

RESEARCH & DEVELOPMENT



# Indian Minerals Yearbook 2016

(Part-I : General Reviews)



**55<sup>th</sup> Edition**

**RESEARCH & DEVELOPMENT**

**(FINAL RELEASE)**

**GOVERNMENT OF INDIA  
MINISTRY OF MINES  
INDIAN BUREAU OF MINES**

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# 5 Research & Development

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The Science and Technology (S&T) programmes of the Ministry of Mines, Government of India, cover the disciplines of Geology, Exploration, Mining, Beneficiation and Mineral Processing, Rock Mechanics, Ground Control and Non-ferrous Metallurgy and Environmental issues related to Mining and

Metallurgy. A meeting was held on 16.07.2016 by Project Evaluation and Review Committee (PERC). Based on Committee's scrutiny report, Standing Scientific Advisory Group (SSAG) in its 47<sup>th</sup> meeting considered and recommended Grant-in-Aid under S&T programme of the Ministry of Mines. The 47<sup>th</sup> SSAG has approved the projects, and summary of the same is given below:

### Summary of Projects Approved by 47<sup>th</sup> SSAG as on 23<sup>rd</sup> Aug. 2016

Title	Institution	Financial Outlay & Duration
i) Geological studies of Archaean greenstone belts of Aravalli craton NW Indian Shield: Implication for crustal evolution & economic Potential.	Aligarh Muslim University, Aligarh	Total Budget ₹ 22.321 lakh, Duration 2 years.
ii) Large scale digital database creation of bauxite & laterite deposits of Maharashtra state using geo-information technology.	JNARDDC & MRSTC, Nagpur	Total Budget ₹ 69.5484 lakh, Duration 2 years JNARDDC ₹ 43.8234 lakh MRSTC: ₹ 25.725 lakh.
iii) Development of environment friendly blasting technique.	Indian School of Mines, Dhanbad	Total Budget ₹ 29.04 lakh, Duration 3 years.
iv) Postural risk analysis of Mining equipment operators and its relation to musculoskeletal disorders.	National Institute of Miners' Health, Nagpur	Total Cost ₹ 37.66 lakh, Duration 2 years.
v) Effect of modified seed properties in precipitation of aluminium hydroxide from Bayer liquor.	JNARDDC, Nagpur	Total Budget ₹ 44.99 lakh, Duration: 2 years.
vi) Development of eco-friendly bio-based reagents for mineral flotation.	Institute of Minerals & Materials Technology Bhubaneswar (IMMT).	Total Budget ₹ 24 lakh, Duration 2 years MoM Rs. 12 lakh CSIR Co-Funding ₹ 12 lakh MoM funds to be released in two equal installments of ₹ 6 lakh subject to proof of co-funding by CSIR
vii) Extraction of potash values from silicate rocks.	Indian Institute of Technology, Roorkee	Total Budget ₹ 20.0 lakh, Duration 2 years.
viii) Technology Development (TRL-7) for calico-thermic reduction of RE metal oxides & establishment of pilot plant for extraction and purification of samarium	Non Ferrous Materials Technology Development Centre, Hyderabad	MoM ₹ 186.5 lakh NFDTC: ₹ 150 lakh. Duration: 2 years.

The SSAG in addition to above approved projects not approved/deferred the following projects.

## RESEARCH & DEVELOPMENT

### Summary of Projects Not Approved by 47<sup>th</sup> SSAG as on 23<sup>rd</sup> Aug. 2016

Title	Institution	Financial Outlay & Duration (Approved/Not Approved)
i) Design of Eco-friendly Thickened tailings slurry pipelines for surface disposal and mine backfilling system.	IMMT Bhubaneswar	Not Approved
ii) Estimation of morpho dynamicity and its remedial action using red-mud based concrete at coastal zone of Eastern Odisha.	JNARDDC KIIT NALCO	Deferred PIs want to recast and submit to next PERC based on feedback given by PERC and SSAG.

## BENEFICIATION

The highlights of work carried out during 2015-16 by IBM and JNARDDC relating to mineral beneficiation and mining & environment are given below:

### 1. IBM

#### 1.1 Copper Ore

***Bench scale beneficiation studies on a bore hole copper ore sample from Thanewana block, Chandrapur district, Maharashtra (for M/s Mineral Exploration Corp. Ltd):*** A bore hole copper ore sample from Thanewana block Chandrapur district, Maharashtra was received through M/s Mineral Exploration Corp. Ltd for conducting bench scale beneficiation studies at the Modern Mineral Processing Laboratory and Pilot Plant of Indian Bureau of Mines, Nagpur. The as received sample assayed 0.53% Cu, 4.25% Fe(T), 78.01% SiO<sub>2</sub>, 5.43% Al<sub>2</sub>O<sub>3</sub>, 0.32% CaO, 2.11% MgO, 1.52% S, 0.162% P<sub>2</sub>O<sub>5</sub>, 0.189% TiO<sub>2</sub>, 0.367% K<sub>2</sub>O, 0.088% MnO<sub>2</sub>, 0.165% BaO and 83.82% acid insoluble. The beneficiation process adopted was froth flotation. Flotation tests were conducted using Sodium isopropyl Xanthate (SIPX), Methyl isobutyl Carbinol (MIBC) as a frother and Lime as a pH modifier. Flotation test at 87.1% - 200 mesh grind at a pH of 10.5 yielded a copper concentrate assaying 20.88% Cu, 7.80% SiO<sub>2</sub> and 8.08% acid insoluble with copper recovery of 90.9 percent and weight percent yield of 2.3.

#### 1.2 Iron Ore

***Beneficiation on an Iron ore sample from Kalane Iron Ore mines, Goa for M/s Samruddha Resources Limited, Mumbai :*** An Iron ore sample from Kalane mines, Goa was received from M/s Samruddha Resources Limited, Mumbai for beneficiation studies at Regional Mineral Processing Laboratory, Indian Bureau of Mines, Bengaluru. The objectives of the test work are to upgrade the ore to > 57% Fe(T) with maximum Fe(T) recovery and to develop a process flow sheet.

The as received sample assayed 55.52% Fe(T), 6.65% SiO<sub>2</sub>, 1.36% Al<sub>2</sub>O<sub>3</sub>, 0.37% CaO, 0.03% MgO, 0.07% Na<sub>2</sub>O, 0.05% K<sub>2</sub>O, 2.98% Mn, 0.20% TiO<sub>2</sub>, 0.01% P and 10.37% LOI.

By simple process of scrubbing, screening followed by tabling of the ground fraction minus 6.25 mm+150 mesh yielded a final concentrate assaying 58.15% Fe(T), 3.11% SiO<sub>2</sub>, 1.61% Al<sub>2</sub>O<sub>3</sub>, 2.76% Mn and 10.15% LOI with 81.30% Fe(T) recovery (wt.% yield 78.10).

The concentrate meets the specification stipulated by the party.

### 1.3 Glauconite

***Beneficiation studies on a glauconite sand stone sample, Shale of Vindhyan Super Group from Kurchha – Barwadih Area, Sonbhadra district, Uttar Pradesh for G.S.I. Northern Region, Lucknow:*** A Glauconite sand stone sample from Sonbhadra district, U.P. was received at the Modern Mineral Processing Laboratory and Pilot Plant, Indian Bureau of Mines, Nagpur for conducting beneficiation tests. The objective of the study was to enrich Glauconite mineral present in the sample so as to explore the utility of indigenous glauconitic sand as potash fertilizer. The as received sample assayed 2.85 %  $K_2O$ , 3.65%  $Fe_2O_3$ , 7.88%  $Al_2O_3$ , 78.52%  $SiO_2$ , 1.20%  $CaO$ , 1.65%  $MgO$ , 0.10%  $Na_2O$ , 0.20%  $TiO_2$ , 0.20%  $F$  and 2.49%  $LOI$ . Mineralogical studies reveal that the sample consists mainly of quartz (~60%) with subordinate amount of glauconite (~20%) and minor amounts of feldspar (~10%) and mica (muscovite, biotite) (6-8%). Very minor amounts goethite/limonite (2-3%) and carbonate (calcite) (1-2%) and traces of haematite and clay. The sample was crushed to minus 10 mesh and stage ground in a rod mill to all passing 30 mesh and ground product was screened at 100 mesh. The - 30 + 100 mesh fraction was subjected to attrition scrubbing and scrubbed product was screened over 100 mesh. The screened +100 mesh fraction was dried and subjected to dry high force magnetic separation at 16 kilogauss to get magnetic and non-magnetic fraction. The composite concentrate of magnetic fraction and scrubbed slime assayed 4.20 %  $K_2O$ , 5.19%  $Fe_2O_3$ , 13.93%  $Al_2O_3$ , 67.34%  $SiO_2$  and 4.06%  $LOI$  with a  $K_2O$  recovery of 70.7% and weight percent yield of 48.9. This suggests that wet process involving stage grinding, screening, attrition scrubbing and dry high force magnetic separation could yield a glauconite concentrate with a reasonably good recovery. The sample is amenable for beneficiation.

### 1.4 Rock Phosphate

***Bench scale beneficiation studies on a low grade rock phosphate sample from a mine in Meghnagar, district Jhabua, Madhya Pradesh for M/s. Samruddha Resources Ltd, Mumbai, Maharashtra:*** A low-grade complex siliceous & magnesia rich rock phosphate ore sample from Madhya Pradesh was taken up for bench scale beneficiation studies with the objective to develop a process flow sheet to produce phosphate concentrate suitable for manufacture of phosphoric acid. Mineralogical studies revealed the presence of apatite, quartz, dolomite and calcite as main minerals and chemically assayed 17.26%  $P_2O_5$ , 33.15% Acid Insol., 32.65%  $SiO_2(T)$ , 3.52%  $MgO$  and 30.61%  $CaO$ .

Beneficiation studies evolved a process flow sheet comprising of ball mill wet grinding to  $d_{80}$  size 61 microns, to liberate phosphate from gangue minerals, with addition of sodium silicate in the mill as silica depressant. Single stage rougher phosphate-carbonates bulk flotation, at pH 10-11, using anionic collector sodium oleate could yield bulk rougher phosphate-carbonate float and discard quartz and silicate minerals in the rougher tails forming reject. Three cleanings of rougher phosphate-carbonate bulk float, at pH 10, followed by reverse flotation of the III cleaner bulk float for separation of phosphate from carbonate at pH 5-6 using sulphuric acid as pH modifier, ortho-phosphoric acid as phosphate depressant and pine oil as frother could yield a phosphate concentrate assayed 32.66%  $P_2O_5$ , 9.77% Acid insoluble, 9.42%  $SiO_2(T)$ , 0.65%  $MgO$ , 1.11%  $Fe_2O_3$ , 0.62%  $Al_2O_3$ , 1.73%  $R_2O_3$  ( $Fe_2O_3+Al_2O_3$ ), 47.34%  $CaO$ , 3.29%  $F$  and 4.32%  $LOI$  with phosphate recovery of 63.1% and weight % yield of 33.1. The study reflects the importance of beneficiation studies in producing a phosphate concentrate suitable for phosphoric acid manufacture in view of utilisation of low grade and complex ores.

## 1.5 Silica Sand

### ***Bench scale beneficiation studies on a silica sand sample from Bharatpur, Rajasthan for M/s LSC Infratech Pvt Ltd:***

A silica sand sample from Bharatpur, Rajasthan was received through M/s LSC Infratech Pvt. Ltd at Regional Mineral Processing Laboratory, Indian Bureau of Mines, Ajmer for conducting bench scale beneficiation studies. The objective of the beneficiation test was to investigate the amenability of the sample for removal of impurities mainly iron and alumina contents.

The as received sample assayed 98.31% SiO<sub>2</sub>, 0.22% Fe<sub>2</sub>O<sub>3</sub>, 0.42% Al<sub>2</sub>O<sub>3</sub>, 0.21% CaO, 0.18% MgO, 0.12% Na<sub>2</sub>O, 0.08% K<sub>2</sub>O, 0.43% LOI.

By adopting the beneficiation test involving attrition scrubbing followed by sieving and perm roll Magnetic separation, the non-magnetic fraction assaying 99.13% SiO<sub>2</sub>, 0.062% Fe<sub>2</sub>O<sub>3</sub>, and 0.22% Al<sub>2</sub>O<sub>3</sub> with a 78.20% SiO<sub>2</sub> recovery (wt. yield 77.40).

The non-magnetic fraction meets the specification of Silica sand grade-II for the glass sand industry.

## 2. JNARDDC

***2.1 Setting up of mini-pilot plant for red mud based light weight foamed bricks for NALCO:*** Under the seven nations Asia Pacific Partnership on Clean Development and Climate (AP-7) JNARDDC, as the nodal agency from India successfully completed the project entitled "Management of bauxite residue/red mud" in Nov. 2009. The Centre developed a bench scale process for Development

of Glass Ceramics and light weight aggregates - Foam Products by utilising red mud, an industrial waste funded by NALCO. The Centre along with NALCO has already filed joint patent for the above two innovative processes.

With a view to scale up the activity to the next level and attract prospective entrepreneurs, JNARDDC set up the Mini pilot/demo plant at NRTC, NALCO.

***2.2 Upgradation & utilisation of laterite of east and west coast deposits:*** Under this project, Centre undertook detailed study of various techniques for beneficiation and optimisation of different process parameters for reduction of iron, silica content as well as increase alumina in the laterite.

Among beneficiation techniques employed, hydrocyclone, magnetic separation and flotation techniques were found to be most effective. Reduction of iron content by 25-35% and silica content by almost 15% could be achieved. The beneficiation studies indicate that iron content can be reduced substantially from ferruginous laterite which shall lead to increase in alumina percentage.

JNARDDC has suggested the optimised process parameters for upgradation of laterite in the report. This can be blended with good quality bauxite for alumina production. As a result, the life of mines as well as supply position of low grade raw material may appreciably be increased, thereby, leading to optimum utilisation of laterite which is lying as a waste at mine site.

## R&D FOR RECOVERY AND UTILISATION OF WASTES

### 1. IBM

#### 1.1 Iron Ore

***Beneficiation studies on an Iron ore dump sample from Subbarayanahalli mines, Sandur taluka, Bellary district, Karnataka for M/s Mysore Minerals Ltd Bengaluru:*** An Iron ore dump sample from Subbarayanahalli mines, Sandur taluka, Bellary district, Karnataka was received from M/s Mysore Minerals Ltd for beneficiation studies at Regional Mineral Processing Laboratory, Indian Bureau of Mines, Bengaluru. The objectives of the test work are to develop a process flow sheet to produce pellet grade concentrate.

The as received sample assayed 52.92% Fe(T), 7.43% SiO<sub>2</sub>, 8.72% Al<sub>2</sub>O<sub>3</sub>, 0.09% CaO, 0.02% MgO, 0.07% Na<sub>2</sub>O, 0.05% K<sub>2</sub>O, 0.20% Mn, 0.81 TiO<sub>2</sub>, 0.02% P, 0.19% S and 6.45% LOI.

The sample was subjected to gravity concentration by tabling yielded the combined concentrate (Table conc. I+II+III) assaying 64.30% Fe(T), 2.72% SiO<sub>2</sub>, 2.69% Al<sub>2</sub>O<sub>3</sub> and 3.49% LOI with 50.90% Fe(T) recovery (wt.% yield 41.90).

The concentrate meets the specification as stipulated by the party.

#### 1.2 Manganese Ore

***Bench scale beneficiation studies on manganese ore sample from black dump rejects of Ukwa manganese mines for MOIL:*** A Manganese ore sample from black dump reject of Ukwa mines, district Balaghat was received at the Modern Mineral Processing Laboratory and Pilot Plant,

Indian Bureau of Mines, Nagpur with a view to assess the possibility of upgradation of the ore for end industrial use. The as received sample assayed 8.02 % Mn, 2.61% Fe (T), 75.41% SiO<sub>2</sub>, 2.63% Al<sub>2</sub>O<sub>3</sub>, 0.68% CaO, 0.23% MgO, 0.13% P, 0.02% TiO<sub>2</sub> and 1.26% LOI. Mineralogical studies reveal that the sample consists predominantly of quartz with subordinate amount of braunite, pyrolusite, bixbyte, jacobsite, hollandite, hausmannite and psilomelane in minor to trace amounts as manganese minerals, whereas other minerals present are mica, pyroxene, haematite, goethite/ilmenite in minor to trace amounts.

The beneficiation process adopted was gravity separation. Tabling on as received sample ground to all – 65 mesh yielded a table concentrate (Concentrate-I) assaying 38.12% Mn, 8.55% Fe(T), 16.53% SiO<sub>2</sub>, 1.97% Al<sub>2</sub>O<sub>3</sub>, 0.23% P and 2.97% LOI with Mn recovery of 43.7% and weight percent yield of 9.2. Magnetic separation test on (table middling and table tailings) yielded magnetic concentrate (concentrate-II) assaying 20.70% Mn, 5.95% Fe(T), 48.57% SiO<sub>2</sub>, 3.25% Al<sub>2</sub>O<sub>3</sub>, 0.13% P and 2.91% LOI with Mn recovery of 42.1% and weight percent yield of 16.3. The composite concentrate obtained by combining table concentrate (concentrate-I) and magnetic fractions of table middling and table tails (Concentrate-II) assayed 26.99% Mn, 6.89% Fe(T), 37.01% SiO<sub>2</sub>, 2.79% Al<sub>2</sub>O<sub>3</sub>, 0.16% P and 2.93% LOI with Mn recovery of 85.8% and weight percent yield of 25.5.

The dump reject sample assaying 8.02% Mn which is less than the threshold value can be beneficiated by gravity separation at -65 mesh size to obtain +35% Mn concentrate with ~44% Mn recovery. Alternately, a combination of gravity cum wet magnetic separation at -65 mesh size could yield a +25% Mn concentrate with ~86%

Mn recovery. These concentrates may find industrial application after agglomeration.

## 2. JNARDDC

*Analysis of impurities (Fe, Si, Ca etc.) in alumina and aluminate liquor using hand-held spectrometer:* The Centre developed an insitu quantitative analytical tool using hand held spectrometer which shall assist in spot determination of decisive inorganic impurity elements such as Fe, Si and Ca in alumina and aluminate liquor.

During the course of R&D endeavor, a selective dissolution procedure was developed for rapid determination of Fe in alumina hydrate, at room temperature (18-30 °C). Also, alkali digestion of alumina hydrate was developed for determination of Si. A typical composition of

sample and flux ratio is identified for preparation of calcined alumina for pH specific colourimetric determination of Ca.

## RECOVERY OF SILICA SAND FROM OVERBURDEN

*Recovery of silica sand from overburden of Katangjhari Manganese ore mine, Balaghat, Madhya Pradesh:* Mineral Processing Division of IBM has developed a process on the overburden of Katangjhari Manganese ore mine to recover silica sand as a value added product to be used as stowing material in the Katangjhari Manganese ore mine of M/s.J.K.Minerals, Balaghat, Madhya Pradesh. Thus, the process developed by Mineral Processing Division of IBM has an achievement to convert the overburden into value added product.