MINERAL BUSINESS DEVELOPMENT (MBD) TECHNICAL LECTURE SERIES 2022

Mineral Processing Technology of IMMT for Selected Value-Added Products

BENEFICIATION AND VALUE ADDITION TO MINERAL RESOURCES

Prof. Suddhasatwa Basu
Director, CSIR-IMMT
Bhubaneswar

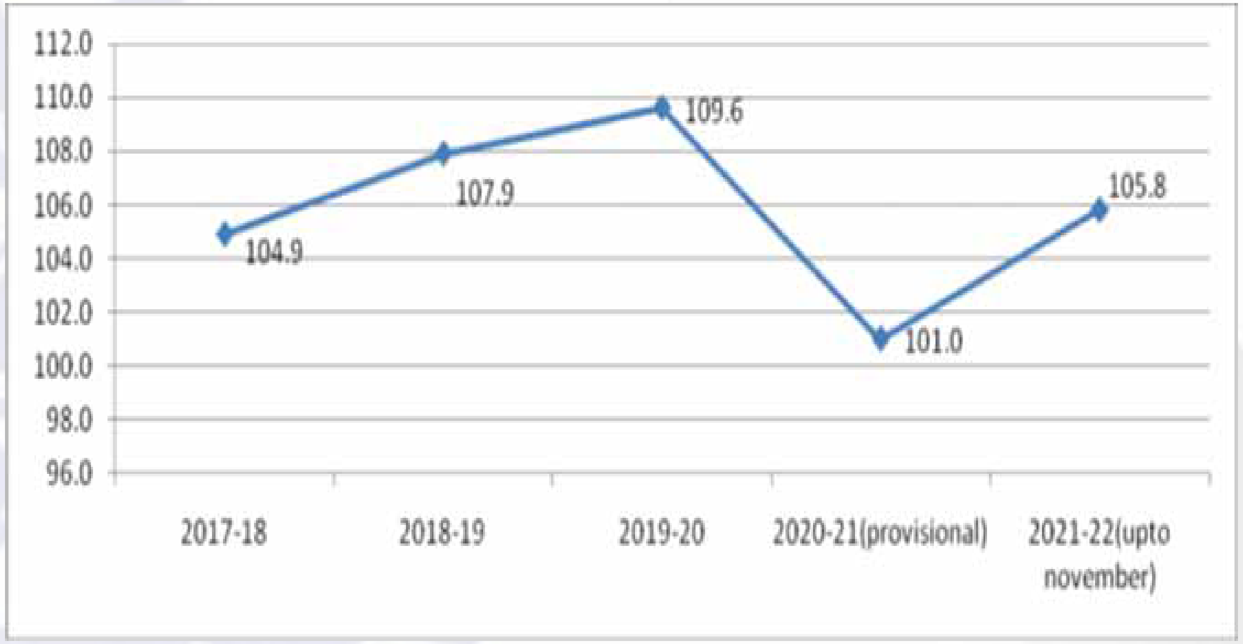
Outline

- Current Scenario
- Challenges & Opportunities
- Changing Scenario
- CSIR-IMMT – R&D intervention
- Suggestions & Recommendations

Current Scenario

- India is well endowed mineral resources, which serve as feedstock for many industries, leading to growth of mineral and metal sector.
- Which will lead to a roadmap of sustained growth and a five trillion-dollar economy
- Matching to this endeavour, the Government has introduced vital reforms to open up the mineral sector to ensure its contribution in achieving the national policy goals

Positive growth of 18.2% in 2021-22



Index of mineral production (Base: 2011-12=100)

Source: Ministry of Mines-2021-22

Challenges & Opportunities

- Depletion of high grade ore
- The additional cost of beneficiation
- Compliance to regulatory norms
- Sustainability of supply chain
- Generation of bulk quantity of industrial waste
- Recovery of mineral values and reuse of these waste into valuable products

Treating these waste as secondary source of mineral

Changing Scenario

- ✓ High demand of Steel → Iron ore
- ✓ Ever increasing Cost
- ✓ Community expectations
- ✓ Skills Shortage
- ✓ Regulatory approvals
- ✓ Industry position
  - Revamp facility with newer and modern equipment
  - Sophisticated, flexible, and responsive production system

Major R&D Focus in Mineral Processing at CSIR-IMMT

1. **Iron, Steel & Coal:** Iron ore beneficiation & palletisation
   Coal characterisation, beneficiation, coke and ferro-coke making
2. **Coal Gasification:** High ash Indian non-coking coal
3. **Aluminium Sector:** Bauxite characterisation & beneficiation
4. **Strategic Minerals:** Extraction of Li, REE, PGE minerals from lean grade resources
6. **Utilisation of Industrial waste:** Red mud, SMS sludge, BF dust, GCP sludge
7. **Technical Audit for Plant Process and Plant Capacity Enhancement, Data Mining**
8. **Equipment Development:** Dry Beneficiation Units, Scrubbers, Jig, F-column
9. **HRD & Skill development activities:** Training of Govt Mining officials, Plant Operators, Students

Utilization of low and lean grade iron ore, fines, slimes, tailings & Value addition

Utilization of low and lean grade iron ore & Value addition

Challenges to Indian Steel Industries

High demand of steel

- ❖ 300 MT of steel in 2030 as per Steel Policy of India
- ❖ Per capita consumption of steel will improve from 60 to 160 kg against 400-600 kg in developed countries
- ❖ 450 MT of high grade iron ore (Calibrated ore/sinter/pellets)

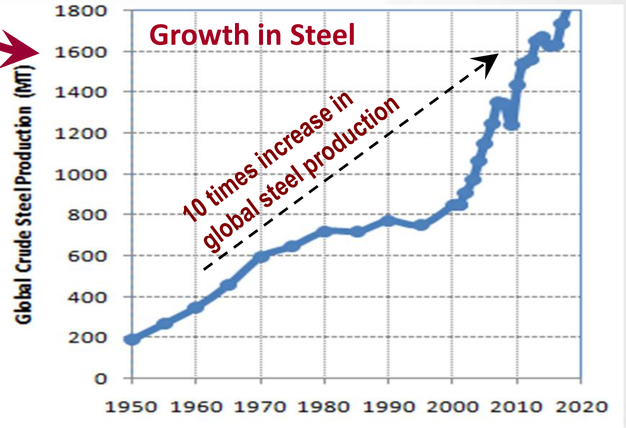
Availability of low grade iron ore/slimes/tailings

- ❖ Low grade iron ore (45-60%Fe) and BHQ/BHJ/BMQ/BGQ
- ❖ Washing plant slimes/Existing beneficiated plant tailing

Sustainability of ore deposits and reduction of emission

2.6 t/tcs of CO_2 in India against 1.75 t/tcs of world average

Major Source of Iron Ore



Commercialisation of Iron Ore Beneficiation Plants

15 MTA Iron Ore Beneficiation Plant of SMPL at Barbil

Process commercialised

1. Essar Steel Ltd. (15MTPA)
2. SMPL (15 MTPA)
3. BRPL (6 MTPA)
4. BMM Ispat (2 MTPA)
5. BSPL (6 MTPA)
6. GM Steel (0.5 MTPA)

15 MTA Iron Ore Beneficiation Plant of Essar Steel at Barbil

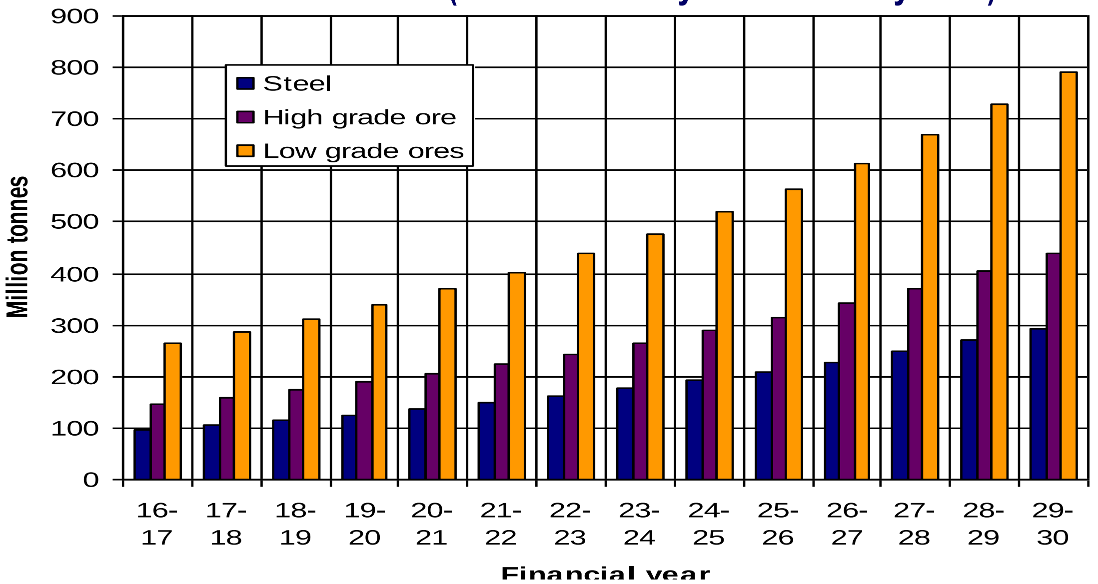
In Process of Commercialisation

1. Bhushan Steel Ltd. (20 MTPA)
2. IPPL (2.4 MTPA)
3. Altrade Minerals (6 MTPA)
4. Essel Mining (2 MTPA)
5. MSPL (2 MTPA)
6. African Natural Resources and Mines Ltd., Nigeria

Problems of the Indian Iron Ore

- Indian hematite ore contains good amount of clay minerals, which affects the process fluid dynamics during beneficiation and also down stream processes.
- These ores are more fragile in nature due to presence of high percentage of goethite.

Production of steel, high grade ores and low grade ores for beneficiation (source: Ministry of steel Policy 2017)

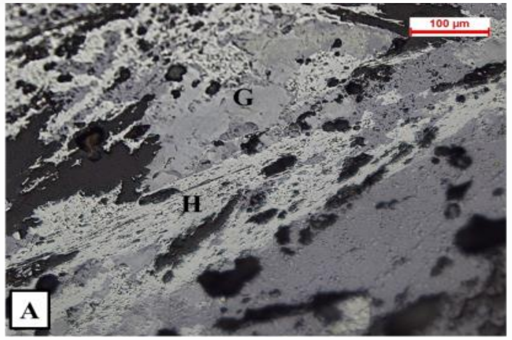


Fragile nature + Liberation size < 200 micron → High Blaine No.

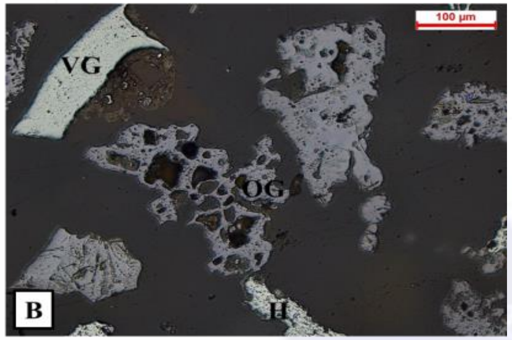
Optimum Blaine fineness of iron ore in the range of 1700–2250 cm^2/g

Goethite + Kaolinite → High LOI

Pelletization Study of High LOI & High Blaine No Iron Ore Fines



-3 mm

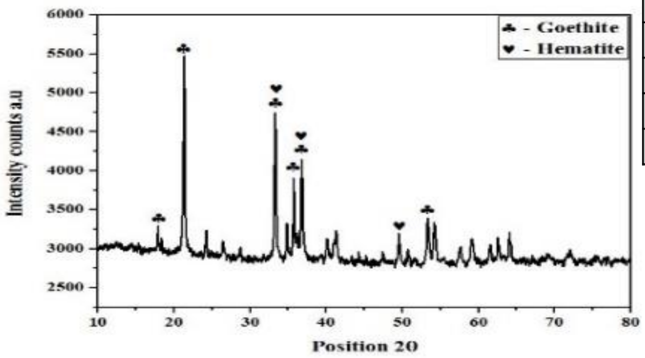


-150 µm

Optical microstructure of different size fractions

A: Goethite and Hematite are the major mineral phases, here Goethite replacing Hematite

B: Vitreous Goethite (VG) grains are separated from the Ocherous Goethite (OG) grains



XRD pattern of feed iron ore

Details	Percentage
Fe	57.49
SiO_2	3.02
Al_2O_3	2.13
Mn	2.87
P	0.105
LOI	8.95

Overall Composition (wt., %)	
Hematite	10.39
Goethite	78.92
Magnetite	0.77
Kaolinite	6.95
Quartz	0.58

Pilot scale disc pelletizer

Parameters	Pot-3
Pellet size, mm	10-11
Reduction Degradation Index (RDI) (ISO-4696-2), %	3.07
Abrasion Index (AI), % (ISO-3271)	1.87
Tumbler Index (TI), % (ISO-3271)	95.73
Cold crushing strength, Kg/ Pellet (ISO-4700)	252
Swelling index, % (ISO 4698)	16.67
Reducibility, % (ISO 7215)	59.03
Porosity, %	17
Fe, % (ISO-2579)	62.83

Pot grate kiln

As received bulk sample

→

Feed sample (-1 mm)

→

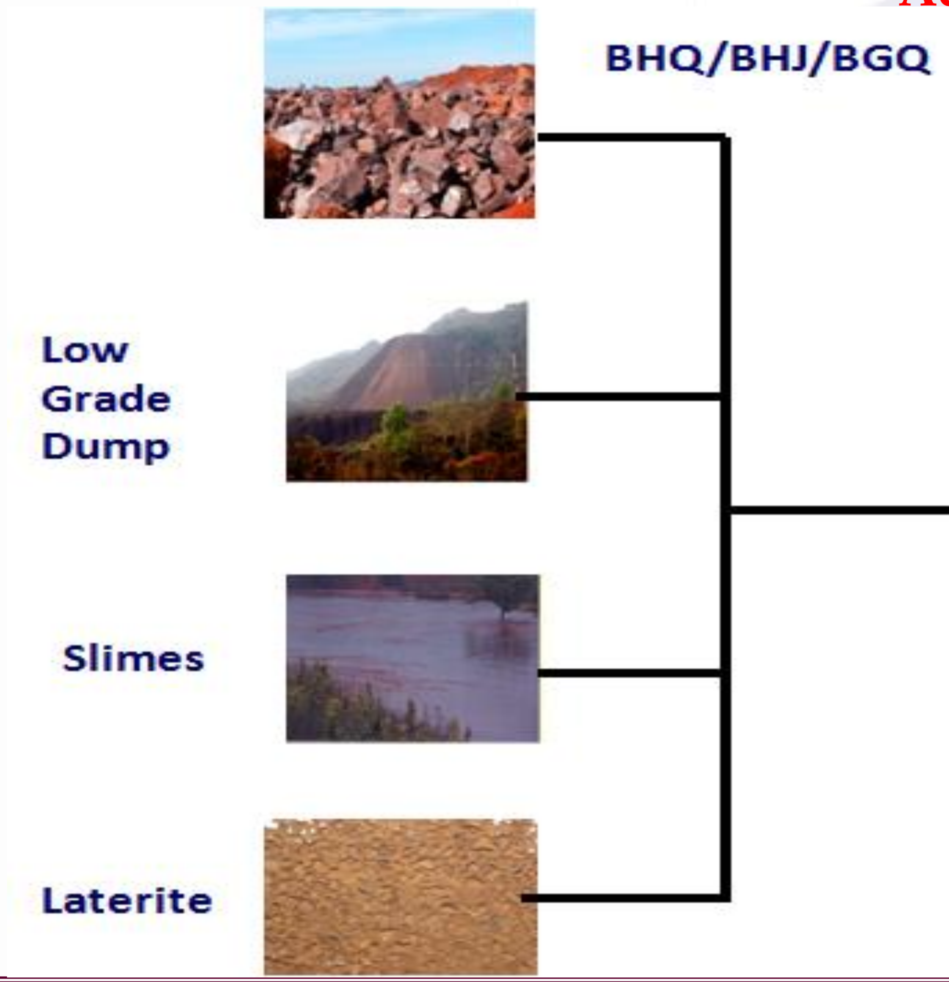
Green pellet (-12.5+10 mm)

→

Fired pellet (-11+10 mm)

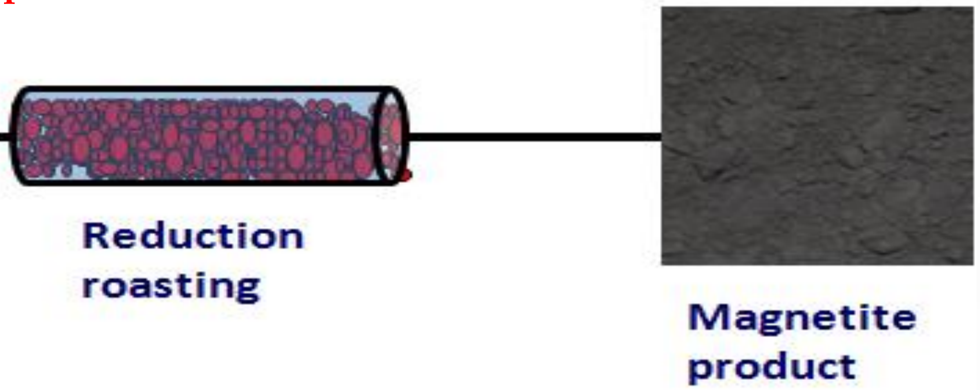
R&D for Process & Product Development

Maximise the recovery of iron values by reduction roasting of lean and low grade iron ore resources followed by low intensity magnetic separation



Advantages:

- ✓15-20% extra yield
- ✓Increased grade
- ✓Reduced grinding energy consumption, maximize recovery of process water
- ✓No tailing pond
- ✓Easy pipeline transportation
- ✓Easy to make pellet & 20-30% less energy required for palletization & improved pellet quality
- ✓Improve the ore conservation and reduces the environmental impact



CSIR-IMMT has made MOU with FL Smidth, Chennai to commercialize this technology.

Utilization of low & lean grade iron ore fines/slimes through Fluidized Bed Roasting

Introduction:

- Ultra fines/slimes (Fe%-35-55) generated in huge quantity during crushing or as beneficiated tailings can be upgraded to more than 60% Fe by utilising high ash Indian non coking coal

Challenges:

- Direct utilization of low and lean grade ultra fines/slimes of iron ore resources is not possible by any existing steel making processes.

Novelty:

- Application of reduction roasting using fluidized bed roaster of ultra fines / slimes to maximize the recovery of iron values.

Advantages:

- Utlization of rejectable low grade iron ore fines/slimes
- Increases yield
- Reduces the overall energy requirement of the process
- Improves the process kinetics
- Improve the ore conservation and reduces the environmental impact

Reduction of Phosphorus Content in high Phosphorus Indian Iron Ore

Objective:

- Development of a process on pilot scale for reduction of phosphorus content in high phosphorus Indian iron ore preferably from Odisha /M.P. region.

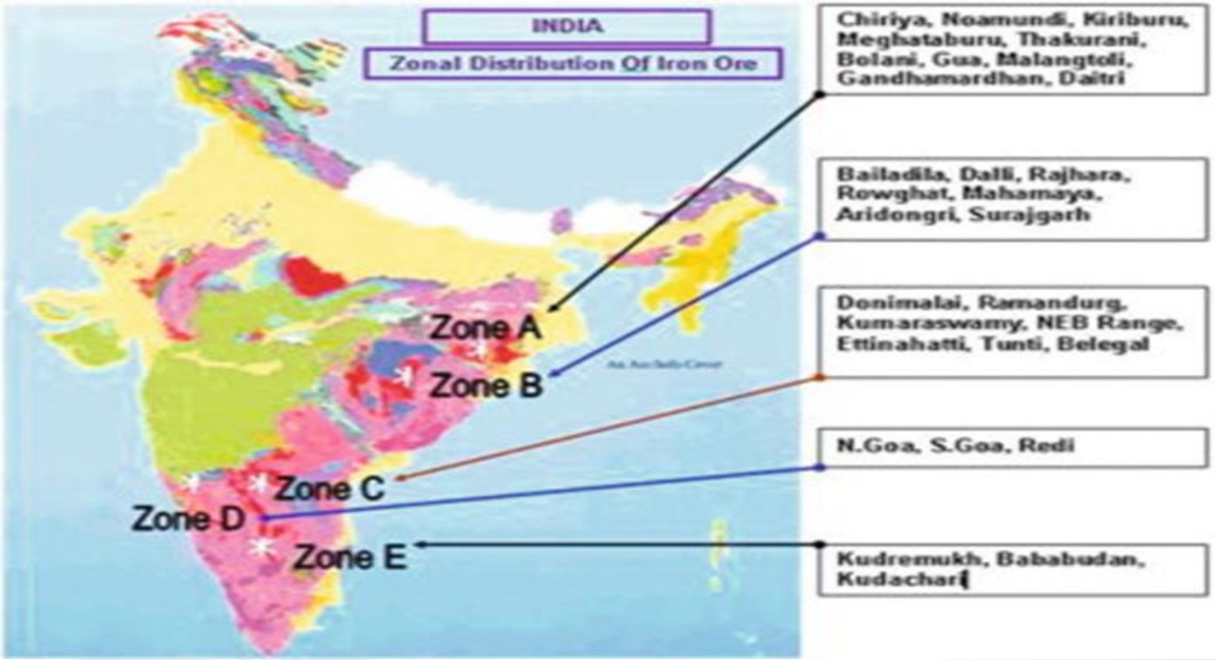
Need for Phosphorus (P) Control :

- Requirement of wide variety of steel with P content < 0.05 and even less than 0.02 %
- Challenge in all steelmaking processes (BF & Secondary route steel making)
- Higher occurrence of "P" content: Iron ore deposits (Eastern India) : 0.1-0.14%
- Need to reduce high phosphorous content in iron ores to below 0.05%

Challenges:

- Varied and complex phosphorous mineralogy
- Genesis, association with other mineral phases, influences P removal route
- Indian iron ore w.r.t. to "P" removal is unfavorable especially in making specialty steel (< 0.02%)

Phosphorous occurrence in iron ore, India



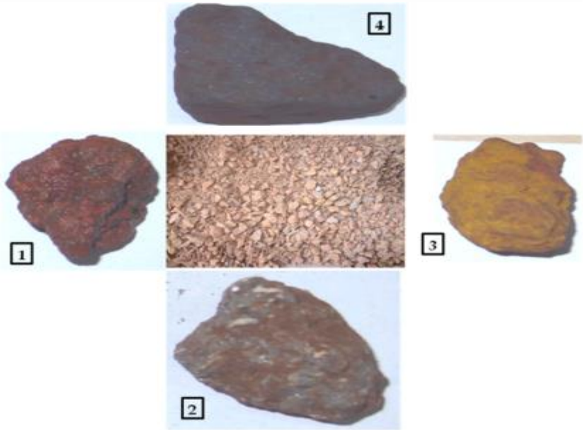
Deposit	Massive, %P	Flaky, %P	Blue dust, %P	Mixed, %P	Lateritic ,%P	Total, %P
Noamundi	0.069	0.085	0.046	-	0.137	0.077
Katamati	0.077	0.066	0.048	0.074	0.101	0.070
Joda East	0.041	0.059	0.029	0.084	0.146	0.066
Banspani	0.037	0.059	-	-	0.129	0.049
Khondbond	0.018	0.027	-	-	0.050	0.030

Source: Journal of Geological Society of India

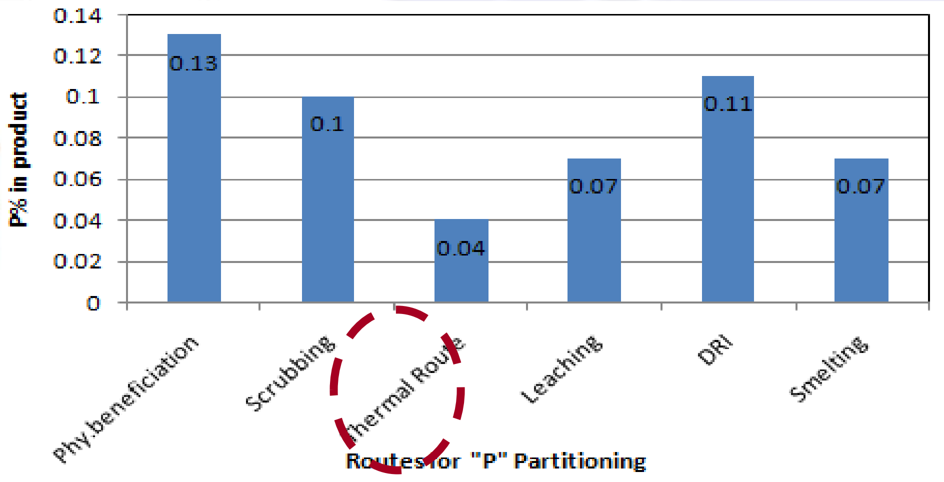
Results on ‘P’ removal from high ‘P” bearing Indian Iron ore

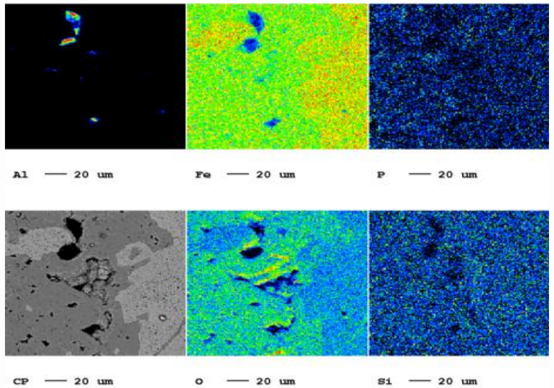
High phosphorous bearing Indian Iron Ore

- ❖ Iron Ore from Jabalpur region (0.13% P)
- ❖ Iron Ore from Joda East Mines (0.09% P)

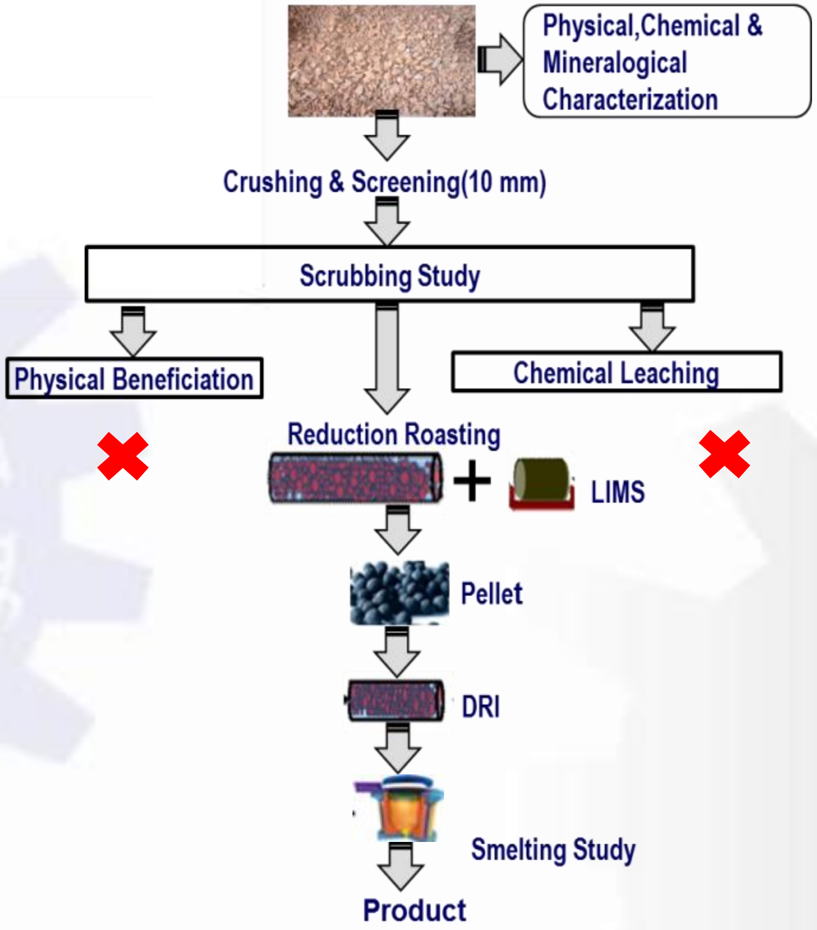


Iron Ore from Jabalpur region





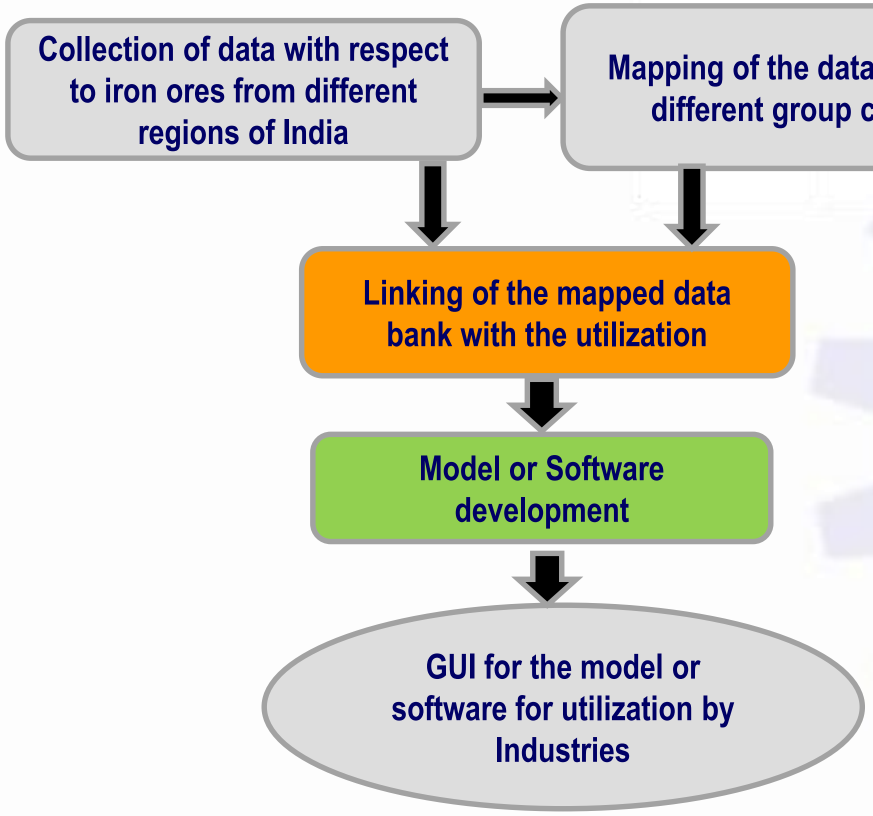
EPMA elemental mapping



Results

- ❖ Iron ore having more than 70% goethitic phase
- ❖ Host bulk phosphorous in goethitic phase in iron ore matrix as apatite
- ❖ Thermal route found to be the best option with 0.04% P in the product

Data Mining and Predictive Model/Software Development for Mineral Resource Utilization (Current Initiative)



Advantages and Impact

- Mapping of the Indian iron ore with respect to feasibility of beneficiation
- Integrated approach of iron ore resource management of the India
- Increase in the productivity of the existing plants
- Overall reduction in the cost of production
- National data bank

Make in India: Technology Licensing

Improved Mineral processing Equipment - Flotation Column, Screw Scrubbers, Pulse Scrubber, Hydraulic Jig, Tribo-Electro Static Separator, (Money received Rs 0.12 crore)

Screw scrubber
(Swagath Urethane)

Column Flotation
(Tega Industries)

(MSP Group Kolkata)

Beneficiation of non ferrous minerals

Process Flowsheet Development for the Beneficiation of Chromite Ores

Objectives:

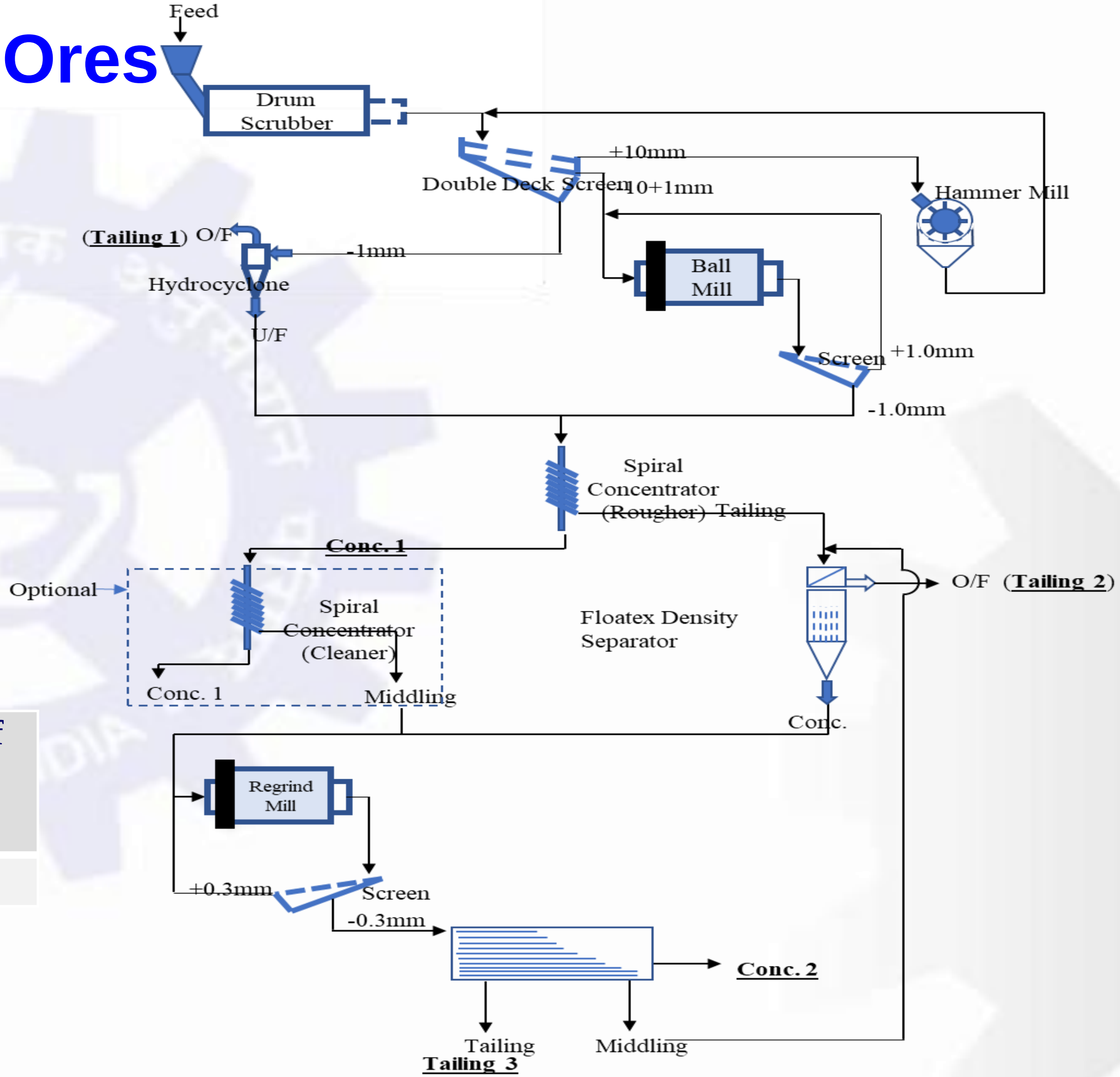
Characterization and process flowsheet development for the beneficiation of low-grade chromite ores.

Chemical analysis of the as-received

Chemical constituent	Percentage
Cr_2O_3	25.3
Fe_2O_3	25.5
Al_2O_3	8.9
SiO_2	24.0
MgO	9.1
CaO	0.3
TiO_2	0.6
LOI	6.3

Chemical analysis of the concentrate

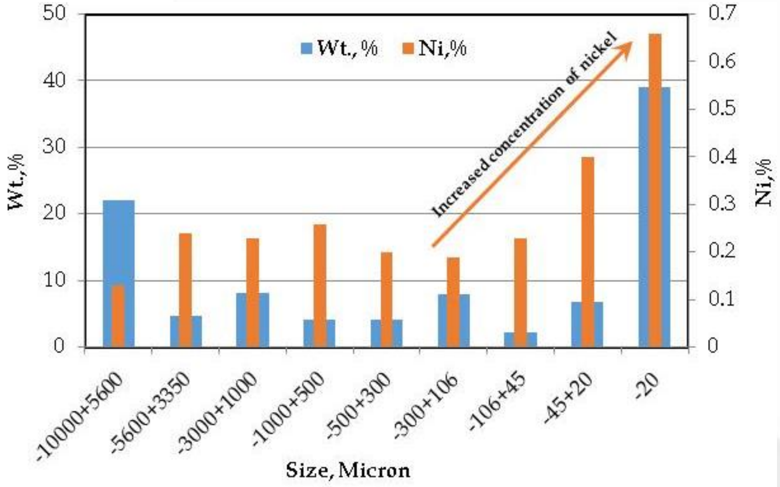
Yield, %	Cr_2O_3, %	Recovery of Cr_2O_3, %
30-42	45-50	65-77



Recovery of Nickel values from chromite overburden

- Nickel bearing laterite and chromitiferous overburden are the only source of nickel available in India.
- In India, 5 MT of such overburden is generated each year in addition to the 140 MT that has already been accumulated over several years of mining and it is estimated to increase with the consumption of chrome ore.
- With the depletion of sulphide deposits and for the future supply of nickel, the industry must develop for the utilization of laterite ore bodies, especially limonite deposits.
- Lateritic overburden containing nickel in Sukinda chromite mines in Odisha containing 92% national deposit, is generated during raising of chromite ore. This chromite overburden contains around 0.5-0.7% nickel.

(Nickeliferrous lateritic chromite overburden , Sukinda,Odisha)



Results of Nickel Recovery

Details	Wt., %	Ni, %	Cr_2O_3, %	Fe, %	Recovery,%
Feed	100.00	0.39	9.18	29.32	
Chromite enriched	10.67	0.09	48.82	17.83	
Nickel enriched	25.08	1.05	0.67	59.67	67.52 (Ni)
Reject	54.30	0.21	6.88	23.76	
Loss in LOI	9.95				

High Pure Quartz and Silicon from Natural Low grade Quartz

Sample Collection & Characterization

Physical Beneficiation of the Ore

a) Size reduction and classification
b) Enhanced gravity separation
c) Magnetic separation
d) Electrostatic separation
e) Flotation
f) High temperature beneficiation

Chemical Beneficiation of the Ore

a) Leaching
b) Digestion

High Pure Quartz/Silica

Quartz Purity: SiO_2 = 99.9 %

Silicon metal preparation

a) Reduction roasting
b) Smelting
c) Reduction – smelting
d) Purification

Silicon Metal

The work is carried out with funding from Ministry of Mines (MOM), Govt. of India

Feed Quartz: 90-93% SiO_2

Beneficiation of low grade Quartz

High Pure Quartz

Quartz Purity: SiO_2 = 99.9 %

Reduction Smelting in Arc Furnace

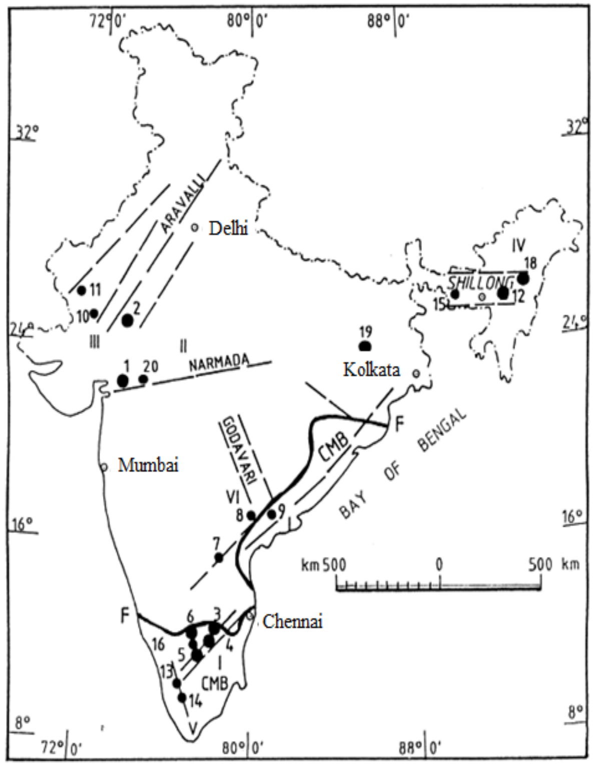
Si metal

Purification

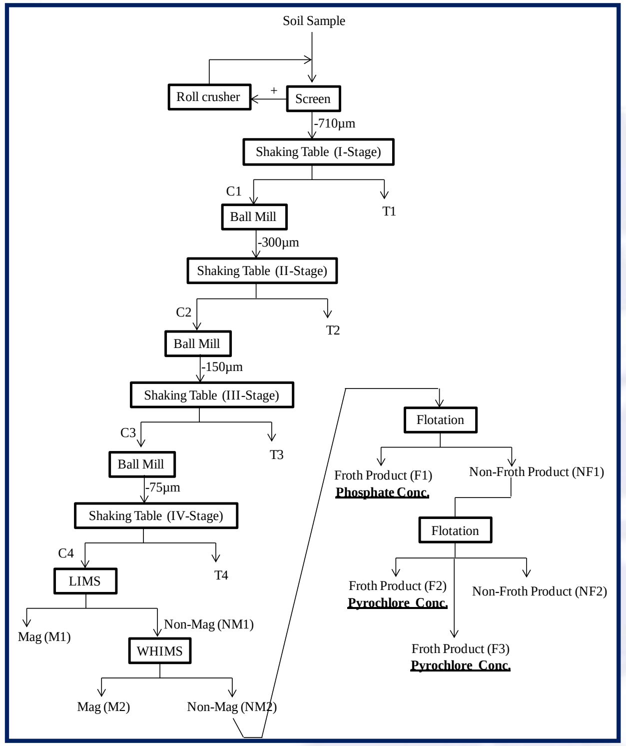
High Pure Si metal
99.9 % to 99.99%

Beneficiation and recovery of critical minerals

Characterization and Mineral Beneficiation of REEs from Indian Resources



Beneficiation Flowsheet



- ❖ **Primary Rocks: Carbonatites, Pegmatitic rocks**
- ❖ **Coal fly ash which is a by-product of Thermal Power Plants**

Carbonatite rocks of Sevattur (Tamil Nadu)
Chemical analysis of the feed sample

Constituents	Nb_2O_5	Ta_2O_5	Al_2O_3	CaO	Fe_2O_3	MgO	MnO	TiO_2	P_2O_5	BaO	SrO	LOI	SiO_2	Others
%	0.068	0.0042	5.11	18.28	25.09	4.67	0.69	2.15	10.49	0.15	0.82	7.0	22.97	2.5

REEs	Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Sm	Tb	Tm	Y	Yb	Total (REE)
PPM	1211	28	19	22	82	0	512	2	587	129	105	11	0	97	3	2805

	Nb_2O_5, %	REE (ppm)														
		Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Sm	Tb	Tm	Y	Yb	Total (REE)
Feed	0.06	1211	28	19	22	82	0	512	2	587	129	105	11	0	97	3	2805
F2	1.05	1222	36	35	25	147	2	595	2	604	146	116	21	0	130	6	3085
F3	0.82	879	25	27	18	104	0	411	2	437	112	75	16	0	100	4	2208
NF2	0.29	383	8	16	5	41	0	195	0	178	42	13	8	0	35	1	922
F1	0.12	2987	71	26	60	67	6	1422	0	1434	375	290	23	0	228	7	6993
NF1	0.72	899	25	26	17	103	0	443	1	423	119	81	18	0	98	4	2255

The REE content could improve from **2805** ppm to **6993** ppm in the flotation concentrate

Earlier reports REE in Fly ash

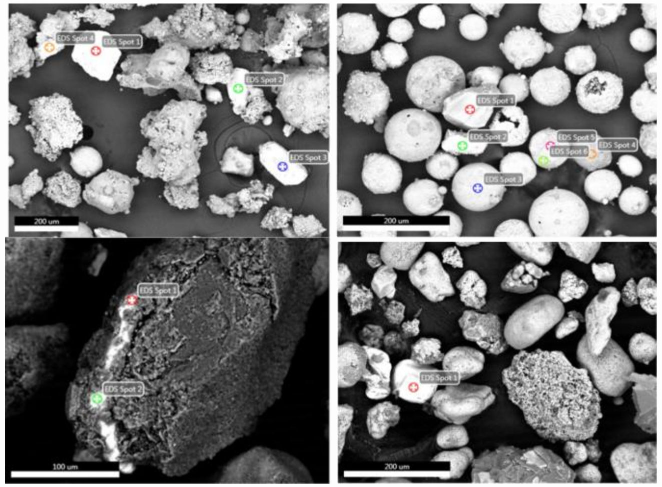
- ✓ Franus et. al. (2015) , 445 ppm REE
- ✓ Mondal et.al. (2019) , 300 -500 ppm REE

In-house Project

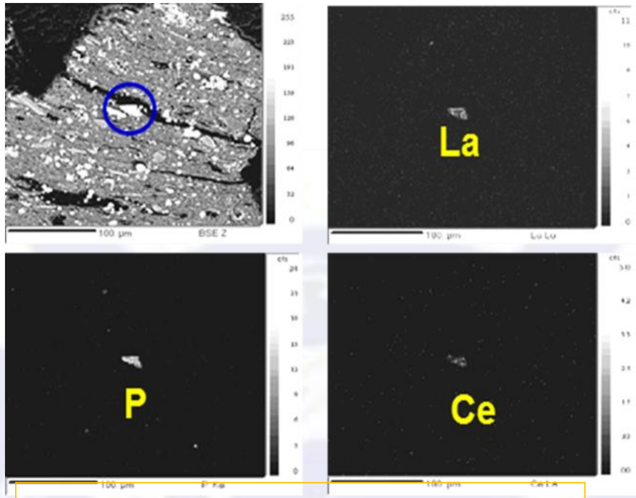
- ✓Four different fly ash from Talcher area, Odisha
- ✓NALCO, JSPL, NTPC Kaniha, NTPC Thermal

FEED → Gravity Concentration → Magnetic Separation → Froth Flotation → REE Concentrate

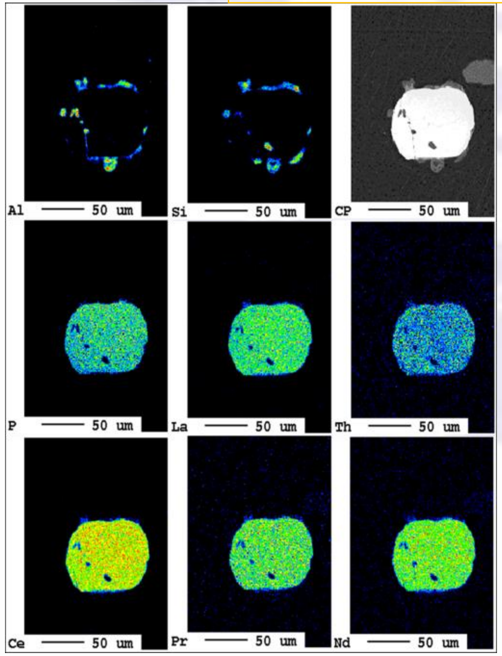
Electron micrographs of concentrates

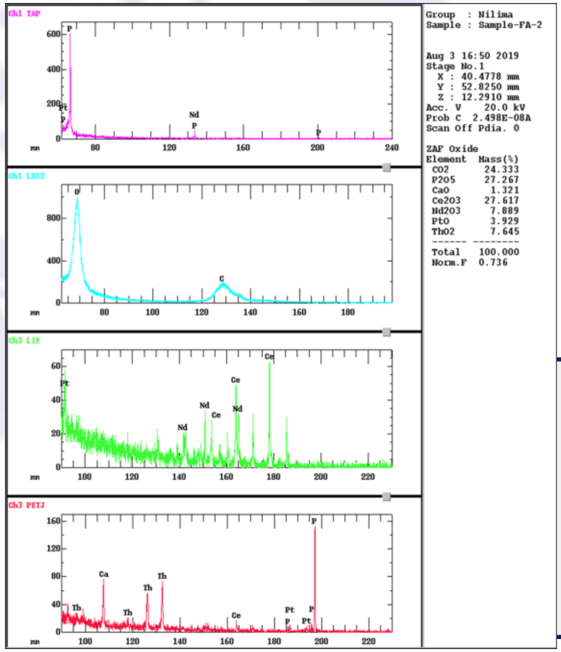


REE in Indian Fly Ash



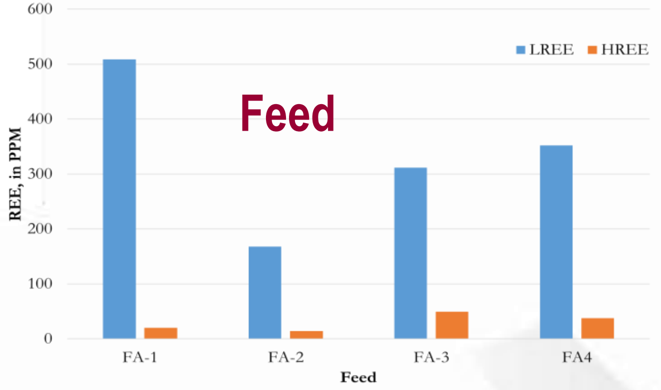
Concentration of Total REE

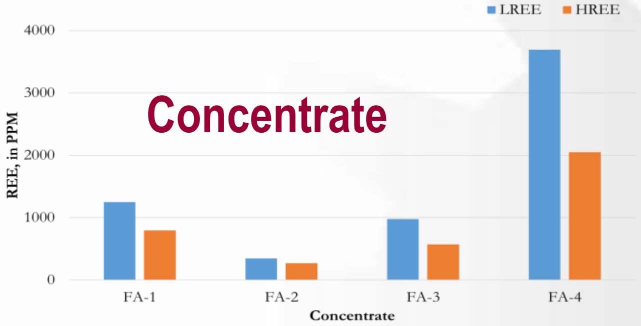




REE in Coal

REE is recognized to be associated with phosphates; monazite

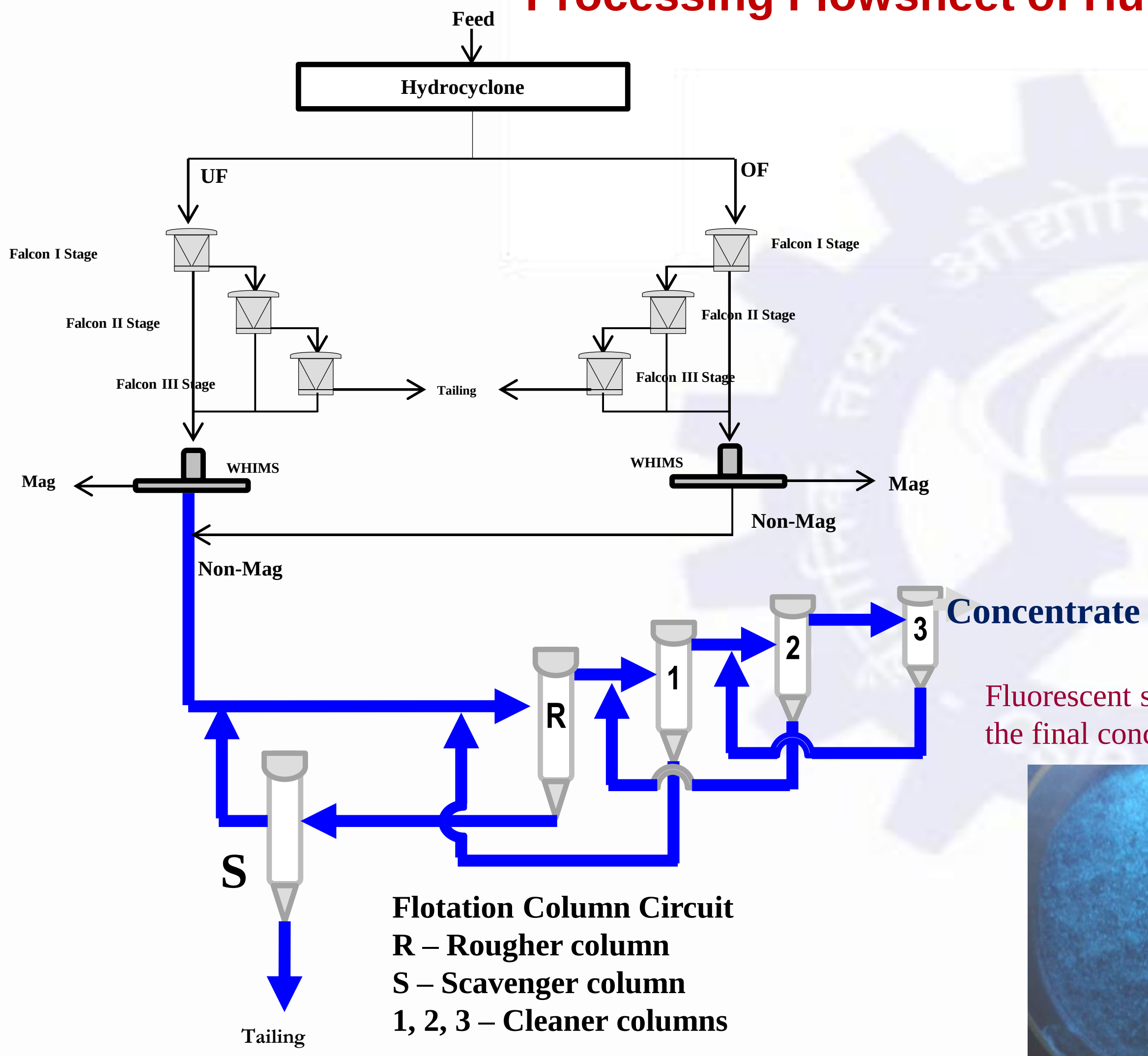




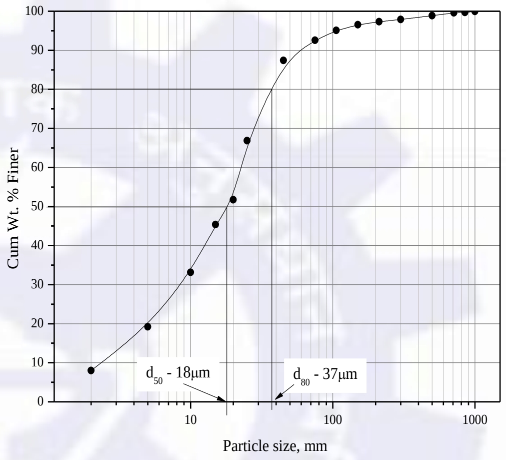
- ❖ Fly ash could be a source of REE.
- ❖ REE minerals could be enriched (up to > 0.5%).
- ❖ Major REE contributing mineral in the studied fly ash is monazite.

Recovery of Strategic Mineral Values from Ores/Tailings

Processing Flowsheet of Hutti Gold Mine Tailings

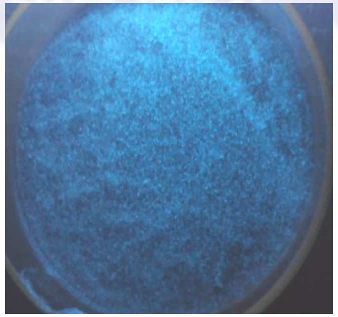


Chemical composition and size analysis



Chemical constituent	Percentage
WO_3	**0.018 - 0.02**
SiO_2	**53.20**
Al_2O_3	12.79
Total Fe as Fe_2O_3	12.00
CaO	9.71
MgO	4.69
TiO_2	0.69
Na_2O	1.95
K_2O	0.83
Total S as SO_3	1.81
Others	2.31

Fluorescent scheelite particles in the final concentrate (2% WO_3)



Characterization and Beneficiation Studies of Low-grade PGE Ores

- ❖ Major deposits of platinum group of minerals (PGMs) are in South Africa
- ❖ Bushveld Complex in South Africa is the world's largest PGM reserve.
- ❖ In India, traces of PGEs have been found at the Precambrian mafic/ultramafic complexes in Odisha.
- ❖ India has a total estimated PGE resource of 15.71 million tonnes (MT).
- ❖ 14.2 MT are located in Nilgiri, Boula Nuasahi, and Sukinda of Odisha

Run of Mine Ore (PGE - 3.8ppm)

↓

Comminution

↓

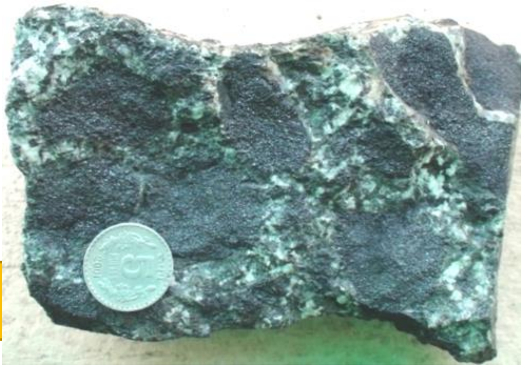
Advanced Gravity Concentration

↓

Flotation

↓

Product Details
Grade: 179.3 ppm



Platinum Group of Elements:

Platinum (Pt)
Palladium (Pd)
Ruthenium (Ru)
Rhodium (Rh)
Iridium (Ir)
Osmium (Os)

- ❖ PGE values in the feed material was 3.8 ppm
- ❖ From Indian ores, PGE values can be enriched to 165 - 200 ppm (179.3 ppm)
- ❖ The beneficiation concentrate has a marketable grade product

Utilization of Industrial Waste

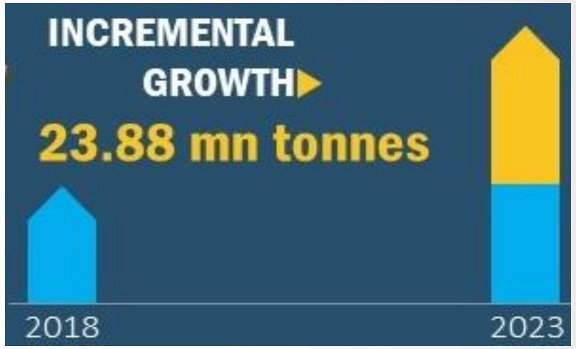
Generation of Bauxite Residue in India and Global

Bauxite Residue (BR) or Red mud is the solid waste residue of the digestion of bauxite ores with caustic soda for alumina (Al_2O_3) production (Bayer's Process)

- ❖ Primary Aluminium Production(2021): 67.243 million tons (Global)
- ❖ Alumina Production: 138.113 million tons (Global)
- ❖ Generation of red mud: 140-150 million tons/Annum (Global)
- ❖ Existing global inventory : 3 billion tons
- ❖ Red mud generation(India) : 9 million tons/Annum
- ❖ Total operating Bayer alumina plants: over one hundred (World)

- ❑ It is one of the largest industrial by-products in modern society
- ❑ The cost of red mud disposal is expensive, accounting for about 2% of the alumina price
- ❑ **Developing and implementing effective storage and remediation of bauxite residue therefore remains a global concern**

Global Aluminium Market Growth Forecast(2018-2023)



Bauxite residue: Its fallout

- ❖ Approximately 35 to 40% of the processed bauxite ore goes into the waste as alkaline red mud slurry which consists of 15–40% solids
- ❖ Approximately 0.8–1.5 tons of red mud is generated per ton of alumina produced.

Usually disposed in mud lakes in the form of slurry impoundment or stacked in ponds as dry mud or directly discharged through a pipeline into a nearby sea.

Leads to catastrophic environmental problems

- ➢ **Soil contamination**
- ➢ **Groundwater pollution**
- ➢ **Fine particles' suspension in the sea**
- ➢ **Occupies huge areas of land**
- ➢ **Dust pollution**
- ➢ **Health problem for the people**

Red Mud Pond

Characteristics & Issues

- ❖ **0.8-1.5 tons of red mud/ton of alumina**
- ❖ High alkalinity (pH 12-13)
- ❖ Ultrafine in nature (90% passing 75 micron)
- ❖ Alkaline airborne dust emissions
- ❖ Huge quantity

Increase in Bauxite Residue generation: forecast

- *Aluminium demand is expected to increase over the next 20 years.*
- *Global metallurgical alumina production is forecasted to grow from 124 MT (2019) to 178MT(2040)*
- ***Global inventory of BR to go up to 7-8 BT by 2040***

Opportunities

- ✓ **To minimise the waste generation by recovering the mineral values from red mud**
- ✓ **Potential source of valuable oxides of iron, titanium, aluminium and rare earth elements (REE)**
- ✓ **Can be used reused, recycled for wide variety of commercial end use**

Typical Composition (Values in BR)

Component	Range(%)
Fe_2O_3	30-60
Al_2O_3	10-20
TiO_2	Trace-25
CaO	2-8
SiO_2	3-50
Na_2O	2-10

Current Technological Status (BR Utilization)

Several applications of BR have been studied

- ❖Amendment of acidic soil
- ❖Tiles and Bricks
- ❖Road Construction
- ❖ Special Cement
- ❖Additive in ferrous metallurgy
- ❖Filler in rubber and plastic industry
- ❖As pigment for paint
- ❖Trapping CO2, SO2 from flue gas
- ❖For making adsorbent and catalyst
- ❖Water and sewage treatment agent

Constraints

Limited commercial utilization
Current Need: Bulk utilization

Opportunity

Iron as oxides/oxyhydroxide is the largest component of red mud (Fe_2O_3=20-45%)

Promising Option

Development of process for iron recovery from red mud

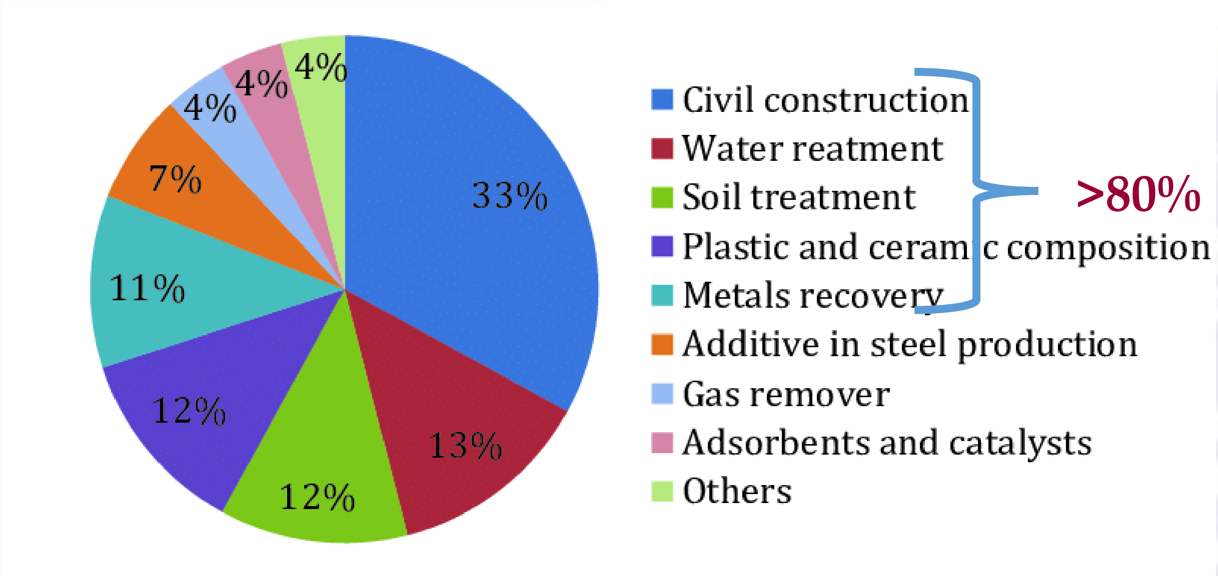
Past work on iron recovery

Reduction Smelting
Solid State Reduction

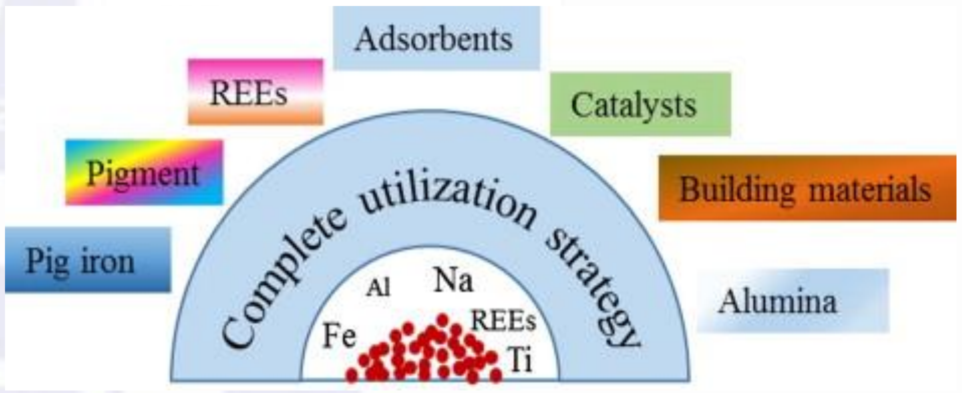
Bench scale
Limited Success

Prior art in utilization of bauxite residue

Worldwide efforts in progress



Complete utilization strategy of BR



What is required ?

- A potential source of valuable metal values such as alumina, iron, titania and rare earths
- The metal recovery technologies developed so far mostly emphasize on recovering a single metal component
- Trial to recover two or more metallic components is recently under active way
- **Need of the hour: Suitable technology for complete utilization of Bauxite residue**

Thermal treatment-magnetic separation process developed at CSIR-IMMT

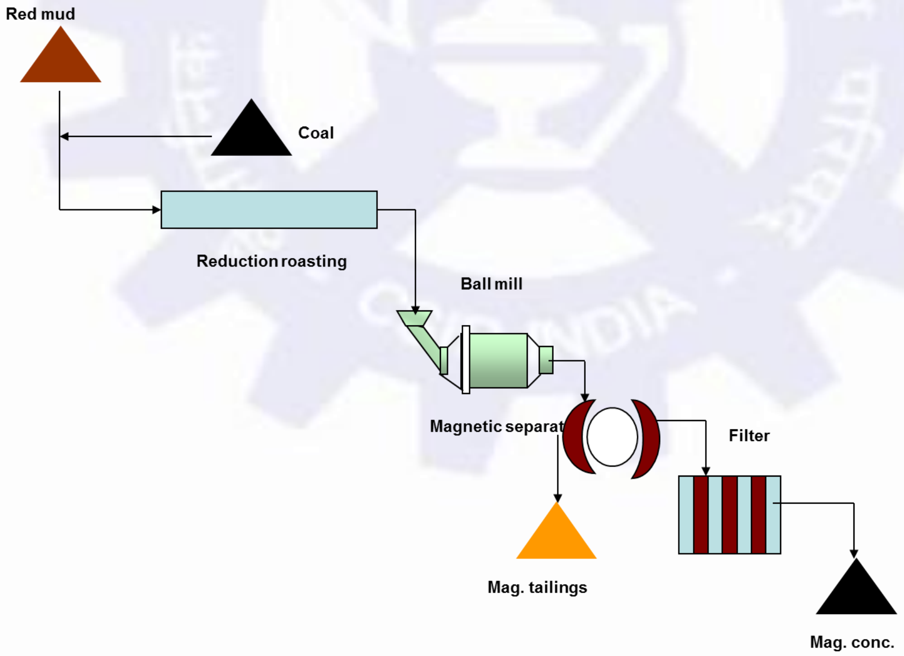
Bauxite residue

↓

Thermal treatment and magnetic separation

← Magnetic fraction → Fe recovery

→ Non-magnetic fraction → Alumina recovery → Ti and REEs recovery



Iron bearing product

25-30% yield
60-65% recovery
60-65% Fe

Approximate cost of production of magnetite concentrate is Rs. 1600-2000 per ton

Technology Development for Holistic Utilization of Red Mud for Extraction of Metallic Values & Residue Utilisation

(under guidance of NITI Ayog)

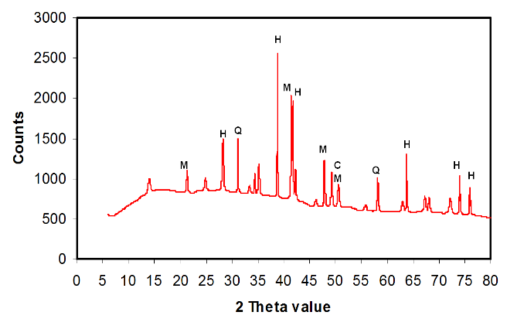
Joint Consortium of R&D labs & Industries involving

CSIR-NML, CSIR-IMMT, JNARDDC, NALCO, HINDALCO, VEDANTA

Joint Deliverables at pilot Scale

- ❖Process for pre-concentration of REE in redmud after beneficiation at 100 kg per batch RM feed scale
- ❖Process for recovery of iron value from bauxite residue at 100 kg per batch RM feed scale
- ❖Process for recovery of alumina value from bauxite residue at 100 kg per batch RM feed scale
- ❖Process for recovery of titanium value from bauxite residue at 100 kg per batch RM feed scale
- ❖Process for recovery of REEs from bauxite residue at 100 kg per batch RM feed scale
- ❖Final Residue Utilisation in cementitious products/ building materials
- ❖Master flowsheet with complete mass and energy balance with techno-economic feasibility

Blast Furnace and SMS Dust/Sludge

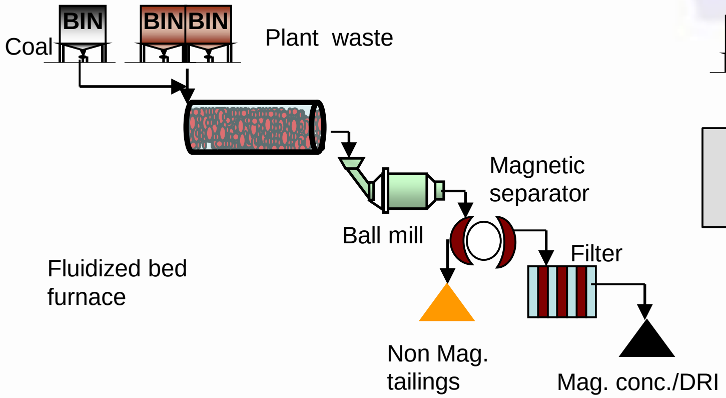


Valuables	Composition
Carbon	25-35%
Fe (T)	35-40%
SiO2	6-9%
Al2O3	2-5%
CaO	2-5%
MgO	0.5-2%
Zn	0.02 – 0.05%

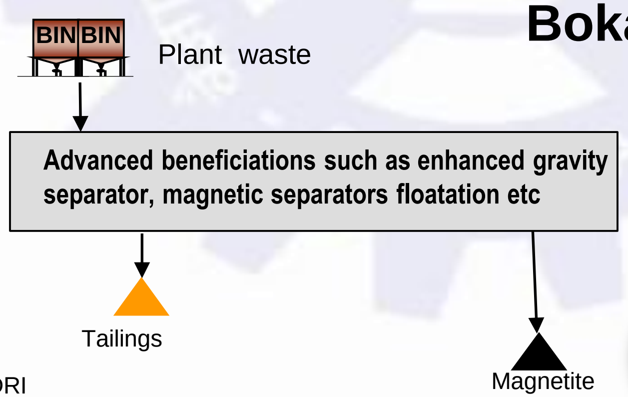
Commercialization

Technology has been transferred to M/s. Techno Environ Services Pvt. Ltd. Bokaro & M/s. Techno Environ Services Pvt. Ltd. Bokaro is now a StartUP of InTEC CSIR-IMMT

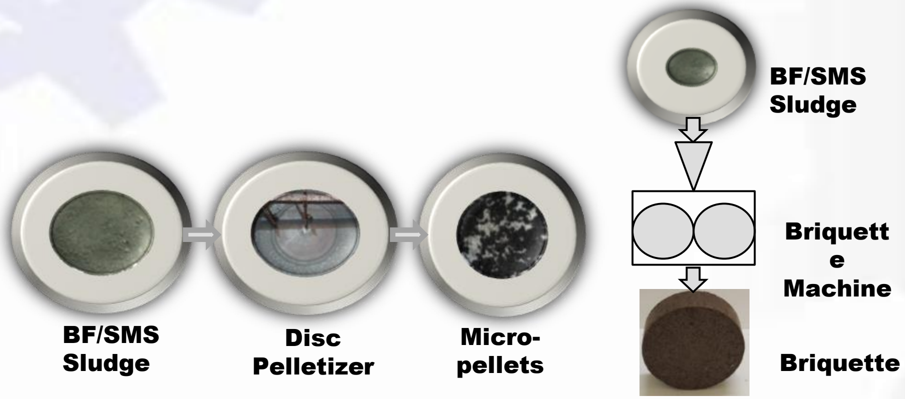
Magnetite



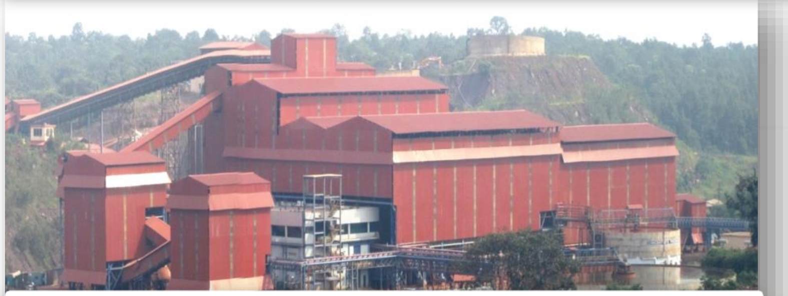
Magnetite/coke fines



Micropellet and Briquette



IMPORTANT ACHIEVEMNTS

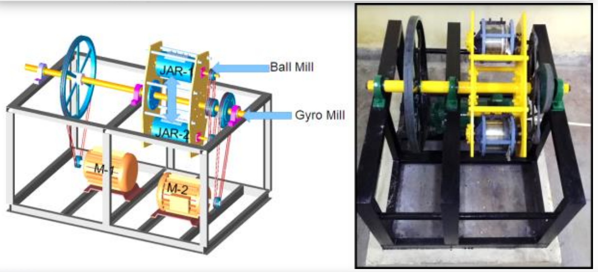


15 MTA Iron Ore Beneficiation Plant of SMPL at Barbil

PROCESS COMMERCIALISED

1. Essar Steel Ltd. (15MTPA)
2. SMPL (15 MTPA)
3. BRPL (6 MTPA)
4. BMM Ispat (2 MTPA)
5. BSPL (6 MTPA)
6. GM Steel (0.5 MTPA)

Graphene oxide from natural graphite: Tata Steel



Slurry pipeline – ore transport @ NMDC

- *1st phase commercial slurry pipeline (135.2 Km long, 550 mm pipe) to transport 15 MTA iron ore concentrate from Beheli to Nagarnar in Chhattisgarh*
- *IMMT design – based on pilot study*

Alum from Waste Aluminium Dross

Waste Dross Processing plant

Alum Crystals

Alum Powders

Alum Blocks

- Indian patent No. 254794
- M/s A.K. Enterprisers put up the plant at Khurda to produce 15-20 tons of alum per day
- *First ever Waste Dross* Processing plant in India.

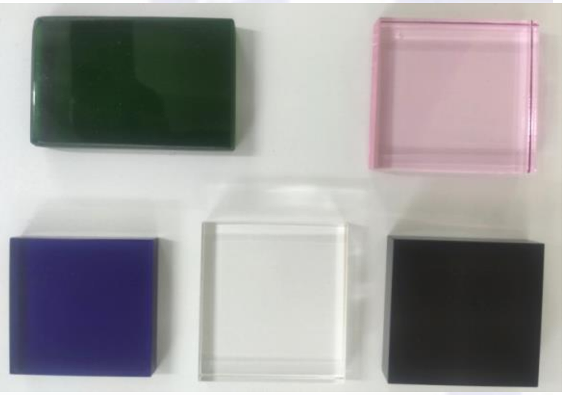
Utilization & Value addition of Flyash

Flow Sheet – Fly Ash Processing

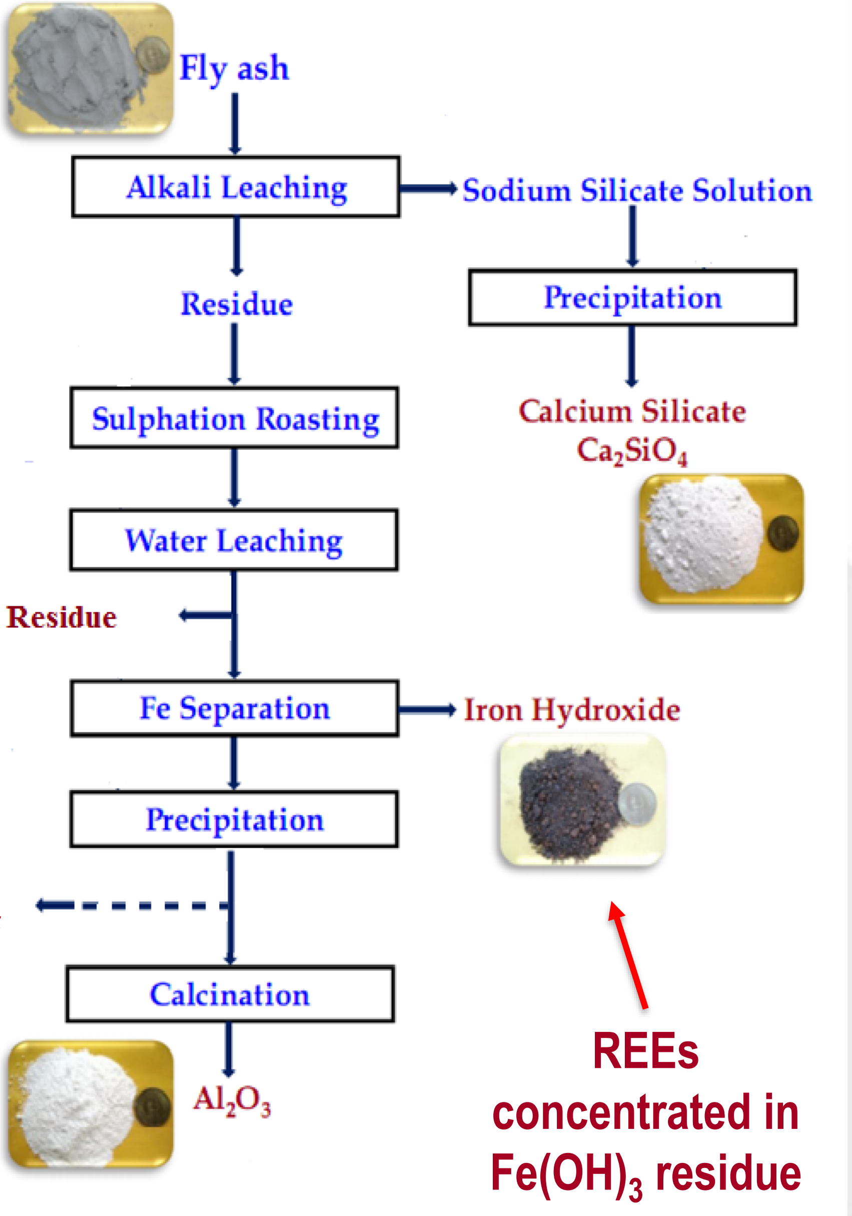
Composition of NALCO fly ash	
Component	(%)
Al_2O_3	25-28
SiO_2	60-62
Fe_2O_3	3-4
CaO	1-1.5

Ceramic cups made utilizing the calcium silicate produced from NALCO Fly ash by CSIR-CGCRI, Naroda

Fly Ash	1 ton
Quartz	410 kg
Calcium silicate	1 ton
Alumina	200 kg
Iron hydroxide cake	65 kg (contains ~ 200 g RE oxide)



Coloured glasses produced from quartz residue obtained from fly ash by CSIR-CGCRI, Kolkata



(Indian Patent no: 344358, A pyro-hydrometallurgical process for the recovery of alumina and calcium silicate from fly ash, 2016, Patent granted on 18th August 2020)

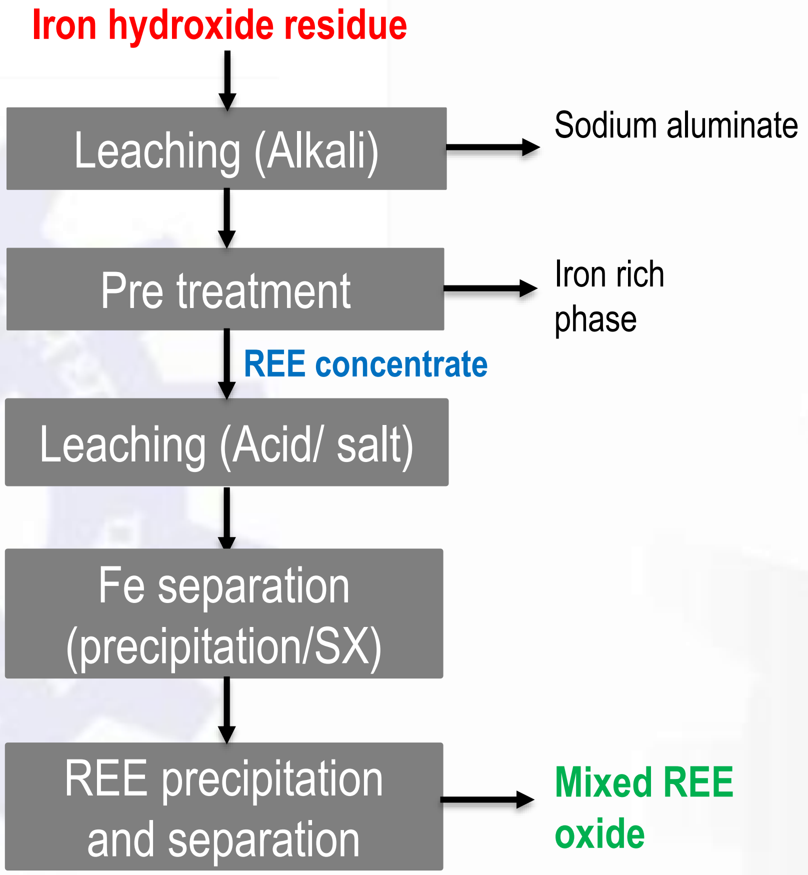
Recovery of Scandium and other REEs in fly ash

Typical composition

Element	NALCO Fly Ash	Hydroxide residue
	ppm	ppm
Sc	15	111.4
Y	51	377.2
La	100	593.6
Ce	155	997
Pr	18	127.6
Nd	66	466.2
Sm	13	93.4
Eu	2.3	16.4
Gd	10	71.4
Tb	1.7	11.6
Dy	9.2	65.8
Ho	1.9	13.6
Er	5.1	36.2
Yb	4.8	34.4
Total	**453**	**3015.8**

**based on 2016 feasibility report by Scandium International Mining Corp for Nyngan Sc project, Australia, with average 409 ppm Sc grade from lateritic ore including mining, high pressure leaching and other process costs which are not considered here*

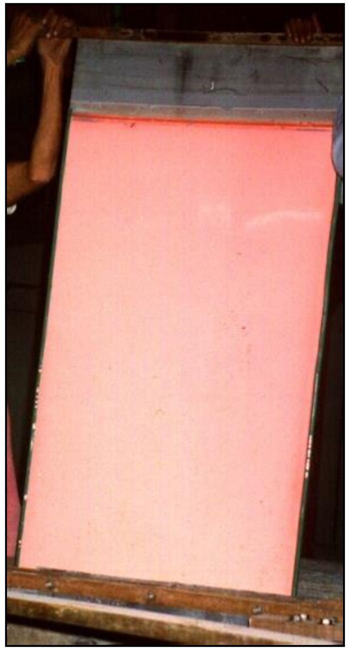
Tentative scheme of REE recovery

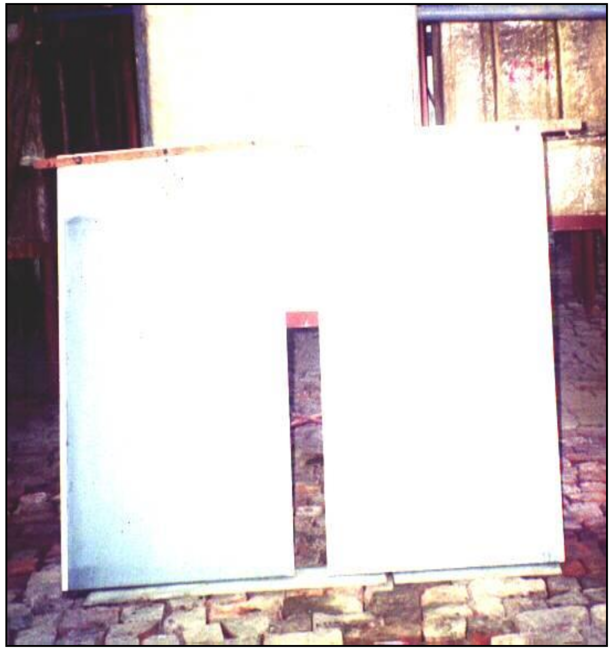


- **Operation cost (chemicals and energy): Rs. 300-500*/ton fly ash**
- **Revenue from REE : Rs. 1050/ton fly ash (assuming overall REE recovery of 40%)**

Copper and Zinc from Spent Catalyst/Brass Ash

- **High pure copper and zinc cathode can be produced using this technology.**
- **Process steps include :** Pre-treatment, leaching, purification and Electrowinning.
- **Raw material:** Spent catalyst from fertilizer industries with Cu=33% and Zn= 35% or brass ash





- **The process for the production of copper and zinc from spent catalyst has been commercialized at a plant capacity of 75 tpa copper and 75 tpa zinc by S.K. Enterprisers, Kanpur.**
- **M/s Pantnagar Fertilizers Limited, Muzaffernagar has commercialized the process** for the processing of brass ash **at a plant capacity of 100 tpa Zinc and 30 tpa copper.**

Return on Investment : 25%

Suggestions & Recommendations

- Transportation and logistic support is not geared up to the scale required to support the present level of mining activities. More than 60% of India's bulk transportation is heavily dependent on road and railways which is hugely cost intensive and environmentally damaging. To address the above issues of bulk transportation of mined ore, the present day requirement is the slurry pipeline transportation. Although only few Indian Iron ore industries have installed the bulk slurry pipe line transportation for iron ore fines to the pelletization plant, but a lot needs to be done in this front as the present technology for slurry pipeline transportation are being imported addition to its huge initial installation cost.
- Involvement of MSME sector is limited in the country with special emphasis to utilization of wastes generated in Iron & Steel industries. Special initiatives need to be taken with R&D-MSME-Ministry partnered together for sustainable economic growth
- Ensuring the quality of product and feasible techno-economics for long term sustainability
- Promoting the indigenous technologies for their deployment
- Linkage between MSMEs and research organizations for betterment of the technological development

Industries/ Ministries We Work With

vedanta

JSW Steel

HIRA
GROWING STRONGER TOGETHER

Ministry of Earth Sciences
Government of India

JINDAL STEEL & POWER

TATA STEEL

JSL
JINDAL STAINLESS

GOVERNMENT OF INDIA
MINISTRY OF MINES

GOVERNMENT OF INDIA
MINISTRY OF STEEL

सेल SAIL

RINL VIZAG STEEL
Pride of Steel

ADITYA BIRLA

Rungta Mines Ltd.

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DAE

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Coal India

cmpdi
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नालको NALCO

KUDREMUKH
IRON ORE COMPANY LIMITED

BMM
POTENTIAL IN TONNES

NMDC

State Pollution Control Board, Odisha
ରାଜ୍ୟ ପ୍ରଦୂଷଣ ନିୟନ୍ତ୍ରଣ ବୋର୍ଡ଼, ଓଡ଼ିଶା

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Thank You!

Thanks!

Any questions?

You can find me at:

Prof. Suddhasatwa Basu
sbasu@immt.res.in