

Prospects and challenges of mineral based industries and utilization of wastes for Make in India

1.0 Introduction

Large mineral based industries like iron and steel, aluminium, cement and base metals are fairly well developed and established in India, however, small and medium sized enterprises mainly focussed on the value addition of minerals/ores/industrial minerals are quite neglected in the country. These industries have vast potential for country like India, which has well qualified manpower, small to medium sized entrepreneurs and necessary technical skills more over they may safeguard our forex reserve by making import substitute products. All these elements make the mineral based industries suitable candidates for the development and promotion of the government sponsored 'Make in India' initiative. Keeping this in view, International Mineral Business Development Conference (MBD-2022) is being organized in Nagpur, India during March 2-4, 2022 in cooperation with Indian Bureau of Mines (IBM) and Federation of Indian Mineral Industries (FIMI). The main objective of this conference is to highlight the major advances in value addition of minerals and utilization of wastes, which directly promotes the Government of India initiative of 'Make in India' and *Atmanirbhar Bharat*.

2.0 Value addition – industrial minerals

Globally, the mineral industry is continuously on the move due to technological progress leading to the development of value-added products and new usages and also to changing supply of raw materials and environmental concerns. Industrial minerals surround us everywhere in the normal life; in houses, paper, plastics, paints, glass, ceramics, cars, pharmaceutical industries and even as additives in food. As the world consumption of manufactured products increases, so will the production of industrial minerals, and additionally new end-uses are being developed. Typical for the industrialised countries, the production of minerals is not limited to construction materials but includes a great number of other minerals mainly exploited for niche products and

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export purposes. Concerning India, there are several reasons for these positive developments;

1. The existence of a diversified geology, including many big mineral and coal deposits,
2. A good geographic position relative to the most important markets,
3. Along coastline with excellent shipping and export possibilities,
4. The increasing role of multinational companies, adding knowhow and market access,
5. The availability of basic infrastructure, qualified manpower and young entrepreneurs,
6. Reforms in the mineral sector by mandating auction of mineral concessions to improve transparency and many more.

Fig.1 provides basic steps in the production of value-added mineral products from the raw minerals.

At present the mineral based industries face multiple challenges, namely,

- i. Dwindling production and deep seated mining,
- ii. Fast depletion of high-grade resources and lowering of threshold value of minerals,
- iii. Changing policies of the exploitation and processing of minerals,

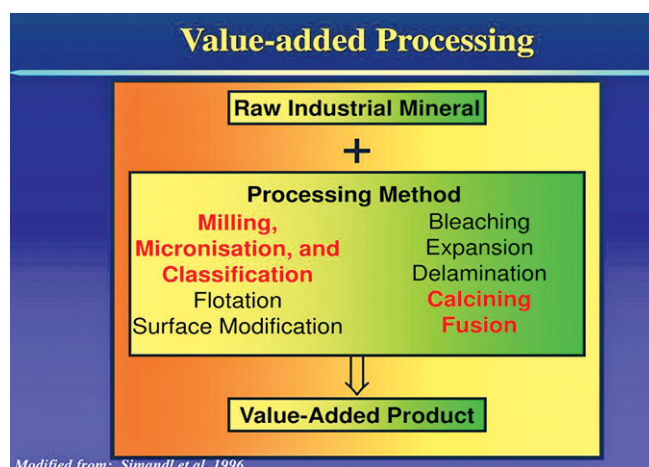


Fig.1: Basic processes for value addition of minerals

- iv. Wavering prices of mineral commodities due to International demand supply scenario to and political instabilities,
- v. Restricted (non-liberal) investments in the mineral sector and long gestation period.

Therefore, in order to make mining more attractive, it is necessary to make optimum utilization of the resources, develop the technologies for extraction of as many products and by-products as possible, and also create the value-added products from the mining wastes. The Government of India has introduced “Make in India” and *Atmanirbhar Bharat* initiatives for encouraging the industries and entrepreneurs to come forward and create a win-win situation for the mutual benefits.

At this backdrop, it is necessary for the stakeholders including entrepreneurs, industries, R&D institutions, and academia to deliberate on the present-day challenges faced by the mineral industry. MBD-2022 provides excellent opportunities and invites technical papers and presentation from the leading experts and companies on industrial minerals, mineral based products, effective use of vast coal resources such as gasification and latest developments and utilization of wastes of mines and mineral processing industries.

3.0 Industrial minerals of India and value-added products

The country is endowed with huge resources of many metallic and non-metallic minerals. Mining sector is an important segment of the Indian economy. Since independence, there has been a pronounced growth in the mineral production both in terms of quantity and value. India produces as many as 87 minerals, which includes 4 fuel, 11 metallic, 22 non-metallic, 3 atomic and 23 minor minerals (including building and other materials) [1]. The major metallic minerals currently mined in India are iron, bauxite, manganese, copper, lead, zinc, tin, silver, gold and scores of industrial/minor minerals. The emphasize of present conference will be on non-metallurgical application and uses of these metallic minerals. For example, there are several non-metallurgical uses and applications of bauxite in making refractory, abrasives, ceramics and minor products. In non-metallic minerals, India ranks second in barytes, bentonites, talc, steatite, pyrophyllite; 3rd in chromite, coal, and lignite; 4th in andalusite, sillimanite, kyanite etc. India ranks 4th in the list of minerals producing countries after China, USA, and Russia. Common industrial minerals mined in India according to IBM (2018) include following:

1. Metallic (ferrous) minerals: iron, manganese, chromite.
2. Metallic (non-ferrous) minerals: bauxite, copper-lead-zinc, platinum group metals.
3. Gems and precious minerals: diamond, gold, emerald, ruby, safire, silver.
4. Refractory minerals: andalusite, graphite, kyanite, magnesite, sillimanite.

5. Ceramics and glass minerals: wollastonite
6. Strategic minerals: cobalt, molybdenum, nickel, rare earth elements, tin, and titanium
7. Other industrial minerals: asbestos, borax, diatomite, fluorite, limestone, marl, perlite, rock salt, vermiculite, zircon
8. Minor industrial minerals: ball clay, barytes, bentonite, calcite, chalk, China clay, corundum, diaspore, dolomite, dunite, feldspar, fire clay, fuller’s earth, granite, gypsum, laterite, marble, mica, ochre, pyrophyllite, quartz and silica sand, quartzite, talc/steatite/soapstone, shale, slate.

As a common practice, one specific mine focuses on specific metal and the rest of the minerals and low grades are considered waste and disposed-off as such. But some of these waste products contain valuable minerals/metals that can be recovered and used sustainably. Instead of being simply dumped, mine tailings can be re-mined/processed to recover valuable minerals/metals. Re-mining tailings extends the operating life of existing mines. Re-visiting mine tailings have more economic and environmental benefits than developing new greenfield mines. The value-added material can also be recovered from mining waste. Few examples are cited here:

- a. Selective enrichment and separation for the recovery of copper and iron components from Daye copper converter slag
- b. Utilisation of red mud from Bayer processing of bauxite
- c. Spent pot lining from aluminium smelting
- d. Fly ash from power generation, slags from smelting operations and the use of wastes in cement, geopolymer concrete etc.

Keeping these in view, it is proposed to create website and depository of all the information/data on availability and quality of wastes/rejects of mineral industries so that these data can be used by interested entrepreneurs.

4.0 Examples of mineral based products

Keeping in view the industrial mineral resources of India, some of the value-added mineral products are named here as examples.

Fig.2 provides an example of an integrated TiO₂ value chain.

Fig.3 shows how the value of mineral increases with product type and quality.

5.0 India’s minerals based companies and their products

In India, there are several leading manufacturers of value-added mineral products and some of them are exporting these in the world market. A comprehensive list of leading Indian producers of main industrial minerals is provided here in the table given below.

TABLE 1

| | | | | | |
|-----------|---|--|--|--|--|
| Baryte | Un-ground baryte ROM | Ground and classified API and OCMA grade | Fine ground / classified filler grade | Chemically produced filler grade | Chemically ultra-purified barium chemical |
| Bauxite | Crushed/screened dried ROM | Heat treated calcined bauxite | Chemically produced Al chemical | Heat treated Calcined alumina | Fused and sintered alumina |
| Bentonite | Ground and classified drilling, foundry, civil engineering grade | Ground and classified API and OCMA grade | Chemically treated soda-ash treated montmorillonite | Chemically treated acid activated montmorillonite | Chemically treated organoclays |
| Chromite | Crushed/screened metallurgical ore | Ground and classified refractory, foundry and chemical ore | Fine ground/classified chromite foundry sand | Chemically produced chrome pigments | Fused ferrochrome |
| Dolomite | Crushed/screened aggregate | Aglime, glass-grade, filler-grade | H.M. and floated chemical metallurgical (dolime) | Heat treatment metallurgical (doloma) | Chemically produced magnesia chemical |
| Feldspar | Crushed/screened non-commercial | Floated glass-grade | Floated high-potash grade | Fine grinding/ classification ceramics/filler grades | |
| Fluorspar | Floated metallurgical-grade | Floated acid-grade | Chemically produced Aqueous hydrofluoric acid | Chemically produced F chemicals (flosilicic acid, synthetic cryolite) | Chemically produced Fluorocarbons |
| Garnet | Crushed/screened water filtration | Classification blasting abrasive and water jet cutting | Heat treatment abrasive grain grade garnet | | |
| Graphite | Graded/classified amorphous powder | Hand sorted small flake crystalline lump (80-95% C) | Hand sorted or floated medium flake crystalline lump (80-95% C) | Hand sorted or floated large flake crystalline lump (80-95% C) | Hand sorted or floated crystalline lump (92-95% C) |
| Gypsum | Crushed/screened wallboard/cement | Ground/classified agriculture grade | Heat treated (calcined) plaster | Ultrafine ground filler | |
| Kaolin | Ground/classified dried kaolin | Fine ground/ classified dry-grade and air floated (filler grade) | Fine ground/classified wet-grade and water washed (filler and coating grade) | Ultrafine ground uncalcined delaminated paint grade | Heat treated (calcined) water-washed and calcined paint and paper grade |
| Kyanite | Floated and magnetic separated raw kyanite (54-60% Al ₂ O ₃) | Heat treated calcined kyanite (59-62% Al ₂ O ₃) | Magnetic and H.M. sep andalusite (57-60% Al ₂ O ₃) | Mag. and heavy media separated sillimanite (70% Al ₂ O ₃) | |
| Limestone | Crushed/screened aggregate/aglime | Glass/filler grade | Ultrafine filler grade | Chemically produced PCC/UF filler | Surface treatment filler |
| Lithium | Heavy media separation petalite conc. (4.2% Li ₂ O) | Floated heavy media and/or mag sep. glass-grade spodumene (5-6.8% Li ₂ O) | Floated heavy media and/or mag sep. spodumene conc. (7.3-7.6% Li ₂ O) | Chemically produced lithium carbonate (40.4% Li ₂ O ₂) | Chemically produced lithium chemicals (bromide, chloride, fluoride, nitrate, sulphate) |
| Magnesite | Crushed/screened H.M. and/or mag. sep. raw magnesite | Heat treatment (calcined) caustic calcined magnesia (agricultural grade) | Heat treatment (dead burned) dead-burned magnesia (natural to synthetic) | Chemically product magnesia chemicals (chloride, carbonate, hydroxide, sulphate) | Fused/electrolytic fused magnesia |

| | | | | | |
|------------------|--|---|---|---|--|
| Manganese | Ground and classified metallurgical-grade manganese ore (35-58% Mn) | Heavy media separation battery and chemical (74-85% MnO ₂) manganese ore | Screened chemical leaching electrolytic synthetic or electrolytic manganese dioxide (EDM) (85-92% MnO ₂) | Chemical product Mn chemical (K permanganate, Mn acetate, carbonate chloride) | Fused high-carbon ferromanganese |
| Mica | Hand split and graded Sheet mica | Floated ground and classified Drilling-mud grade | Floated ground joint-cement grade | Floated dry fine ground (micronized and classified) paint/plastic filler grade | Floated wet ground and classified filler Grade |
| Neph. Syenite | Crushed/screened Non-commercial | Magnetic separation Glass | Fine ground/ Classified Ceramics | Ultrafine ground/ classified Filler | |
| Olivine | Crushed/screened blast furnace grade | Ground/classified refractory grade | Fine ground foundry sand | Ultrafine ground olivine flour (filler-grade) | |
| Phosphates | Washed, screened and floated crude phosphate rock | Chemically Produced acidulation of P rock with sulfuric acid Phosphoric acid 80-85% P ₂ O ₅ (commercial and technical grades) | Chemically produced acidulation of P rock with sulfuric acid or phosphoric acid single (18-20% P ₂ O ₅) or triple superphosphate (44-46% P ₂ O ₅) | Chemical product and blended phosphate ammoniamixed fertilizers (MAP, DAP) | Chemically product Phosphate chemicals (e.g., STPP, P pentoxide) including food-grade |
| Pyrophyllite | Hand selection and crushed/screened White cement (9-12% Al ₂ O ₃) | Hand selection and ground/classified blended Ceramic grade | Hand selection and ground/classified blended high-grade refractory grade glass-fibre grade (18-21% Al ₂ O ₃) | Hand selection and fine ground/classified and blended filler-grade (20-21% Al ₂ O ₃) | Hand selection and ultrafine ground/ classified and blended filler-grade |
| Salt | Feedstock salt salt in brine | Heat treatment evaporated/bulk | Agglomerated pressed block | Chemically concentrated chemical grade | Chemically ultra-purified USP sodium chloride |
| Silica Sand | Crushed and screened construction sand | Ground/classified foundry, filtration, chemical, metallurgical, abrasive sand | Floated and ground/ classified flat and container glass grade | Floated and fine ground/ classified ceramic, fiberglass, scouring powder | Floated and ultrafine ground/classified silica flour, filler in paint plastic and rubber |
| Soda Ash (trona) | Crushed and screened non-commercial | Calcined calcined trona | Chemically concentrated dense soda ash (glass) | Chemically concentrated light soda ash (detergent) | Chemically ultra-purified sodium carbonate decahydrate (chemical) |
| Talc | Floated or crushed/ screened crude talc | Floated or fine ground/classified filler and ceramic grade | Floated or ultrafine ground/ classified micronized talc pitch-control talc | Floated or ultrafine ground/classified chemically ultrapure cosmetic grade talc | Floated or ultrafine ground/classified surface treated filler in plastic |
| Titanium | Magnetic/gravity and electrostatic separated of heavy mineral fraction ilmenite (54%TiO ₂) | Ground gravity separated, roasted and smelted ilmenite in an electric arc furnace titanium slag (75-85% TiO ₂) | Reduction of ilmenite at high temperatures with coal in a rotary kiln synthetic rutile (91-96% TiO ₂) | Chlorination of high-titania material at high temperature titanium tetrachloride (TiCl ₄) | Chemically produced from ilmenite/rutile via sulfuric acid or chlorination reduce TiCl ₄ TiO ₂ pigment Ti sponge |

| | | | | |
|--------------|--|---|---|--|
| Vermiculite | Crushed/screened/blended/gravity separated and floated raw vermiculite concentrate | Heat treatment exfoliated vermiculite | | |
| Wollastonite | Mag.separation and ground/classified low aspect ratio (LAR) ceramic | Special fine ground/classified high aspect ratio (HAR) filler | Special ultrafine ground surface treatment high aspect ratio (HAR) hiller | |
| Zircon | Magnetic/gravity and electrostatic separated standard and premium grade zircon | Special fine ground/classified zircon flour (ceramic opacifier) | Chemicallyultrapure zirconium oxide electronic, insulating, stabilized | Reduction of ZrCl4 zirconium powder, sponge, sheet, bars, etc. |

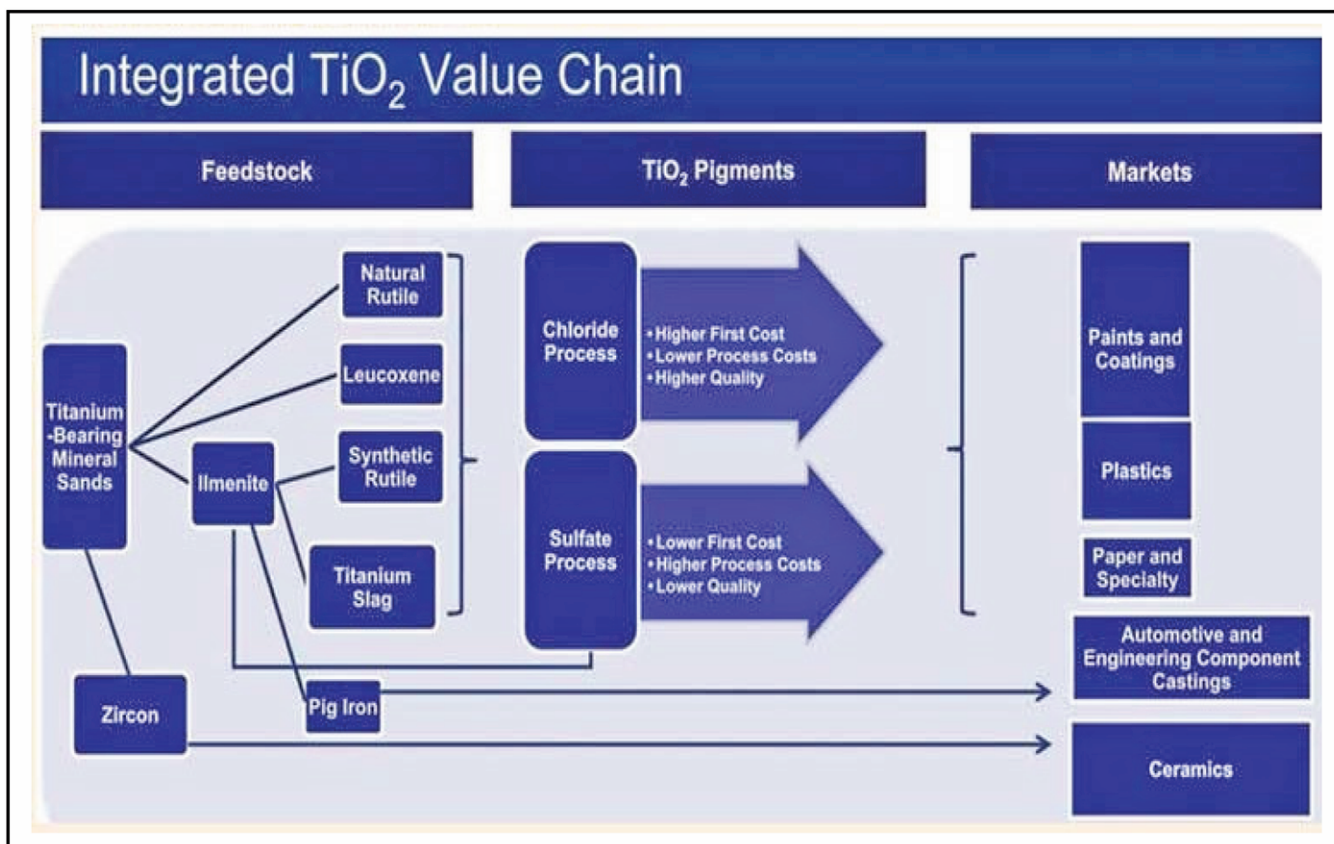


Fig.2: Value added products of TiO₂

6.0 Mineral Business Development (MBD) Conference and Exhibition

Keeping in view, the importance of mineral based products and valorisation of mineral waste in the world, the Mineral Business Development (MBD-2022) conference and exhibition is being organized in India by a team of mineral specialists. Despite having vast mineral resources and qualified technical manpower, India is lagging behind in the production of value-added mineral products and import several high-end items, which can be produced in India. Country offers excellent opportunities in attracting foreign

| Energy-intensive Value-added Products | | |
|---------------------------------------|-----------------|------------|
| Mineral | Product | US\$/tonne |
| Magnesite | Raw | ≈50 |
| | Caustic MgO | 119 - 138 |
| | Dead-burned MgO | 105 - 135 |
| | Fused MgO | >320 |
| | Mg Metal | ≈2430 |

Fig.3: Example of magnesite products and prices

TABLE 2: MAJOR VALUE-ADDED MINERAL PRODUCERS OF INDIA

| Mineral | Leading Producers | Main Products |
|----------------|--|--|
| 1. Barytes | Gimpex, 20 Microns, Alcore Minerals | White and grey barytes lumps, barytes powder, ceramics and micronized barytes etc. |
| 2. Bauxite | AshapuraMinechem, Saurashtra Calcine, CUMI (Carborundum), Calderys (Imerys), Vesuvius India etc. | Calcined bauxite, brown fused alumina, ceramics and proppants etc. |
| 3. Bentonite | Ashapura, Gimpex-Imerys, 20 micron, Trimex Industries Pvt.Ltd., Kandla Agroand chemicals Pvt Ltd | Bentonite clay, bentonite lumps, |
| 4. Chromite | The Orissa Mining Corporation Ltd, The Tata Steel Ltd, Balasore Alloys Ltd, Indian Metals & Ferro Alloys Ltd, Ferro Alloys Corporation Ltd, Bhakti International, Haibru Export Private Limited and Zenith Steels | Chromite ore sand, ferro-chrome, sillico-chrome, charge-chrome and Chromium metal etc. |
| 5. Dolomite | Ashapura China Clay Pvt. Ltd., Aarjay Minerals, Steel Authority of India Ltd, Bisra Stone Lime Co. Ltd, Rastriya Ispat Nigam Ltd, Tata Steel Ltd, Mysore Minerals Ltd, Aravali Polyart Pvt. Ltd, Dolomite Mining Corp. | Fertilizer, glass, bricks, ceramics, etc. |
| 6. Feldspar | A & J Microns Pvt. Ltd., Aarjay Minerals, Cementation India Pvt Ltd, Earth Chem Exim Pvt Ltd, Friends Salt Works & Allied Industries, Karnataka Silicates, Kedar Industries, Leuco Microns Pvt Ltd, | Feldspar powder, potash feldspar lumps, potassium feldspar and soda feldspar etc. |
| 7. Garnet | Trimex Sands Pvt. Ltd, Indian Rare Earths Ltd, Transworld Garnet India Pvt. Ltd and V.V. Minerals | Gem stones, garnet abrasive and garnet sand etc. |
| 8. Graphite | Tamil Nadu Minerals Ltd, Graphite India Limited (GIL) and Tirupati Graphite | Graphite moulds, graphite tubes and graphite bricks etc. |
| 9. Gypsum | Rajasthan State Mines and Mineral Ltd., Thoothukudi, Tamilnadu. | Cement, fertilizer, moulds etc. |
| 10. Kaolin | Ashapura Minechem Ltd. | Paper, Rubber, Paint etc. |
| 11. Kyanite | Pavri Kyanite Mine (Maharashtra) Nawargaon-Chowa Kyanite Mine (Maharashtra) | Refractories, ceramic products etc. |
| 12. Limestone | Nandini Limestone Mines, (Chattisgarh) Bhawanathpur Limestone mine, Jharkhand Jabalpur (M.P.) & Satna (M.P.) Cuddapah (Andhra Pradesh) | Food additive, Paint, Paper, Rubber, Glass and Plastic etc. |
| 13. Lithium | Khanij Bidesh Ind Ltd. | Batteries. |
| 14. Magnesite | Tamil Nadu Magnesite Ltd, (Tanmag) | Refractory material, fertilizers etc. |
| 15. Manganese | Bharveli manganese mine, Balaghat (M.P.), Nagpur-Bhandara region (Maharashtra), Tentulidihi Manganese Ore Mining, Dengula, (Orissa). | Clear glass, Paint, Filler in dry cell Batteries, etc. MnO as cattle feed industry |
| 16. Mica | Gudur Premier Mica Company, Andhra Pradesh, Aravalis (Rajasthan), Koderma (Jharkhand). | Electrical insulators in electronic equipment, Glassblushes, lipsticks, lip gloss, eye liner, eye shadow, foundation, glitters, mascara, nail polish, toothpaste, etc. |
| 17. Olivine | Maxworth Minerals Pvt Ltd, Andhra Pradesh. | Refractory bricks, Mould, etc. |
| 18. Phosphates | Jhamarkotra Rock Phosphate Mine (RSMML), Udaipur | Fertilizer, Water-based paints and coatings, Metal polishes, Flame retardants, Processed foods, Personal care products, pharmaceutical products etc. |
| 19. Talc | Golcha Group, Rajasthan, SKKU Minerals India Pvt Ltd. Rajasthan | Paint, Rubber, Food, Electric cable, Pharmaceuticals, Cosmetics, Ceramics, etc. |
| 20. Pumice | Siddhivinayak Dyechem Pvt. Ltd. Mumbai | Medicine, Soap Bar, Concrete, Cinder Block, etc. |
| 21. Zircon | V.V. Mineral Pvt. Ltd. Tamil Nadu. | Ceramics. |
| 22. Quartz | Vinayaka Microns (I) Pvt. Ltd. Rajasthan. Veejee Mines and Mineral, Andhra Pradesh. Sharma Basaveshwara Mining Co. Karnataka. Vidhatri Mines and Minerals, Andhra Pradesh | Ceramics, Glasses, Alloy Steel, Cement, Fertilizer, Foundry, etc. |

investments and in export of value-added mineral products.

MBD-2022 will provide a platform for the mineral producers, technology/equipment suppliers and R&D organizations to highlight latest technological developments in mineral processing and its commercialization. The conference will seek to highlight the strategic linkage between the technological and commercial sides of the mineral industry from discovery to exploitation and production of value-added products. The emphasis of this conference will be to highlight potential of industrial minerals, non-metallurgical products and high-end mineral based industries. This vital industrial area was neglected in the country so far and this is the right time to work

on the mineral based value-added products in India.

The organizing committee of MBD-2022 invites all stakeholders including mine owners, mineral producers, technocrats, R&D institutes and entrepreneurs around the world to come together and interact for the development of this vital industry. This conference will provide an excellent opportunity to interact with mineral producers, buyers, traders and experts in the field of minerals and mineral based products. Please visit website <http://www.mineralinfo.netfor> details.

¹ https://www.mines.gov.in/writereaddata/UploadFile/National_Mineral_Scenario-converted.pdf

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