9. Beneficiation

Barytes is mined and sold directly after crushing and grinding. Sometimes high grade baryte produced from the mine is directly used after hand sorting and seletive screening. In certain cases baryte is beneficiated for following reasons:

i) To upgrade low grade baryte to produce concentrates suitable for drilling mud grade, etc.

ii) High grade barytes are beneficiated to remove objectionable impurities such as iron, silica, etc. to produce super grade concentrate for filler grade in paints, pharmaceuticals and chemical use.

iii) Baryte concentrates are produced from sulphide tailings as a by product.

9.1 General Methods

The characteristic physical properties of barytes such as high specific gravity between 4.2 and 4.5 and low hardness (2.5 to 3.5 Moh's scale) and its chemical inertness are advantageous to concentrate from associated impurities mostly quartz, calcite, dolomite, fluorite, clay, iron minerals and heavy sulphide minerals. The beneficiation techniques adopted mostly depend on the following factors.

i) Grade of the ore

ii) Nature of the gangue

iii) Liberation size i.e size at which baryte is free from contaminating impurities.

The methods which are commonly followed to process barytes ores are simple to complex in nature depending on the factors mentioned above.

Some of the processes generally used are as follows:

i) Crushing followed by hand shorting, dry screening etc.

ii) Crushing followed by log washing or wet trommel screening.

iii) Heavy media drums and cone separation.

iv) Wet and dry jigging.

v) Tabling and spiral concentration.

vi) Classification by cone and rake classifier and hydrocycloning.

vii) Dry and wet high intensity magnetic separation.

ix) Flotation.

x) Bleaching.

The most common method for beneficiation is jigging. Nearly 48 percent of ores that are beneficiated are treated by jigging and other gravity methods and neary 26 percent are beneficiated by floation. The rest is by hand sorting, screening etc.

Heavy media separation and jigging are normally employed on high grade and coarsely liberated ores. The general beneficiation methods normally adopted on the basis of liberalisation sizes are listed below:

Barytes Beneficiation

Size Range	General Methods Adopted
-50 mm + 12 mm size	HMS Jigging
-12 mm + 2 mm	Optical sorting
-2 mm + 0.2 mm	Tabling spiral concentration. Mag, Separation and Electro static separation
Below 0.2 mm and fines	Flotation and WHIMS

9.2 Beneficiation in the World

In the United States processing of baryte ores varies from district to district. In Missouri the ore is washed in trommel and then fed to jigs to reject quartz and dolomite contamination. In Georgia and Tennesee the ore is washed in log washers and screened to different sizes. The coarse is hand sorted. The intermediate is concentrated by jigs

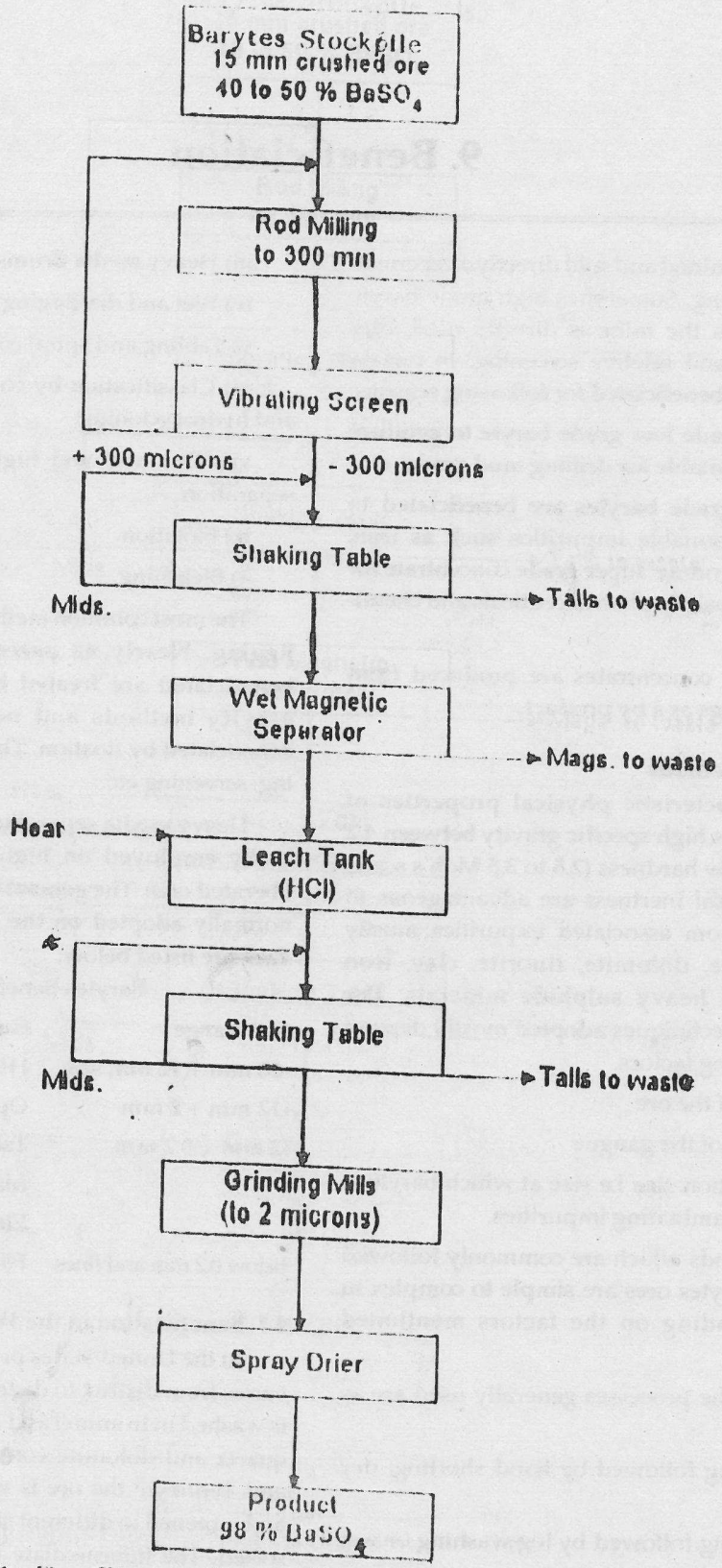

FIG-1 : Flow Diagram, Nystone Chemicals Ltd. Debert,N.S.

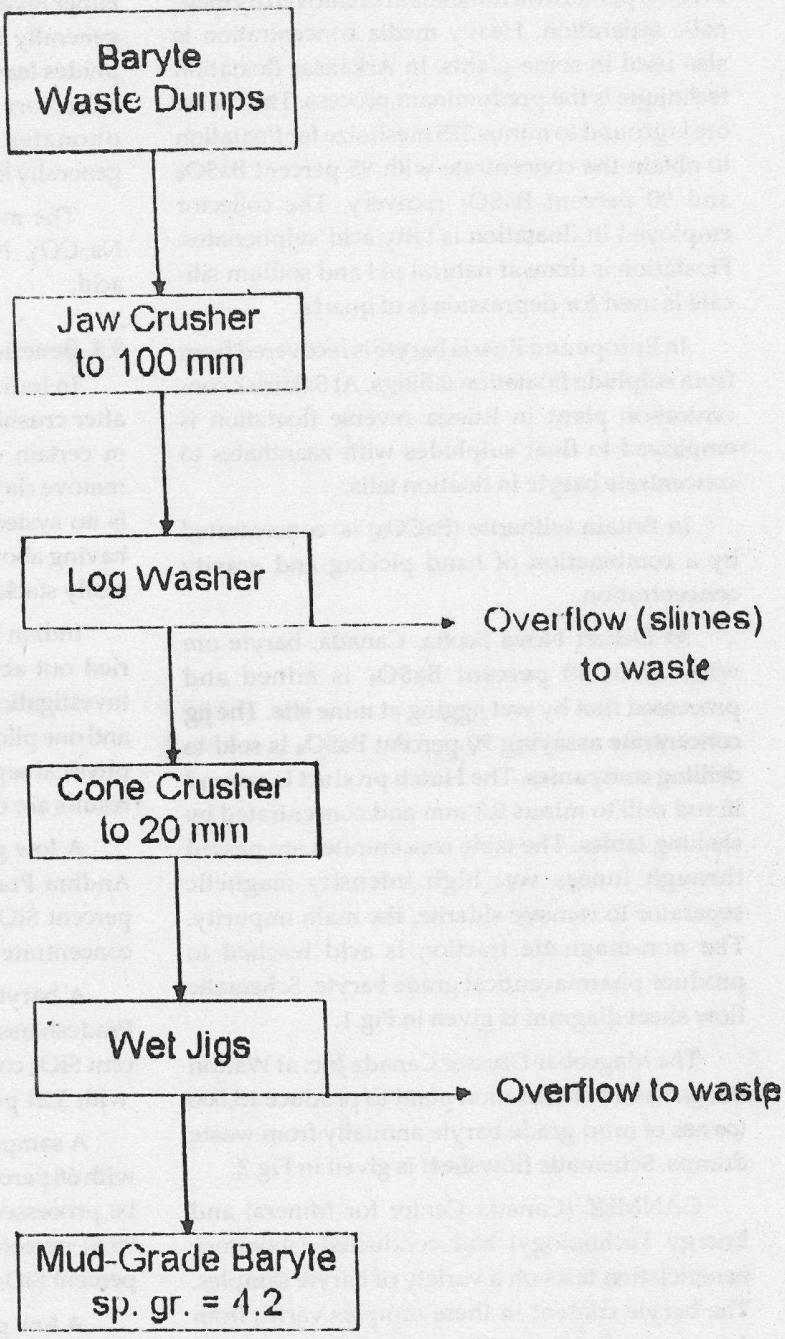

FIG.-2 : Flow Diagram, Magcobar Dresser Canada, Inc., Baryte Recovery, Walton N.S., Waste Dumps.

and -10 mesh material is concentrated on tables. In some plants iron minerals are removed by magnetic separation. Heavy media concentration is also used in some plants. In Arkansas floatation technique is the predominant process. The coarse ore is ground to minus 325 mesh size for floatation to obtain the concentrate with 95 percent $BaSO_4$ and 90 percent $BaSO_4$ recovery. The collector employed in floatation is fatty acid sulphonates. Floatation is done at natural pH and sodium silicate is used for depression is of quartz.

In Europe and Russia baryte is recovered from from sulphide floatation tailings. At Salairisk concentration plant in Russia reverse floatation is employed to float sulphides with zaanthates to concentrate baryte in floation tails.

In Britain witherite ($BaCO_3$) is concentrated by a combination of hand picking and gravity concentration.

At Debert Nova Scotia, Canada, baryte ore with 40 to 50 percent $BaSO_4$ is mined and processed first by wet jigging at mine site. The jig concentrate assaying 90 percent $BaSO_4$ is sold to drilling companies. The Hutch product is ground in rod mill to minus 0.3 mm and concentrated by shaking tables. The table concentrates are passed through Jonees wet high intensity magnetic separator to remove siderite, the main impurity. The non-magnetic fraction is acid leached to produce pharmaceutical grade baryte. Schematic flow sheet diagram is given in Fig.1.

The Magcobar Dresser Canada Inc. at Walton mines has a beneficiation plant to produce 15,000 tonnes of mud grade baryte annually from waste dumps. Schematic flowsheet is given in Fig.2.

CANMET (Canada Centre for Mineral and Energy Technology) had conducted laboratory beneficiation tests on a variety of baryte samples. The baryte content in these samples varies from 4.4 percent $BaSO_4$ to 85 percent $BaSO_4$. Gravity concentration techniques were largely successful in concentrating baryte ores to above 90 percent $BaSO_4$. Failure to achieve 90 percent $BaSO_4$ was generally related to low grade head samples e.g. below 30 percent $BaSO_4$ and fine interlocking.

In many samples baryte is concentrated by either reverse or direct flotation. Reverse flotation generally involves floatation of base-metal sulphides leaving a concentrated baryte tailing. The collectors generally preferred are alkyl sulphonates. The collector concentration was generally between 250 and 500 g/t.

The modifiers are depressants used include Na_2CO_3, Na_2SiO_3 Quebracho, $BaCl_2$ and citric acid.

9.3 Beneficiation in India

In India, the mined baryte is shipped directly after crushing, hand sorting and screening. Only in certain cases air ellutriation is employed to remove clay and shale impurities. However, there is no systematic processing of low grade baryte having about 60-70 percent $BaSO_4$ which are normally stacked as low grade dumps.

Indian Bureau of Mines had successfully carried out about 15 laboratory scale beneficiation investigations on different types of baryte samples and one pilot plant investigation adopting various physical separation processes. Some of the salient results are discussed below.

A low grade barytes sample from Tadapatri Andhra Pradesh with 64 percent $BaSO_4$ and 34 percent SiO_2 could be beneficiated to produce a concentrate of 94 percent $BaSO_4$ by tailing alone.

A barytes sample from Khammam, Andhra Pradesh assaying 89 percent $BaSO_4$ and 8.8 percent SiO_2 could be upgraded to 93 percent $BaSO_4$ with 3.21 percent SiO_2 by hydroclassification.

A sample from Udaigiri, Nellore district A.P. with 68 percent $BaSO_4$ and 20 percent Fe_2O_3 could be processed to produce a concentrate assaying 95.61 percent $BaSO_4$, 1.51 percent Fe_2O_3 and 1.77 percent SiO_2 by dry magnetic separation.

A low grade sample from Mangampeta area of Cuddpah district A.P. with finely interlocked quartz gangue required flotation at very fine grind (about 9-percent -325 mesh) to produce concentrate useful for drilling mud grade. The floatation was done at natural pH with three or four cleanings using sodiumoleate or Neo fat as collector.

The low grade barytes beneficiated by floatation varying in $BaSO_4$ content from 66 percent to 78 percent and SiO_2 from 12 percent to 23 percent. The concentrates assay above 94 percent BaSO4 with 2.5 percent SiO_2. The recoveries of $BaSO_4$ were above 80 percent.

Indian Bureau of Mines has also been successful in recovering mud grade barytes as by-product from lead-zinc ores of Dariba Rajpura containing as low as 13 percent $BaSO_4$.

Barytes concentrates obtained by froth floatation being non water wettable were unsuitable for use in oil well drilling industry. This problem was tackled successfully by IBM and floatation concentrates were made water wettable by heating/acid treatment.

The summary of salient results of beneficiation tests work carried out by IBM given in Annexure-1 (at this chapter end).

9.4. Need and Scope for Beneficiation of Low Grade Barytes

India is the third largest producer of barytes and so far, high grade barytes is mined and exported. Nearly 30 percent of the low grade barytes assaying around 60 percent $BaSO_4$ are dumped as waste material. These low grade barytes which are amenable to beneficiation are not utilized. More over these waste dumps have become environmental hazards. The specific gravity of low grade barytes ranges from 3.5 to 4.1 with no marketability. This is the right time that these low grade barytes needs to be beneficiated to produce mud-grade concentrates to conserve our valuable natural resources. There is a need to establish beneficiation plant of suitable capacity to treat low grade ore as well as some of the high frade ore to produce super grade concentrates for pharmaceutical, chemical and paint industry. Indian exporters of barytes have already entered into a memorandum of understanding with M/s. CARPCO, U.S.A. for setting up of a beneficiation plant at Magampeta.

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DETAILS OF BENEFICIATION OF BARYTES CARRIED OUT BY IBM

Annexure-1

Sl. No.	Title of Investigation	Original Assay %		Mineralogy	Wt%	Concentrate Assay %		Recovery %		Process adopted
1.	Beneficiation of Barytes from Khammam, A.P.	$BaSO_4$	89.85	Valuable Mineral	89.86	$BaSO_4$	92.91	$BaSO_4$	92.92	Hydroclassification
		SiO_2	8.80	Barytes		SiO_2	3.21			
		Fe_2O_3	0.80	Gangue						
		Quartz Goethite								
2.	Beneficiation of low grade barytes from Tadapathri A.P.	$BaSO_4$	64.00	Valuable Mineral	56.29	$BaSO_4$	94.02	$BaSO_4$	78.80	Tabling
		SiO_2	34.20	Barytes						
		Fe_2O_3	0.95	Gangue						
		CaO	Trace	Quartz						
		MgO	Trace							
		LOI	0.48							
3.	Beneficiation of finely ground barytes from Tadapathri, A.P.	$BaSO_4$	64.00	Valuable Mineral	42.62	$BaSO_4$	94.04	$BaSO_4$	59.28	Tabling
				Barytes						
				Gangue						
				Quartz						

Sl. No.	Title of Investigation	Original Assay %		Mineralogy	Wt%	Concentrate Assay %		Recovery %		Process adopted
4.	Beneficiation of a low grade barytes sample from Mangampet area Cuddapah Dist., A.P.	$BaSO_4$	66.00	Valuable Mineral	55.90	$BaSO_4$	93.69	$BaSO_4$	79.20	Flotation at a grind of 88% 325 mesh & Neofat & Pineoil as collector & frother
		SiO_2	23.30	Barytes		SiO_2	2.38			
		Al_2O_3	6.02	Gangue						
		Fe_2O_3	2.62	Quartz						
		CaO	0.94							
		MgO	0.11							
		LOI	0.77							
5.	Beneficiation of low grade barytes sample from Kodanada Rama barytes Mines., Udaigiri Taluq, Nellore Dist., A.P.	$BaSO_4$	68.11	Valuable Mineral	60.80	$BaSO_4$	95.61	$BaSO_4$	82.12	Dry magnetic separation at 35 mesh grind
		SiO_2	7.56	Barytes		Fe_2O_3	1.51			
		Al_2O_3	1.18	Gaugue Magnetitie		SiO_2	1.77			
		Fe_2O_3	20.55	Goethite Hematite		Al_2O_3	0.15			
		LOI	1.35	Lepidocrocite & quartz		LOI	0.50			
6.	Beneficiation of low grade barytes sample from Vijayalaxmi	$BaSO_4$	77.14	Valuable Mineral	68.88	$BaSO_4$	95.45	$BaSO_4$	85.00	Flotation at a grind of 97% 325 mesh & Sod. Oleate as collector
		SiO_2	15.74	Barytes		SiO_2	2.70			
		Fe_2O_3	2.33	Gangue						
		Al_2O_3	2.73	Quartz						

Sl. No.	Title of Investigation	Original Assay %		Mineralogy	Wt%	Concentrate Assay %		Recovery %		Process adopted
	pit No.2 gray barytes mine Mangampet area Cuddapah Dist., A.P.									
7.	Recovery of barytes from the tailings obtained after bulk flotation of sulphides from calc silicate sample from Dariba-Rajpura, Rajasthan (Hindustan Zinc Ltd.)	$BaSO_4$ $BaCO_3$ Pb Zn SiO_2 Fe Al_2O_3	9.02 5.30 2.25 10.26 40.70 8.04 1.28	Valuable Mineral Barytes & Whiterite Gangue Sohalarite pyrite galena calcite	6.04	$BaSO_4$ $BaCO_3$	34.89 6.53	$BaSO_4$	53.92	Flotation at grind of 89% 200 mesh Sod.Oleate & Sod. Petroleum sulfonate as reagents

Sl. No.	Title of Investigation	Original Assay %		Mineralogy	Wt%	Concentrate Assay %		Recovery %		Process adopted
8.	Recovery of barytes from the tailings obtained after bulk flotation of sulphides from calc silicate graphite-mica-chist (85:15) mixed sample from Dariba-Rajhara mines, Rajasthan (Hindustan Zinc Ltd.)	$BaSO_4$	5.09	Valuable Mineral	2.09	$BaSO_4$	74.79	$BaSO_4$	30.78	Flotation
		$BaCO_3$	3.02	Barytes &		$BaCO_3$	11.57			
		Pb	1.98	Whiterite						
		Zn	10.66	Gangue						
		SiO_2	42.44	Sphalarite pyrite						
		Fe	9.68	gelena quartz						
		Al_2O_3	2.34	& calcite						
9.	Beneficiation of barytes sample from Madurai, Tamil Nadu for use in chemical industry	$BaSO_4$	88.55	Valuable Mineral	77.25	$BaSO_4$	98.00	$BaSO_4$	86.09	Flotation at a grind of 85.7% 200 mesh with lactic acid Sod. Oleate & pineoil as reagents
		SiO_2	5.40	Barytes		Fe_2O_3	0.28			
		Fe_2O_3	2.00	Gangue		SiO_2	0.32			
		CaO	0.57	Quartz, Mica						
		MgO	0.32	limonite						

Sl. No.	Title of Investigation	Original Assay %		Mineralogy	Wt%	Concentrate Assay %		Recovery %		Process adopted
	(for Travancore Chemical Manufacturing Co. Ltd.)									
10.	Beneficiation of a low grade barytes sample from Satter barytes mine, Mangampet area, Cuddapah Dist., A.P.	$BaSO_4$ SiO_2 Fe_2O_3 Al_2O_3 Sp.Gr.	78.20 12.35 2.11 4.40 3.90	Valuable Mineral Barytes Gangue Quartz,clay & limonite	76.55	$BaSO_4$ Fe_2O_3 SiO_2 Sp.Gr.	94.23 0.81 3.10 4.22	$BaSO_4$	92.24	Flotation at a grind of 90% 325 mesh with Sod.Oleate as collector.
11.	Recovery of barytes from a lead-zinc ore sample of Rajpura-Dariba mines, Rajasthan	$BaSO_4$ $BaCO_3$ Fe SiO_2 Al_2O_3 CaO	7.62 4.18 2.76 50.26 6.25 6.69	Valuable Mineral Barytes quartz,calcite amphibole & dolomite	8.8	$BaSO_4$ $BaCO_3$	88.09 5.06	$BaSO_4$	61.8	Flotation at a grind of 84% 200 mesh with Sod. Petroleum sulfonate as collector

Sl. No.	Title of Investigation	Original Assay %		Mineralogy	Wt%	Concentrate Assay %		Recovery %		Process adopted
	(for HZL.)	MgO	3.00							
		Pb	1.78							
		Zn	6.92							
		Cu	0.09							
		S	10.75							
12.	Pilot Plant beneficiation studies on a low grade barytes sample from, Mangampet area, Cuddapah Dist., A.P. (for Gimpex Pvt. Ltd., Madras)	$BaSO_4$	74.45	Valuable Mineral Barytes	38.2	$BaSO_4$	97.97	$BaSO_4$	48.9	Flotation
		SiO_2	18.17	Gangue						
		FeO	0.07	Quartz, clay						
		Fe	1.27	limonite						
		Al_2O_3	3.47							