(7) GYPSUM AND SELENITE

Gypsum and Selenite have the same chemical composition but differ in crystallisation habit. Selenite is usually crystalline and the association of the impurities is superficial which are eliminated by washing. Gypsum is fine grained in nature and is beneficiated by flotation only. Both the minerals find extensive use in the fertilizer industry and a minor quantity in the manufacture of plaster of paris and cement industry.

Beneficiation studies at N.M.L.

A Selenites

Two selenite samples from Rajasthan were received from M/s. Bikaner Gypsums Ltd., Calcutta, for the reduction of the insolubles in the samples.

Sample No. 1

The sample was composed of crystalline selenite which was usually white and transparent. Occasionally grey colour crystals were also observed and had a fine coating of clay. The sample was to be upgraded for the manufacture of plaster of paris. Complete chemical analysis of the sample was as follows :

Constituent	*Assay %*
SO_3	45.20
CaO	31.80
H_2O	20.60
CO_2	0.48
SiO_2	0.44
Al_2O_3	0.85
NaCl	0.50
Fe_2O_3	0.15
L.O.I.	22.50
Alkalies & MgO	Trace

Soaking of the sample in selenite saturated water and washing with ROM sample, increased the grade to 45.45% SO_3 with 99.2% SO_3 distribution.

Similar tests conducted at 10 mm size yielded a product analysing 45.65% SO_3 and 0.31% insolubles with 97.7% SO_3 distribution in it. Soaking and washing at —10 mesh size produced a concentrate assaying 46.10% SO_3 but the recovery was 91.6% SO_3 only. Further improvement may be achieved if the sample is ground further before washing and desliming.

Sample No. 3

The sample was received from M/s. Bikaner Gypsums Ltd., for batch and pilot plant scale investigations. Complete chemical analysis of the sample was as follows :

Constituent	*Assay %*
SO_3	45.16
CaO	31.71
Fe_2O_3	0.32
Al_2O_3	0.08
SiO_2	0.97
Insolubles	1.06
Moisture	0.12
Combined H_2O	19.50
CO_2	0.29
LOI	20.86
MgO	Nil
NaCl	Trace

Soaking and washing tests with the ROM sample reduced the insolubles to 0.73% with 68% insoluble distribution in it. Similar tests conducted at 19 mm, 10 mesh and 20 mesh sizes respectively yielded concentrates analysing 0.64% in-sol. with 61% distribution, 0.64% in-sol. with 54.3% distribution and 0.4% in-sol. with 20.9% distribution in it respectively. As the results warranted for washing at finer size, 19 mm washed lump were ground to 10 mesh and 20 mesh and washed again where in the concentrates analysed 0.54% in-sol. and 0.41% in-sol. with in-sol. distribution of 44.5% and 27.2% respectively. Based on the batch scale results

it was concluded and pilot plant scale tests were conducted with two stage washing i.e. washing the ore after crushing to 19 mm size followed by regrinding to 20 mesh and washing again.

In the pilot plant run the ROM ore was crushed to 19 mm size, scrubbed in a gravel washer and then the slimes were separated in a rake classifier. The classifier underflow which contained the lumps was ground in a continuous ball mill to 20 mesh size and washed in a spiral classifier where in the selenite sand and slimes were separated. The slimes i.e. classifier overflow was further treated in a hydro-classifier to recover some more sand which was combined with the classifier sand. The combined sand product obtained from spiral classifier and hydro-classifier analysed 0.41% insolubles with 29.6% in-sol. distribution. The product is quite suitable for the plaster of paris industry.

Sample No. 2

A low grade selenite sample drawn from Thobo area in Baramer Dist., Rajasthan was received from the Director State Mining & Geology for beneficiation studies. The final concentrate should be suitable for the manufacture of surgical grade of plaster of paris. Complete chemical analysis of the sample was as follows :

Constituent	*Assay %*
SO_3	27.54
CaO	28.02
MgO	2.34
H_2O	13.17
SiO_2	12.28
Al_2O_3	3.69
CO_2	4.74
Alkalies	1.33

Examination of the sample indicated the presence of large amount of clay which was actually responsible for the poor grade of the selenite.

Dry screening tests with the ROM sample as well as 19 mm crushed sample after removing the —10 mesh fines respectively analysed 30.77% SO_3 with 96.5% SO_3 distribution and 33.7% SO_3 with 90.3% SO_3 distribution in them.

Washing tests with ROM sample yielded a concentrate analysing 45.36% SO_3 with 97.2% SO_3 distribution in it. Soaking, scrubbing and washing tests with ROM sample yielded a concentrate assaying 45.77% SO_3 and 0.6% in sol. with 91.8% SO_3 distribution. Similar test with 19 mm crushed sample produced a concentrate analysing 46.16% SO_3 and 0.32% in-sol. with 90.1% SO_3 distribution in it.

Continuous semi-pilot plant scale tests with 19 mm crushed ore incorporating scrubbing, and washing produced a washed selenite concentrate assaying 45.5% SO_4 with 87.6% SO_3 distribution in it.

B Gypsum

Six different samples of gypsum from different areas in Rajasthan and having different analysis were received from M/s. Bikaner Gypsums Ltd. In the first batch four samples were there and two different samples subsequently.

Batch No. 1

Four samples were received in this batch from Jamsar area and their complete chemical analysis was so follows :

Constituent	*Assay %*			
Sample No.	1	2	3	4
SO_3	32.84	37.15	38.55	36.56
CaO	28.83	29.19	32.73	29.78
Combined H_2O	14.83	16.40	17.66	16.70
Free H_2O	0.68	0.45	0.46	0.50
CO_2	2.43	3.11	3.98	3.17
SiO_2	14.37	8.98	4.32	8.95
Al_2O_3	3.84	2.34	0.85	1.85
Fe_2O_3	1.08	0.66	0.63	0.86
MgO	0.80	0.89	0.82	1.03
NaCl	0.01	0.01	0.01	0.01
Insolubles	19.23	11.99	5.23	11.37

Microscopic examination of the samples indicated the presence of crystalline aggregates of gypsum. The gangue was composed of quartz followed by hornblende, calcite, clay and occassionally occurring garnet, magnetite and celestite. Gypsum was liberated from the gangue below 14 mesh size.

Heavy media separation tests to separate the silicates as heavy portion conducted with the —10 mesh sized portions indicated that upto —48 mesh size, there were no separate silicates and

the grade of the products was always over 40% SO_3. Sink product obtained in +65 and +100 mesh portions was very little (less than 0.5%) in each portion. Float portions obtained from 100 mesh and below sizes analysed were of poorer grade. It was concluded from the overall test results that by discarding the —150 mesh fines from the 10 mesh ground product would produce 87% gypsum grade with recoveries ranging from 85-90% SO_3.

Hydro-classification of the —10 mesh sample of the four samples yielded sand portions analysing 38.0% SO_3 with 81.3% SO_3 distribution, 40.76% SO_3 with 85.5% SO_3 distribution, 40.01% SO_3 with 80.6% distribution and 40.37% SO_3 with 82.2% SO_3 distribution. If the coarser sand portion was only taken, the analysis would be 40-43% SO_3 with 40 to 46% SO_3 distribution in it. Hence hydro-classification method was considered helpless for the production of fertilizer grade of gypsum concentrate.

Flotation tests with the —150 mesh fines obtained from —10 mesh crushed product with 0.25 kg/tonne of sod. oleate produced concentrates analysing 45.51%, 45.55%, 45.81% and 45.06% SO_3 with recoveries 70.1%, 83.1%, 85.5% and 66.3% respectively for samples No. 1, No. 2, No. 3 & No. 4.

Flotation test conducted with —10 mesh sample ground to 100 mesh using amines to float the deslimed silicates and leaving gypsum in the tailing produced a gypsum concentrate analysing 44.57% SO_3 with 85.6% SO_3 distribution in it.

Sample No. 5

A low grade amorphous gypsum was received for beneficiation studies. It composed of fines of which 80% pass the 10 mesh screen. Complete chemical analysis of the sample was as follows:

Constituent	*Assay %*
SO_3	37.71
CaO	29.70
CO_2	2.80
SiO_2	7.80
Al_2O_3	2.24
FesOs	0.36
MgO	1.17
NaCl	0.01
Combined H_2O	16.94
Insolubles	10.58

Mineralogical examination of the sample indicated that crystalline aggregates of gypsum were associated with quartz and calcite followed by minor amounts of micas, hornblende chlorite, tourmalene, garnet and clay minerals. Quartz was liberated at 65 mesh size and the test of the gangue at 100 mesh size.

Chemical analysis of the sieve products revealed that the product coarser to 100 mesh analysed 41.3% SO_3 with 79.57% SO_3 distribution in it. Portions finer that 100 mesh analysed about 26% SO_3 with 20.5% SO_3 distribution in it, indicating the seggregation of the silicates insolubles in the —100 mesh portions.

Rougher flotation with —150 mesh portion from the sample with 0.5 kg/tonne of sod. silicate followed by two cleanings produced a concentrate assaying 43.62% SO_3 with 54.9% distribution (w.r.t. —150 mesh portion of the r.o.m.) in it. Rougher flotation tests with 1.5 kg/tonne NaOH, 1.0 kg/tonne of sod. silicate, 1.25 kg/tonne of sod. oleate and 0.05 kg/tonne of pine oil, followed by four cleanings produced a concentrate 44.85% SO_3, 0.54% insol. with 87.3% SO_3 distribution in it.

Sample No. 6

The sample was of amorphous nature, containing almost all fines and occasional lumps upto 80 mm in size. Complete chemical analysis of the sample was as follows:

Constituent	*Assay %*
SO_3	36.05
CaO	28.90
CO_2	2.95
SiO_2	8.22
Al_2O_3	1.85
Fe_2O_3	0.50
MgO	2.10
Combined H_2O	16.33
Insolubles	10.40

Microscopic examination indicated the presence of considerable amount of calcareous matter along with small quantities of quartz, and small crystals of selenite were also observed. Quartz was liberated at 65 mesh size, but the calcite, being the cementing medium for the gypsum grains, was not liberated at even at 200 mesh size.

Rougher flotation tests with 80.7% —200 mesh grind using 1.0 kg/tonne sod. silicate, 1.0 kg/tonne of oleic

acid emulsion, and 0.12 kg/tonne of pine oil, followed by two cleanings with 0.5 kg/tonne of sod. silicate yielded a concentrate analysing 45.5% SO_3, 0.75% insolubles with 58.6% SO_3 distribution. When 1.0 kg/tonne NaOH in the roughing stage, and 0.5 kg/tonne of NaOH in the cleaning stages of the above test; the final concentrate analysed 45.44% SO', 0.7% insolubles with 69.4% SO_3 distribution in it. When this concentrate was cleaned once more i.e. with a total of three cleanings, the product analysed 46.3% SO_3 and 0.55% insol. with 43.4% SO_3 distribution in it.

Gypsum from Nagaur Mines:

The sample was received from the Rajasthan State Industrial and Mining Development Corporation Ltd., for beneficiation and consisted of 125 mm lumps and fines. The sample had the following chemical analysis:

Constituent	*Assay %*
SO_3	36.89 (79.3% gypsum)
CaO	28.76
CO_2	3.33
SiO_2	11.36
Al_2O_3	1.03
NaCl	0.06
MgO	1.50
Fe_2O_3	0.26
Combined water	16.67
Acid insolubles	12.53

Mineralogical examination revealed the presence of calcareous matter as cementing medium for the gypsum grains and quartz. Minor amounts of clay was also observed. Gypsum was liberated at 150 mesh size.

Flotation tests were conducted with a grind passing 93% —200 mesh using 1.5 kg/tonne of sodium silicate as dispersant for silicates and 0.9 kg/tonne of oleic acid emulsion as collector for gypsum. The concentrate thus obtained analysed 45.3% SO_3 with 81.9% SO_3 distribution in it. When 0.8 kg/tonne of soduim hydroxide was used as a dispersant for the clayey matter, the tailing losses were reduced. When the concentrate was cleaned twice, the final concentrate analysed 46.3% SO_3 (99.4 gypsum) with 72.5% SO_3 distribution in it. Use of Katha (Tannin extract) did not show any improvement over the grade.

The consolidated results of the above samples are given in table No. 47.

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4. Beneficiation of Gypsum sample from Jamsar Mines, Rajasthan. NML. IR. NO. 107/57.

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6. Beneficiation of gypsum samples from Jamsar Mines, Rajasthan. NML. IR. NO. 290/64.

   By S.K.Banerjee, G.V.Subrahmanya & P.I.A. Narayanan.

7. Bench scale beneficiation studies on gypsum sample from Nagaur Mines, Rajasthan. (received from RSIMD CO.) NML. IR. NO. 821/75.

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TABLE 5.6—BENEFICIATION RESULTS OF SELENITE AND GYPSUM

State & Locality	ROM sample Assay %	Beneficiation method	Concentrate Assay %	Concentrate Recovery %	Remarks
Rajasthan:					
I. Selenite I	45.20 SO_3	Washing and desliming at 10 mesh size	46.10 SO_3 0.31 insol.	91.6 SO_3 —	
Baramer Selenite II	27.54 SO_3	Washing & desliming at 19 mm size.	46.16 SO_3 0.32 insol.	90.1 SO_3	
Selenite III	45.16 SO_3	Washing at 19 mm followed by regrinding to 20 mesh and washing.	0.41 insol.	29.6 insol.	Medical grade concentrate for Plaster of Paris
II. Gypsum I	32.84 SO_3 19.23 insol.	Grinding to 10 mesh and rejecting —100 mesh fines	40.70 SO_3	85.0 SO_3 15.4 insol.	
		Flotation of fines rougher fotation followed by two cleanings.	45.51 SO_3 0.37 insol.	70.1 SO_3	
Gypsum II	37.15 SO_3 11.99 insol.	,,	41.8 SO_3	83.6 SO_3	
		,,	45.55 SO_3 0.83 insol.	83.1 SO_3	
Gypsum III	38.55 SO_3 5.23 insol.	,,	40.70 SO_3 46.0 SO_3 0.23 insol.	78.9 SO_3 71.4 SO_3	
Gypsum IV	36.56 SO_3 11.37 insol.	,,	41.2 SO_3 45.06 SO_3 0.43 insol.	82.3 SO_3 66.36 SO_3	
Gypsum V	37.71 SO_3	Screening on 150 mesh screen followed by flotation of the —150 mesh fines with four cleanings.	44.85 SO_3 0.54 insol.	87.3 SO_3	
Gypsum VI	36.06 SO_3	Rougher flotation followed by 3 cleanings.	46.3 SO_3 0.55 insol.	43.4 SO_3	
III. Gypsum from Nagaur	36.89 SO_3 11.36 SiO_3 1.03 Al_2O_3	**Flotation:** Grind 93% —200 mesh 1.5 kg/ton. sod. silicate 0.9 kg/ton. oleic acid emulsion three cleanings.	46.3 SO_3	72.5 SO_3	

PRECIOUS METALS

A Recovery of precious metals from Drosses:

Two samples of dross marked 'A' and 'B' were received from M/s. Andheri Metal Refinery and Foundry, Bombay for the recovery of gold and silver.

Sample-A

The sample was reported to be the table tailing of silver dross and had the following analysis.

Constituent	*Assay %*
Pb	22.00
Cu	0.98
Ag	35.8 oz/ton.

Gravity methods of separation could not be tried with the sample as it was too fine. Cyanidation tests did not produce satisfactory results. Hence it was recommended to test the sample in a lead smelter for the recovery of lead and silver.

Sample-B

The sample consisted of slag particles, graphitic material and clay the last two being derived from the crucibles used for the melting of the precious metals. Examination of the panned concentrate under microscope revealed the presence of prills or mots of gold-silver alloy. The dross was composed of fines finer than 28 mesh size.

The sample analysed 13.68 dwt/ton of Au and 10.8 oz/ton of silver.

Tabling tests with 100 mesh feed yielded a concentrate analysing 386 dwt/ton of gold and 50.2 oz/ton of silver with 42.5% Au distribution. Additional 33.1% Au was recovered by cyanidation of the table tails for 48 hours.

Cyanidation tests at −65 mesh size yielded a residue assaying 4.6 dwt/ton of Au and 5.49 oz/ton of Ag with 66.4% Au distribution. At 100 mesh and 200 mesh size the Au assay was 5.8 dwt and 7.8 dwt/ton but the Au distribution was 57.6 and 43.0% respectively. Ag analysis was 5.64 oz and 6.00 oz/ton respectively. The Au assay did not improve with the fineness due to the interference of graphite particles.

Addition of diesel oil has improved the Au recoveries in − 100 mesh and − 200 mesh feed to 64.9% and 62.0% respectively. Au recovery in −65 mesh feed remained 66.4%.

Beneficiation Studies on Precious Metals

Roasting followed by cyanidation for 48 hrs. tests with −100 mesh feed yielded a residue assaying 2.6 dwt/ton Au and 1.04 oz/ton Ag with 81.0% Au distribution.

Flotation tests conducted to eliminate graphite indicated 42.7% of total Au in the graphite concentrate. Flotation tests with −200 mesh feed using 0.05 kg/tonne each of aerofloat 608 and Aeroxanthate 301 yielded a concentrate assaying 56.23 dwt/ton Au with 73.7% Au distribtuion in it. Additional 11.3% Au was recovered from the flotation tailings by cyanidation totalling to 85.0% of Au. The consumption of cyanide was 0.75 kg/tonne of dross.

B Improvement of gold recovery from Nandydroog gold ore:

The sample was almost 200 mesh in size and represented the feed to the cyanidation plant at KGF. Mineralogical examination both under transmitted light and incident light indicated the presence of pyrrhotite, arsenopyrite, chalcopyrite and traces marcasite and pyrite in the matrix of quartz. Small veins of natural gold were found in the siliceous grains and fine particles of gold in arsenopyrite. Hornblende, chlorite and biotite were the non-metallic gangue present in the ore. Complete chemical analysis of the sample was as follows:

Constituent	*Assay %*
Au	2.30 dwt/ton
Total S	2.90
Sulphate S	0.42
Fe	13.30
Al_2O_3	7.60
SiO_2	55.50
CaO	7.80
MgO	4.30
Ag	0.41
LOI	2.90
Pb, Zn & Cu	Trace

Cyanidation tests employing 0.27 kg/tonne of NaCN and 0.85 kg/tonne of CaO resulted in a residue assaying 0.3 dwt/ton of gold with 94.6% Au recovery in solution.

Magnetic separation to separate pyrrhotite, followed by flotation of arsenopyrite and cleaning tests with cyanidation residue yielded a concentrate assaying

4.8 dwt/ton. Au with an additional 3.3% Au recovery w.r.o. sample.

Magnetic separation followed by tabling of the cyanidation residue yielded a combined concentrate assaying 2.65 dwt/ton Au with 3.5% Au. distribution. The residue obtained after cyanidation from Nandydroog plant analysed as follows:

Constituent	*Assay %*
Au	0.54 dwt/ton
As	0.40
Total S	3.10
Sulphate S	0.47
Fe	13.60
Al_2O_3	6.80
SiO_2	56.10
CaO	7.00
MgO	4.60
LOI	2.70
Cu, Pb & Zn	Trace

Cyanidation tests with the sample with 0.27 kg/tonne of NaCN for 17 hrs. reduced the Au content of the residue from 0.54 dwt/ton to 0.27 dwt/ton with 50% Au recovery w.r.t. feed. Tabling tests with sample yielded a concentrate assaying 3.6 dwt/ton Au with 47.4% Au distribution w.r.t. feed.

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