** 85 (1985).
15. Charles, J. Kaiser and William, C. Kelly, Economic Geology. **82,** 719 (1987).
16. J. N. Plummer, Economic Geology, **66,** 252 (1971).
17. D. L. Leach, Economic Geology, **75,** 1168 (1980).
18. C. David Miller, Mel Baryte - Lead-Zinc Deposits, Yukon Territory in the Geology of Industrial Minerals in Caada (G. R. Guilled and W. Martin), The Canadian Institute of Mining and Metallurgy, **29,** 295(1984).
19. M. J. Mayall and M. Cox, Sedimentary Geology, **59,** 77 (1988).