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Mining Engineers' Association of India

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Not Just Mining Minerals...

MINING HAPPINESS

Odisha_mining | OmcOdisha

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this issue contains...

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President's Message.....

Dear members..

The latest developments in the mining sector in India during April 2026, reflecting both the opportunities and challenges before our industry. The sector is witnessing a significant transition towards technology-driven operations. The recent initiative to establish an artificial intelligence–focused center of excellence for mining marks a progressive step toward embracing Mining 4.0. Such advancements are expected to enhance operational efficiency, safety, and data-driven decision-making across the industry.

At the international level, India's efforts to secure critical minerals essential for energy transition and advanced technologies continue, although certain negotiations have encountered challenges. This underlines the importance of strengthening strategic partnerships and ensuring resource security for the nation's future.

Domestically, steps are being taken to revive mining activities, including the auction of mining dumps in Goa, which reflects a positive approach toward resource optimization and economic revival. At the same time, the government has introduced reforms aimed at expediting the auction process and operationalization of mines, which is a welcome move for the industry. These developments highlight the need for greater transparency, accountability, and adherence to statutory regulations.

I urge all members to actively contribute toward building a transparent, safe, and technologically advanced mining ecosystem.

Geopolitical tensions in West Asia due to war between Iran and Israel disrupting the import of key raw materials for India's mining sector and other manufacturing sectors. Supply chain issues and higher freight costs have increased import expenses. This is affecting the availability and prices of essential inputs like coking coal, fertilizers, and processing chemicals. Consequently, the mining sector in India is facing cost pressures, highlighting the need to strengthen domestic resource security and reduce import dependence.

I congratulate the Belgaum Chapter for organizing different activities for student members. I also appreciate the Jodhpur Chapter for organizing an educational mine visit for MBM College students, as well as for conducting a three-day "QGIS-based Remote Sensing & GIS Training Program."

I am pleased to note that the Tamil Nadu Chapter is organizing a one-day National Seminar and also hosting the 3rd National Council Meeting at the Learning and Development Centre, Neyveli, NLC India Limited, Tamil Nadu. I encourage all members to attend the seminar, as it will offer a valuable platform for knowledge enhancement, capacity building, and professional growth.

I extend my appreciation to the Kolkata Chapter for coming forward to host the 4th Council Meeting and 53rd AGM in June 2026.

It is also my pleasure to note that some of our chapters are also conducting technical training programs, industrial visits for student members, and workshops in their respective regions. Such initiatives play a vital role in nurturing young professionals and equipping them with the skills and perspectives required to meet the evolving challenges of the mining industry.

D.B. Sundara Ramam
President

Mining Engineers' Association of India

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India's Golden Opportunity

Dr. P.V. Rao
Chief Editor, MEJ

Mining the Future

Gold occupies a unique place in India's civilizational consciousness. From the temples of antiquity to modern wedding halls, the metal has always represented wealth, security, and cultural identity. Yet, paradoxically, a nation so deeply wedded to gold remains startlingly dependent on imports for its supply—a structural weakness that drains foreign exchange and widens the current account deficit year after year. The time has come for India to treat gold not merely as an ornament of tradition but as a strategic industrial resource.

India's gold mining history stretches back over two millennia. The Kolar Gold Fields (KGF) of Karnataka, once among the deepest and richest mines in the world, produced over 800 tonnes of gold during their operational life under British administration and thereafter. At their peak in the early twentieth century, KGF mines employed thousands and powered regional economies. However, mismanagement, rising extraction costs, and policy neglect led Bharat Gold Mines Limited to cease operations in 2001, shutting the door on a glorious chapter of domestic production. Today, the Hutti Gold Mines in Karnataka remain virtually the only active producer, contributing a modest 1.5–2 tonnes annually—a fraction of national demand.

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SUBSCRIPTION RATES

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India is the world's second-largest consumer of gold, absorbing between 700 and 900 tonnes annually. With domestic production languishing in the low single digits, virtually the entire demand is met through imports. Gold consistently ranks among India's top two or three import commodities, with annual import bills routinely exceeding $35–40 billion. This places immense pressure on the rupee, inflates the current account deficit, and leaves the economy vulnerable to global commodity price shocks. The imperative for developing a robust domestic gold industry is, therefore, not merely commercial but macroeconomic.

The Geological Survey of India (GSI) has intensified its exploration mandate in recent years. Preliminary estimates place India's gold ore resources/reserves at over 500 million tonnes with nearly 600 million tonnes of metal content, with significant deposits identified in Rajasthan's Bhukia-Jagpura belt, Jharkhand's Singhbhum region, and the underexplored terrains of Andhra Pradesh and Chhattisgarh. The National Mineral Exploration Policy and successive amendments to the Mines and Minerals (Development and Regulation) Act have attempted to streamline block auctions and reduce the exploration-to-production timeline. The government's push for auctioning mineral blocks through competitive bidding is a positive structural shift, though procedural delays and state-level clearances continue to slow momentum.

Recognizing that domestic resources/reserves alone may not suffice in the near term, India has explored the route of strategic overseas acquisition. State-owned entities, including MMTC and, more recently, frameworks under the National Mineral Policy 2019, have been encouraged to acquire gold-bearing assets in mineral-rich geographies of Africa, Latin America, and Central Asia. While India lacks the aggressive overseas mining footprint of China, which has systematically locked in mineral assets across three continents, there is a growing recognition that resource diplomacy must become an integral element of India's foreign economic policy. Bilateral mineral agreements, concessional financing for Indian entities bidding for overseas mines, and dedicated sovereign support mechanisms are urgently needed.

The private sector's role in Indian gold mining has historically been constrained by regulatory ambiguity, lengthy environmental clearances, and community resistance. Progressive liberalization, however, is slowly changing the landscape. Composite licences that bundle prospecting and mining rights, along with provisions for end-to-end exploration funding, have made entry more attractive for private players. Companies such as Deccan Gold Mines Limited have been quietly advancing grassroots exploration, demonstrating that private enterprise, given a level playing field, can supplement state capacity meaningfully. What the sector needs is a dedicated gold mining policy, favourable royalty structures for early-stage producers, and fast-tracked environmental assessments in non-ecologically sensitive zones.

India's gold dependency is a structural vulnerability. The geology is favourable, the demand is certain, and the macroeconomic case for import substitution is unanswerable. What has been missing is the political will to treat gold as a strategic industrial sector—not merely a cultural one. A calibrated combination of aggressive domestic exploration, targeted overseas acquisitions, and private sector empowerment could, within a decade, meaningfully reduce import dependence and convert a perennial liability into a sovereign asset.

- Chief Editor

NEWS FROM THE MINERAL WORLD

Codelco in talks with India's HCL for Chile copper joint venture

Chile's Chuquicamata open pit copper mine moved underground last year. It was the world's largest.

Codelco is negotiating a copper venture with India's Hindustan Copper Ltd. as the Chilean state-owned miner turns to foreign partnerships to develop unexploited deposits, according to people familiar with the matter.

The deal under discussion is for a joint venture in which Codelco would put up one of its undeveloped deposits in Chile, with HCL taking on capital commitments, said the people, who asked not to be identified discussing ongoing confidential talks. Investments would exceed $1 billion, they said.

Codelco "maintains multiple conversations and negotiations" on potential partnerships to develop a portfolio of exploration projects, the Santiago-based company responded when asked about talks with HCL. HCL didn't respond to a request for comment.

Codelco, one of the most indebted global miners, is teaming up with foreign firms - including BHP Group and Rio Tinto Group - in a bid to drill deposits without adding to its already heavy investment burden as new projects get trickier and pricier to develop. At the same time, Chile's new government under President Jose Antonio Kast is cutting red-tape and easing regulation in a bid to unlock investments in mining.

Codelco is turning more to India as a buyer of its copper. Indian companies, meanwhile, are looking to Chile, which boasts the world's biggest copper reserves, to secure supply, integrate upstream and stay competitive in a tightening global market.

The prospective Codelco-HCL deal comes a year after both state-owned companies signed a memorandum of understanding during former Chilean President Gabriel Boric's visit to India. The MoU focuses on exchanging information to facilitate exploration, mining, and mineral processing, along with employee training and capacity building.

Bloomberg News | April 15, 2026

India-Zambia talks on critical minerals stall over mining rights

Lusaka, Zambia. Stock image.

India's talks with Zambia over critical minerals mining have stalled amid a lack of assurances from Lusaka on mining rights, two sources familiar with the matter told *Reuters*.

India last year received an allocation of 9,000 square km (3,474.92 square miles) to explore cobalt - a key component in batteries for electric vehicles and mobile phones - as well as copper, widely used in power generation, electronics and construction.

India dispatched a team of geologists last year, who have since returned with samples of minerals, including cobalt and copper.

The exploration program in Zambia was set to run for three years, after which New Delhi had planned to invite private sector companies to participate, subject to securing mining rights. It was not immediately clear why Zambia was withholding assurances for mining rights.

New Delhi is making efforts to restart discussions with Zambia, but the situation is still uncertain, one of the sources said. They declined to be identified as the discussions are not public. India's federal Ministry of Mines did not respond to a *Reuters* request for comment.

India has been in talks with several African countries to acquire critical mineral blocks on a government-to-

government basis, while also exploring opportunities in Australia and Latin America.

The Indian government last year held internal discussions over the country's growing vulnerability to a tightening global copper market and ways to secure supplies from resource-rich countries during ongoing trade negotiations.

India's copper imports have risen sharply since the 2018 closure of Vedanta's Sterlite copper smelter. The country imported 1.2 million metric tons of copper in the fiscal year ending March 2025, up 4% from the previous year.

India is almost entirely dependent on cobalt imports, with shipments of cobalt oxide rising 20% in 2024-25 to 693 metric tons, government data showed.

Reuters / April 16, 2026

➢ India's first private gold mining project is all set for launch in Andhra Pradesh

Kurnool: From the time of Emperor Ashoka to the renewed push for an Aatmanirbhar Bharat, India's enduring love affair with and fascination for the precious yellow metal has been both cultural and economic. Now, in the parched, mineral-rich terrain of Andhra Pradesh's Kurnool district, a centuries-long dormant ambition is finally turning into reality.

Jonnagiri: All that glitters

The processing plant of Geomysore Services India Pvt. Ltd.'s Jonnagiri gold project, India's first large-scale private gold mine since Independence, is all set to go live in the first week of May. Hectic activity can be witnessed at the plant as it goes through the pre-commercial operations process with the management closely monitoring the run-up to full-fledged production.

Heavy dependence on imports

For decades, India's gold quest has been defined by dependence. The country imports over 800 tonnes of gold every year, which puts sustained pressure on foreign exchange reserves.

Domestic production, meanwhile, has remained limited. The state-run Hutti Gold Mines continues to be the only significant producer, yielding roughly 1.5 tonnes annually, while the iconic Kolar Gold Fields ceased operations in 2000, leaving a void in large-scale gold mining.

Public sector enterprises like Navratna miner NMDC Ltd. too have diversified into gold mining, but that has been done by acquiring mining companies and mines abroad.

It has been mining at the high-grade Mt Celia gold project that is operated by its subsidiary Legacy Iron Ore Ltd. to tap the key deposits at Blue Peter and Kangaroo Bore and was successful in producing the first ore in early 2024.

India's first private sector gold mine

But the Jonnagiri gold project, which is spread across nearly 598 hectares in Jonnagiri, Erragudi, and Pagidirayi villages of Kurnool, represents a major private sector foray into gold mining in India. Geomysore Services, which is backed by Thriveni Earthmovers & Infra, one of India's largest mine developers and operators, and Deccan Gold, is a BSE-listed company. The keenly watched project has already attracted an investment of over ₹400 crore.

Andhra Pradesh Chief Minister Chandrababu Naidu is expected to dedicate the project to the nation in early May. "This is a landmark moment -not just for Andhra Pradesh, but also for India's broader (gold) mining ambitions," said Mukesh Kumar Meena, principal secretary, mines and geology, Andhra Pradesh.

Project on fast track

The processing plant was commissioned in 13 months. "Jonnagiri reflects what India is capable of when vision, technology, and execution come together. We are not just building a mine but creating a model for responsible, efficient, and globally competitive mining in the country," said B Prabhakaran, founder and managing director of Thriveni Earthmovers.

The project is backed by robust resource estimates. The certified resources stand at 13.1 tonnes of gold, with exploration indicating a potential upside of up to 42.5 tonnes. At peak capacity, the mine is expected to produce up to 1,000 kg of refined gold annually over the next 15 years.

Project sparks hope of golden mining future

"Success of this project should encourage many investors to come into the gold and critical mineral sector, which is the need of the hour for India, both commercially and strategically," said Dr Hanuma Prasad Modali, director of Geomysore and managing director of Deccan Gold.

He pointed out that several untapped gold and critical mineral deposits across the country could be brought into production with sustained exploration. "India should aim at producing at least 50 to 100 tonnes of gold per annum in the next decade. " Deccan Gold

is also developing a gold mine in Kyrgyzstan and exploring resources including copper, nickel, lithium, and tungsten in India and abroad.

Jonnagiri is also being positioned as a socially integrated project with initiatives spanning education, healthcare, sanitation, drinking water and skill development in surrounding villages. This emphasis on what industry experts term a "social licence to operate" has helped the project gain acceptance among local communities.

The Chandrababu Naidu led-NDA govt has played a facilitating role, aligning the project with its industrial development goals and supporting clearances.

Experts say that the project may not immediately transform India's gold import bill, but it marks a structural shift - signalling that the country is once again ready to tap into its own mineral wealth.

From rocks to riches

Before dawn breaks over the rugged stretches of Kurnool, silence at the Jonnagiri gold fields steadily gives way to a rising mechanical symphony-drills piercing the earth, controlled blasts cracking ancient rock, and giant excavators clawing through layers that have guarded their secrets for millennia.

What unfolds here is nothing short of modern-day alchemy, where ordinary stone is coaxed, crushed, and transformed into gold.

At the Geomysore Services gold project in Jonnagiri, the process begins with open-pit mining. Precision drilling and controlled blasting break down hard rock formations, exposing gold-bearing ore.

Massive dumpers then transport the mined material to the processing plant, where it undergoes systematic crushing and grinding into fine particles. This powdered ore is first subjected to gravity separation, enabling early recovery of coarse gold.

The finer material then enters the carbon-in-leach system, a critical stage where a cyanide solution dissolves the remaining gold. The dissolved metal is adsorbed onto activated carbon, setting the stage for extraction. Through elution and electro-winning, the gold is separated and collected as a dense sludge.

In the final stage, intense heat within smelting furnaces transforms this residue into doré bars-solid, gleaming proof of a remarkable journey from rock to riches.

Samdani MN / TI | Apr 19, 2026

➢ AI and subsurface intelligence reshape mining

The global mining industry faces intensifying pressure to secure critical minerals, not because they are scarce, but because discovering and extracting them economically and sustainably is becoming harder.

Waihi operation, New Zealand.

Beneath strong commodity prices lies a tougher reality: deposits are deeper, ore grades are declining, and development timelines now stretch 16 to 18 years from discovery to production. The industry needs a different kind of intelligence, one that combines geoscience expertise, integrated data, and AI to better understand the subsurface and make faster, more informed decisions.

Exploration itself is changing. Success no longer comes from drilling more holes, but from connecting fragmented datasets and extracting insight. Today, mining specialists spend nearly one-third of their time managing data, yet only 39% of organizations have a defined data framework. At the same time, 51% of geoprofessionals are already using or considering AI. Without stronger data foundations and a clear enterprise strategy, that interest will not translate into results.

Data to action

The shift from data wrangling to decision-making is critical. AI-ready subsurface data allows geologists to focus on interpreting the ground rather than organizing information. This matters because one of the biggest bottlenecks in mining is the so-called permitting paradox: companies must prove to regulators, investors, and communities that risks are understood and managed, even when their data is incomplete or fragmented.

AI-supported subsurface intelligence helps break that deadlock. It does not remove uncertainty, but it makes uncertainty manageable. The most effective approaches embed AI directly into workflows, grounded in reliable data and domain expertise. This enables faster

(Continued on Page 19)

Mining Engineers' Association of India
Hyderabad Chapter

National Conference on
MINING 4.0

KEY THEMES

- AI & Intelligence & Machine learning in Exploration and Mine Planning
- Automation & Robotics & Autonomous Equipment
- Digital Twin & Smart Mines Systems
- Advanced Drilling, Blasting & Fragmentation Control
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CRITICAL MINERALS AND THE FUTURE OF THE ENERGY TRANSITION IN INDIA: SUPPLY, SECURITY, AND SUSTAINABILITY

Dr Pankaj Kumar Satija [a], Ankit Agrahari [b]

Abstract

Critical minerals form the material backbone of the global energy transition and advanced manufacturing, underpinning technologies such as renewable energy systems, electric mobility, defence applications, medical devices, semiconductors, and data infrastructure. In India, securing reliable and environmentally responsible access to these minerals has become increasingly important amid geopolitical uncertainty and highly concentrated global supply chains. While the country possesses notable geological potential for several critical minerals, including rare earth elements (REEs), domestic mining, beneficiation, and processing capacities remain underdeveloped, limiting value addition and supply security.

India's position within the global critical minerals landscape is characterised by structural gaps across the mining-to-processing continuum, high import dependence for refined materials, and limited downstream integration. These constraints persist despite resource availability, reflecting technological, regulatory, and environmental challenges associated with low-grade ores, complex mineralogy, and chemical-intensive separation processes. Secondary sources such as e-waste, coal fly ash, and metallurgical slags offer supplementary pathways for resource recovery and waste minimisation, though their deployment is constrained by economic feasibility, recovery efficiencies, and environmental safeguards.

A sustainable pathway for India requires integrated development of mining and beneficiation capacities, advancement of cleaner and resource-efficient processing technologies, strengthened environmental regulation, and responsible utilisation of secondary resources. Coupled with targeted international partnerships, such an approach can enhance mineral security while aligning critical mineral development with long-term environmental protection and sustainable resource management objectives.

Keywords: Critical Minerals, Rare Earth Elements (REEs), Energy Transition, Supply Chain Security, Strategic Minerals Policy Sustainable Mining and Processing, Advanced Manufacturing, Secondary Resource Recovery, Environmental Sustainability, Circular Economy

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1. CRITICAL MINERALS: AN OVERVIEW OF APPLICATIONS AND STRATEGIC SIGNIFICANCE

Globally-and particularly in the Indian context-critical minerals are defined as non-fuel mineral resources that are essential for economic development and national security, and whose supply chains are highly susceptible to disruption. These minerals include rare earth elements, precious metals, and other strategic materials that underpin contemporary technologies and critical infrastructure. They are indispensable for a wide range of applications, including smartphones and computers, aircraft and satellite systems, advanced medical equipment, electric vehicle batteries, and renewable energy technologies such as wind turbines and solar photovoltaic systems. In addition, critical minerals are used in several consumer products, including cosmetics and specialty chemicals.

The United States Geological Survey (USGS) has identified 60 minerals as critical, of which 15 are rare earth elements. In parallel, India has designated 30 minerals as critical, encompassing a total of 51 elements, including six platinum group elements and 17 rare earth elements-namely the 15 lanthanides along with scandium and yttrium. Certain minerals considered critical by the United States-such as manganese, magnesium, gold, silver, chromium, aluminum, arsenic, boron, fluorspar, and barium-are not classified as critical in the Indian context due to either adequate domestic resource availability or the presence of viable substitutes.

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Conversely, minerals such as molybdenum, cadmium, selenium, osmium, and promethium are included in the India's critical minerals list but do not currently feature in USGS's designated list.

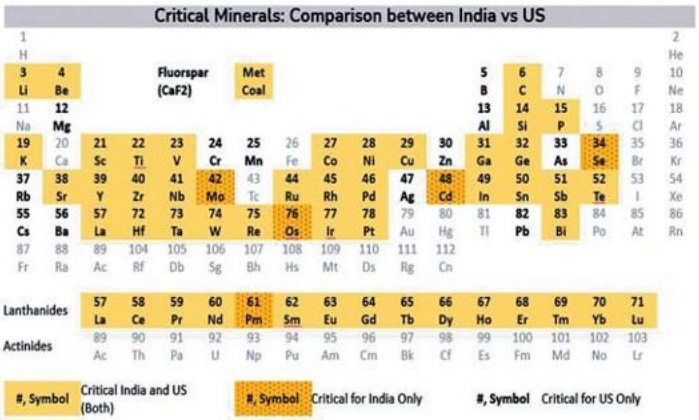

Figure 1- Comparative snapshot of critical minerals and elements designated by India and the United States

2. CRITICAL MINERALS IN ENERGY TRANSITION, E-MOBILITY, AND ADVANCED MANUFACTURING

Critical minerals constitute the foundational building blocks of emerging and strategic technologies that are central to economic growth, climate action, and national security. A synopsis on sectoral use of critical minerals is depicted in following section:

2.1 Energy Transition and Renewable Energy Systems: The shift from fossil fuel–based energy systems to renewable and low-carbon alternatives is inherently mineral-intensive. Technologies such as wind turbines, solar photovoltaic (PV) systems, grid-scale energy storage, and hydrogen electrolysers rely heavily on critical minerals. Similarly, electric mobility represents one of the fastest-growing sources of demand for critical minerals. The availability, affordability, and viable sourcing of these minerals directly influence EV adoption rates, supply chain resilience, and the overall sustainability of the transport sector.

2.2 Data Centers and Digital Infrastructure: The rapid expansion of digital infrastructure, including data centers, cloud computing, and artificial intelligence (AI) systems, has emerged as a significant driver of critical mineral demand. With the gradual transition from Industry 4.0 to more advanced paradigms such as Industry 5.0 and Industry 6.0 over the coming decades, the role of critical minerals will become increasingly pivotal, surpassing their present-day strategic significance.

2.3 Defence and Strategic Technologies: Critical minerals are indispensable to defence systems and strategic technologies due to their unique physical, chemical, and magnetic properties.

2.4 Medical Technologies and Healthcare Systems: The medical and healthcare sector increasingly depends on critical minerals for advanced diagnostics, treatment, and life-saving equipment.

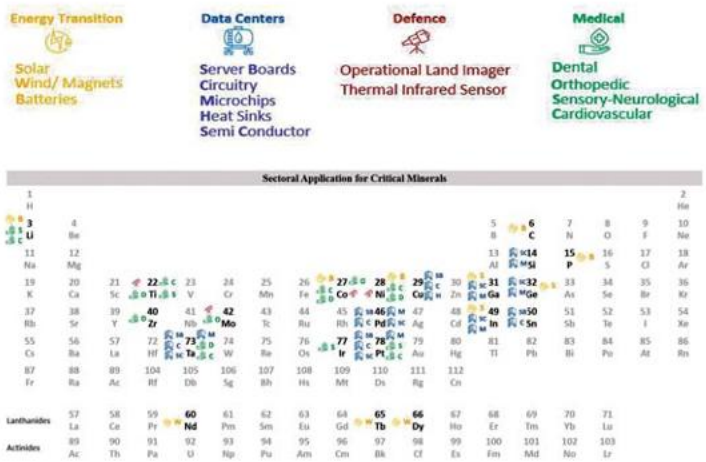

Figure 2 – Uses of critical minerals in various strategic sectors

3. RESOURCE AVAILABILITY FOR CRITICAL MINERALS IN INDIA

To secure India's critical mineral supply chain, it is essential to ensure reliable and long-term availability of strategic minerals from both domestic and foreign sources. India has some domestic reserves of critical minerals such as graphite, certain rare earth elements (REEs), and silicon/industrial minerals. Current production of domestic critical minerals is relatively low due to limited geological data and advanced exploration results. High capital investment requirements for mining and processing facilities is one of the major factor.

However, many high-demand minerals like lithium, cobalt, and nickel are not commercially available in significant quantities at present and India is almost entirely dependent on imports- in some cases 100%.

3.1 Import Dependency for India: India is highly import-dependent for the supply of several critical minerals-including cobalt, lithium, germanium, rhenium, beryllium, niobium, tantalum, vanadium, strontium, nickel, and rare earth elements-owing to limited domestic availability and production. This dependence is further reinforced by historically inadequate and unsystematic mineral exploration, resulting in a weak indigenous resource and processing base for many strategic minerals.

3.2 Secondary Sources of Rare Earth Elements: Rare earth elements are often used in small quantities and low concentrations in various electronics products and their components. They remain economically challenging to recycle, even from components with a higher content, and recycling therefore- currently accounts for only around 1%

or less of demand. With the exception of lithium (Li) and germanium (Ge), several critical raw materials, primarily rare earth elements, are difficult to recycle from e-waste. In 2022, approximately 1200 T of these elements were present in the e-waste generated globally, with neodymium (Nd) accounting for 7200 T (commonly used in magnets) and yttrium (Y) accounting for 1800 T. Platinum-group critical raw materials that have potentially high recovery rates if processed at the right final treatment facilities. Platinum-group metals, especially palladium, are primarily used in printed circuit boards. When they are processed in copper route smelters, palladium recycling rates can reach 95% or higher.

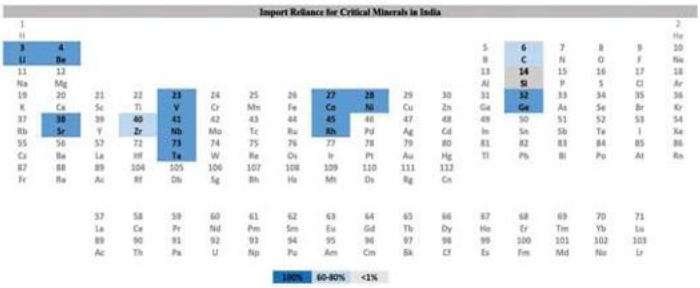

Figure 3 - Import dependence of India for selected critical minerals

The Indian study suggests that the fly ash sample contains 2160 ppm total rare earth elements (TREE) with Light REE and Heavy REE contributes 69% and 31% respectively. Steel slags (BF and LD/BOF) contain REEs at trace levels - typically a few hundred ppm in BF slag and somewhat variable (tens to low hundreds ppm) in LD slag. These concentrations are lower than typical ore deposits but slags are abundant industrial wastes, making them potential secondary resources for REE recovery.

4. INDIA'S POSITION IN GLOBAL LANDSCAPE AND STRATEGIC IMPLICATIONS IN A VOLATILE GLOBAL ENVIRONMENT

The global rare earth (RE) supply chain is characterised by a high degree of geographical and structural concentration, creating systemic vulnerability for resource-importing economies. China currently dominates rare earth mining, accounting for nearly 70% of global concentrate production, followed by the United States (11.5%), Myanmar (8%), and a small group of producers including Australia, Nigeria, and Thailand, each contributing approximately 3%. India's contribution remains marginal at approximately 0.7%, placing it outside the group of influential producers despite possessing significant geological potential.

A similar imbalance is evident in reserve distribution. China holds nearly 50% of the world's known rare earth reserves (approximately 44 million tonnes), reinforcing its long-term strategic position. Brazil ranks second with 23.3% of global reserves, while India ranks third with 7.7%, followed by Australia, Russia, Vietnam, and the United States. However, reserve abundance alone does not translate into strategic advantage. China's dominance is sustained not merely by geological endowment but by systematic state-driven industrial policy, technological accumulation, and supply chain integration.

Over the past four decades, China has pursued a deliberate development strategy encompassing production subsidies, export controls, investments in refining and separation technologies, and inward technology acquisition. This has enabled China to capture value across the entire value chain-from mining and processing to advanced material manufacturing-creating significant entry barriers for latecomers. As a result, rare earth geopolitics today is less about resource availability and more about industrial capability, technological control, and market concentration.

In this context, advanced economies such as the United States and the European Union are actively pursuing diversification strategies through trade partnerships, reshoring initiatives, and strategic stockpiling. Nevertheless, the scale of China's industrial embeddedness presents formidable economic and technological barriers to reconfiguration. India, despite early exploration efforts and substantial reserves, continues to lag in downstream processing, manufacturing, and innovation capabilities, effectively positioning it as a peripheral actor in the global RE ecosystem.

4.1 Why Critical Minerals Are Strategic to India's Future:

During periods of geopolitical or economic stress, access to critical minerals directly influences national energy security, defence preparedness, public health resilience, and industrial competitiveness. The current global environment, characterised by geopolitical volatility and increasing strategic competition, has heightened supply risks and reinforced the urgency of domestic capability development.

Ensuring a stable and resilient supply of critical minerals, while advancing the energy transition in a socially, economically, and environmentally sustainable manner, is therefore essential to safeguarding India's long-term strategic interests and development trajectory.

4.2 Almost the lost opportunity for India

The strategic risk for India lies not merely in import dependence but in structural oblivious exclusion from high-value segments of the supply chain. In the absence of concerted policy reform and large-scale investment in domestic processing and manufacturing capacity, India risks remaining a resource holder rather than an industrial participant. Therefore, rare earths in the Indian context must be analysed not only as a resource management issue

but as a test case of industrial policy coherence, strategic foresight, and technological ambition within an increasingly fragmented global order.

5. SUSTAINABILITY ASPECTS AROUND CRITICAL MINERALS ECONOMY

The environmental case load of REE production arises primarily from mining and beneficiation of low-grade ores, chemical-intensive separation processes, and the management of radioactive and hazardous waste streams, particularly those containing thorium, uranium, fluorides, and acidic effluents. The environmental footprints depend on the ore grade and recovery of the particular REEs. The major contributor to total GHG footprint of REE processing is hydrochloric acid, followed by steam use and electricity. More than of GHG is due to use of energy in various forms (i.e., diesel, steam, fuel oil and electricity).

From a sustainability perspective, the net environmental benefit of renewable energy systems depends not only on operational emissions but also on the life-cycle impacts of critical mineral extraction and processing. If REE production is pursued without stringent environmental safeguards, the ecological burden associated with mining, processing, and waste disposal risks offsetting the climate benefits achieved through renewable energy generation. This creates a "burden-shifting" scenario, where decarbonization gains in the energy sector are achieved at the cost of localized environmental degradation.

Overall, production of rare earth is associated with environmental case load. It may need a tight rope balance between generation of renewable energy and REE production, so that generation of renewable energy should not be outweighed by excessive environmental case load due to Rare Earth production.

6. STEPS TAKEN AND THE JOURNEY AHEAD: FROM DISADVANTAGE TO STRATEGIC ADVANTAGE

India's transition from a structurally disadvantaged position in the rare earth value chain towards strategic self-reliance requires a multi-dimensional and sequential policy approach. A critical first step involves aligning domestic mining and processing capacities with national demand forecasts to ensure security of supply for rare earth concentrates and intermediate products. Concurrently, emphasis must shift toward piloting, replicating, and scaling indigenous refining and separation technologies to reduce dependence on external processing hubs and enable domestic value addition. The promotion of rare earth consumption within priority sectors such as defence manufacturing, medical technologies, data infrastructure, and renewable energy systems is essential to strengthen domestic demand signals, catalyse private sector investment, and justify scale economies in refining and manufacturing. In parallel, India must pursue carefully designed international partnerships with resource-rich but processing-deficient countries to secure long-term mineral access while enabling reciprocal technology transfer and capability building. These measures, when executed in a coordinated manner, can transform India's current supply vulnerability into a strategic opportunity by fostering an integrated ecosystem spanning extraction, processing, manufacturing, and high-technology end-use applications.

6.1 Strategy around Critical Minerals Economy

6.1.1 Building the skills and capacities: REE processing involves multiple complex and sequential steps-physical beneficiation, chemical cracking, solvent extraction, and individual element separation-each requiring advanced process control, chemical engineering know-how, and strict environmental management. REE extraction is a complex and expensive process requiring high level of skills as its content in Indian resource is to the extent of only 0.06% (REO). The issue of economy of scale adds to further complication. REE resources are available in many countries but only a few (3 to 4) have processing facility on account of such reasons. Small deviations in process parameters can significantly affect recovery efficiency, purity levels, and operating costs.

6.1.2 Extraction and Beneficiation: The maximum value addition in the REE value chain occurs at the stages of extraction, beneficiation, and chemical refining**,** rather than at the mining stage alone. REE ores are mineralogically complex, often comprising multiple rare earth-bearing phases (e.g., monazite, bastnäsite, xenotime) intergrown with gangue minerals.

6.1.3 End use application and complete supply chain: Backward integration in terms of components and various input materials is one of the globally available methods of developing an end-to-end value chain ensuring availability of supply.

7. CONCLUSION

India possesses significant geological potential for a large proportion of the critical minerals essential for advanced manufacturing across strategic sectors, including energy transition, e-mobility, defence, healthcare technologies, and data infrastructure. For a limited set of critical minerals that are not available domestically, supply security can be ensured through diversified sourcing and strategic international partnerships. However, domestic capabilities across the critical mineral value chain-particularly in mining, processing, refining, and beneficiation to end-use specifications-remain at a nascent stage.

The most pronounced supply-chain vulnerability lies downstream, in the manufacturing of high-value components and equipment such as solar photovoltaic modules, wind

turbine assemblies, permanent magnets, semiconductors, server hardware, satellite sensors, and advanced medical implants. Transitioning from import dependence to becoming a reliable global manufacturing hub and export partner in these critical products will require sustained, long-term policy coherence, targeted fiscal incentives, and blended public–private financing. Equally important is the development of robust technological partnerships, underpinned by high-quality domestic research, development, and innovation ecosystems.

The growing economic significance of these minerals, coupled with heightened supply risks and geopolitical sensitivities, underpins their classification as critical. Consequently, India's policy and strategic frameworks must adopt an integrated, forward-looking approach that simultaneously addresses resource security, industrial competitiveness, and environmental sustainability. Such a framework is essential to position India advantageously within the evolving global critical minerals and advanced manufacturing landscape.

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(Continued from Page 13)

interpretation, more rigorous testing of assumptions, and continuous updates as new information emerges.

No model will ever fully replicate the complexity of the underground, and pretending otherwise undermines credibility. What matters is improving how data, interpretations, and models come together so decisions reflect the best available understanding at any given time. Dynamic, traceable models replace static interpretations, allowing companies to show regulators and investors how their understanding evolves. That transparency strengthens trust without overstating certainty.

A $10M beakthrough

The financial impact is already clear. At OceanaGold's (TSX: OGC) Waihi mine, a cloud-based AI tool re-analysed legacy drill data and identified a previously unmodelled vein in just 60 minutes, generating an estimated $10 million in value. This kind of insight reduces speculative drilling, cuts waste, and shrinks environmental impact. When companies can target drilling with greater precision, the economics of entire projects improve.

PT Stargate has seen similar gains, achieving a 10% improvement in grade control efficiency and reducing drilling needs by 80% through advanced digital workflows. These are not marginal gains. They translate into lower costs, higher productivity, and more sustainable operations.

Beyond economics, subsurface intelligence is becoming a geopolitical advantage. Countries that can accelerate mining timelines while maintaining environmental and safety standards will shape future supply chains. Better

(Continued on Page 37)

EDITOR'S REVIEW

All About Diamonds in a Nutshell

Dr. K. Srinivasa Rao & S. V. Satyanarayana

Published by the Natural History Society of India (NHSI) · 2025

Rare is the science book that reads like a journey of wonder. *All About Diamonds in a Nutshell* is precisely that-a meticulously structured yet warmly readable account of one of nature's most coveted treasures, authored by two veteran geologists who devoted over three decades to the Geological Survey of India. Published by the Natural History Society of India, this 2025 volume sets out to demystify diamonds for every reader, from the curious schoolchild to the seasoned connoisseur, and it largely succeeds.

The book's architecture is its first strength. Spanning fifteen purposefully sequenced chapters-from *Diamond's Unique Properties* and *Where and How Do Diamonds Form?* through *Mining for Diamonds*, *Evaluation*, *Diamond Grading*, and culminating in the eminently practical *Diamond Buying Tips*-the authors track the full arc of a diamond's existence. The reader is carried from the earth's mantle, 150–200 km below the surface, where diamonds crystallize over hundreds of millions of years, all the way to a retail showcase. Five richly curated appendices-covering the Glossary of Scientific Terms, Suggestions for Further Reading, and catalogues of historically famous Indian and world diamonds-extend the book's value well beyond its final page.

One of the volume's most compelling contributions is its assertion of India's diamond heritage. India, the authors remind us, introduced diamonds to the world before the 4th century BC and remained the sole diamond-producing nation for nearly two millennia. The Krishna River gravels of Andhra Pradesh yielded the Koh-I-Noor, the Hope, the Great Mogul, and all four of the world's great pink diamonds. This lineage, traced through Kautilya's *Arthasastra* and Varahamihira's *Brihat Samhita*, situates Indian geology at the very heart of global diamond history-a fact that Western-centric gemological literature has long undervalued. Equally striking is the contemporary statistic: eight out of every ten polished diamonds in the world bear an Indian craftsman's touch, and the Surat Diamond Bourse now stands as the largest commercial building on earth.

The chapter on *Diamonds: Synthetics and Simulants* arrives at precisely the right moment. As laboratory-grown diamonds produced through HPHT and CVD methods rapidly gain market share, the authors offer clear, jargon-light guidance on distinguishing them from natural stones and from imitation simulants-information that both consumers and trade professionals urgently need. The chapter on *Future Scenario of Diamonds in India* further elevates the book from popular science to industry commentary, addressing exploration prospects and market trajectories with the confidence of practitioners.

Pedagogically, the book is thoughtfully designed. The opening, *Some Interesting Takeaways*-that diamonds are 990–3,300 million years old, that the Mir Mine in Russia is large enough to generate its own air currents, and that cremated human remains can be transformed into memorial diamonds-functions like a film trailer, hooking the reader before the narrative even begins. The appended glossary and reading suggestions make the volume equally suitable as a classroom reference or a gift for a diamond enthusiast.

The foreword by Dr. Jayshree Panjikar, FGA-an internationally credentialed gemologist-lends the work considerable authority, while the President's Note from NHSI frames it within a broader mission of scientific outreach. The inclusion of photographs of legendary stones such as the Hope, the Shah, and the Golden Jubilee adds a welcome visual dimension to what might otherwise have remained an abstract chronicle.

If there is a minor quibble, it is that a topic of such visual splendour perhaps deserves a richer photographic supplement. The prose carries the weight admirably, but images of mining landscapes, rough stones, and iconic cuts would elevate the reading experience further.

In a publishing landscape where Indian authors on gemmology remain scarce, *All About Diamonds in a Nutshell* fills a genuine and long-standing void. It is authoritative without being aloof, comprehensive without being exhausting. The NHSI is to be commended for bringing this work to print. This reviewer recommends it unreservedly to students of earth science, gem trade professionals, and anyone who has ever held a diamond to the light and wondered at its origins.

Reviewed by ***Dr. P.V. Rao***
Chief Editor, MEJ

KNOWLEDGE, SKILLS AND ATTITUDE (KSA) FRAMEWORK FOR BLASTING OPERATIONS AND HANDLING OF EXPLOSIVE MATERIALS

G R Adhikari[1] and M O Sarathy[2]

Abstract

Blasting operations involving explosives and initiation systems are inherently hazardous, requiring personnel to possess appropriate knowledge, skills and attitudes (KSA) to perform their tasks safely and efficiently. This study examines the KSA framework and its application to blasting operations by defining the competencies required for different operational roles, including blasters, supervisors, engineers, technical service personnel, academics, researchers and consultants. Competencies identified through a systematic review of regulatory standards, statutory guidelines and relevant literature are organized within the KSA dimensions. They are further classified according to specific operational roles. The framework provides a structured basis for training, assessment and workforce development. Its practical applicability can be evaluated through expert validation and field-based assessments. The role-specific competency structure supports professional development and enhances safety, efficiency and reliability in modern blasting practices.

1. INTRODUCTION

Blasting operations are essential for hard rock excavation in mining and civil engineering. Due to the inherently hazardous nature of explosives and initiation systems, handling explosive materials and conducting blasting operations require sound technical knowledge, strict adherence to safety procedures, statutory regulations and disciplined execution. The Knowledge, Skills and Attitudes (KSA) framework provides a structured approach to ensure that blasting activities are conducted both effectively and safely.

Regulatory bodies such as Occupational Safety and Health Administration (OSHA) USA, Mine Safety and Health Administration (MSHA) USA, Directorate General of Mines Safety (DGMS), Petroleum and Explosive Safety Organization (PESO) and Bureau of Indian Standards (BIS) in India define eligibility, licensing, safety requirements, traits of personnel handling explosives and carrying out blasting operations, definitions, product specifications-standards. However, these regulations primarily specify who is authorised to perform tasks rather than how competence should be developed, assessed or maintained. Consequently, compliance with regulations does not necessarily guarantee expertise development, field competence or safe and effective performance of persons engaged for the tasks.

Despite extensive statutory regulations, existing literature and regulatory frameworks define eligibility, licensing and safety requirements for blasting personnel but do not provide a structured, role-based competency framework integrating knowledge, skills and attitudes. This study addresses this gap by developing a role-specific KSA framework tailored to blasting operations, explicitly mapping regulatory requirements, operational responsibilities and behavioural competencies across professional roles. The proposed framework moves beyond credential-based authorization to support structured training, assessment and workforce development grounded in demonstrated field competence.

In addition to regulatory and experiential considerations, technological advancements are reshaping competence requirements. With automation, electronics, blast monitoring tools including high-speed videography, blasting is increasingly becoming a precise and data-driven discipline. Professionals must continually update their technical knowledge, acquire new practical skills for operating advanced instruments and cultivate attitudes that promote adaptability, responsibility, teamwork and safety awareness.

This paper discusses the KSA framework and its role in developing competent blasting professionals. It identifies the knowledge, skills and attitudes required across various operational roles - including blasters, supervisors, engineers, educators, consultants, researchers and technical service personnel - to meet the evolving demands of modern blasting operations. By aligning technical, procedural and behavioural competencies, the proposed KSA framework addresses the gap in standardized role-based competence assessment. In doing so, it bridges the difference between regulatory authorization and demonstrated field proficiency, thereby enhancing safety, efficiency and reliability in blasting practices.

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2. LITERATURE REVIEW

2.1 Regulatory Framework and Standards for Blasting Personnel

Blasting operations involve handling explosives that are sensitive to Friction, Impact, Static electricity and Heat (FISH), which can cause accidental or premature detonations. Extreme care is therefore required during transportation, storage, handling and use. Regulatory frameworks provide essential guidance to ensure safe blasting practices. In India, the Petroleum and Explosives Safety Organization (PESO) and the Directorate General of Mines Safety (DGMS) govern licensing, operational procedures and statutory compliance. The Bureau of Indian Standards (BIS) provides technical specifications and testing standards for explosives, detonators and related equipment. While manufacturer's technical data sheets (TDS) offer operational guidance, BIS standards provide added assurance for product quality, reliability, safe handling and use. Table 1 lists key documents relevant to blasting personnel, covering commercial explosives, blasting accessories, Ammonium Nitrate and blasting.

These regulations inform the Knowledge, Skills and Attitudes (KSA) of blasting personnel:

Knowledge: Standards such as BIS specifications for detonators, detonating fuses and explosives, blasting (e.g., IS 4081: 2013, Blasting and Related Drilling Operations - Code of Safety, Reaffirmed 2023) and PESO Explosive Rules provide the theoretical foundation for understanding explosive properties, proper handling, storage, transport of explosive materials, operational hazards, statutory compliance requirements such as maintaining proper records and detonation procedures.

Skills: Operational regulations, including DGMS mining regulations (metalliferous and coal) and PESO procedural rules, emphasize practical abilities required to apply knowledge safely. Competencies include planning, executing blasts, accurate loading and initiating explosives, monitoring blast outcomes and following the prescribed safety protocols in field operations.

Attitudes: Regulatory requirements regarding minimum age (18 years), fitness, prohibiting persons who are intoxicated or with physical-mental disability for work, cultivate behavioural competencies such as responsibility, diligence, adherence to safety norms and ethical decision-making. These provisions reinforce a safety-first mindset essential for high-risk operations such as handling, use of explosive materials and blasting operations.

By synthesizing regulatory requirements through the KSA lens, it becomes clear how legal standards translate into competencies for blasting personnel, supporting structured training, assessment and role-specific competence development.

Table 1. Representative regulations and their KSA implications.

Regulatory Source	KSA Dimension	Competency Implication
PESO Explosive Rules	Knowledge Attitude	l Understanding legal and technical requirements for handling, storage and transport of explosive materials l Cultivating responsibility, safety consciousness and adherence to procedures
BIS IS 4081:2013 Safety Code	Skills	Ability to safely plan, load and detonate explosives
DGMS Metalliferous Mines Regulations & Coal Mines Regulations	Knowledge & Skills	Supervision, operational planning and technical competence in mining and blasting - procedures and methods

By linking regulatory standards to the KSA framework, this synthesis provides a structured basis for developing the competencies required for safe, effective and legally compliant blasting operations. The statutory rules, regulations and standards reviewed for identifying competency-related requirements such as DGMS regulations, PESO rules, AN rules, BIS specifications, testing standards and other documents are consolidated in Appendix A.

2.2 Competent Person and Qualified Person

In India, the Metalliferous Mines Regulations (MMR) and Coal Mines Regulations (CMR) define a competent person as an individual appointed by the Manager, responsible for assigned duties, including blasting operations. The Bureau of Indian Standards (IS 4081-2023) defines a blaster as "the person assigned the duty of loading and blasting the explosives", while PESO Explosives Rules restrict engagement of individuals below 18 years of age, intoxicated personnel and those with physical or mental challenges, as mentioned earlier.

These definitions highlight that competence encompasses knowledge of regulatory and technical requirements, practical skills in executing tasks, attitudes reflecting responsibility and safety consciousness. Regulatory frameworks ensure that individuals meet minimum eligibility criteria but do not

fully integrate knowledge, skills and attitudes required for safe and effective blasting operations.

This gap provides a clear rationale for adopting the KSA framework, which systematically maps regulatory expectations and operational competencies onto the three dimensions of competence (Figure 1). By doing so, the framework ensures that blasting personnel are not only legally authorized but are also equipped with the cognitive understanding, practical capabilities and behavioural dispositions necessary for high-risk operations.

2.3 Competency Frameworks in High-Risk Industries

High-risk industries commonly adopt the Knowledge, Skills and Attitude (KSA) model to define competence. Knowledge refers to theoretical understanding, Skills to practical application and Attitude to behavioural and ethical judgement [Baartman & De Bruijn, 2011; Stevens & Campion, 1994]. Variants such as KSAO (Knowledge, Skills, Abilities, Other Characteristics) and ASK (Attitude, Skills, Knowledge) emphasize mindset and behaviour in safe operational performance [Hlavac, 2023]. Research consistently shows that behavioural attributes strongly influence compliance, ethical conduct and operational safety [Seufert et al., 2021; Hornung et al., 2018]. The KSA model has proven effective in other safety-critical industries and provides a structured framework for developing professional competence in blasting operations.

2.4 Lessons from Other Safety-Critical Industries

Studies in aviation, nuclear operations and chemical processing indicate that accidents frequently result from procedural deviations, judgment errors and inappropriate risk tolerance [IATA, 2023; Tusher et al., 2022]. Competency frameworks in these sectors emphasize that personnel must demonstrate not only technical knowledge and operational skills but also sound decision-making capability under pressure, collaboration and proactive safety behaviour [IATA, 2024; Sanderson et al., 2022]. These insights are directly applicable to blasting operations, where deviations from procedures or poor judgment can result in severe operational, environmental and safety consequences. Implementing a structured KSA framework ensures that blasting personnel are equipped with the theoretical understanding, practical skills and behavioural attitudes required to operate safely and effectively.

The review of regulations, role definitions, and competency frameworks highlights the need for a structured approach to developing competence in blasting operations. While rules define eligibility and safety requirements and lessons from other industries emphasize integrating knowledge, skills and attitudes, a systematic method is needed to translate these into role-specific competencies. This study therefore adopts a structured methodology to identify, categorize and map KSA-based competencies for various operational roles, providing a practical framework for training, assessment and workforce development.

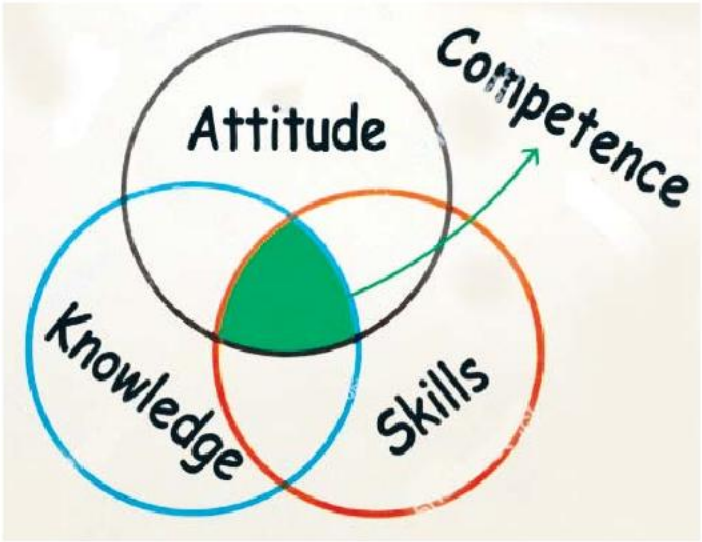

Figure 1. KSA Venn Diagram Defining Competence

3. METHODOLOGY

To develop a structured KSA-based Blasting Competency Framework, a three-stage qualitative process was adopted (Figure 2):

1. Competency-related statements were systematically collected from regulatory documents, published articles and industry guidelines relevant to blasting operations and handling explosives.
2. The extracted statements were analyzed thematically and categorised into the three KSA dimensions: Knowledge, Skills and Attitudes.
3. The identified competencies were mapped to key operational roles, including Blasters, Supervisors, Engineers, and Technical Service personnel, to ensure role-specific applicability.
4. Refined competencies were consolidated into the comprehensive KSA-based Blasting Competency Framework, providing a structured approach for developing and assessing competence across different professional roles.

The KSA model was chosen for its clear differentiation of the three dimensions essential to high-risk operations. Its proven effectiveness in other safety-critical industries - such as aviation, nuclear operations and chemical processing, further supports its suitability for defining competency requirements in blasting operations [Hornung et al., 2018; Ritzhaupt et al., 2018]. By explicitly linking Knowledge, Skills and Attitudes to role-specific responsibilities, this framework bridges the gap between regulatory authorization and

demonstrated operational competence, addressing the limitations identified in Section 1.

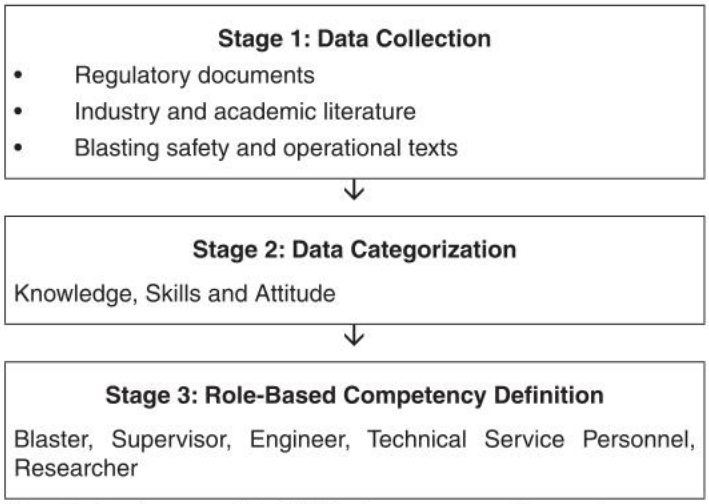

Figure 2. Development of the KSA blasting competency framework

4. DEVELOPMENT OF KSA FRAMEWORK

4.1 Theoretical and Conceptual Foundations

The Knowledge-Skills-Attitude (KSA) framework has been widely adopted in high-risk industries to define and operationalize professional competence. Its conceptual strength lies in distinguishing three interdependent dimensions: knowledge, as the theoretical and procedural understanding; skills, as the practical application of that knowledge; and attitudes, as the behavioural dispositions that influence safe and effective performance.

In the context of blasting operations, the integration of these dimensions is critical due to the inherently hazardous nature of explosives and initiation systems. Knowledge provides the foundation for understanding materials, designs, procedures and regulations; skills ensure the correct application of that knowledge in field operations; and attitudes govern how knowledge and skills are executed under pressure, promoting safety, ethical behaviour and adherence to standard operating procedures (SOPs). Evidence from other safety-critical domains, such as aviation, nuclear power and chemical processing, demonstrates that combining cognitive, practical, and behavioural competencies enhances operational reliability and reduces human-factor errors. This establishes the KSA framework as a theoretically grounded approach for defining role-specific competencies in blasting operations.

4.2 Rationale for Including Knowledge, Skills, and Attitudes

Some researchers define KSA as Knowledge, Skills and Abilities [Hlavac, 2023; Holloway & Radcliffe, 2018; Hornung et al., 2018; Sanderson et al., 2022], while others define it as Knowledge, Skills and Attitudes [Baartman & De Bruijn, 2011; Bakarman, 2005; Gilbert et al., 2024; Gomes et al., 2024, Seufert et al., 2021; Stevens & Campion, 1994]. Since skills and abilities largely overlap, including Attitudes provides a more behaviourally relevant framework. Within this model, knowledge offers the conceptual foundation, skills represent the practical application of that knowledge and attitudes shape how knowledge and skills are applied, particularly under pressure.

The rationale for each component is as follows:

- Knowledge provides the theoretical foundation necessary to interpret regulations, explosive properties, blast mechanics, blast design and environmental considerations.
- Skills denote the ability to apply knowledge through practical execution, including blast design, safe handling of explosives, operation of monitoring and initiation equipment.
- Attitudes reflect the mindset, risk perception, commitment to safety, ethical practices, sincerity and integrity in reporting issues related to safety concerns, ensuring that knowledge and skills are applied reliably under real-world conditions.

Incorporating attitudes explicitly account for human factors critical to accident prevention, regulatory compliance, and continuous professional development.

4.3 Knowledge

Knowledge is acquired through formal education and training and encompasses core principles of blasting techniques, product characteristics, regulations and industry standards. In routine blasting operations, this includes the properties of explosives, initiation systems, blast design theory, detonation physics, rock mechanics, environmental effects (e.g., ground vibration, airblast overpressure, flyrock), legal and regulatory standards. Knowledge enables understanding, planning and informed decision-making. Continuous learning is essential to maintain competence, particularly as technologies and operational standards evolve rapidly.

4.4 Skills

Skills refer to the practical abilities required to apply knowledge effectively in real-life blasting operations. Key technical skills include blast pattern design, charge calculations, drillhole timing and initiation sequencing, safe handling and initiation of explosives, operation of exploders and blast monitoring equipment. Additional skills involve using blast design software, assessing risks, interpreting geotechnical data, conducting precise field measurements, optimizing drilling patterns and performing safety audits. Skills are observable, measurable, developed through systematic training and repeated practice, thus bridging the gap between theory and execution.

4.5 Attitudes

Attitudes encompass the behavioural dispositions, values and safety-oriented mindsets that influence how knowledge and skills are applied. In high-risk activities such as blasting, attitudes shape judgment, risk perception, compliance with procedures and responses under pressure. Honesty and integrity are imperative when existing safety concerns have to be addressed and reported such as presence of misfires, unsafe work conditions, deteriorated explosives, products that have exceeded their shelf life, hot boreholes, approaching thunder storm and lightning activity during loading of drillholes and hooking up for the blast etc.

Constructive attitudes such as responsibility, situational awareness, diligence and commitment to safety - support consistent adherence to established procedures and reinforce safe operational behaviour. They also encourage continuous learning, careful evaluation of potential hazards and disciplined decision-making. Conversely, complacency, bravado, overconfidence or disregard for safety protocols can undermine technical competence and increase operational risk, even when knowledge and skills are adequate. Attitudes thus form the behavioural foundation ensuring that knowledge and skills translate into reliable, safe practices.

Tables 2, 3, and 4 illustrate how knowledge, skills, and attitudes interact in ensuring the competence and safety of blasting engineers.

5. KSA FRAMEWORK AND ROLE-SPECIFIC COMPETENCIES FOR BLASTING PROFESSIONALS

The Knowledge-Skills-Attitude (KSA) framework provides a structured approach to defining competence in blasting operations. This section applies the framework across different professional roles, highlighting how role-specific responsibilities shape the emphasis on Knowledge, Skills, and Attitude. Accordingly, both operational and non-operational roles are considered, differentiated by risk exposure, decision authority, and proximity to field execution.

5.1 Rationale for Role-Based Differentiation

Blasting operations encompass a wide range of responsibilities - from direct field execution to technical oversight, design, and research - each characterized by varying levels of operational risk, cognitive complexity, and decision-making authority. These differences necessitate role-specific emphasis across the Knowledge, Skills, and Attitude (KSA) dimensions. Figure 3 presents a histogram-style representation of the role-based KSA emphasis for major professional categories in blasting operations.

5.2 Role-Specific Applications

The relative emphasis of Knowledge, Skills, and Attitude varies across professional roles in blasting operations, reflecting differences in responsibilities, risk exposure, and decision-making requirements (Figure 3).

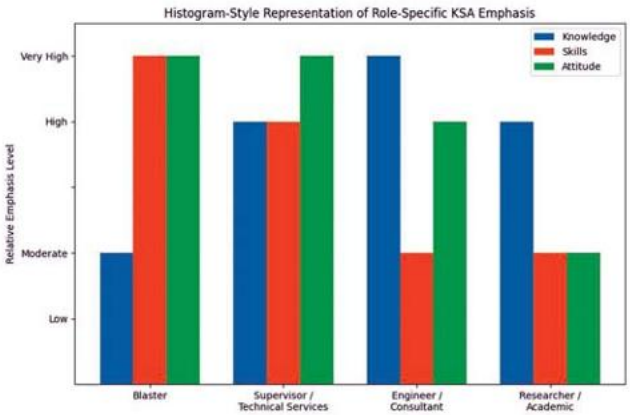

Figure 3. Role-specific Knowledge-Skills-Attitude (KSA) emphasis in blasting operations.

Blasters are primarily responsible for the safe and accurate execution of field operations. Their work is highly procedural, time-sensitive and directly exposed to operational risk. Consequently, competence in this role requires very strong skills, particularly in handling explosives, implementing blast designs, performing pre-blast and post-blast checks. Attitude is equally critical, as situational awareness, safety-oriented behaviour and adherence to protocols directly influence operational safety. While knowledge of principles and regulations is necessary, it is applied mainly to support practical decision-making and safe execution.

Supervisors and technical service personnel serve as intermediaries between field execution and managerial oversight. Their responsibilities include coordinating field activities, ensuring compliance with statutory standards, evaluating operational risks and providing technical support. These roles require a balanced combination of knowledge and skills, supported by a strong attitude toward leadership, safety stewardship and accountability.

Engineers and consultants focus on the design, analysis and optimization of blasting operations. Tasks include interpreting geological data, modelling blast patterns, evaluating environmental impacts and ensuring operational plans to comply with regulations. Competence in these roles is Knowledge-dominant, supported by Skills in simulation, data analysis and technical problem-solving, while Attitude guides professional integrity, thoroughness and conservative risk assessment.

Researchers and academics contribute to knowledge creation and technology development in blasting. Their competence is Knowledge-dominant, supported by Skills in experimental design and data analysis, while Attitude supports ethical research conduct, methodological rigor,

Table 2. Knowledge (What the blasting engineers need to know)

Knowledge	Description
Geology and rock mass characteristics	• Understanding different rock types and their properties. • Knowledge of geological structures and how they influence blast design and fragmentation.
Explosives and initiating systems	• Knowledge of various types of explosives, their specifications, properties and characteristics. • Understanding different initiating systems and their proper application and safety protocols. • Knowledge of the safe storage, transportation, and disposal procedures for explosives.
Blast design principles	• Understanding blast design parameters like drill hole diameter, burden, spacing, bench height, stemming, sub-grade, charge weight and powder factor. • Ability to calculate charge requirements based on rock properties and desired fragmentation. • Knowledge of different blast patterns (e.g., staggered, in-line) and initiation sequences (row, diagonal, V, V1) - when to apply them based on the desired outcome. • Understanding the principles of controlled blasting techniques (e.g., pre-splitting, smooth blasting) to minimize overbreak and damage to surrounding rock, improve slope stability.
Safety regulations and procedures	• Awareness of safety regulations and codes related to the handling, storage and use of explosives. • Understanding emergency procedures and protocols in case of misfires or other incidents. • Knowledge of exclusion zones and minimum safe distances during blasting.
Environmental considerations	• Understanding the potential environmental impacts of blasting, such as ground vibrations, air blast (noise and overpressure), flyrock, high wall slope stability. • Knowledge of techniques to minimize these impacts (e.g., blast timing, stemming optimization).
Equipment and tools	• Familiarity with the tools and equipment used in drilling, charging explosives and firing the blasts. • Basic understanding of the maintenance and safe operation of electric circuit testing, authorized ohm-meters, exploders and hardware used with electronic detonators. • Operation of blasting seismograph, high-speed video camera, laser face profiler, blast design and fragmentation measurement software.

Table 3. Skills (What the blasting engineers need to be able to do)

Skill	Description
Blast design and planning	• Ability to interpret geological data and apply it to blast design. • Applying blast design principles to create effective blast patterns. • Skill in calculating charge weights and designing blast patterns to achieve desired fragmentation, displacement and muck pile profile. • Ability to perform pre, in and post-blast monitoring. • Proficiency in using blast design software.
Drilling operations	• Competence in directing or checking drilling performance as per the blast plan, ensuring correct drill hole diameter, depth and angle. • Ability to identify and address drilling issues (e.g., blocked-collapsed drillholes, deviations).
Charging and priming	• Skill in safely and accurately loading explosives into boreholes according to the blast design. • Competence in selecting and installing appropriate primers and initiating systems. • Ability to handle explosives with care and precision.
Connecting and firing	• Safely handling and charging boreholes with explosives and initiation system. • Connecting initiating systems (hook-up) safely and correctly for ensuring desired initiation sequence.
Risk assessment and hazard identification	• Ability to identify potential hazards associated with blasting operations. • Skill in conducting thorough risk assessments and implementing appropriate control measures.
Communication and teamwork	• Effective communication with the drilling and blasting crew and other relevant personnel involved in operations. • Ability to work collaboratively as part of a team.
Problem-solving	• Ability to diagnose and resolve issues that may arise during blasting operations (e.g., misfires, flyrock, poor fragmentation, high ground vibrations or airblast).
Record keeping	• Skill in accurately documenting blast details, including design parameters, materials used and outcomes for future reference. Statutory records of daily inspections, stock-issue/return of explosives and initiation systems

Table 4. Attitudes (How the blasting engineers should behave)

Attitude	Description
Safety-first mindset	• A strong commitment to safety of people, nearby communities and surrounding structures (including historical/archaeological importance) during operations. • A proactive approach to identifying and mitigating risks. • A willingness to follow safety procedures meticulously. • Avoid BRAVADO and RECKLESSNESS in blasting.
Responsibility and accountability	• Taking ownership of blast outcomes and being accountable for the safe and effective execution of blasts including reporting mistakes immediately. • A responsible attitude towards the handling and use of explosives.
Attention to detail	• Meticulous checking in all aspects of blasting operations, from design to firing. • A focus on accuracy to ensure safety and achieve desired results. • Checking everything twice before blasting.
Professionalism	• Maintaining a professional and ethical approach to their work. • A commitment to continuous learning and improvement.
Respect for regulations and procedures	• A positive attitude towards adhering to all relevant regulations, record keeping and company procedures. • Understanding the importance of compliance.
Respect for the environment	• A concern for minimizing the environmental impact of blasting. • A willingness to implement practices that reduce noise, vibration and flyrock.
Teamwork and Cooperation	• A collaborative spirit and a willingness to work effectively with others as a good team member. • Openly sharing knowledge to support the growth and development of less experienced colleagues.
Commitment to continuous learning	• Staying updated on new blasting techniques, explosives technologies and safety procedures.
Statutory obligations	• Strict adherence to statutory requirements governing eligibility, fitness, conduct and prescribed blasting hours (time of blasting). • Compliance with legal prohibitions related to age, intoxication, physical or mental fitness, smoking.

and responsible dissemination of findings. Operational risk exposure is lower than in field roles, but their work significantly influences industry practices and long-term competency standards.

5.3 Integrative Applications

Linking role-specific KSA emphases enables competency-based training, performance assessment beyond credentials, enhanced safety and optimized workforce planning. Across all roles, attitude governs how knowledge and skills are applied under operational pressure, while integration of theory and practice ensures role-aligned competence.

6. CONCLUSIONS

This study proposed a knowledge-skills-attitude (KSA) framework to define competence in blasting operations as the integration of technical knowledge, practical skills and behavioural reliability. By linking knowledge for planning and regulatory interpretation, skills for safe execution, attitude for ethical and safety compliance, the framework provides a structured basis for assessing operational competence and mapping requirements to role-specific duties for blasters, supervisors, engineers and technical services personnel. The framework supports a shift from credential-focused evaluation to evidence-based competence, enhancing safety, accountability and operational consistency. It emphasizes Attitude instead of Ability as critical for procedural compliance, ethical decision-making and reducing human-factor failures, especially as technological complexity continues to increase. This study is conceptual and based on literature synthesis and empirical validation is needed to confirm the framework's effectiveness in real-world blasting operations. Overall, the proposed KSA framework offers a standardised foundation for training, assessment, workforce planning and continuous professional development, preparing personnel for safer, more efficient and reliable modern blasting operations.

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Annexure A - List of useful documents for personnel associated with blasting.

Directorate General of Mines Safety (DGMS), Dhanbad

- Metalliferous Mines Regulations 1961, revised in 2018
- Coal Mines Regulations 1957 revised in 2017
- DGMS (Tech) (S&T) Circular No.6 of 1997 dated 28/5/1997: Damage to below ground structures due to blast induced vibration in nearby opencast mines
- DGMS (Tech) (S&T) Circular No.7 of 1997 dated 29/8/1997: Damage of structures due to blast induced ground vibrations in the mining areas

Petroleum and Explosives Safety Organization (PESO), Nagpur

- Explosive Rules 2008 originally framed under the Explosives Act 1884, revised in 2008 and amended in 2024
- Ammonium Nitrate Rules, 2012

Bureau of Indian Standards (BIS), New Delhi

- IS 7632: 1975 - Specifications Detonators
- IS 7738: 1975 - Specifications Safety Fuse for commercial use
- IS 7526: 1996 - Specifications Detonating Fuse
- IS 15447 (Part 2): 2008 - Specifications Commercial blasting explosives Part 2: Slurry/Emulsion Explosives
- IS 18462: 2023 - Specifications Electronic Detonators
- IS 19141: 2025 - Specifications Cord Relays
- IS 19229: 2025 - Specifications Shock tube detonators
- IS 6609 Parts 1 to 5 - Testing methods for various products and their performance
- IS 4081: 2013 - Blasting and related drilling operations - Code of safety, Reaffirmed 2023
- IS 14881: 2001 - Method for blast vibration monitoring - Guidelines

Manufacturers of products, instruments and equipments

- **Explosives and Blast initiation systems**
  - Product brochures / Technical Data Sheets (TDS)
  - Material Safety Data Sheets (MSDS)
- **Instruments and Equipments**
  - User Manual / User Guide / Operating Manual / Maintenance Manual

MEAI NEWS

BELGAUM CHAPTER

9th March 2026, Dr Prabhakar Sangurmath, visited Geology Department, GSS College. Had interaction with BSc students about Opportunities in Geology. Also, he presented a Photo of Hutti Gold Mines consisting from Raw materials to final Production, as well as his recent published book to department, library and to staff.

12 March 2026, from our chapter Shri Rachappa VPIII, Dr P T Hanamgond, Shri SS Hiremath, Mr Amit Ghooly and Mr Anant Mahajan were present. Mr Anant also presented a paper on "AI, ML, & IoT in Mineral Exploration & Mining", at National Seminar "Mining for Vikasit Bharat Vision 2047, at Indian Institute of Engineers', Bangalore.

BELLARY – HOSPET CHAPTER

Executive & Development Committee Meeting & Technical Talk on "Digital Platforms for Mining" held on 13-3-2026

Members Present in the Meeting

Office Bearers

1. Shri. Mallikarjuna SHM (Chairman)
2. Shri. P. Venkateshwar Rao (Secretary)
3. Shri. Basavrajappa HJ (Joint Secretary)
4. Shri. J. Srikanth (Treasurer)

Ex-officio and Council Members

5. Shri K. Madhusudhana (Past President)
6. Shri G. Laxminarayana
7. Dr. Prabhakar Reddy

Executive Committee Members

8. Shri T. Vinay Kumar
9. Shri. Nishant Natiye
10. Shri R. Shivananda Reddy
11. Shri T. Jintender Reddy
12. Shri. Rakesh MM

Development Committee Members

13. Shri. Gopal Joshi
14. Shri. Bharath Kumar
15. Shri. S Satyanarayana
16. Shri. Chandrashekar Halli
17. Shri. Ram Koteswara Rao
18. Shri. Krishnudu

First Aid Committee Members

19. T Vinay Kumar (Chairman)
20. Rakesh MM (Secretary)
21. S Ravindra

Details of Executive Committee Meeting

The Executive Committee (EC) meeting of the chapter was held on 13th March 2026 at Hotel Mallige**.** The meeting was attended by Past President Shri K. Madhusudhana and National Council Members Shri Laxminarayana G. and Shri Prabhakara Reddy**.** The meeting was conducted by Shri Mallikarjuna SHM, Chairman of the BH Chapter**,** and Shri P. V. Rao, Secretary of the Chapter**.**

During the meeting, the agenda items were discussed in detail, with particular emphasis on the Action Plan for the Financial Year 2026–27**.** The committee also deliberated on organizing an electrical training session for electrical engineers, supervisors, and wiremen in association with the Mine Safety Week Association of Karnataka. The Chairman & the Secretary insisted on supporting the MEAI membership drive by various organizations and also asked seniors to get enrolled as Fellow Memberships.

Glimpse of the EC Meeting

The Executive Committee members also appreciated the First Aid Committee for their consistent efforts in organizing regular first aid training batches, which have been beneficial to mining professionals. It was also decided to conduct a one-day workshop on the recent developments in the Occupational Safety, Health & Working Conditions (OSH) Code, 2020 & also the technical advancements in the explosive & blasting methods, followed by the electrical ones in mines. It was decided to finalize the date based on the convenience of the officials and mining organizations.

During the Executive Committee meeting, an update on the financial status of the chapter was presented. The Secretary placed a detailed financial report before the committee, outlining the total income generated from membership fees, sponsorships, and other sources, which was subsequently discussed by the members.

In this regard, the past president, Shri Madhusudhana K., advised the chairman & secretary to utilize the benefit of flexi services provided by the banks and also to keep the amount in fixed deposits. The Members also accepted the advice.

Following the EC meeting, technical talk sessions were conducted. The session featured presentations on "Digital Platforms for Mining" **by** Polygon Geospatial Pvt. Ltd., Hyderabad**,** and "Mine Planning Solutions" by GTS Ltd., CK Birla Group.

The highlight of the event was the formal release of the book titled "Low Grade Iron Ore Beneficiation," authored by Dr. P. Sharath Kumar, Head of the Department of Mineral Processing, VSKU PG Center, Nandihalli, an active member of the association. The felicitation to Dr. P. Sharath Kumar was done considering his efforts and contributions he has made towards the beneficiation of iron ore. The author expressed his sincere gratitude towards the association for the continuous support & the encouragement he has received.

The event provided a valuable platform for industry professionals and experts to share knowledge and discuss modern mining technologies and beneficiation practices**.** Approximately 75 members participated in the session and appreciated the efforts of the organizers in conducting such an engaging and informative program for the mining fraternity.

The release of the book "Low Grade Iron Ore Beneficiation", authored by Dr. P. Sharath Kumar

A view of the audience listening to the technical talk

The vote of thanks was delivered by Shri. Rakesh MM, who expressed his gratitude to all the National Council Members, Executive Members, Development Committee Members, and First Aid Committee Members; the representatives from various organizations & the speakers from Polygon Geospatial Pvt. Ltd., Hyderabad**,** GTS Ltd., and CK Birla Group; and the staff of Hotel Malligi for their support and contributions toward the successful completion of this meeting and the technical members' sessions.

Technical Talk on Kirloskar DG Sets: Engineering Excellence in Power Generation

Date: 14.2.2026

Location: Hotel Pearl – Priyadarshini, Toranagallu

Kirloskar Powergen represents the power generation business of Kirloskar Oil Engines Limited (KOEL), a flagship company of the Kirloskar Group. The Kirloskar Group was founded in 1888 by Laxmanrao Kirloskar, laying the foundation for India's engineering and manufacturing excellence. KOEL was established in 1946 in Pune to manufacture diesel engines and later expanded into power generation equipment. Over the decades, the company

emerged as one of India's leading manufacturers of diesel and gas generator sets (gensets), serving diverse industrial and commercial sectors. Under the brand Kirloskar Green, the Powergen division offers a wide range of gensets from small residential units to large industrial systems (2 kVA to 5000+ kVA). The company caters to sectors such as mining, infrastructure, healthcare, telecom, data centers, manufacturing, and commercial establishments requiring reliable backup and prime power solutions.

Kirloskar Powergen is known for fuel-efficient engines, emission-compliant products, and technologically advanced alternator integration. The company continuously aligns with CPCB emission norms and global environmental standards, reinforcing its sustainability commitment. With a strong pan-India sales and service network, trained technicians, and robust after-sales support, KOEL ensures high uptime and customer satisfaction. It also exports products to several international markets, strengthening its global footprint.

Today, Kirloskar Powergen stands as a trusted and established name in India's power backup industry, backed by over seven decades of engineering expertise, innovation, and commitment to quality.

Welcome Address by Shri T. Jitender Reddy, AGM – Mines, M/s Baldota

Shri T. Jitender Reddy extended a warm and cordial welcome to all dignitaries and participants assembled for the technical talk. He respectfully invited the esteemed dignitaries to the dais for the ceremonial lighting of the lamp, marking the formal inauguration of the program.

He welcomed Dr. Prabhakar Reddy, CEO, M/s SUMS; Shri S.H.M. Mallikarjun, Chairman, BH Chapter; and Shri P.V. Rao, Secretary, BH Chapter, for their gracious presence and continued support of industry initiatives.

He also extended a special welcome to Shri Suhas T., manager, Kirloskar Power, and Shri Chandrashekhar D., regional manager, Kirloskar Power, for sharing their technical expertise and insights. He expressed his appreciation to Shri Suresh B., Proprietor, Arvind Power System, for his association and support in organizing the program. Further, he warmly welcomed all mine representatives, electrical supervisors, engineers, members of the BH Chapter, and non-members who had gathered from different mining organizations to participate in this technical session.

He stated that such technical talks strengthen knowledge sharing, improve operational efficiency, and enhance safety standards in the mining industry. He concluded by wishing the program great success and meaningful technical deliberations for all participants.

The technical talk was inaugurated with the ceremonial lighting of the lamp by Dr. K. Prabhakar Reddy, CEO of SUMS and the chapter's chairman and secretary, along with the Kirloskar Powergen officials' team.

Technical Talk on Kirloskar DG Sets: *Engineering Excellence in Power Generation*

The technical talk on "Kirloskar DG Sets – Engineering Excellence in Power Generation" was delivered by Mr. Suhas T., manager, Kirloskar PowerGen, and Shri Chandrashekhar D., regional sales manager, Kirloskar PowerGen. The session provided detailed technical insights into the design, performance, and operational efficiency of Kirloskar diesel generator sets manufactured by Kirloskar Oil Engines Limited (KOEL). The speakers explained the advanced engineering features of DG sets, including fuel-efficient engine design, turbocharged and aftercooled systems, high-performance alternators with Class H insulation, and robust cooling systems suitable for high ambient conditions. They highlighted compliance with CPCB emission norms, low-noise acoustic enclosures, and digital control panels equipped with AMF functionality, real-time monitoring, and safety protection systems. Emphasis was also given to proper installation practices, preventive maintenance schedules, synchronization for parallel operation, and the importance of genuine spares to ensure reliability and longevity. The session was highly informative and beneficial, particularly for participants from mining, industrial, and infrastructure sectors who rely on dependable power solutions for continuous operations.

Engine Engineering & Design Features

The technical aspects related to engine engineering and

design features were explained in detail by Mr. Suresh B., Proprietor, M/s Arvind Power System. He elaborated that Kirloskar DG sets are designed with high fuel efficiency engines incorporating optimized combustion systems to ensure maximum energy output with minimum fuel consumption. The advanced fuel injection technology ensures finer atomization of fuel, resulting in better combustion efficiency and reduced emissions. He further explained the advantages of turbocharged and aftercooled engines, which enhance air intake efficiency and improve power density. The low-vibration design with precision-balanced crankshaft assemblies contributes to smooth operation and longer engine life. In addition, heavy-duty alternators with Class H insulation provide superior thermal endurance and reliable performance under continuous load conditions.

Emission Compliance & Environmental Standards

Under the topic of **Emission Compliance and Environmental Standards**, Mr. Suresh B emphasized that modern DG sets comply with CPCB II and CPCB IV+ norms, ensuring adherence to statutory environmental regulations. He highlighted the improved exhaust gas management systems that effectively reduce particulate matter (PM) and nitrogen oxide (NOx) emissions. Special attention was given to acoustic enclosures designed to maintain noise levels within prescribed limits, typically around 75 dB(A) at a one-meter distance, making them suitable for urban and industrial installations. He stressed that environmental compliance is now a critical factor in selecting DG sets for industrial and mining operations.

Control & Protection Systems

Explaining the control and protection systems, Mr. Suresh B detailed the advanced digital control panels integrated into modern DG sets. These panels are equipped with AMF (Auto Mains Failure) functionality, enabling automatic start and stop operations during power interruptions. Real-time monitoring of key parameters such as voltage, frequency, load, oil pressure, and coolant temperature ensures safe and efficient functioning. He also described the automatic shutdown mechanisms in case of abnormal conditions, protecting the engine from damage. Additionally, remote monitoring and IoT-enabled solutions in select models allow operators to supervise performance from distant locations. Synchronization panels for parallel DG operations were also discussed, which are essential for handling higher load demands in industrial applications.

Performance & Reliability Aspects

While discussing performance and reliability aspects, Mr. Suresh B explained that Kirloskar DG sets are engineered for high transient load acceptance, ensuring stability during sudden load variations. Voltage regulation is maintained within ±1%, and frequency stability is ensured for consistent power output. He highlighted the robust cooling systems designed to operate efficiently in high ambient temperatures up to 50°C, which is particularly important in mining and construction sites. These features collectively enhance operational reliability and minimize downtime.

Application Areas Highlighted

In his concluding remarks, Mr. Suresh B elaborated on the wide application areas of DG sets, including the mining industry, construction projects, hospitals and healthcare facilities, data centers, commercial complexes, and large infrastructure projects. He emphasized that dependable and uninterrupted power supply is critical in these sectors, and technologically advanced DG systems play a vital role in ensuring operational continuity and safety.

Vote of Thanks by Shri P. V. Rao, Secretary, BH Chapter

The Vote of Thanks was proposed by Shri P. V. Rao. He expressed his sincere gratitude to the team of Kirloskar Powergen for providing a valuable opportunity to enhance the technical knowledge and professional skills of the participants through the informative technical talk. He conveyed his appreciation to the speakers and management of Kirloskar Oil Engines Limited for sharing their expertise and practical insights. He also thanked all the managers, electrical engineers, and mechanical engineers from various mines and organizations whose active participation made the session meaningful and interactive.

He further extended his thanks to all the members of the MEAI BH Chapter for their coordination and support in organizing the program. Special appreciation was conveyed to Hotel Pearl Priyadarshini for their hospitality and arrangements. He mentioned that around 65 members attended the technical talk and emphasized that the session was highly beneficial in clarifying technical doubts and strengthening the understanding of power generation systems among the engineers.

RAJASTHAN CHAPTER- JODHPUR

Educational Mine Visit by MBM University Students

Bhilwara, March 28, 2026 – A one-day educational mine visit was successfully organized for second-year mining engineering students of MBM University, Jodhpur, to the JSW Mines in the Bhilwara district. The visit was coordinated by the Mining Engineers' Association of India, Rajasthan Chapter, Jodhpur, with the support of Jindal Saw Limited.

Spread across approximately 1,500 hectares, the JSW Mines represent one of the largest mechanized iron ore open-cast mining operations in the state. Around 60 students, accompanied by Prof. Ram Prasad Choudhary, Head of the Department of Mining Engineering, and MEAI officials, participated in the excursion.

The visit provided students with valuable practical exposure to modern mining practices, safety protocols, and advanced mechanization techniques. It served as a bridge between classroom learning and real-world applications, offering insights into operational aspects of the mining industry.

The hospitality and guidance extended by the JSW Mines team were highly appreciated. Special acknowledgement was given to Shri Naveen Airam, AVP-Mines and MBM alumnus, and Er. Bheem Singh, SME, for their active involvement in making the visit impactful. Prof. Ram Prasad Choudhary and MEAI officials, including Er. Rakesh Purohit, secretary; Er. Mool Chand Tater; and Shri S. P. Goyal, retired controller of mines, Indian Bureau of Mines, India, also played a pivotal role in facilitating the program.

The students expressed gratitude for the opportunity to witness large-scale mining operations firsthand. The visit was hailed as an excellent initiative to nurture the next generation of mining engineers with practical knowledge and industry exposure.

Three-Day QGIS-Based Remote Sensing & GIS Training Program

April 4, 2026-The Mining Engineers' Association of India, Rajasthan Chapter Jodhpur, proudly announced the successful completion of its three-day QGIS-based Remote Sensing & GIS Training Program, held from April 2 to April 4, 2026, at the MBM Alumni Association Hall, Ratanada, Jodhpur. The program was organized under the K. D. Dutta Memorial Skill Development Fund as part of MEAI's ongoing commitment to advancing technical knowledge and professional skills in the mining and geo-informatics sector.

Inaugural Session

The program was inaugurated by Dr. Manju Bohra, Chief Guest, who paid tribute to the legacy of Late Shri Kishore Dutta. The inaugural ceremony was graced by eminent dignitaries, including Smt. Lele Kumari, Prof. D. M. Surana, Prof. Sushil Bhandari, Er. S. S. Patel, Dr. P. C. Purohit, Shri S. P. Goyal, Shri J. K. Mahnot, and Shri Y. S. Sehwal. Their presence underscored the importance of skill development initiatives in shaping the future of mining professionals.

Training Highlights

The sessions were conducted by Dr. Virat Arora, a former ISRO scientist and Remote Sensing & GIS consultant, who shared his expertise through interactive lectures, hands-on demonstrations, and practical exercises. Over 75 participants, including students, engineers, geologists, and working professionals, actively engaged in the program. On the final day of the three-day QGIS-based Remote Sensing and GIS training program, a quiz competition was organized; cash prizes were awarded to the winners, and certificates were presented to all participants.

Key features included

Day 1: Fundamentals of QGIS and Remote Sensing, introduction to spatial data formats, and map-making basics.

Day 2: Advanced spatial data handling, geo-referencing, raster and vector analysis, and mining-related applications.

Day 3: Map design principles, visualization techniques, and exporting professional reports.

A quiz with 25 multiple-choice questions was conducted to assess participants' learning, adding a competitive and engaging dimension to the training.

Valedictory Function

The valedictory session was presided over by Prof. R. P. Choudhary as chief guest, with Shri Manish Verma as guest of honor. Senior members, including Shri B. S. Dhaka and Er. M. C. Tater, also attended. The top three participants were awarded prizes, and certificates were distributed to all attendees who successfully completed the training.

Organizers' Contribution

The program was meticulously coordinated by Er. Rakesh Purohit, secretary of the Jodhpur Chapter, with strong support from Shri B. S. Bhati and Er. M. C. Tater. Their efforts ensured smooth execution and a memorable learning experience for all participants.

Conclusion

The event concluded on a highly successful note, marking a significant step in bridging academic knowledge with practical applications in mining and geo-informatics. The initiative reaffirmed MEAI's dedication to nurturing the next generation of mining engineers and professionals through impactful skill development programs.

Glimpses of the program

RAJASTHAN CHAPTER - UDAIPUR

A Report on Technical Talk

Important Initiative on Conservation of the Aravalli, Scientific Definition, and Balanced Mining

(L to R) Dr. Hitanshu Kaushal, Jt. Secretary; Dr. GS Bhardwaj, Speaker; Sh Asif M. Ansari, Secretary & Dr. Anupam Bhatnagar, Professor & Head of CTAE.

A technical talk on the topic "Strategic Pathways for Sustainable Mining in the Aravalli Region-A National Perspective" was organized by the Mining Engineers' Association of India (MEAI), Rajasthan Chapter, Udaipur, at UCCI, Mewar Industrial Area, Udaipur, and held on 29-03-2026. On this occasion, the keynote speaker, Dr. Govind Singh Bhardwaj, former professor, Department of Mining Engineering, CTAE, MPUAT, elaborated in detail on the geological, economic, environmental, and policy aspects of mining in the Aravalli region, Udaipur.

At the beginning of the program, Dr. Hitanshu Kaushal presented the outline of the program and briefly introduced the keynote speaker, Dr. Govind Singh Bhardwaj. The keynote speaker was welcomed by Shri Arun Kumar Kothari, former Chairman, MEAI, and Shri Asif M. Ansari, Secretary, MEAI-Udaipur.

Geological and National Importance of Aravalli

Dr. Bhardwaj stated that the Aravalli Region is one of the oldest mountain ranges in the world (approximately 2 billion years old), extending about 670 km across Gujarat, Rajasthan, Haryana, and Delhi.

This region is rich in mineral resources, including lead-zinc, copper, marble, granite, limestone, and other industrial minerals. The Aravalli region contributes significantly to India's mineral economy, such as 100% of the country's zinc production, major shares in lead, silver, gypsum, and marble, and approximately 16% of the national mineral value.

Economic Contribution and Ground Reality

In Rajasthan, the mining sector has an annual production of approximately ₹23,869 crore and provides employment to around 30 lakh people. It contributes about 4.4% to the state's Gross State Domestic Product (GSDP). Dr. Bhardwaj emphasized that mining is not just an industrial activity but also the backbone of rural and tribal economies. He clarified that a complete ban on mining would lead to loss of employment, increase in imports, and rise in illegal mining, while unregulated mining would increase environmental damage. Therefore, a balanced approach is necessary.

Current Mining Scenario and Challenges

The important challenges include:

- Complex geological structure (heterogeneous ore, slope instability)
- Environmental clearances and legal complexities
- Misconceptions about mining (misinformation)
- Unscientific mining and inadequate rehabilitation in some areas

  He also mentioned that only about 0.54% of Rajasthan's total area is under mining.

The Aravalli region is highly sensitive from an environmental perspective, as it helps in preventing desertification, serves as a major source of groundwater recharge, and supports biodiversity conservation.

The Supreme Court (November 2025) accepted a uniform definition of Aravalli and directed the preparation of a Management Plan for Sustainable Mining (MPSM). Dr. Bhardwaj highlighted that the difference between "Geological Aravalli" and "Legal Aravalli" is a major challenge in policy formulation.

Sustainable Mining: The Way Forward

The key message of the program was "Mining in Aravalli should not be stopped; rather, unscientific mining must be stopped and scientific mining should be promoted."

Strategic Suggestions

In the end, the chapter secretary, Shri Asif M. Ansari, expressed his vote of thanks and stated that issues related to the Aravalli Region are not limited to environmental conservation but are also linked to employment generation, mineral utilization, and regional development. Therefore, it is essential to maintain a balance among all these aspects. The proposal submitted by MEAI is a positive step in this direction, which will help provide scientific and objective information to the honorable court. This initiative will assist in ensuring that decisions related to the Aravalli region are taken in accordance with the principles of environmental conservation, sustainable development, and responsible mining. Ultimately, it can be said that coordinated efforts of all stakeholders are essential on this important issue related to the conservation and development of the Aravalli Range so that natural resources are preserved and minerals are utilized in a balanced manner for future generations.

Representation to the Supreme Court

The representative organization of mining professionals, the Mining Engineers' Association of India, Rajasthan Chapter, Udaipur, has sent an important letter dated 10.03.2026 to the Learned Amicus Curiae in connection with the pending case before the Hon'ble Supreme Court titled ***"Definition of Aravalli Range and related issues"*** (Suo Motu Writ Petition (Civil) No. 10/2025).

Through this letter, the organization has offered its technical expertise on scientific, environmental, and regulated mining aspects of the Aravalli region. It has also mentioned that the organization has experienced experts in mining, geology, environment, and regulatory domains who can meaningfully contribute to the high-level expert committee proposed by the honorable court. Additionally, the organization has proposed the name of Dr. Hitanshu Kaushal as an expert member, who has extensive experience in mining technology and legal matters. This initiative is considered a significant step towards establishing harmony between environmental conservation, balanced development, and scientific mining in the Aravalli region.

Other Highlights

On this occasion, Holi Milan and Eid Milan celebrations were also organized. Around 70 mining experts, academicians, industry representatives, and administrative officers, including Shri A.K. Kothari, Shri P.R. Ameta, Shri Himanshu Kaushal, Shri Maqbool Ahmed, Shri M.S. Paliwal, and Shri Y.C. Gupta, participated in the program. The program was conducted by Dr. Hitanshu Kaushal, Joint Secretary.

Blood Donation Camp – A Noble Initiative

April 18, 2026

A blood donation camp titled "A Noble Initiative – Your One Step Can Become Someone's Lifeline" was successfully organized on 18 April 2026 at the Indoor Stadium of M.B. College, Udaipur. The camp was jointly conducted by Vipra Foundation Youva Prakosth, Vifa Rakiya Sevarat Prakosth & the Rajasthan Chapter-Udaipur.

The objective of the camp was to promote voluntary blood donation and raise awareness about its importance as a life-saving act. The initiative received an encouraging response from members of **MEAI**, social workers, and local youth, who participated with great enthusiasm.

A dedicated team from multiple blood banks efficiently managed the blood collection process. With the collective efforts of all participants, a total of 175 unit**s** of blood were successfully donated. The blood collection was carried out with the support of Saral Blood Bank, RNT Blood Bank, Lok Mitra Blood Bank, Pacific Blood Bank, and Ananta Blood Bank.

The event was graced by the presence of several distinguished members, including Shri R.P. Gupta (Patron, MEAI Udaipur), Shri Asif M. Ansari (Secretary, MEAI Udaipur), Dr. Hitanshu Kaushal (Joint Secretary), Shri Madhusudan Paliwal (Former Chairman), Shri R.C. Purohit (Treasurer), and National Council Members Dr. S.K. Vashishtha, Shri P.R. Ameta, Shri N.M. Pitalia, Shri Mohan Lal Paliwal, and Shri Om Prakash Agal; many others were also present.

The success of the camp was made possible through the dedicated efforts and coordination of all organizing members. In recognition of their noble contribution, all blood donors were awarded certificates by the Vipra Foundation Youva Prakosth.

The event concluded on a positive note, reinforcing the spirit of social responsibility and the importance of voluntary blood donation in saving lives.

(Continued from Page 19)

data and more reliable models influence which projects get funded, how quickly they are approved, and who ultimately controls access to critical minerals.

The path forward is clear. Mining will not advance by replacing human judgment, but by strengthening it. When geoscience, engineering, and data come together through open and intelligent systems, uncertainty becomes manageable and decisions become defensible. That is how the industry builds the foundation for a more resilient and sustainable future.

Graham Grant, Mining.Com / April 7, 2026

➢ **BRICS+ nations hold over 17% of world's gold reserves: Report**

Global central banks have been buying up gold at a record pace, purchasing on average about 1,000 tonnes over the past four years, and the momentum has continued into 2026.

A large part of that can be attributed to emerging economies, led by BRICS+ nations, which have used bullion as a go-to strategy to shield themselves against geopolitical risks and US currency influence.

A new report by EBC Financial Group estimates that the bloc now holds about 6,000 tonnes of the world's gold reserves, or 17.4% of the global total, up from 11.2% in 2019. Russia leads the group with 2,336 tonnes, followed closely by China at 2,298 tonnes. The next largest holder is India at 880 tonnes.

Stock image.

Between 2020 and 2024, BRICS+ nations accounted for more than half of all gold bought by central banks globally, EBC said, highlighting what it views as a "structural shift" in their reserves strategy tracing back to Western sanctions against Russia in 2022, after which gold purchases doubled from about 500 tonnes to 1,000 tonnes.

Shift in reserve strategy

But, as the London-based financial group notes, the gold accumulation is only one side of the shift. The other is the declining share of the US dollar in global reserves. IMF data shows that dollar's share fell from 71% in 1999 to roughly 57% by the end of 2025, its lowest reading since 1994.

Since 2014, central bank holdings of dollar-denominated assets have remained essentially flat, ECB noted.

Meanwhile, gold's share of official reserve assets has more than doubled from below 10% in 2015 to over 23% today. Much of this reflects gold's price appreciation, but it unmistakably highlights that central banks are allocating a growing share of their portfolios to gold, and the war in the Middle East only reinforced this urgency, the group said.

The report also cited the World Gold Council's 2025 survey, which revealed that 73% of central bankers globally believe the dollar's reserve share will decrease further over the next five years, and 43% of surveyed central banks plan to increase their gold holdings, both record-high readings.

Trends to monitor

On whether the gold-buying would accelerate, the ECB report highlighted several key developments that could be worth monitoring.

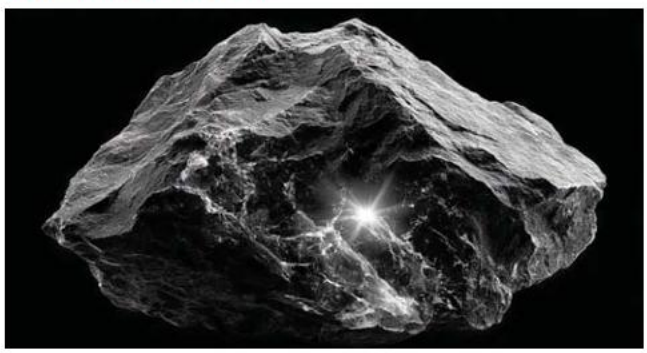
One is China, such as whether it would resume public reporting of gold reserve additions, which it has not done since May 2024. As of the end of March, the Chinese central bank has bought gold for 17 straight months.

Another potential driver is whether nations like Saudi Arabia or the UAE would follow the Russia-China playbook and increase their formal allocations of gold. Saudi Arabia, in particular, is considered as a wild card. A move to just 5% gold allocation would require purchases equivalent to the entire projected central bank demand for 2026 from a single buyer, ECB noted.

In addition, the group said to watch for further declines in the dollar's reserve share in the next IMF COFER release, since each incremental drop reinforces the narrative driving sovereign gold demand.

Staff Writer, Mining.Com | April 7, 2026

➢ Oxford spinout raises $2.3M for deep-underground critical minerals tech



Volcanic glass formation. AI-generated stock image by LuDo.

Ascension, an Oxford University spinout advancing a geothermal alternative to conventional rare earth mining, has secured £1.7 million ($2.3 million) in combined public and private backing to accelerate development of its underground critical mineral recovery technology.

The funding comprises a £670,490 grant from Innovate UK's Growth Catalyst program alongside £1 million in matched investment from the UK Innovation & Science Seed Fund (UKI2S), managed by Future Planet Capital, with co-investment from Oxford Science Enterprises and East X. This brings the company's total capital raised to £6.2 million.

The funding supports Ascension's Selective Recovery program, which aims to enable targeted metal selection underground - reducing processing steps traditionally

carried out at the surface and significantly lowering environmental impact, the company said.

Rare earth elements and other critical minerals are essential to electric vehicles, semiconductors and modern defence systems. Yet global supply remains heavily concentrated in a small number of regions, exposing the UK and its allies to strategic and supply chain risk.

Ascension said it addresses this challenge by recovering critical minerals from volcanic glass - a historically untapped resource formed by past volcanic eruptions.

Conventional mining relies on surface excavation, energy-intensive milling and high-temperature chemical processing, but Ascension's approach uses naturally occurring geothermal heat to recover minerals directly from volcanic rock deposits underground. This, it said, eliminates the need for excavation while significantly reducing environmental impact and land disturbance.

"For decades, securing critical minerals has meant digging larger mines, processing more rock and accepting significant environmental damage as the price of progress. That model is outdated," Ascension co founder Motoaki Sumi said.

"By working with natural geothermal systems rather than against them, Ascension is demonstrating that critical minerals can be recovered with far lower environmental impact. This support from Innovate UK, UKI2S and our co-investors enables us to accelerate development and move towards field validation," Sumi added.

Staff Writer, Mining.Com I April 17, 2026

OBITUARY

Shri. M. Nanjundappa
(LM-6531)
(08/08/1946 - 21/03/2026)

Shri M. Nanjundappa was born on 08-08-1946 in Doddankanahalli village, Bangarpet taluk, Kolar District, Karnataka, into a respectable agriculturist family. After completion of his matriculation in Bangarpet in 1962, he joined the School of Mines KGF for a diploma in mining engineering and passed out in the year 1966.

During 1967 he joined the then Kolar Gold Mine Undertaking (KGMU) and completed PDPT. In 1968 he was appointed as Survey Foreman in Survey department of Champion Reef Mine of BGML & served for 28 years in world famous Kolar Gold Field different mines with lots of zeal and dedication. During His service in BGML, he worked in all most all the BGML Survey Depts like Champion reef mine, Mysore mine, Nundydroog mine & Chigarigunta mine etc. He was elevated as Senior Surveyor in BGML during 1987 and sent to INDIAN SCHOOL OF MINES, DHANBAD, for a two-week refresher course on advanced mine surveying from October 12th to 24th, 1987. Under diversification activities of BGML, he worked on mine projects like HZL, etc. He opted for VRS in the year 1995 & retired as chief surveyor.

Then he joined Mysore Minerals Limited (now Karnataka State Mineral Corporation Limited), a Karnataka state government PSU, and worked in Sandur, Bhyrapur, Hospet, and the Bellary region in many opencast mines in various mineral deposits. Though he was a mining engineer, he dedicated his service only to the mine survey work for a period of half a century.

He was jolly with everyone; he had built up a good relationship with all officials of the Directorate of Mine Safety. The mining industry has utilized his sincere service, which is unforgettable. He lost his last breath on 21.03.2026 at the age of 80 years. He is survived by his wife, Smt. Savithramma, and daughter, Subhasini. He was a life member in MEAI & felicitated by the Bellary-Hospet chapter during 2024-25.

The Mining Engineers' Association of India prays for the divine place in heaven for the departed soul and courage for bereaved family members to sustain irreparable loss to the family.

CONFERENCES, SEMINARS, WORKSHOPS ETC.

INDIA

23 May 2026: **A one-day National Seminar and the 3rd National Council Meeting of MEAI** at 3.00 PM. Location: The Learning and Development Center, Neyveli, NLC India Limited, Tamil Nadu. Organized by the MEAI Tamil Nadu Chapter. For more details: Please contact Shri Sanjeevi. R, Chairman – Tamil Nadu Chapter, at sanjeevi.r@nlcindia.in or Shri Muthukkumaran. M, Council Member, MEAI, at muthukkumaran_m@nlcindia.in.

12-13 Jun 2026: **National Conference on Advanced Technologies for Safe and Sustainable Mining Operations MINING 4**. Organized by the Mining Engineers Association of India, Hyderabad Chapter. Venue: Novotel Hyderabad Airport, Rajiv Gandhi International Airport, Shamshabad, Hyderabad. For details, contact Mr. Randhir Kumar at 9109197660 or Mr. Lakkarsu Krishna at 9955393916.

30-31 Oct 2026: **National Conference & Exhibition on "Frontiers in Rock and Mining Engineering" (FRAME-2026)**. Organized by the Mining Engineers Association of India, Dhanbad Chapter, in association with CSIR–Central Institute of Mining and Fuel Research (CSIR-CIMFR), Dhanbad, Jharkhand, India. Venue: CSIR-CIMFR, Barwa Road, Dhanbad. For details, contact frame2026cimfr@gmail.com or Dr. Santosh Kumar Ray, Organizing Secretary, at santoshray.cinfr@csir.res.in.

ABROAD

5-7 May 2026: **Global Resources Innovation Expo 2026. Perth Convention & Exhibition Centre**, Perth, Australia. Hosted by Austmine and AusIMM.

18-19 May 2026: **International Conference on Mining and Economic Geology (ICMEG -2026)**. London, United Kingdom. Website URL: https://waset.org/mining-and-economic-geology-conference-in-may-2026-in-london.

24-25 May 2026: **International Conference on Mining and Economic Geology (ICMEG 2026)**. in London, United Kingdom. Website URL: https://waset.org/mining-and-economic-geology-conference-in-may-2026-in-london.

24-26 Jun 2026: **The 27th World Mining Congress and exhibition in Peru**. Contact details: Phone: +48 32 324 66 03; e-mail: wmc@gig.katowice.pl.

29-30 Jun 2026: **International Conference on Geological and Earth Sciences ICGES** in Istanbul, Turkey. Website URL: https://waset.org/geological-and-earth-sciences-conference-in-june-2026-in-istanbul.

20-21 Jul 2026: **Accelerating Commercial Exploration, Discovery and Extraction** in Cairo, Egypt. Conference Enquiry: conference@egyptminingforum.com.

9-10 Aug 2026: **International Conference on Geology, Geophysics and Earth Sciences ICGGES** in New York, United States. Website URL: https://waset.org/geology-geophysics-and-earth-sciences-conference-in-august-2026-in-new-york.

6-7 Sep 2026: **International Conference on Mining and Petroleum Geology (ICMPG-2026)**. Málaga, Spain. Website URL: https://waset.org/mining-and-petroleum-geology-conference-in-september-2026-in-malaga.

5-7 Oct 2026: **Mine Health & Safety Conference 2026. Pan Pacific Perth**. Contact on: T: 1800 657 985 or +61 3 9658 6100 OR Po Box 660 Carlton, VIC 3053, Ground Floor, 204 Lygon St, Carlton VIC 3053.

19-21 Oct 2026: **Mill Operators Conference. Brisbane Convention and Exhibition Centre**, Brisbane. Contact on T: 1800 657 985 or +61 3 9658 6100 OR Po Box 660 Carlton, VIC 3053 Ground Floor, 204 Lygon St, Carlton VIC 3053.

25-26 Oct 2026: **International Conference on Hydrometallurgy and Mining ICHM** in Istanbul, Turkey. Website URL: https://waset.org/hydrometallurgy-and-mining-conference-in-october-2026-in-istanbul.

17-19 Nov 2026: **Strategic Mine Planning Conference 2026**. Residence on Langley Park, Perth. Contact on: T: 1800 657 985 or +61 3 9658 6100.

REQUEST TO READERS/ MEMBERS OF MEAI

The Editorial Board of the Mining Engineers' Journal (MEJ) requests our esteemed Readers/ Members of MEAI to share their valuable Research work in geosciences/ mining or Best practices developed/ adopted while employed in the mineral industry, for publication in our Mining Engineers' Journal (MEJ), for the benefit of the mineral industry fraternity.

Interested professionals may please contact the Editor, MEJ for obtaining "Author(s) guidelines" for submitting technical papers at **editor.mej.meai@gmail.com**.

Chief Editor, MEJ

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