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Mining Engineers' Association of India
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Vol. 23 No. 9 MONTHLY April - 2022

this issue contains...

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President's Message.....

Dear members,

Greetings .....

I wish to put forth the activities undertaken by the Association in the preceding month....

The Bangalore Chapter conducted a National seminar on "***Safe usage of explosives & winning of minerals***" on March 3, 2022. Shri. Pankaj Kumar Pandey, Secretary, Commerce and Industry department (MSME & Mines), Government of Karnataka graced the event as the Chief Guest. DGMS officials of the Southern Zone, DMG officials of Karnataka State and industry people have also graced the event. I am delighted to share that the event was well organised and evoked very good response from the participants. As this Seminar was intended for Minor Minerals quarries, it attracted the lessees of Minor Minerals in large numbers and made it a successful one. I am happy to note that the professionals and lessees from Minor Minerals industry carried home valuable knowledge on explosives, safe usage of explosives and winning of minerals and rules pertaining to it.

The recently concluded maiden ***MEAI Professional Development Program (MPDP)*** received an overwhelming response from the industry. 35 resource industry professionals and mining companies' representatives attended the sessions that were conducted online for 6.5 days on 4th, 5th, 11th, 12th, 18th and 19th March 2022, with the concluding function held on 20th March 2022. I received several good feedbacks, congratulatory notes and thanks giving messages from the participants, expressing their contentment on the valuable knowledge gained from this program that would enhance their technical skills and managerial competencies.

It is also worth sharing that in the past couple of months the State Governments of Karnataka, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand, Orissa and Maharashtra have notified auction of minerals and coal blocks and released NIT. I do hope that industry will avail this opportunity and secure the supply of raw materials for the future.

It is a pleasure to note that MEAI has received an invitation from the Geological Survey of India to attend 61st Central Geological Programming Board (CGPB) meeting on 24th March 2022 at New Delhi and our Association participated in this event.

It is also my pleasure to note that some of our Chapters are also planning to conduct technical talks and workshops in their respective regions in the Month of April. MEAI Belagavi Chapter has proposed to organize a one-Day National Seminar on **"*Sustainable Mining and Waste management*"** at Bagalkot on 24th April, 2022.

The MEAI and NACRI have announced jointly organising the third training program on IMIC (Indian Mineral Industry Code for reporting Mineral Resources and Mineral Reserves in India) online from 18th April to 13th May 2022, spread over 40 hours. The resource industry professionals may take advantage of attending this professional development program to update their professional knowledge on public reporting of mineral resources and reserves complaint to CRIRSCO international reporting standards.

I call up on our Chapters' Chairmen and secretaries to plan for increased professional activities in their respective regions to better serve our fraternity and the mineral industry.

Regards,

K. MADHUSUDHANA
President

Mining Engineers' Association of India

Regd. Office : Rungta House, Barbil (Odisha)

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EDITOR'S DESK

Dr. P.V. Rao
Editor, MEJ

The Mining Engineers' Association of India (MEAI or Association) endeavors in promoting the highest professional and ethical standards of its members through a robust focus on professional ethics and best practice implementation of professional codes, as outlined under Para 4 of its Memorandum of Association. According to Rule 4 of the Association By-Laws, all members are bound by the Association's Code of Ethics as well as other National Council-approved codes (including the IMIC- The Indian Mineral Industry Code for reporting Mineral Resources and Mineral Reserves in India) when acting in certain capacities as a mineral industry professional. These codes serve to protect communities, other members and the profession by providing the community and financial markets with confidence in the mineral industry.

Upon registration, the Registered Competent Person (RCP) of the Association commits to the principles set out in the Code of Ethics for RCP and reaffirms that commitment when renewing the RCP membership each year. In this way, the MEAI positions itself as a trusted and representative voice for resources professionals. In its Annual General Meeting held on January 24, 2018, the members of the Association ratified the amendments made to the professional conduct rules & regulations, with application across all the membership categories.

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SUBSCRIPTION RATES

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The Complaints resolution process of the Association is integral to upholding the professional standards of RCPs. It involves judgement by peers and designed to ensure that members are held accountable for any conduct that breaches the Code of Ethics, Professional Codes and the By-Laws. The Code of Ethics requires the RCPs to adhere to IMIC requirements and the complaints resolution process deals with breaches of this Code. Penalties that can be imposed on RCP, where a breach of the Code of Ethics and/or professional codes is found, include caution/warning, mediation and/or counselling, further education and/or training, membership suspension or expulsion from MEAI, publication of details of the breach in MEJ, including public naming of the professional found to be in breach.

The intent of the Complaints resolution process is to ensure a sanction is appropriate to the breach while preserving the integrity of the profession and the Association

The intent of the Complaints resolution process is to ensure a sanction is appropriate to the breach while preserving the integrity of the profession and the Association. The process is informed by natural justice principles and includes an avenue for appeal. All deliberations of the Complaints Resolution and Ethics Committees are strictly confidential. The identity of the complainant is not disclosed to the person(s) about whom the complaint has been made or to any parties not involved in the process of determining the validity of the complaint. The identity of the complainant and respondent remains confidential except where (a) the complainant agrees to reveal the name to the respondent when necessary to pursue the complaint, (b) the Ethics Committee has resolved that notice of a breach be published, in which case the name of the respondent may be made public, and (c) in the unlikely event that the matter advances to legal proceedings independent of the MEAI process where the identity of the complainant may become known as part of the discovery of documents or if the MEAI is directed by a court (or other legally empowered person) to make such information available.

The Complaints Resolution and Ethics Committees are jointly responsible for investigating and determining the outcome of complaints. The Complaints Resolution Committee investigates each complaint received, with referrals made to the Ethics Committee if it is determined that a significant breach of the Code of Ethics has occurred. The distinguished members of these two committees for 2021-23 are:

MEAI Complaints Resolution Committee

1) Mr K Madhusudhana, President MEAI; 2) Mr SN Mathur, Vice President-I MEAI; 3) Mr OP Gupta, Vice President-II MEAI; 4) Mr DB Sundara Ramam, Vice President-III MEAI; 5) Mr TN Gunaseelan, NACRI Founding Member; 6) Mr Deepak Rathod, NACRI Founding Member; 7) Mr KS Solanki, NACRI Founding Member; 8) Mr M Narsaiah, Secretary General MEAI;

MEAI Ethics Committee

1) Mr TV Chowdary, Former President MEAI; 2) Mr T Victor, Former President MEAI & Former Co-Chair NACRI; 3) Mr Arun Kumar Kothari, Former President MEAI & Former Co-Chair NACRI; 4) Mr Sanjay Kumar Pattnaik, Former President MEAI & Former Co-Chair NACRI; 5) Mr K Madhusudhana, President MEAI & Co-Chair NACRI; 6) Dr PV Rao, Founding Co-Chair NACRI; 7) Dr Abani Samal, Former Co-Chair NACRI; 8) Mr M Narsaiah, Secretary General MEAI.

- Editor

NEWS FROM THE MINING WORLD

NMDC becomes first Indian co to cross 40 MT iron ore production in a year

Mining major NMDC on Monday informed the exchanges that it has crossed the milestone of producing over 40 million tonnes (MT) of iron ore in a year, becoming the first Indian company to do so. "Starting from 4 million tonnes in 1969-70, NMDC crossed 10 million tonnes in 1977-78, added another ten million by 2004-05, crossed 30 million tonnes within a decade and has now breached the 40 million mark," the company said in a statement.

"The company's perseverance and consistency have paid off and I congratulate the team for this historic accomplishment. I am confident that we will continue to cross many more milestones on our way to fulfill the nation's vision of #AtmanirbharBharat. This achievement also shows that we are on the track to become a 100 MTPA company by 2030," said Sumit Deb, Chairman and Managing Director, NMDC.

NMDC says it has now set a target of becoming a 100 MTPA company by 2030. The CPSE also plans to leverage its expertise in moving towards a multi-mineral outlook with coal, diamond, gold, and other strategic minerals of national interest in their portfolio.

ET online | Mar 21, 2022

MCL becomes the largest coal producing company in India

The Mahanadi Coalfields Limited (MCL), a unit of the CIL, has crossed 157 million tonne (MT) in coal production in the financial year of 2021-22, to become the leading coal producing company in the country, a release said.

On March 12, 2022, the company produced 7.62 lakh tonne of dry fuel which is the highest in a day during the current financial year reaching 157.7 MT with a growth of around 16 per cent over the last financial year, the company release said.

Chairman-cum-Managing Director of the company, OP Singh congratulated all officers, staff, employees of contracted companies and other stakeholders for their contribution in making MCL the leading coal producing company in the country. "MCL has to play a bigger role in ensuring energy security to the nation," said the CMD in his congratulatory message to all the employees.

Surpassing all previous records, MCL has despatched over 166 MT dry fuel to the consumers, registering 22 per cent growth over a previous financial year while it has also removed 195 MCuM (million cubic meters) of over burden registering 19 per cent growth over the last financial year, the release added.

PTI | Mar 14, 2022

India expects private coal mines to produce at least 350 million tonnes by 2030

India expects coal mines owned by private companies to produce 350-400 million tonnes of coal by 2030, a senior coal ministry official told an industry conference on Tuesday, potentially reducing the country's dependence on imports. India, the world's second largest coal consumer behind China, opened up coal mining to the private sector companies, such as Adani Enterprises and Vedanta, for the first time in 2020, after years of lobbying by coal users to privatise coal mining. The increased domestic production could mean lower imports. Indonesia, Australia and South Africa are the country's largest suppliers, and together account for over 90% of coal imports.

India's imports have fallen in the recent months due to high global prices, increasing dependence on Coal India. The state-run miner accounts for over 80% of India's domestic output, and is targeting an output of 670 million tonnes in 2021-22. M Nagaraju, the additional secretary at the federal coal ministry, said he also expected mines recently allocated to state-owned firms along with those auctioned to the private sector to produce 80-85 million tonnes of coal in 2021-22. The output from these mines is expected to increase by about 60% to 130-135 million tonnes during the year ended March 2023, Nagaraju told the Indian Coal Markets Conference. India has since awarded licences to the private sector to operate 42 coal mines with a combined capacity of 86 million tonnes per annum. But nearly 75% of the 145 mines auctioned in the first three rounds have so far attracted no interest from private sector participants. Only 11 of the 99 mines auctioned in the fourth round have received any interest from bidders. The fourth round auction process is still ongoing. (Reporting by Sudarshan Varadhan. Editing by Jane Merriman)

Reuters | Mar 08, 2022

Coal ministry eyes private companies to run Abandoned mines of CIL

The coal ministry on Thursday said state-run Coal India Ltd.'s proposed contracts for sub-contracting abandoned mines on a revenue sharing model could attract companies like Essel Mining, Adani Group,

Tata Grotp, JSW Group and Jindal Steel & Power. Coal India is looking to offer more than 100 such mines to the private sector on revenue sharing basis, similar to the government's commercial coal block auctions, an official statement said. Earlier in the day, the ministry had held a stakeholder consultation with the private sector for discontinued/closed mines of Coal India. The consultation has attracted huge participation from the private sector, the ministry said in the statement.

A senior Coal India executive said the sub-contracting will be on the "mine developer and operator (MDO)" model, in which the company will mine the coal on a revenue-sharing basis. "There will be no transfer of ownership of mines," he said. Coal India expects a good response from companies--primarily from plants which import coal--given that the international price of coal has surged. - Our Bureau

ET Bureau | Feb 25, 2022

'Make in India' need of hour if seen through prism of national security: PM

'Today, the world is looking at India as a manufacturing powerhouse,' Modi said while addressing DPIIT's webinar on 'Make in India for the World'

Prime Minister Narendra Modi on Thursday said Make in India is the need of the hour and appealed to the industry to reduce dependence on imports and boost domestic manufacturing. He urged the industry to take challenges and make efforts to cut imports of goods that can be manufactured in India. "Today, the world is looking at India as a manufacturing powerhouse," Modi said while addressing DPIIT's webinar on 'Make in India for the World'.

The Prime Minister added that the industry will have to maintain global standards and compete globally and it is not acceptable that a country like India ends up merely as a market.

He said that the Budget has many significant provisions for Aatmanirbhar Bharat and Make in India. He pointed towards supply chain disruptions during the pandemic and other uncertainties to underline the critical importance of Make in India. Positive factors like demographic dividend of young and talented population, democratic setup, and natural resources "encourage us to move towards Make in India with determination", he said.

The Prime Minister asked the captains of the manufacturing sector to pick up some areas and work to remove foreign dependence on them. Referring to his call for 'zero defect-zero effect' manufacturing, Modi said Indian products should not have any defect at all and in this competitive world, quality is the key.

"Aatmanirbharta is all the more important if we see from the prism of national security," he said, adding that manufacturing accounts for 15 per cent of India's GDP, but there are infinite possibilities for Make in India and "we should work with full strength to create a robust manufacturing base in India".

The Prime Minister also cited the examples of new demands and opportunities in sectors like semiconductors and electric vehicles where manufacturers should move with a sense of removing dependencies on foreign sources. Similarly, areas like steel and medical equipment need to be focussed for indigenous manufacturing, he added. He also pointed out the difference between the availability of a product and the availability of made-in-India products in the market.

Modi expressed his dismay that many foreign products are supplied for India's various festivals, which can be easily provided by local manufacturers. The ambit of 'vocal for local' goes well beyond buying 'diyas' on Diwali and the private sector should push the factors of 'vocal for local' and Aatmanirbhar Bharat in their marketing and branding efforts, the Prime Minister said.

Take pride in the products your company makes and instil this sense of pride in your Indian customers as well. For this, some common branding can also be considered," he stated.

Modi also highlighted the need to find new destinations for the local products while exhorting the private sector to enhance spending on R&D and diversify and upgrade their product portfolio.

The demand for millets is increasing in the world. By studying the world markets, we should prepare our mills in advance for maximum production and packaging, he said, adding that new possibilities are there due to the opening up of areas like mining, coal and defence sectors and the industry should prepare a new strategy. Further, he said that reforms in the Special Economic Zone Act will provide a boost for exports.

Talking about reducing compliances, he said Common Spice Form and National Single Window System are examples where the industry is feeling the government's development-friendly approach at every step. The Make in India campaign is the need of 21st century India, and it gives an opportunity to show our potential, Modi said,

adding that "we should work with full force to build a robust manufacturing base".

India has to become self-reliant in the semiconductor segment as there is no choice and this sector has brought huge opportunities for Make in India and it is the need also for the country's security, he noted. Citing an example of iron ore, he said that the country would not gain anything from exporting raw materials. "Manufacturers should see that the dependence of the country on the outside is minimised," he said.

Press Trust of India | March 3, 2022

Chile a step closer to nationalizing copper and lithium

Chile's constituent assembly, in charge of writing the country's new Constitution, approved on Saturday an early-stage proposal that opens the door to nationalizing some of the world's biggest copper and lithium mines. The motion by the environmental committee, which gathered over the weekend for the first time since its creation as a deadline to wrap up proposals looms, received 13 votes in favour with three against and three abstentions.

The proposal, targeting mostly large-scale mining of copper, lithium and gold has yet to be approved by two thirds of the full assembly to become part of Chile's new charter, which will be put to a national referendum later this year. Analysts consider the motion a direct attack on private interests since the Chilean state already owns the underlying mineral rights, gives the government one year to nationalize companies.

These firms, which work with metallic and non-metallic minerals, as well as hydrocarbons, would likely not receive indemnification for losing their mining rights. The comptroller would determine this based on the book value of the companies, paid over a maximum of 30 years, the proposal states.

The text also states that operations and projects which began before 1993 would have to submit to environmental evaluation within three years. Concessions in excluded areas, such as those near glaciers and on indigenous lands, would be revoked. The environmental committee — stacked with young activists — voted on a first draft of this motion in early February, triggering immediate backlash, even from Chilean authorities themselves.

Diego Hernández, president of the National Mining Society (SONAMI), which represents companies in the sector, qualified the idea as "barbaric" and "with clear and obvious legal errors". The centre-left mining veteran has said the measure targets both companies and resources, which would have a major economic and legal impact in Chile. "Given the world's globalization, I would expect affected companies to resort to treaties to defend their legitimate interests," Hernández has said.

Socialist politician Sergio Bitar, who was Minister of Mines under the deposed government of leftist Salvador Allende in 1973, has referred to the initiative as "a delirious return to the past." Chile passed a law in 1967 requiring companies to be at least 51% owned by nationals. Four years later, the state bought the remaining 49% of shares and companies were completely nationalized. "I recall all the problems we had trying to sell copper outside of the business circle, I remember when Congress voted not to pay any compensations to the companies for assets and lost profits, which is what I am listening [to] now," Bitar said in an interview with MercoPress.

"One thing are dreams, wishful dreams," the veteran politician said. "The other is reality, which shows how dependent Chile is of global powers (…) For example China now buys a third of Chilean copper, so what will be our strategy with nationalized mining companies? Lower exports?", he noted.

Higher royalties

Chile, the world's largest copper producer and host to the two biggest lithium miners, is rewriting its Constitution to replace a market-centric one that dates back to the military dictatorship of General Augusto Pinochet. The nation produced 5.6 million tonnes of copper in 2021, about 25% of the total generated in the world, and has a pipeline of almost $70 billion in possible mining projects this decade, much of which would never materialize if the country nationalized its resources.

Politicians at the world's top copper-producing nation are also fine-tuning a new mining royalty bill, which will raise tariffs on firms based on gross sales and profitability. "We estimate that, if the new taxes are approved, Chilean copper mining companies could see their tax rates increase to as much as 80% and profit margins drop by more than 50% at current copper prices," FTI said in its latest report.

The analysts believe that, while the likelihood of outright nationalization as proposed is small, a radical new royalty regime stands a much better chance. It could "push the Chilean tax system into pseudo-expropriation territory, especially with prices likely to stay above $4 per pound, which is where the 75% rate kicks in."

They conclude that Chile could become the nation with the highest tax burden on copper mining, forcing companies to revisit the viability of their current and future investments.

Cecilia Jamasmie | March 7, 2022

The Metals Company signs MoU for PFS on world's first deep-sea nodule processing plant

Image from The Metals Company.

The Metals Company (NASDAQ: TMC), formerly Deep Green Metals, an explorer of lower-impact battery metals from seafloor polymetallic nodules, announced Thursday that it has signed a non-binding Memorandum of Understanding with Epsilon Carbon to complete a pre-feasibility study for a commercial-scale deep-sea nodule processing plant in India called Project Zero Plant.

The company said targeted production capacity is more than 30,000 tonnes per annum (TPA) of an intermediate nickel-copper-cobalt matte product used for active cathode material (CAM) for Nickel Manganese Cobalt (NMC) and other nickel-rich cathode chemistries for lithium-ion batteries and more than 750,000 TPA of manganese silicate by-product expected to be used in manganese alloy production for the steel industry.

Mining international waters is in the spotlight as companies and countries are looking at minerals concentrated on the ocean floor that can be used in batteries for smart phones and electric vehicles. Last year, the company said the nodule resource is now estimated at four megatons (Mt) measured, 341Mt indicated and 11Mt inferred mineral resources. In January, TMC announced the completion of its latest offshore research campaign, Environmental Expedition 5E, a targeted sampling campaign of both benthic and pelagic fauna with wider investigations to characterize ecosystem function on the abyssal seafloor.

The completion of the six-week expedition — the company's fifth environmental campaign in the last twelve months — marked the latest offshore campaign required to develop an environmental baseline of the proposed operating environment in the Clarion Clipperton Zone (CCZ) of the Pacific Ocean and characterize the potential impacts of its proposed nodule collection operations to source critical battery metals from deep-sea polymetallic nodules.

The polymetallic nodule fields in the CCZ of the Pacific represent the largest known, undeveloped nickel resource on the planet. A DeepGreen-commissioned white paper found that nodules under exploration contracts in the CCZ contain more than enough battery metals to power one billion EVs and with a fraction of the social and environmental impacts when compared to land-based ores.

Environmentalists have called for a ban on deep-seabed mining that would extract resources including copper, cobalt, nickel, zinc, lithium, and rare earth elements from nodules on the ocean floor.

TMC said in Thursday's release that through its subsidiaries, it intends to supply polymetallic nodules and onshore processing expertise while Epsilon Carbon intends to finance, engineer, permit, build and operate the Project Zero Plant. TMC has shared with Epsilon Carbon the near-zero solid waste processing flowsheet developed with Canadian technology and engineering firms between 2018 and 2021 and technical results from a pilot plant program completed in 2021 at FLSmidth's facilities in Whitehall, Pennsylvania and at eXpert Processing Solutions' (XPS) facilities in Sudbury, Ontario.

Epsilon Carbon intends to deliver a pre-feasibility report for a plant in India powered by renewables and with the targeted processing capacity of 1.3 million tonnes per annum (Mtpa) of wet nodules and production start in time to receive nodules collected from NORI-D area starting around Q4 2024, provided that TMC's subsidiary NORI secures an exploitation contract from the International Seabed Authority. The companies said they expect to enter a binding Heads of Terms for construction and operations of Project Zero Plant by September 30, 2022.

Safety, environmental and social impacts

"Over the last three years, we have engaged with many parties and visited plants around the world in search of the right onshore partners," TMC CEO Gerard Barron said in the media release. "In Epsilon Carbon, we have found a rare mix: a proven operational execution track

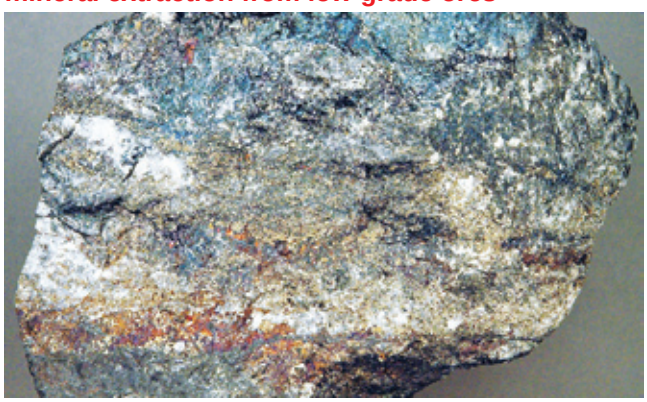
record in anode materials, a 21st century approach to industrial development grounded in making use of waste products, deep care about safety, environmental and social impacts, and an entrepreneurial ambition to develop cathode precursor materials."

Barron said that Prime Minister Modi's allocation last year of $600 million for India's Deep Ocean Mission and the development of a polymetallic nodule collection system shows the country's commitment to this new, abundant, secure, lower-cost and lower-ESG-impact potential source of critical metals. "Having developed technology to tap an unconventional source of graphite — a waste stream from steel manufacturing — we are rapidly growing our anode materials business in India and…our strategy is to expand into cathode materials by 2024," said Vikram Handa, founder of Epsilon Carbon.

"TMC's polymetallic nodule resource struck us as a game-changing opportunity to tap another unconventional resource with several intrinsic properties that potentially allow us to develop a cathode precursor materials business with a much lower environmental and social impact. We have started with a PFR for a relatively small-scale plant but we believe that the scale of TMC's resource has the potential to turn India into a significant supplier of critical minerals for battery and steel industries."

Staff Writer, Mining.Com | March 17, 2022

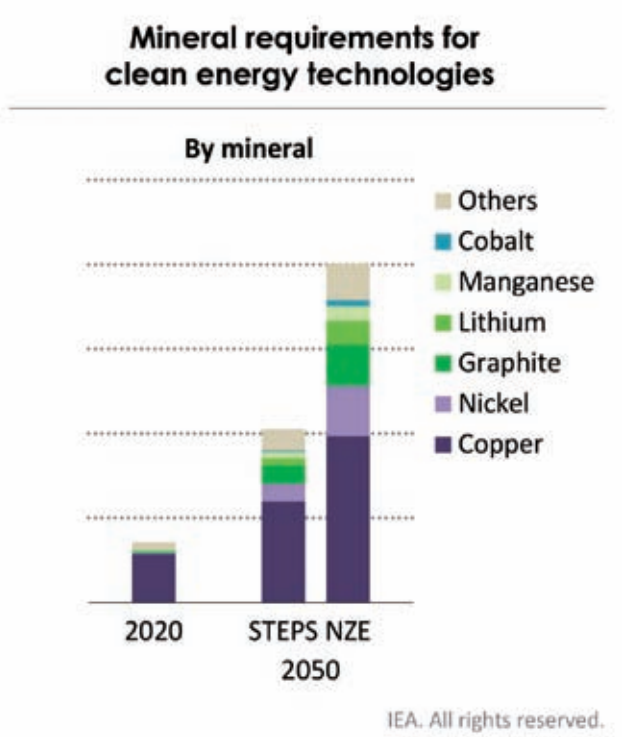
Carbon-neutral biosurfactants may help boost mineral extraction from low-grade ores



Copper ore. (Reference image by James St. John, Flickr).

Cleantech company Locus Fermentation Solutions announced the launching of a new mining operating division whose focus will be on developing and commercializing carbon-neutral biosurfactant additives to boost mineral extraction from low-grade ores. Biosurfactants are compounds of microbial origin that lower the surface tension between two liquids, between a gas and a liquid, or between a liquid and a solid. Thus, they may act as detergents, wetting agents, emulsifiers, foaming agents, or dispersants.

In a press release, LFS said its biosurfactant technology shows potential as an effective, environmentally friendly solution for extracting essential minerals needed to fuel the green energy revolution.



(Graph provided by Locus Mining Solutions).

According to the US-based firm, when tested in traditional copper extraction processes, its renewable biosurfactant additives resulted in 138% more acid-insoluble copper recovered and 28% better performance than sulfuric acid.

The technology also allowed for a 40% reduction in carbon dioxide emissions, while also lowering sulphur oxide-associated emissions by 70% and nitrogen oxide-associated emissions by 70%. "The world's growing reliance on minerals and metals in the transition to a clean energy future is exceeding current extraction capabilities creating an imperative need for sustainable technologies that can reach trapped resources," Andrew Lefkowitz, co-founder of Locus FS, said in the media brief.

"Our zero-carbon biosurfactants have an unmatched ability to reach and extract more natural resources. We're addressing critical environmental and economic concerns to transform the industry, reduce

environmental impact and support economic growth in the US."

Staff Writer, Mining.Com | March 17, 2022

Tata Steel eyes other nations amid uncertain Russian coal supply

The IJmuiden Works plant in the Netherlands. (Image courtesy of Tata Steel).

Tata Steel Ltd., India's biggest producer, is seeking alternative sources for coal supply to its European and Indian operations due to difficulties of doing business with Russia after its invasion of Ukraine, a top official said Saturday. The geopolitical crisis after Russia's invasion of Ukraine has spurred fears of supply disruptions and surging costs of commodities from aluminum to coal and iron ore.

Tata Steel will look at alternative markets for coal imports as transactions with Russian suppliers and bankers at present comes with a "lot of uncertainties," Managing Director T.V. Narendran, told reporters on the sidelines of an event in Kolkata. The company used to buy upto 15% of its coal requirements from Russia, he said. "For Europe, we have to buy more from North America," he said, adding that India usually buys coal from Australia.

The supply vacuum left by Russia and Ukraine also opens up export opportunities for Indian steel producers, particularly to countries like Turkey and Europe, he said. But Tata Steel's Indian business will stick to exporting about 10%-15% of its sales in the next financial year starting April, he said.

"We want to focus on best prices when selling that 10%-15%, so southern Europe is now a better option than South East Asia," he said. The company's margins should improve in the immediate future, because the price increases are more than input costs and there may be scope for further hikes, Narendran said.

"In the next couple of months, the cost increases will start hitting everyone. So I think to the extent you have inventory in the system you have advantage for a couple of months. But otherwise it will catch up," Narendran said.

Bloomberg News | March 12, 2022

India's Russian coal imports could be highest in over two years in March

Coal mine in Russia. (Image from Pxhere, CC0)

India's coal imports from Russia in March could be the highest in more than two years, data from research consultancies showed, as Indian buyers continue buying the fuel from a market that is now increasingly isolated by sanctions. Vessels carrying at least 1.06 million tonnes of coking coal, mainly used for steelmaking, and thermal coal, used primarily for electricity generation, are set to deliver the fuel at Indian ports in March, the highest since January 2020, data from consultancy Kpler showed.

Russia, usually India's sixth largest supplier of coking and thermal coal, could start offering more competitive prices to Chinese and Indian buyers as European and other customers spurn Russia because of sanctions, traders said, adding that the trade could also be boosted by a rouble-rupee trading arrangement.

About 870,000 tonnes of Russian coal have already delivered or are expected to be delivered at Indian shores until March 20, the highest since April 2020, Indian consultancy Coalmint says. The number would be higher if more coal was loaded at Russian ports since mid-February, as it typically takes about a month for Russian vessels to deliver to India, said Aditi Tiwari, coal market head at Coalmint. "Indian buyers have taken a backseat after the SWIFT ban and sanctions on Russia. They are looking out for alternatives from Australia and the U.S," Tiwari said.

A number of Russian banks have been cut off from the SWIFT secure messaging system that facilitates

(Continued on Page 25)

DRONE-BASED TECHNOLOGY SOLUTIONS FOR THE MINING INDUSTRY

Krunal Kalbende[1], Srikant Annavarapu[2]

Abstract

The implementation of new technologies in the mining industry often lags behind that in other industries due to the harsh environmental conditions and the lack of awareness and exposure to these technologies in remote locations. Few mineral industry professionals are able to implement such solutions without a technology company and technology companies often resist implementations in the remotely located mining operations. Drones have the ability to carry a set of sensors for measuring various parameters and collect this information over a large area quickly. Geotagging of each datapoint allows the assessment of a large number of parameters with the required spatial reference and the analysis of this data can yield interesting and useful results and correlations if viewed or assessed by a competent mineral industry professional in association with a data scientist. The number and complexity of the sensors used for the collection data depends on the requirements of the mine site. Compliance with relevant regulations can also be made more convenient using drone-based technologies using various sensors. This paper presents some innovative drone-based technology solutions which may improve the quality and quantity of significant data collected from the mines and enhance productivity while lowering data acquisition costs.

Keywords: *drones, exploration, metal mining, open pit mining, sensors, underground*

1. Introduction

The design and fabrication of drones (also referred to as Unmanned Aerial Vehicles or UAVs and Micro Aerial Vehicles or MAVs) is carried out in different countries to address the needs of the major industries in those countries. Drones come in various configurations based on the type of motion such as Single-Rotor Drones, Multi-Rotor Drones, Fixed-Wing Drones, Fixed-Wing Hybrid Drones, Tactical Drones, Reconnaissance Drone, Large Combat Drones, Non-Combat Large Drones, Target and Decoy Drones, GPS Drones, Photography Drones (Hassanalian and Abdelkefi, 2017, Vergouw et al, 2016). Drones have been utilized for different types of missions by civilian and military agencies around the world. When integrated with various sensors including single and stereo cameras, LiDAR, spectral imaging, thermal imaging, magnetic resonance, drones can map the earth surface for various visual, chemical, biological and mechanical characteristics with appropriate geotagging, if GPS systems are enabled on the drone. The data can then be used for the development of digital elevation models (DEM), material movement assessments, 3-D mapping, fragmentation assessments, stability monitoring, geotechnical assessments, illumination assessments, environmental impact monitoring, and many more such evaluations for enhancing productivity or optimizing the use of resources at the mine.

In the mining sector, drone-based technology solutions have the potential to significantly reduce manual labor in spatial surveying, geotechnical assessment and slope monitoring, collection of surface and sub-surface data, sample collection, pipeline and conveyor belt inspection, aerial mapping of mineral prospect zones, disaster mitigation, management and monitoring, machine life tracking, infrastructure structural monitoring, mine and mill safety, and security surveillance (Hagemann, 2014). The collected data can be integrated and used for the development of mine plans and schedules and can also help in mine operations through machine and operator tracking, traffic monitoring, environmental and ecological monitoring (Lee and Choi, 2016).

Drones have been used for mapping of the working and disturbance areas with respect to lease boundaries and compliance with requirements of forest clearance through the mapping of the forest boundaries adjacent to the mining areas. The planning and monitoring of reclamation efforts, including monitoring of the status of the vegetation in the reclaimed areas, can also be efficiently conducted using drone mounted sensors often used in the agriculture. Drones have also been used to drop saplings encased in a nutritious hydrogel in precise locations in inaccessible areas.

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2. Drone technology for mines

The large areal extent of surface and underground mines, and the hazards in accessing remote areas make drone-based technologies an obvious choice for data collection and assessment. Mounting advanced job-specific sensors help collect the required information from the site at different stages of a mining project.

At the time of exploration, drones provide an opportunity for the explorer to get an aerial view of the area to be explored for planning the exploration program in the first place (Figure 1). Drone aerial surveys allow the explorer to look ahead into the area of exploration and plan the approach to the designated targets. The ability of the drone to carry basic sensors also helps focus the exploration effort in specific areas based on the initial information collected from closer to the ground than standard aerial surveys. Drone surveys are also easier to conduct and more cost effective. Once basic exploration is completed, heavier drones carrying more sophisticated sensors for conducting aeromagnetic and other surveys can be deployed to gather more relevant information for designing the possible drilling programs. Drones may be used for a variety of tasks including mineral deposit mapping, exploration target surveying, mineral exploration through remote control (Le at al, 2020).

Figure 1: Exploration team using drones

Once the exploration is completed and a mine is being constructed, drone surveys can provide information regarding the progress of mine construction and help identify bottlenecks so that the construction schedule can be maintained. Most mines bleed money due to delays at the time of construction and some part of it can be circumvented through the acquisition of adequate information for decision making based on drone reconnaissance. Active overviews of the construction site help in optimizing the process and address problems before they cause delays.

Several mining companies have already started implementing drone-based solutions in mines using imaging systems mounted on the drones to collect primarily photogrammetry data for general survey, stockpile management, and excavation assessment because it allows for quicker and more accurate volume calculations and greater efficiency, leading to increased profits. Drones can collect multiple sets of data over large areas of the mine and the data can be analyzed to assist the mining and monitoring teams for facility management, construction management, mine safety management, excavation stability, thermal and spectral mapping, and mine operation analysis (Biljecki et al, 2015).

Drones with unique sensor technologies can also provide instant inspection of mining areas to provide necessary governance and compliance information and can also help in the identification of hazards in the mining area. Tata Steel has used drones in the Noamundi Iron Ore Mine to help stop illegal mining, monitor the compliance with the mining plan, production, dispatch, and royalty payment (Satija et al, 2017).

2.1. Drone applications in surface mining

Surface mines have been using drones for tracking excavation progress and for volume calculations of excavations and stockpiles, which can be used to develop guidelines for mine planning and safety (Figure 2). A drone equipped with a hyperspectral frame camera was employed to monitor the safety of a surface mining operation. Equipment tracking and maintenance at times of breakdown has also resulted in better management of the mining equipment and the restoration of the equipment to production mode.

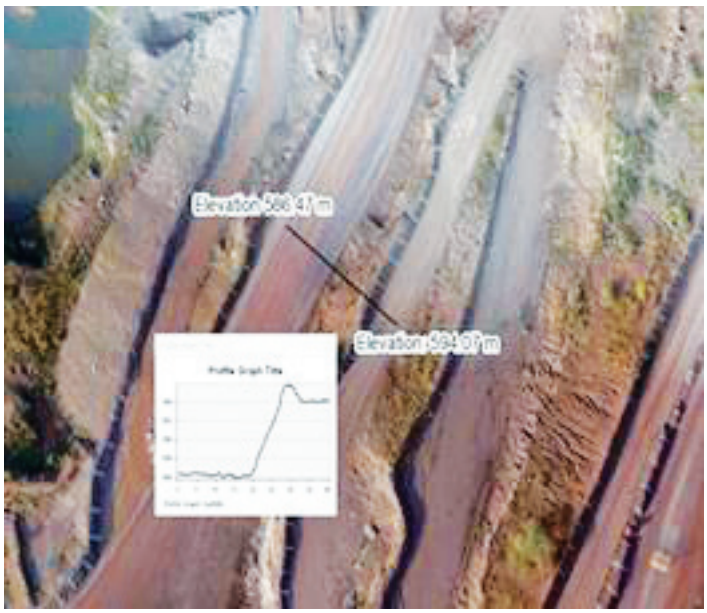

Figure 3: Drone photograph of slope between two benches in Noamundi Iron Ore Mine (Satija et al, 2017)

The monitoring of the stability of critical stopes through videography and remote data collection helps in the optimization of slope angles in the pit, which is critical for reducing production costs, increasing mining efficiency, and recycling resources (Sibanda et al, 2021). The use of special sensors has also provided data on ground stability and for water management, which are critical to the safe operation of the open pit. The mapping of discontinuities for the assessment of slope and dump stability can be accomplished using terrestrial LiDAR technology.

Drones equipped with thermal sensors are being used to monitor changes in the geographical and temporal distribution of surface moisture content in iron mine tailings (Sayab et al, 2018). Analysis of the correlation between moisture content and stability of mine tailings facilities, can be beneficial in the management of mine tailings. Mine mapping, stockpile mapping, optimized blast design, reconciliation and time lapse photography, high resolution photography, and identification of cracks in mine faces/hanging walls are all applications where drone technology is particularly helpful (Le at al, 2020).

2.2. Drones in underground mining

Underground mining poses a different set of challenges to mine operations and the data required for continued safe and productive operations often includes assessment of the stability of underground excavations and monitoring of air quality in remote locations. The long and often circuitous tunnels leading to the working areas as well as the production areas themselves need to be monitored to ensure safety before personnel are deployed for work in the area.

The deployment of drones in underground mines is also difficult due to restricted space, decreased visibility, increased dust, turbulence in the air currents, and the absence of reliable wireless communication systems (Green, 2013, Nieto et al, 2015). In addition, gassy coal mines restrict the use of powered equipment unless they are certified to be flameproof. These restrictions limit the usage of drones for data collection in underground mines. The navigation of drones using sensors which evaluate their position with respect to obstacles is an advantage in many cases (Figure 3), though this often limits the range of operation of the drones (Shahmoradi et al, 2020, Annavarapu and Chakravarty, 2016).

In spite of the above limitations, drones have been used for the inspection of large underground stopes where physical entry is not possible. Drones have also been used to assess the quality of the work atmosphere before the start of work in the production areas and to evaluate the conditions in a hazardous area before the entry of mining personnel. The processing and analysis of images captured from drones at the draw points can be used for assessing fragment size distributions after blasting in underground mines (Zhang et al, 2021, Afzal et al, 2020).

Figure 4 Autonomous Quadrotor drone flight in coal mine (after Annavarapu and Chakravarty, 2016)

As a result of their small size and dexterity, drones are able to access difficult-to-reach locations in underground mines, such as open stopes and ore passes, without putting personnel at risk (Rathore, 2015). In some mines, where a void has opened up above a working area, tele-operated drones could be navigated into the void and complete image of the void can be generated using a LiDAR scanner mounted on the drone. Repeated scans can reveal the sources of instability in the void and help assess the remedial measures to be taken for continued safety of mine operations. In operating open stopes, the results of blasting and the areas of movement in the stope walls can be assessed to help improve fragmentation and reduce dilution from the stope walls. The images from the drones can also be used to estimate the fragment size distribution within the stope and, with the right sensors, the possible grade of the material within the stope (Afzal et al, 2020)

Robotic vehicles integrated with drone automation have been designed for use during the monitoring of inaccessible regions and as part of rescue and recovery efforts (Jones et al, 2019). The detection of hazardous gasses, mapping and photography of freshly mined areas, and the evaluation of ground stability can also be undertaken using drones (Mochammad et al, 2016). Tunnel mapping using LiDAR sensors provides significant information about the stability of the tunnels (Tkáč and Mesároš, 2019, Ozaslan et al, 2017). With the advancements in sensor technology, drones now have the capability of mapping the orientation of geologic formations, constructing Discrete Fracture Network (DFN) models, and combining observations of seepage to build a hydrogeological flow model, which are useful for underground mining inspections and evaluations (Rogers et al, 2010)

3. Sensors used in drones for mining

Different types of sensors are available for the collection of required information in the mining industry. A combination

of sensors can be mounted on the drones to collect data with a timestamp and with a geo-spatial tag so that the data collected can be overlaid for better understanding and analysis. Integration of the collected data with mine planning data can also help review actual mining progress and deviations from the mining plan, if any. The selection of sensors will depend on the type of information required and the selection of the appropriate drone will be based on the area to be covered and the weight and power requirement of the sensors.

3.1. Infrared light (IR)

Infrared Sensors (IR), sometimes known as heat sensors, are low-cost obstacle detector sensors that can detect the energy radiation emitted by objects in the near infrared spectrum. In general, all materials above absolute zero that are exposed to the infrared spectrum release waves. Despite their low resolution, infrared sensors are capable of detecting persons with ease. It also has the benefit of being able to detect through fog, smoke, and all hours of the day and night. The pictures captured by the sensor, however, may be distorted by flames and other high-temperature sources and do not function efficiently in highly dusty environments.

3.2. Ultrasonic sensors

Ultrasonic Sensors (US) are also low-cost sensors that can be used in a variety of applications, primarily related to the detection of obstacles and boundaries. These are the only common sensors in drone technology that are not dependent on electromagnetic waves (EM). Instead, they identify obstacles by emitting high-frequency sound waves and collecting reflected waves from the surrounding environment. Calculating the time-of-flight allows us to measure the distance between the obstacles and the aircraft. One downside is that, as compared to other sensors, they have a limited operating range (Suherman et al, 2020).

3.3. Red-Green-Blue (RGB) sensors

In surveying and mapping, road traffic monitoring, stockpile volume computation, security monitoring, and other applications, an RGB camera is often used to capture images. Depth assessment is performed with the help of two active stereo images or time-of-flight sensors. The selection of the RGB camera must be done with care, taking into consideration the drone's energy consumption. In typical circumstances, a tiny camera is ideal for fixed-wing drones since they are unable to transport large or heavy objects (Svensgaard et al, 2021)

3.4. Stereo cameras

The stereo camera, which is analogous to the human visual system, is fitted with two or more lenses that allow it to produce high-resolution 3D pictures. It is capable of producing three-dimensional pictures with great precision in a clean environment by using distinct image sensors. Due to the distortion of the light waves, stereo cameras perform poorly in foggy or smoky environments.

3.5. Laser range finders

Obstacle detection in drones is accomplished with the use of Laser Range Finders (LRFs), which are expensive sensors. In the LRF, a laser beam is directed towards an obstacle and the distance to the item is measured by receiving the reflected wave and taking the duration of flight into account. Because LRFs employ optical wavelengths, they are not appropriate for usage in the presence of fog, smoke, or dust.

3.6. LiDAR sensors

LiDAR sensors work by sending out pulses of laser light and measuring the time taken for these pulses to return after bouncing off the ground and the intensity of the return pulse. This enables a very precise direct measurement of the distance from the sensor to the ground.

3.7. Ultra-wideband radar (UWB)

Ultra-Wideband (UWB) radar detects barriers in the radio spectrum by producing electromagnetic waves in that range. Target distance is calculated in the same way as in the US and LRFs by computing the reflected wave and time-of-flight. Radio waves have a larger wavelength than visible light and infrared light, allowing them to penetrate deeper than visible light in dust, smoke, fog, and other unfavorable environmental circumstances (Svensgaard et al, 2021).

UWB radar is particularly well suited for use in mines because it is more accurate and has a greater picture resolution than ultrasonic sensors when used in hostile environments. In addition, UWB consumes very little energy (less than 1 watt) which saves a significant amount of drone battery power. The low spectral density of UWB causes the least amount of interference with other wireless applications such as flight controllers and telemetry links. UWB is also capable of detecting objects with a variety of properties such as edges and corners and can also determine the three-dimensional coordinates of an item closest to the user.

3.8. Hyperspectral Imaging

Several broad wavelength bands separated by spectral segments are detected by the majority of multispectral imagers, such as Landsat, SPOT, and AVHRR, which detect the reflectance of Earth's surface material. Hyperspectral Imaging (HSI) sensors, on the other hand, are small and lightweight devices which analyze the reflected radiation as a succession of narrow and continuous wavelength bands.

Hyperspectral sensors typically monitor these bands at intervals of 10 to 20 nanometers and provide information that may otherwise be inaccessible using conventional techniques. These sensors are frequently employed in geology, mineral mapping, and exploration.

3.9. Aero-magnetic sensors

Accurate measurements of the magnetic field are obtained through magnetic sensors which evaluate disturbances and changes in the magnetic field, including flux, intensity, and direction of the field. The weight of a Cesium magnetometer is about 0.82 kg in its natural state. The calculation of three-dimensional magnetic field gradients necessitates the use of four magnetometers, which weigh a total of 3.28 kg when assembled. These sensors are often used in mineral prospecting (Calou and Munschy, 2020).

3.10. Visible and Near-Infrared Light (VNIR)

A wavelength in the visible and near-infrared (VNIR) section of the electromagnetic spectrum is between 400 and 1400 nanometers, and it is divided into two groups. From the visible to infrared end of the spectrum to the water absorption band at wavelengths between 1400 and 1500 nm, this range includes the whole visible spectrum as well as an adjacent portion of the infrared spectrum. The surface wetness of open pits, tailing dams, subterranean areas walls, and surfaces may be measured using VNIR sensors, which are often deployed on drones because of their compact size and low weight. Furthermore, each particulate mineral has a distinct signal in the VNIR spectrum, which is a benefit when mineral discovery is carried out by drones equipped with a VNIR sensor.

3.11. Air Quality Sensors

Sensors for monitoring air quality may be mounted on a drone to carry out specific jobs, such as air quality assessment, gas detection or dust monitoring. Optical-based air quality sensors, ultrasonic air quality sensors, and electrochemical air quality sensors are the most often used in environmental monitoring. These sensors may be mounted on a drone based on the type of monitoring, the time required for release, and the measurement specifications.

4. Conclusions

Technological innovations and implementations in mines are imperative to improve safety and productivity and drone-based solutions for data gathering and visualizations. The advances in sensor and drone technology can be used to great advantage to cover large distances in the mines and collect multiple types of data with geotags efficiently. While there are still some environmental issues which may restrict the use of drones in all situations, the ability of the drones to present large volumes of data for analysis and assessment will enable technical personnel to be deployed to areas of criticality in the mines expeditiously. As the use of drone technology grows in the mining industry, sensors can be developed for collecting data relevant to the mining industry. The development of appropriate navigational systems for use in the surface and underground mines, where GPS signals may not be available, is another area where research efforts can be directed to enhance the ability of the drones to be used in dusty, humid and confined areas.

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NMDC CSR ACTIVITIES

CMD MESSAGE

"From empowering women to upskilling youth, generating employment opportunities to addressing public health, NMDC has been a steady pillar in enabling progress in the hinterlands of India. We have witnessed the transformational impact education and awareness can bring in uplifting communities and commit to continue taking CSR initiatives that create value for people's lives."

Sumit Deb
CMD, NMDC

OVERVIEW

NMDC's social capital is built on decades invested in community engagement, building of infrastructure in education and health, and contributions to essential development needs of our host communities. Our social objectives are aimed at improving the quality of life of people around our mining operations and their socio-economic environment. The CSR expenditure of NMDC has steadily grown from Rs. 86 crore in 2011-12 to Rs. 200 crore in 2019-20, considerably above the statutory 2%.

The social initiatives of NMDC have led the way to development because they emerge from a sense of duty and compassion. Our Unique Stakeholder Consultation mechanism has been lauded by the Department of Public Enterprises, Government of India and recommended for emulation by other Public Sector Enterprises. The company considers inclusive growth as a means to achieve corporate growth and sustainability. To keep our CSR policies updated and in alignment with the nation building goals, the NMDC Management proactively conducts periodical review of its social initiatives.

KEY FOCUS AREAS

EDUCATION

Education has been a key focus area of our CSR programmes. NMDC has constructed Residential Schools for tribal children including for those specially-abled. The company awards scholarships to socio-economically disadvantaged students for pursuing higher education. NMDC also operates Polytechnic College and Industrial Training Institutes to impart technical knowledge in remote regions of the country. CSR initiatives in the field of education are -

1. ***Balika Shiksha Yojana***

   Our flagship CSR initiative *Balika Shiksha Yojana* completed a decade of service in 2021, contributing to the journey of over 400 tribal girl students becoming healthcare professionals of the country. Under the scheme, we support the education of 40 girl students at Apollo Institute of Nursing, Hyderabad every year.

2. ***Residential School at Nagarnar, Bastar***

   To create a conducive learning environment for the local tribal children, NMDC has established a Residential School at Nagarnar in 2010-11. In 2021, the strength of the school was 600 students in Class I to XII. Impact can be gauged from the fact that many of the students are first generation school goers.

3. ***Shiksha Sahayog Yojana***

   A scholarship scheme for tribals and SC students of Chhattisgarh and Karnataka. The objective of the

scheme is to help students pursue higher education. 18000 scholarships have been distributed under the scheme till 2021.

4. ***Support to Mid Day Meal Programme***

   NMDC has been providing financial support to the mid day meal scheme to ensure nutritious and wholesome meals for the students. The scheme covers 8000 students in the schools of Karnataka.

5. ***Education City***

   The Education City runs educational facilities ranging from primary school to professional institutes in a single campus. NMDC supports this initiative of the Government of Chhattisgarh to help children receive quality education. The initiatives supported by NMDC include:

   a. Astha Gurukul - A residential school for children affected by naxalite violence in the region and underprivileged communities is operated by NMDC

   b. Saksham - A residential school for children with special needs

   c. Polytechnic College - To provide technical education to the youth

6. ***ITI at Bhansi and Nagarnar, Chhattisgarh***

   NMDC has two Industrial Training Institutes at Bhansi and Nagarnar to equip students with technical skills. ITI Bhansi is rated as the best Industrial Training Institute in Chhattisgarh by CRISIL.

7. Education and Sports City in Bijapur was built by NMDC

8. *Choo lo Asman* helps students prepare for competitive exams and provides coaching for national and state medical and engineering entrance tests.

9. *Ujjar 100* provides financial assistance to tribal students for pursuing higher education.

10. *Lakshya Yojana* provides short term special coaching to youth for writing job-oriented competitive exams in State and Central Governments/ PSUs.

HEALTHCARE

NMDC provides free medical treatment, annually benefitting around 10,000 in-patients and 1,00,000 out-patients, at its hospitals located near the mines, organizes routine medical camps and takes primary healthcare facilities to the most remote regions through its mobile hospitals. With its campaigns on Menstrual Hygiene and Cleanliness Drives, NMDC has become a champion in health management. Details of CSR initiatives in the field of healthcare are,

1. ***Hospital on Wheels***

   This initiative benefits about 40,000 villagers with free medicare facilities at their doorsteps through state-of-the-art mobile medical vans. In Karnataka and Chhattisgarh, NMDC has partnered with State authorities for operation of Mobile Medical Units to provide basic healthcare facilities to people.

2. ***Menstrual Health Management (MHM)***

   In partnership with the District Administration of Dantewada, *Mehraar Cho Maan* aims at promoting hygiene during menstruation and the usage of sanitary napkins. The initiative has reached out to 23000 women in Chhattisgarh.

3. ***Cleanliness Campaign***

   Campaigns were run to bring behavioral change and awareness on personal hygiene and safe sanitation in the villages of Dantewada, Chhattisgarh. The program has facilitated the construction of 1850 household toilets, with 100% household toilet coverage in one village making it an Open Defecation Free (ODF) village.

4. ***Swachh Vidyalaya*** - 2089 toilets were constructed in schools in Bastar, Chhattisgarh and Panna, Madhya Pradesh.

5. NMDC has partnered with the Government of Chhattisgarh for installation of solar power-based electrification facilities in health centers and is providing solar maternity and mother care kits in health centers of Bastar, Chhattisgarh.

6. NMDC is extending financial support to reduce the prevalence of malnutrition and anemia among children, adolescent girls and women of reproductive age group in Bastar, Chhattisgarh.

INFRASTRUCTURE DEVELOPMENT

Infrastructure building in remote regions and interior locations of the country to provide better connectivity and facilitate overall development has been a long standing goal of NMDC. The company has constructed all weather roads, bridges/culverts, community centers, hospitals and also an Education City in some of the remotest regions of the country. Some major infrastructural initiatives include,

1. 123 km of WBM roads laid in villages around NMDC Projects
2. Construction of a high level bridge over Dankini River in Dantewada
3. *Gaurav Path* (4 way lane) in Dantewada, Kirandul and Bacheli
4. Construction of Jagdalpur Bypass
5. Construction of Community Centers in Bastar
6. Solar electrification works in the villages of Bastar

SAFE DRINKING WATER

Regular initiatives are being taken to provide clean and safe drinking water in the villages around Projects. NMDC also ensures that adequate infrastructure is created to ensure people have access to clean water. NMDC has partnered with the Government of Chhattisgarh to provide solar power based drinking water facilities for far off places. It is supporting the Group Water Supply Scheme to provide clean drinking water to the villages in Dantewada, Chhattisgarh. Other initiatives include,

1. Installation of hand pumps, borewells and digging of open wells, ponds around Projects
2. Providing piped drinking water supply to villages around Panna, Madhya Pradesh

SKILL DEVELOPMENT

NMDC contributes to the National Skill Mission by rolling out Skill Development programmes for the tribal youth. We provide training to local youth in trades of the Mining and Steel sector. We conduct training programmes in Bell Metal, Bamboo and Tumba Art, which are traditional skills of the tribal community. Some sustainable income generation and skill development initiatives of NMDC are as follows,

1. Industrial Training Institutes and Polytechnic Colleges impart technical education to the youth of Bastar in the trades that have a high Employability Rate
2. Training tribal youth in skills relating to operation of equipment, dialysis, blood bank, ECG EEG, and ward technician, for them to join the healthcare sector
3. *Kaamdhenu Project* - Promotes dairy farming in Dantewada and provides local community members with the necessary training
4. Livelihood generation training in Bamboo, Bell Metal, Wood, Jute and Tumba Art is provided to tribal youth and women of Bastar, Chhattisgarh

AWARDS

NMDC was conferred with the prestigious S&P Global Platts Global Metals Awards consecutively in 2018 and 2019 in the CSR Category for the emancipation of local communities. NMDC is the first Indian Company to win an award in this category. For our CSR initiatives, we have recently won -

- ASSOCHAM National CSR Awards 2020 for Women Empowerment
- Indian Chamber of Commerce (ICC) Social Impact Awards 2020 for Healthcare
- Best Practices in CSR Awards 2020 from Institute of Public Enterprises (IPE) for Education Development in Remote Tribal Areas
- Governance Now PSU Awards for the Best PSU (Navratna) Implementing CSR in 2021

(Continued from Page 14)

cross-border payments. But at least three vessels carrying coal set sail to India from Russian ports after Russia launched its invasion of Ukraine on Feb. 24, according to Refinitiv vessel tracking data and an industry source.

"Indian buyers are still getting coal from Russia into the market here, but are starting to find it increasingly difficult because banks are not willing to open letters of credit," the industry source said. "Bankable long-term customers are being handed over coal on a trust basis, while relatively new customers aren't able to procure coal because of financing issues," the source said.

V R Sharma, the managing director of Jindal Steel and Power Ltd (JSPL), said importing from Russia would be difficult unless there is a "rupee-rouble" trade. India is exploring ways to set up a rupee payment mechanism with Russia to soften the blow on New Delhi of Western sanctions imposed on Russia. "If rupee-rouble trade is approved, then we can get coal at affordable and cheaper prices from Russia," Sharma told Reuters. JSPL is among the importers from Russia in March, along with Tata Steel, Kalyani Steels and JSW Steel. JSW declined to comment, while Kalyani and Tata Steel did not respond to Reuters requests seeking comment.

A trader at Sibuglemet, one of Russia's major exporters, said the firm and his competitors are continuing to supply coal to India, but said "some issues are appearing." "Tomorrow, if they were to put strict controls on payments, then trade would be organised through buyers in other countries," he said.

Reuters | March 10, 2022

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MINERALOGICAL CHARACTERISTICS RELATED TO CHIGARGUNTA GOLD DEPOSIT IN THE SOUTHERN PART OF KOLAR SCHIST BELT

G H Kotnise*

Abstract

The Chigargunta gold deposit is located in the southern part of Kolar Schist Belt (KSB) about 30 km south of Kolar Gold Field in the Archean Greenstone belt of younger age between 2.7 to 2.3 Ga in Eastern Dharwar Craton. The gold found mineralized in quartz vein and dispersed in altered metamorphic rocks in distinict amphibolites schist belt and in peninsular gneiss. The mineralogical changes attribute to the movement of ore-forming fluids of magmatic origin along shears/fractures. Fifty micro-thin sections of various litho units studied from the study area indicate that the differential stress and effect of metamorphism has resulted in the change in mineralogical characteristics related to alteration/transformation of minerals, growth of minerals, crystallization process, variation in structure and texture. The study also indicate hornblende schist as the predominent rock unit metamorphosed to lower amphibolite facies with the true metasomatic derivtive in mineral assemblage such as biotite-plagioclase-quartz granulite with an increase in the percentage of quartz and feldspar. This paper aimed to identify the geochemical control like mineralogical chanracters/metasomatic changes related to magmatic origin of auriferrous desposits which help in estimating the potential gold bearing zones. The satellite images also shows wide spread biotitic and calcite-sericitic alteration zones of hydrothermal origin along shears and fractures.

***Key words**: Archean green stone belts, epigenetic gold mineralization, Kolar Schist Belt, Metasomatic derivative,*

1.0 Introduction

In India the economic gold deposits are mainly confined to the Achaean greenstone belt, East Dharwar Craton. The dwindling of rich gold reserves at Kolar Gold Fields (earlier yielded 800 tons of gold) warranted the Geological Survey of India (GSI) to search for gold in the southern part of Kolar Schist Belt in early 1980. After two sessions of field work GSI identified potential gold deposit at Bisanatham – Chigargunta belt. Subsequently, Mineral Exploration Corporation Ltd. (MECL) carried out underground exploratory development. Bharat Gold Mines Limited undertaken commercial gold mining operations for over two decades and latter suspended from March 2001.

In Chigargunta gold mineralization is of epigenetic origin found dispersed in quartz veins hosted by altered metamorphic rocks in distinct amphibolite schist and peninsular gneiss, which have undergone remarkable changes in mineral assemblages due to metamorphism. Such alteration zones are identified by satellite images along shears/ faults which are considered as probable channels for gold mineralization. Therefore, study of mineralogical variation help in finding the metamorphic origin of gold and the magnitude of the gold deposits.

Geological Setting

The study area is located in southern part of KSB from Chigargunta, Chittoor District, Andhra Pradesh to Maharajagadai, Krishnagiri district, Tamil Nadu trending N-S (lat: $12^0$42’30” to $12^0$44’00” and long: 78^0 14’30” to 78^0 15’ 00”) (Fig.1). The linear southern stretch of Kolar Schist Belt splits into two at Mallappagonda forming narrow synformal strips one on the east and the other towards the west, both limbs separated by gneisses and granites over an average width of 6.0 to 7.0 km (Suthanadam et al., 1987). Chigargunta is located amidst a large stretch of gneissic rocks of granodiorite to the tonalitic peninsular gneiss.

The major lithology units comprises of metamorphosed basic lava, acid lavas, tuffs, banded iron formation (BIF), graphite-sulphide schist, and polymictic conglomerate (Narayanaswami et al., 1960). These are classified into three basic lithology units based on the order of abundance viz. (i) mafic schist (ii) felsic rocks (champion gneiss) and (iii) BIF and graphite-sulphide schist (Roy, 2015). The dominant rock type is komatiitic/tholeiitic volcanic that are transformed into amphibolites (Chardon et al., 2002). In Chigargunta Champion genesis (felsic unit) and hornblende schist (mafic units) constitutes the major rock types. This part of schist belt is subjected to folding and refolding forming small rafters in the schist belts.

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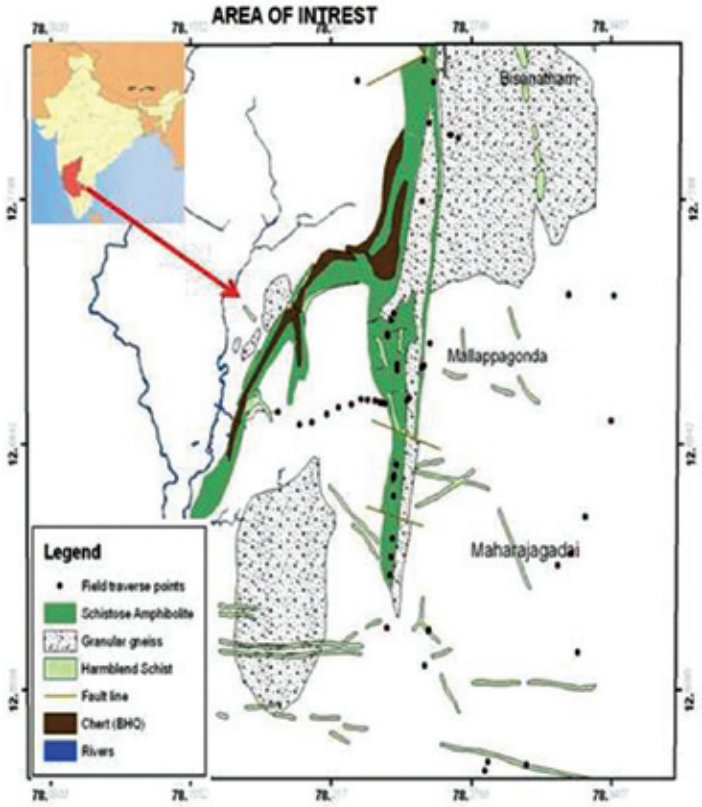

Fig. 1 Geology map of southern part of Kolar Schist belt

Methodology

Studies were made to identify mineralogical and structural characteristics especially the effect of metamorphism, metasomatism on the associated host rocks in relation to gold mineralization. This study comprises of (i) micro thin sections of various host rock units and (ii) alteration zones and (iii) structural controls shears/faults in relation to gold mineralization using LANDSAT images.

Fifty micro thin sections of rocks were prepared from the representative samples collected from the field from both mafic and felsic units, quartz veins, BIF, sericite, intrusive like dolerite dyke and pegmatite were studied to find the mineralogical alterations/transformation due to true metasomatic changes under metamorphic conditions. The associated structure and texture, growth of minerals are identified which attribute to differential stress. The micro rock thin sections were studied in the Indian Bureau of Mines (IBM), Bangalore under Olympus Optical Microscope.

The LANDAST images of study area processed at Seismotectonic lab, National Institute of Rock Mechanics, Bangalore. By visual analysis of images compared with known spectral properties of rocks and identified the alteration zones like sercitization and biotization, structural deformation like fracture/shears zones considered as potential channels for gold mineralization.

Metamorphism

The field observation indicate that metamorphism proceeded more rapidly on the flanks of the schists at the central and north-south ridge composed of less altered basalt due to thermal metamorphism rather than dynamic changes. There is no uniformity in increase in metamorphic effects, however the differential stress seems to be the dominant factor in inducing changes in the rocks as they are converted to schistose structure by retaining their primary basaltic, gabbroidal or amygdaloidal /porphyritic structures. In almost all cases the rocks have passed through this stage and converted into the schistose type and are classified as 'hornblende schist'. At this stage metasomatic changes superseded metamorphic transformations.

The rocks have undergone different grades of metamorphism spreading along the KSB from North to South. In the field identified six different types of schist may well be classified; the types of rocks each is very distinctive, but tend to grade into each other.

Out of six types, first four are truly metamorphic, first three are mainly due to thermal metamorphism

Fig.2 a. Meta basic fine grained Hornblende schist

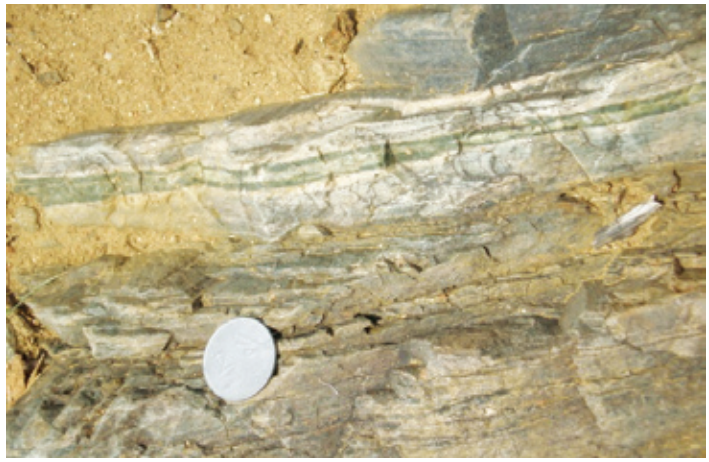

Fig.2 b. Quartz- hornblende banded hornblende near Bisanatham

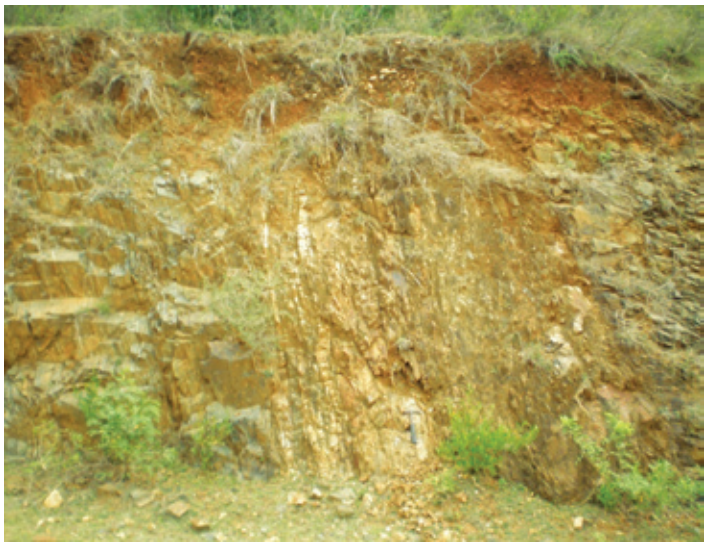

Fig.2 c. Quartz-calcite stringers in amphibolite exposed at Adakonda road cutting

(a) Uralite Basalt
(b) Uralite Diabase
(c) Porphyritic types

and the fourth may be derived from the foregoing by dynamic metamorphism dominent - Hornblende schist. The remaining two types may be considered to have developed by metasomatic changes in the schists viz. Hornblende granulite-acidification effect and Amphibolites – basification effects.

The host rock associated with gold mineralization comprises of high-grade amphibolites (Fig 2.a), banded amphibole -quartzite (Fig.2b), magnetite –quartzite and silicified quartz-calcite stringers in amphibolite (Fig.2c). The felsic units such as quartzo-felspathic geniss which is generally referred to as champion gneiss, metabasalt migmatite granite. The main minerals assemblages observed under the microscope are Diopside – hornblende – plagioclase; Hornblende – plagioclase; Garnet – hornblende – plagioclase – biotite – muscovite; Grunerite – pyrrhotite – quartz – (Garnet); K-plagioclase – microcline – quartz – biotite – muscovite and Actinolite – albite – epidote – chlorite – biotite – muscovite.

The location of samples collected, main minerals present and texture observed are given in Table-1.

Metasomatic Changes

Hornblend schist

Hornblendic schist is formed of an older rock. It is the primary rock and it is the main source for supply of minerals for many new mineral assemblages by alterations. Amphibolites of the hornblende schist series may have been formed by basification of normal hornblende schist due to interaction with solutions rich in iron, magnesia and calcium which was released during the process of granitization. Biotite is completely absent in the hornblende schist series, however, potassium is type of β biotite. This development of biotite from hornblende recalls the normal reaction of Bowen's reaction series developed in the cooling of a truly igneous rocks.

According to Nickolds the metsomatic exchange involved in the formation of biotite from honrnblede following addition of Al_2O_3+H_2O+Alkalis-K_2O since NaO_2 already present in the Hornblende (-) SiO_2 CaO + MgO by the silicates of Mg, Fe. as true metasomatics.

Goldschmid classified these changes under 'Alkali Metasomatism' that is binding alkalies biotite-plagioclase-quartz granulite as during this process the percentage of quartz and feldspar increses. As peak metamorphism pleagiocalse consuming hornblende observed at drainage at Adagonda (Fig.3).

The micro thin section of amphibole rock from Chigargunta shows small prisms and granules of hornblende, with sharp outlines magnetite in a base of granular plagioclase. This is attributed to prismatic and radiating crystals of actinolite forming interlocking network; some interstitial zoisite-epidote instead of more usual chlorite (Fig. 7-B). Actinolite is non-aluminous character of the amphibole found in the diabrochitic types of load rocks forming 'amphibole schist'. Actinolite by the metamsomatic changes altered to biotite.

The effect of dynamic metamorphism which has obliterated igneous structure (Fig. 7-A). The load rock sample from Chigargunta shows silicon, aluminum, etc. with high energy level the rocks get transform into granited in various forms within the peninsular gneiss.

Thus peninsular gneiss developed in more magmatic and intrusive phase resulting in changes leading from hornblende schist to hornblende granulite with an increase in plagioclase and quartz at the expense of

Fig.3 Mineralogical changes as the plagioclase consuming hornblende during peak metamorphism at Adakonda drainage.

Table-1: Major litho units

Location	Rock type/texture	Main minerals
Chigargunta	Amphibolite/ Idiomorphic	Pl, Hlb, Qtrz, Mn
Naralapalli	Amphibolite/Granoblalstic	Pl, Qtz, Hlb, Ilm,
Shiva temple/Athinatham	Hornblende schist/fine grained	Pl, Hlb, Qrtz.,
Sankarsanahalli	Peninsular Gneisses	Pl, Qtz, KF, Hlb, Bt,Opa
Maharahagadai	Granodiorite/porphyritic	Pl(Olg), Hlb, Qtz, Bt
Plutonic body in west	Quartz-Monzonite/granular	Pl, Amp, Bi, Qtz, Opa
East of Bisanatham	Granotoid Xenoliths	Pl, Qtz, Amp, Bt, Opa
Varathanampalli	Diorite/Granular	Pl, Amp, Cpx, Opa,
Kotamannganapalli	Leuco Granite/porphyry	Pl, KF, Qtz, Bi, OPa
Adakonda strip	Quartz vein/ porphyry	Pl, Qtz,
Kotmaganapalli	Chlorite-sericite schist	Pl, Sr, Qtz, Ms
Ganacharpur	Graphite-quartz schist	Qrtz, Gr, Py
Onnapanayankottur	Dolerite dyke/hypidomorphic	Cpx, Bt
Kondgarapalli	Pegmatite/	Pl, KF, Qrtz, Tur

Granitization –Peninsular Gneiss

In Dharwar Super Group the peninsular gneiss is considered to have been formed by the granitization. However, the fact is that the hornblendic schist best-resisted to amonanitization. The transformation of the hornblendic schist into gneissic granite by emanations of elements such as soda, potassium hornblende. As a result the schistosity of the parent rock is completely lost. On the western side beyond quartzites, an ultra-basic type of schist develops within the migmatitic facies of the peninsular gneiss is prominent, it seems ultrabasic types is of diabrochitic in origin. The peninsular gneiss attained its most development in areas formerly occupied by pellitic or semi-pellitic sediments was responsive and readily granitized due to migmatisation.

The presence of remanants of hornblende schist or geneiss show the ease with which the basic rocks have undergone basification and or desilicification as varied type of supercrustal rocks subjected to granitization processes. These rocks have experienced by syn-migmatitic dextral shear bands (Harish Kumar, 2002).

In Sangarsanahalli area the peninsular geneiss (Fig. 4-a) micro thin section under microscope shows large prisms of hornblende lying with their long axes all parallel. The hornblende is ideoblastic against feldspar which occus as large crystals. The centre of some of these are highly clouded (Fig. 7-C). The mineral assembleges are quartz + plagioclase + K-feldspar hornblende + biotite. Zircon and sphene are the important accessoried besides epidote. The composition of the minerals is 40% to 50% quartz, 20% to 30% plagioclase (Oligoclase), 5% to 10% remaining accessory minerals.

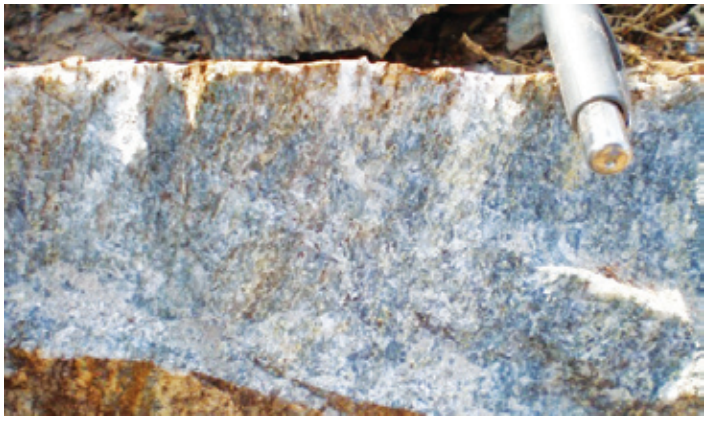

Fig. 4a. Peninsular gneiss -location Sangarsanahalli

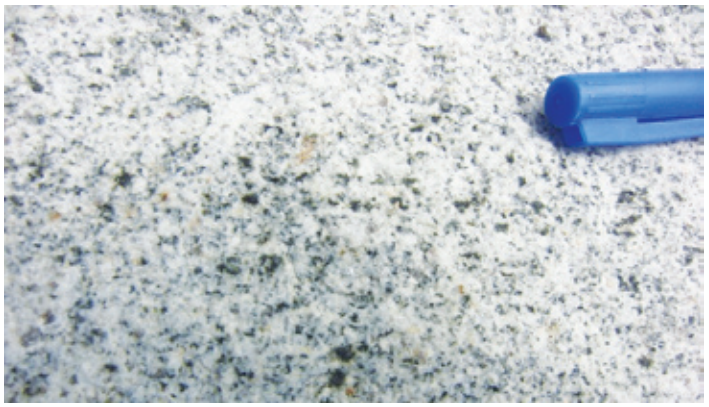

Fig. 4b. Hornblende bearing Granodiorite Maharajagadai

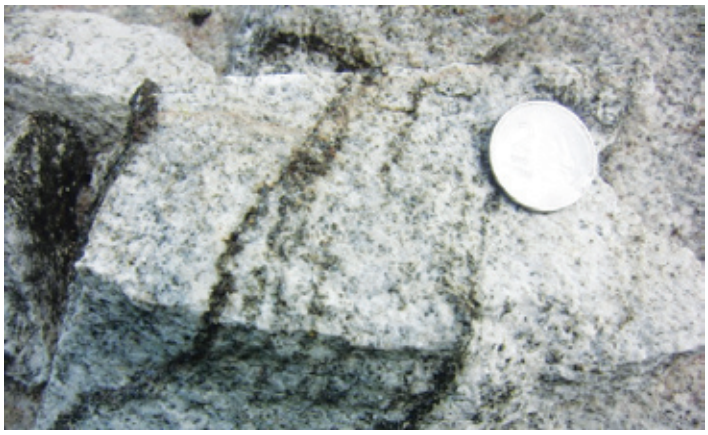

Fig. 4c. Banded granitic gneiss-location quarry at Vappanampalli

The micro thin section of granodiorite sample (Fig. 4-b) from Maharajagadai shows large phynocrysts of microcline at the junction of the basic enclaves. The phynocrysts slightly altered in the enclaves as biotite has formed at the expense of the hornblende but rugged hornblende may also found in the granitic base (Fig. 7-D). The banded granitic gneiss exposed in a quarry located at Vappanampalli show alternate banding of rich leucocratic quartz, felspar, biotite and melanocratic hornblende (Fig. 4 -c).

Hydrothermal alterations

Rock alteration means the change in mineralogy of rocks. The earlier minerals present are either grow or replaced by new minerals due to change in temperature, fluid chemistry or gas content. They are often associated with and indicative of the presence of mineral deposits (McLaughlin, 1933).

Following hydrothermal alteration, the basic rocks have undergone propylitization or the formation of cholorite and epidote, particularly from the ferromagnesian minerals. The other alteration types associated with gold deposits are sericitization, ferric oxide (gossans), volcanogenic massive sulphides, silicification, carbonization, and ammonization (Kotnise, 2015).

Chlorite-Sericitic Alteration

In this the new mineral sericite is formed due to replacement of feldspar by metasomatic action. Among the metavolcanic schist, the Chlorite-sericite schist is considered as the most important rock type which hosts the auriferous quartz lode including sulphide minerals. Chlorite-Sericite schist occurs at Kotmaganapalli about 2.0 km north of Chigargunta. The width of the exposure band varies from 2.0 m to 3.5 m along the stream. The weathered surface of the rock is brown in colour and often Sericite typically formed due to alteration of feldspar (by replacement) and sericitic implies low p^H (acidic) conditions. The potash feldspar is well oriented in chlorite schist with an appreciable amount of calcite. The quartz grains of different sizes exhibit granulations.The chlorite mineral is filled with black carbonaceous material and occurs as shapeless with biotite and sericite as secondary minerals. The rock occurs as a band representing the sheared zone of the meta-andesite in the western auriferous zone.The rock is well-developed with schistosity and dipping 50^0 to 60^0 East as very fine-grained, golden brown, soft with greasy feel, mica, and calcite present in white colour (Fig. 5).

Sericite forms from a potash feldspar by the action of hyroxyl with the removal of K_2O, SiO_2, or by carbonated water with the removal of K_2CO_3 and SiO_2. But sericite may also formed by the replacement of Na or Ca by K in a plagioclase feldspar and Goldschmit noted that “sericitization of plagioclase involving the addition of potassium is found in the vicinity of many gold-quartz veins”. The sericite in thin section show invariably associated with the presence of tourmaline (Fig. 7-E)

Fig. 5. Chlorite-Sericite schist exposed at Kotmaganapalli about 2 km south of Chigargunta.

Biotitic alteration

Generally vein deposits form along the fractures and faults as open space filling or replacements. The core area contains “potassic” alteration in the form of potassium feldspar and biotite. Biotite is developed by metasomatic changes of actinolite in the primary hornblende in the vicinity of the quartz vein is perhaps the most common change of all those which transform the hornblende schists into lode rocks. The potassium must have been supplied along with the other material which formed the vein quartz. The potassium does not form more than 0.35% in these rocks. The development of biotite from hornblende recalls the normal reaction series of Bowen’s cooling history of igneous rocks. The alteration amounts to the addition of Al_2O_3 with water and alkalies – K_2O since Na_2O already present in the hornblende and subtraction of SiO_2, CaO and MgO. Goldsmith classified this as ‘Alkali Metasomatism’ as it is the binding of alkali by the silicates of Mg and Fe. The propylitic alteration turns rocks to green colour, because the new minerals formed are green. These minerals include chlorite, actinolite and epidote.

The alteration zones are well reflected in the multispectral images on different band width. On visual analysis of ASTER 4-3-2 band indicates goethite (gossan) in variations of reddish brown, granitic rocks in pink (more feldspar), biotite-chlorite in light blue and black-BIF (western margin) (Fig. 6).

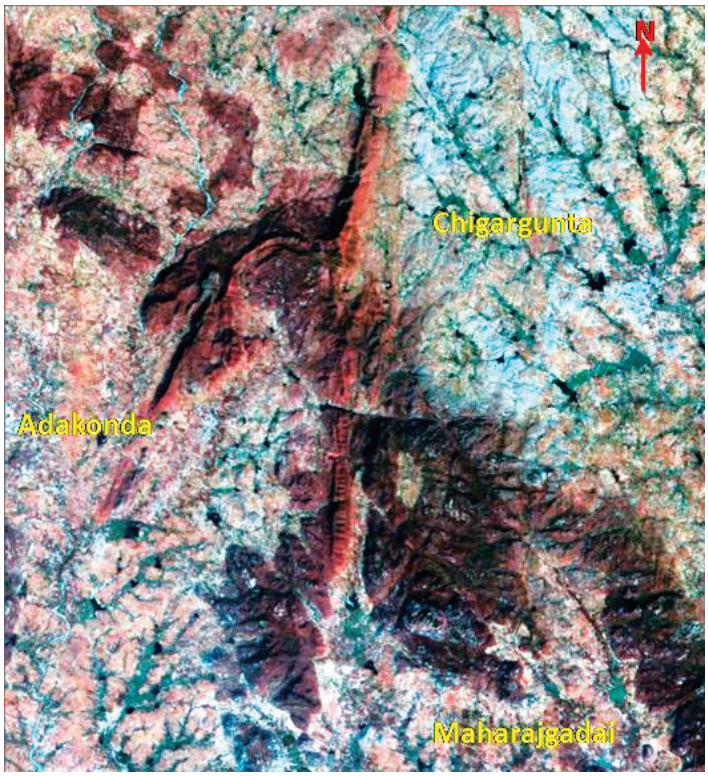

Fig.6. LAND SAT image with ASTER band combination 4-3-2(RGB).

Gold Mineralization

This southern part of the Kolar schist belt shows typical Archean hydrothermal lode gold mineralization (Ridley et al, 1990) and generally found near to the contact of the metabasalt (amphibolite) with felsic volcanic, metasediments of the champion gneiss. In epigenetic gold occurrence good amount of fluid (H_2O-CO_2 rich) is derived during shear deformation and regional scale retrograde metamorphism of high grade rocks under greenschist-amphibolite facies conditions (Srikantappa, 2001). Gold is confined to quartz vein and its distribution study suggests that it was introduced after the deformation which resulted in fissure filling of fracture/shears in the quartz vein (Fig. 8) (Kotnise, 2021). Eventually, gold is transported by pressure sensitive

Au-corbonyl complex circulated by hydrothermal solution bearing gold ions (Mishra et al., 1998) and mineralized in the quartz veins.

The wall rock in quartz vein is due to addition of K^+, H^+, and CO_2 to and removal of Fe, Ca, Na and SiO_2 from the host rock with the presence of biotite and ankerite along the foliation plane of the host rock confirms the possibility of fluid flow and deposition of metals in the vein system in the favourable channels at shearing/fracture (Krishnamurthi et. al., 2005). Microphotograph of quartz vein section observed under crossed Nicole shows coarse quartz grains breaking down along undulating fractures approximately parallel to 'C' axis perpendicular to this axis, the coarser quartz is shearing along rupture (Mylotonized).

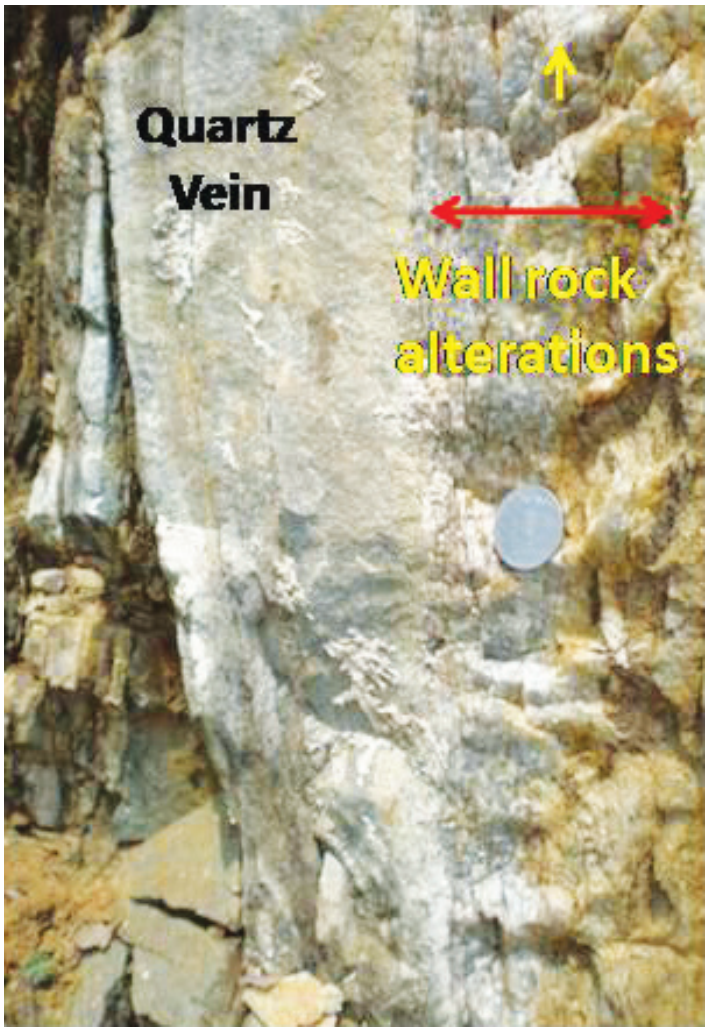

Fig. 8 The wall rock alteration with calcite in smoky quartz reef- fissure filling in Adakonda – Chigargunta

Results & Discussions

Fifty micro thin sections of different litho units have been prepared for studies. The highlights of the study are given in the Table-2.

The study area of the KSB had been subjected to metamorphism of different grades which are reflected in the mineral assemblages. Successive changes taken place indicate the chronological alteration displayed by different assemblages. Especially the sequence indicates

Mineral abbreviations: Pl – plagioclase. Qtz – quartz, Kf –potassium feldspar, Bt – biotite, Hlb-hornblende, Amp- amphibolite, Hm – Hematite, Apt – Apatite, Ep – Epidote, Ms – muscovite, Cls – Chlorite, Sr – Sericite, Bt - Biotite

A. *Fine grained amphibolite-small prism and granules of hornblende showing sharp outlines with little magnetite in a base of granular plagioclase. The arrangements and distribution of the hornblende controls schistocity. Dynamic metamorphism has obliterated igneous structures.* **B.** *Prismatic and radiating crystals of actinolite forming interlocking network; some interstitial zoisite-epidote instead of chlorite. Biotite is formed by metasomatic changes of actinolite.* **C.** *Microphotograph of peninsular gneiss from Sangarsanahalli under CN 10x. Dark green hornblende enclosing a prism of apatite and dark brown biotite with some epidote. All set in a base of orthoclase feldspar which is altering to sericite.* **D.** *Micro section under CN 10x, Granodiorite from Maharajagadai show large phenocryst of microcline at the junction of the basic enclave. The phenocryst slightly altered and in the enclave, biotite has formed at the expense of the hornblende in the granitic base.* **E.** *Kotmaganapalli - Sericite and muscovite were found in significant quantity. Sericite has resulted from the alteration of plagioclase feldspar and grown into idioblastic crystals often mutually interfering. F. Microphotograph of quartz section with coarse quartz grains breaking down along undulating fractures approximately parallel to 'C' axis perpendicular to this axis, the coarser quartz is shearing due to induced stress (Mylotonized) CN 10x.*

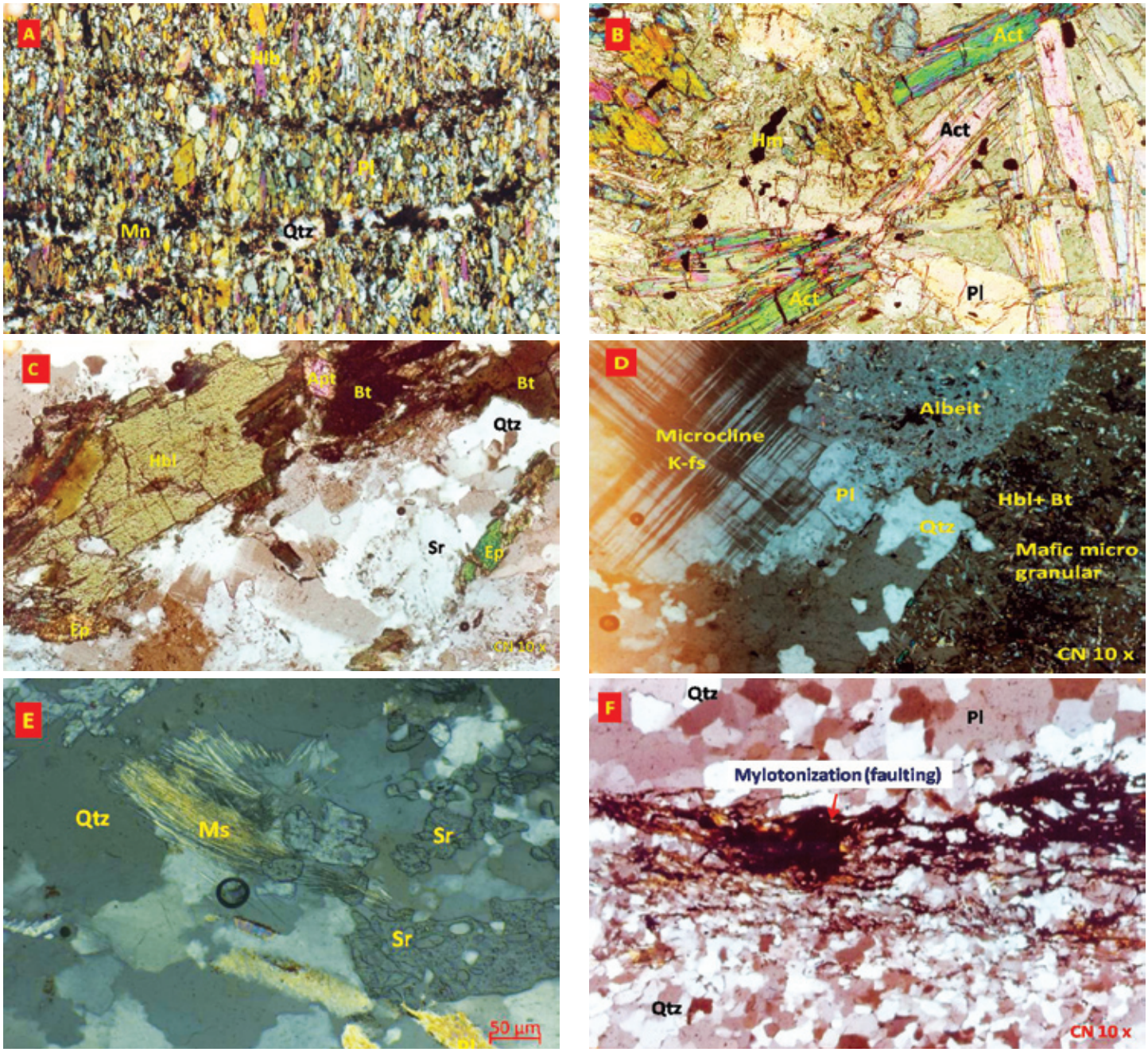

Fig. 7 Micro thin section Study

Table-2.0 Mineralogical Characters

Sl. No.	Rock Micro - thin section	Optical observation	Variation	Inference
01	Hornblende Schist Chigargunta (Fig. 6-A)	Small prisms and granules of hornblende	Granular arrangement of hornblende and plagioclase showing sharp outline	Hornblende controls schistosity- dynamic metamorphism has obliterated igneous structure
02	Load rock Chigargunta (Fig.6-B)	Prismatic and radiating crystals of actinolite interlocking network	Non-aluminous character of amphibole found in the diabrochitic type load rock	Actinolite by metasomatism altered to biotite suggest late catalcastic action
03	Quartz vein Anagonda area (Fig.6-F)	Quartz vein under differential stress	Quartz grains breaking down along undulating fractures parallel to 'C' axis shearing and ruptures	Diagnositc of cataclastic and and mylotonized due to differential stress.
04	Amphibolites	Saussuritized Plagioclase phenocryst in uralite basalt	Original idiomorphic feldspar seen clouded with development of epidote	Original Plagioclase lathes remain unchanged but later altering to amphibloite
05	Hornblende schist	Small prisms and granules of Hlb	Hlb controls the schistosity	Dynamic metamorphism has obliterated igneous structure
06	Hornblende schist	Hlb & Pl in equal quantities of equal grain size	Growth of feldspar has erased schistose structure, biotite formed	Indicating introduction of potassium
07	Peninsular gneiss	Myrmokite in later granite forming part of peninsular gneiss	Intergrowth of plagioclase and vermicular quartz replacing potash feldspar	Found at the paulopost stage of consolidation or later period of plutonic activity
08	Peninsular gneiss	Spessarite garnet, hornblende/actinolite	Enclosed in large plate of ophitic quartz.	Formed from Dharwar schists with different primary composition
09	Quartz vein	Fine grained flaking of the interstitial chlorite	Fragmentary nature of much of the actinolite	Strong suggestion of late cataclastic action, though no fault is visible

the way the mineralogical transformation in alteration zones superimposed on green schist facies to form lower amphibolite facies assemblages. It will be appreciated that the textural relationship remains consistent indicating the alteration history (Mukerjee et al., 1985).

There are so many varieties of hornblende exist in the KSB, however, the most recognizable is the formation of amphibole chiefly derived from uralitization of pyroxene. Hornblende granulite and amphibolite are formed because of metasomatic changes. Undoubtedly, true metasomatic derivatives of the hornblende schist might have been classified as "Biotite- Plagioclase- quartz granulite". The non-aluminous character of amphibole found in the diabrochitic type of lode-rocks signifies amphibolite schist of the Dharwar Series, which is very prominent. Similarly, the metasomatic changes in actinolite (non-aluminous amphibole) have resulted in biotite.

It would appear that the quartz had been crushed due to deformation. This crushing of the quartz controlled introduction of tourmaline, apatite, gold silver, galena, pyrite, chalcopyrite and scheelite. These minerals have two common characteristics; they have formed after the vein quartz, but they are found only in the quartz vein and load rock thus act as indicator for gold mineralization.

The study also reveals that the primary quartz formed as coarse grain latter due to induced stress has broken down this primary quartz into a fine grained type. In the quartz micro section the quartz grains seen subjected to differential stress as a result the quartz causing undulating fracture showing mylotonitic feature (Fig .7-F). The folded quartz veins in the host rock suggest that the auriferous quartz veins were present before the major tectonic event.

The gold mined at Chigargunta (Fig. 9) is of epigenetic origin found in super crustal rocks of metamorphic origin. The rock types and structural features since closely resemble that in central KSB located just 30km north at Kolar Gold Field. Hence there is ample scope of finding potential gold deposit in Bisanatham-Chigargunta belt.

Fig. 9. Shaft located in the Southern part of Kolar Schist Belt at Chigargunta.

Conclusion

The Precambrian gold deposit located in southern part of Kolar Schist Belt at Chigargunta, confines to epigenetic in origin distributed in the altered metamorphic rocks. The micro thin sections study of the various lithological units in Chiagargunta area indicate that the mineral assemblages with biotite (secondary), calcite, epidote are the resultant of the metasomatic alterations/transformation related to metamorphic events associated with gold mineralization. Hence, these mineralogical characters signify gold deposits particularly of metamorphic origin. The fractures and regional faults are found responsible in controlling the emplacement of the gold deposit as the prominent hydrothermal alteration zones identified surrounding the fractures/ openings that are considered as conduits for gold occurrences.

It is relevant to mention that as the lithological units and structural characters found almost similar in southern part of the KSB and in the Central KSB at Kolar Gold Field (KGF) the gold mineralization might have took place in the same period. As central KSB hosted an excellent gold deposit that yielded about 800 tons of gold and both located just 30km apart it is optimistic to suggest that occurrence of such rich ore-shoot in the Chigargunta area is possible to be identified by adopting recent exploration techniques.

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NOMINATIONS FOR MEAI AWARDS 2022

The Mining Engineers' Association of India presents awards sponsored by the Industry/individuals during Annual General Meeting in June -July every year. Nominations for the following Awards are invited in the prescribed form, so as to reach the Secretary General by **15th of April 2022**. Nomination can be made by one member for one award only.

1. **MEAI - Sitaram Rungta Memorial Award** for the best paper on Mining related issues during the year 2021.
2. **MEAI NMDC Award** for significant contribution to Iron Ore Industry during the year 2021.
3. **MEAI Simminds Award** for significant contribution to limestone industry during the year 2021.
4. **MEAI Smt. Bala Tandon Memorial Award** in recognition of contribution to Mining Industry for improving ecology, environment and a forestation during the year 2021.
5. **MEAI Abheraj Baldota Memorial Gold Medal Award** (Mining Engineer of the year 2021) in recognition of significant contribution to Mining Industry by a Mining Engineer with 20 years of experience in the Industry.
6. **MEAI Abheraj Baldota Memorial Gold Medal Award** (Young Mining Engineer of the years 2021) in recognition of significant service to Mining Industry by an Young Mining Engineer who has not completed 35 years of age as on 2020.
7. **MEAI-SRG Informational Technology Award** for the year 2021, In recognition of significant contribution to Mining Industry adopting Information Technology during the year 2021.
8. **MEAI-Smt. Gullapalli Saraladevi Memorial Award** (Lifetime Achievement by a Mining Engineer) during the year 2021.
9. **MEAI Master Tanay Chadha Memorial Geologist Award** for the year 2021 in recognition of significant contribution by a geologist in the field of Mineral Exploration, quality control and production, mine planning etc. during the year.
10. **MEAI- Smt Veena Roonwal Memorial Award** for the year 2021 to a Mining Engineer/Geologist/a qualified person involved with Mining Industry with 10 years' experience for presenting a paper during the year in a seminar/ symposium workshop organized by MEAI on "Water Management in and around a working mine" or "Implementation of New/Latest Technology in Mining and allied subjects.
11. **MEAI- Smt Kiran Devi Singhal Memorial Award** for the year 2021 only to a person (MEAI Member/Non member- need not necessarily be from mining discipline) for his/her contribution in the field of "Development and Conversation of Minerals and Environment" in and around Metalliferous mines (excluding Coal and oil) during the year 2021.
12. **MEAI Award to a best paper in Mining Journal** Published in the Mining Engineers' Journal in the year 2021.
13. **MEAI-SCCL Coal Award** for the year 2021 to a Mining Engineer, a Geologist, a Mechanical Engineer and a Foreman/Over man for meritorious contribution to the Coal Industry.

For detailed guide lines please visit website **www.meai.org**
or memorandum of association and rules and regulations (as on 01.03.2018)

Applications and Guide Lines

Application must be supported by at least two council members and must reach MEAI NHQ in Prescribed Format at Hyderabad before **15th April 2022**.

Application shall be sent in soft copy in PDF format by email with the subject written as "MEAI Awards 2022" to **meai1957@gmail.com**.

MEAI NEWS

MEAI PROFESSIONAL DEVELOPMENT PROGRAM

The maiden **MPDP COURSE** that was the vision of MEAI President, Sri K. Madhusudhana, was successfully concluded on 20th March 2022. The president was ably supported by the Training, Development & Program Committee of MEAI comprising seven experts from Mineral Industry headed by the Committee Chairman Sri Deepak Vidyarthi, a fellow member of MEAI.

The first course of its kind launched by MEAI was carried out with a lot of zeal and vigor for 6.5 days during the month of March 2022 on three consecutive weekends running from 09:00 am to 05:00 pm. The course, held on line on WebEx platform, was designed for mid-level professionals and was well executed by industry experts with qualification backed by practical experience!

Altogether 35 participants from 10 reputed mining organizations were the lucky participants as 15 faculty members shared their invaluable knowledge through various case studies and group tasks, covering 20 most relevant subjects during 26 sessions.

Subjects dealt included Blast Design, Mine Safety Management System, Mine Costing, Mine Design & Planning, Mineral Resources & Reserves Classification & Reporting, Mineral Auction, Remote sensing and GIS in Mineral Exploration by overseas experts, Geostatistics in Mining, Mineral laws, Mining Plan, FMCP, EC, FC, Innovative technologies in Opencast mining, Environmental clearance etc. etc.

An additional attraction for RCPs who attend the MPDP course would be that they get a Credit of 40 points!!!

It would be worth mentioning that the president himself evinced such a keen interest that he presented one of the topics for a full session on Forest Clearances! Presentations made by various faculties were duly lauded by the participants who endorsed by excellent feedback as it was an outstanding platform for knowledge-sharing!

The course began on 4th March 2022 with a formal Welcome address by the Committee Chairman followed by traditional lighting of the lamp (of course, it was e-lighting) by the Chief Guest Sri Dilip Kumar Mohanty, Director (Production) NMDC and Sri K. Madhusudhana, President, MEAI.

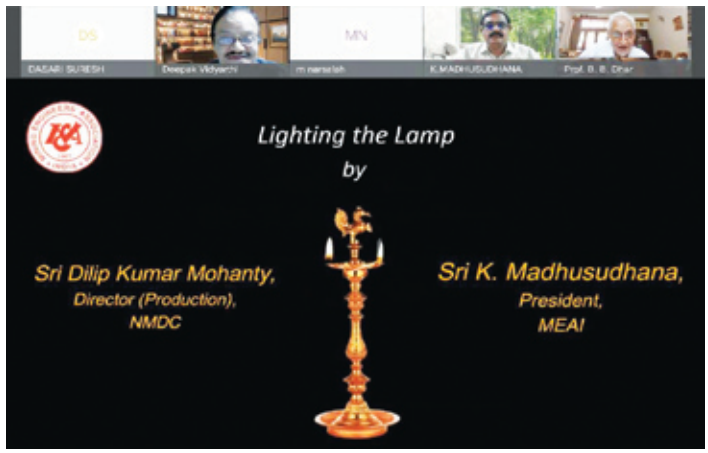
The course concluded on 20th March 2022 with an Assessment of the participants that was mandatory, followed by a well-organized Valedictory function on-line! Sri Sabyasachi Mohanty, Director (Technical) OMC graced the occasion as the Chief Guest.

The Valedictory function began with a warm Welcome by the Committee Chairman Sri Deepak Vidyarthi, followed by observations made by Prof BB Dhar, Prof BC Sarkar IIT (ISM), Sri Pankaj Satija, MD, Tata Steel Mining, followed by the feedback from participants Sri MK Devarajan, Head of Exploration, GEOVALE services pvt. Ltd, Sri Ashok V Rao, Independent Consultant, and Sri Chirag Munet, Tata Steel Mining.

An exhilarating speech followed by the Chief Guest, appreciating the entire course and hoping that such courses be continued on-line as well as off line and assuring full support from his company, OMC. The Presidential remarks then followed by an invigorating address by Sri K. Madhusudhana who promised to take the program further, extending to off line courses depending on the prevailing circumstances.

The program concluded with a Vote of Thanks proposed by Sri T.R. Rajasekhar, Consultant Mine Planning who acknowledged everybody's contribution in making MPDP a grand success!

Welcome To MEAI Professional Development



Lighting of Lamp by Chief Guest and President, MEAI

Special thanks to Mr. Deepak Gupta for arranging the course through WebEx and word of appreciation for Sri Tejeswaran, MSPL for the excellent coordination & support.

Welcome address by Sri Deepak Vidyarthi, Chairman, Training, Development & Program Committee, MEAI

Address by Chief Guest Sri Sabyasachi Mohanty DT (Opn) OMC

Presidential Address by Sri K. Madhusudhana, President, Mining Engineers' Association of India

Assessment of Participants

MINING ENGINEERS' ASSOCIATION OF INDIA

CERTIFICATE OF PARTICIPATION

MEAI PROFESSIONAL DEVELOPMENT PROGRAM (MPDP)

This is to certify that Mr .....
of.....(*chapter / organization*)
has participated and successfully completed the **MPDP** Course conducted online by the Mining Engineers' Association of India on 04th, 05th, 11th, 12th, 18th , 19th & 20th March, 2022.

Certificate of Participation

BELGAUM CHAPTER

A BRIEF REPORT ON WORLD WATER DAY CELEBRATION

The World Water Day with a theme on "**Groundwater making the invisible visible**" was commemorated on 22nd March 2022 to raise awareness about the importance of water and educate people to conserve it. This was organised by the Centre for Natural Disaster Management and Skill Development in association with the MEAI-Belgaum Chapter, Karnataka State Pollution Control Board, MNRA College of Education, Belagavi and Geological Society of India Regional Center, Belagavi.

Dr. B. Venkatesh, Head, National Institute of Hydrology, Belagavi was the Chief Guest. Speaking on the occasion Dr. Venkatesh expressed his concern over the declining groundwater table and related issues leading to water quality deterioration. Dr. Nirmala Battal, Principal of the College of Education, who was Guest of Honor, explained the social and environmental problems connected with water. She also stressed the need for water conservation and management in the context of urbanization and industrialization. Dr. B K Purandara, President and Emeritus Scientist & Chairman of Belgaum Chapter, presided over the function. In his address, he enlightened the youth to cultivate the habit of using water judiciously and to conserve the water for future generations. Mr. Miles Schelling, student researcher, University of Rhodes Island, USA, explained the role of River Bank Filtration techniques in the removal of microbial organisms, He was successful in removing microbial organisms to an extent of 99% purity using RBF methods. He also explained the methodology he adopted at Nersa village of Khanapur. Shri DS Malkai, retd. Sr.Geologist and past President of Belgaum chapter talked about the occurrence of springs in different parts of Belagavi city and stressed the need for conservation of springs. Dr. Pramod Hanamgond, Head, Dept of Geology, GSS College & Chairman of Geological Society of India briefed about the World Water Day, importance of water and the water conservation needs.

At the outset, a video was released on Suvarna Vapi – Sun's ponds on the inventory of springs in more than thousand spots of Western Ghats starting from Satara (Maharashtra) to Belagavi district of Karnataka. The theme was conceived by Dr. Purandara Bekal that headed the team. Shri Arjun Goudelar and Dr. Vidya Arjun were the key persons behind the video presentation. Shri S R Hegde, retd. Senior Geologist and past President of Belgaum Chapter released the video. Shri. S R Hegde explained the hydrological significance of springs and reasons for their destruction in the recent years.

Dr. Godappa Patil coordinated the program and conveyed the vote of thanks to everyone. Shri Sagar Waghmare, Treasurer of the Chapter conducted the program. Dr. Varadarajan, NIH, Belagavi, Prof. Chidanand Patil, KLECET, Belagavi and over 50 students and a few staff members of MNRA College of Education were present.

Audience at the World Water Day programme

Dr P T Hanamgond, briefing about the World Water Day

Mr Miles Schelling, US Student researcher presenting his research

OBITUARY

Shri Nand Lal Bansal
(LM- 1803 / Rajasthan Chapter-Udaipur)

Rajasthan Chapter-Udaipur regret to inform the sad demise of Shri Nand Lal Bansal, who left for his heavenly abode on 4th March, 2022 at Pune.

He obtained his degree in Mining Engineering from MBM Engineering College, Jodhpur in 1966. After graduation, he obtained a management diploma from Chandigarh University. He was a regular participant in the activities of Udaipur Chapter.

He joined Bikaner Gypsum Ltd. and worked in the Gypsum Division for nearly 13 years. Later he joined Jhamarkotra Rock phosphate Mines of RSMML and worked in mines contracts, mine planning and operations departments. He retired as GGM from the Material Management Department of the Co. He was a very sincere and honest person and had thorough knowledge of the subject. His simplicity, integrity and dedication to work will be an inspiration for all and will be well remembered.

The members of MEAI express their heartfelt condolences and profound sympathies to the bereaved family of Shri Nand Lal Bansal and pray for his soul to rest in peace.

OBITUARY

Shri S. K. Agnihotri
LM-464, Himalayan Chapter
(17.07.1943 – 18.02.2022)

Shri. S K. Agnihotri was a native of Una, Himachal -Pradesh. He served in the Himachal Pradesh Govt. as a geologist. After retirement, he served as Consultant to the Grasim Industries Ltd of Aditya Birla Group.

The members of MEAI express their heartfelt condolences to the bereaved family members. May his soul rest in peace and the family be given strength to bear this irreparable loss.

3RD TRAINING PROGRAM ON IMIC BY NACRI

Mining Engineers' Association of India (MEAI) rolled out the registration of Competent Person (RCP) under Indian Mineral Industry Code (IMIC). MEAI is a Professional Organisation (PO) in India, recognised by National Committee for Reporting Mineral Resources and Reserves in India (NACRI), with the obligation to offer professional development programs to its members, register CPs and oversee the ethical behaviour of RCPs. NACRI is the National Reporting Organisation (NRO) recognised by the Committee for Mineral Reserves International Reporting Standards (CRIRSCO).

The previous two training programs on IMIC were successfully held by NACRI in January 2021 and April 2021 with around 25 participants in each program, representing the mining companies, consulting companies and individuals. All the participants, barring a few, have successfully completed the training program.

Prerequisites for registration of CP

RCP has been defined under Clause #9 of IMIC 2019 as follows:

RCP is a mineral industry professional who is a member of a professional organisation headquartered in India and approved by NACRI or a member of a 'Recognised Professional Organisation' (RPO), as included in a list of similar bodies headquartered outside India available on the NACRI website. These organisations have enforceable disciplinary processes including the powers to suspend or expel a member. An RCP must have a minimum of ten years professional experience, which includes five years relevant experience in the style of mineralisation or type of deposit under consideration, and in the activity which that person is undertaking.

In addition to the above minimum professional experience required by PO members for registration as RCP, the NACRI, vide Article 2.2.ii, further specifies that the potential RCP shall obtain at least 40 hours of professional development credits every year through participation in seminars, conferences, workshops, training programs or webinars, recognised by it.

Accordingly, those eligible mineral industry professionals in India interested in registering as Competent Person under IMIC should be a Life Member of MEAI, attained at least 10 years of professional experience and acquired 40 hours of professional development credits recognised by NACRI, at the time of making application to MEAI.

RCP certification shall be valid for a period of one year from the date of issue of the certificate and renewed annually thereafter. The annual CP registration fee has been fixed at Rs 5,000 (Rupees five thousand only + GST @18%) and payable to MEAI.

Professional Development Program on IMIC

The fee for this mandatory IMIC training program, to register as CP under IMIC, may be paid online. The fee chargeable for the 40-hour training program is Rs. 10,000 (Rupees ten thousand only that includes applicable GST @18%) and payable to:

Account Name: MEAI-National Core Committee Fund
Bank Name & Address: UCO Bank, Abid circle, Hyderabad
S/B Account No: 14410110037089
IFSC: UCBA0001441

NACRI has formulated a 40-hour IMIC online training program, which every prospective RCP must undergo before applying for RCP certificate. This IMIC training course includes basic knowledge sharing on all aspects of IMIC and mineral industry best practices; and general guidance to the prospective RCP. The programs contents include:

- Introduction to MEAI/ NACRI Charter/ IMIC/ Code of Ethics
- Competence and Responsibility
- Reporting of Exploration Results
- Reporting of Mineral Reserves
- Technical studies
- Table 1 and QA/QC
- Scope of IMIC
- Reporting Terminology
- Reporting of Mineral Resources
- Reporting of Coal Exploration Results, Resources and Reserves
- Other topics including CRIRSCO 2019
- Industry best practices

Every RCP should attend an 8-hour mandatory refresher program on IMIC prior to making an application for renewal of RCP. The RCPs may acquire additional professional development credits by attending NACRI accredited seminars/ workshops/ conferences/ training programs/ webinars. The MEAI headquarters shall maintain the records of each trainee/ RCP and provide the same to the MEAI RCP Registration committee.

Professional development program schedule

The NACRI Core group shall conduct the 40-hour online IMIC training program in four weeks with the topics scheduled thrice a week, and each session not exceeding 3 hours at a stretch. The NACRI Core Group will be responsible for conducting the training program under the guidance of Mr T.R. Rajasekar and Dr A. Srikant. **The 3rd IMIC training program will be held from 18th April to 13th May 2022.**

Contact details

Interested mineral industry professionals may please contact the Secretary General, MEAI at meai1957@gmail.com / Phone no. 040-66339625/ 040-23200510 or Dr PV Rao, Co-Chair NACRI at drpvrao@gmail.com for more details on this training program.

Dr PV Rao, Co-Chair NACRI

MEJ RIDDLES

Dear Readers of MEJ,

In order to increase the readership of MEJ, which has been felt essential in the interest of our ardent members, the mineral industry professionals as well as the mining sector, the Editorial Board of MEJ has decided to hold a monthly QUIZ. The monthly QUIZ will designed and printed in MEJ based on the content published in the previous month's MEJ. The MEJ readers will be given five objective questions with multiple choices to choose; and expect them to respond with their correct answer by email to the Editor at editormejmeai@gmail.com by 20th of the current month. If more than three members responded with the correct answers, then the three winners will be decided by draw. Each winner will be issued a certificate of merit and a nominal cash prize of Rs 500.

Request the members to participate in the QUIZ in large numbers and benefit from the enhanced knowledge by reading the Journal from end to end.

Questions based on MEJ March 2022 issue

1. Which Chapter organized a webinar on "Safe usage of explosives & winning of minerals"?

(a) Barajamda (b) Bellary-Hospet
(c) Bangalore (d) Bhubaneswar

2. What is the limit of mean temperatures (degree centigrade) rise set by the 2015 Paris Climate agreement?

(a) 1 (b) 3
(c) 2 (d) 4

3. The name of MEAI Council Member that initiated the MoU, signed with BVVS Science College, Bagalkote on 28 January 2022?

(a) Dr SK Vashisth (b) Mr Anil Kumar Garg
(c) Mr MS Rachappa (d) Mr PC Bakliwal

4. Who organized MEAI Professional Development Programme online in March 2022?

(a) Bangalore Chapter (b) Rajasthan Chapter-Udaipur
(c) MEAI TDP Committee (d) Goa Chapter

5. Which was the largest single country committed investment for energy transition in 2021?

(a) USA (b) India
(c) China (d) European Union

WINNERS OF RIDDLES PUBLISHED IN THE MEJ MARCH 2022 ISSUE

Congratulations to proud winners:

Mr Satish Kumar Agrawal
Ex Mining Engineer, Laxmi Marble Granite Pvt. Ltd

Mr Gunjan Pande
Assistant Manager (Environment), GUJARAT MINERAL DEVELOPMENT CORPORATION Ltd.

Mr Satya Prakash Sahu
Asst. Manager (Min.), MCL Hq., Mob. No. 9064080116

To receive the cash prize of Rs 500, the winners are requested to please contact the Secretary General, MEAI by email at **meai1957@gmail.com** or Mob. 9177045204.

CONFERENCES, SEMINARS, WORKSHOPS ETC.

ABROAD

1-2 Apr 2022: **International Conference on Sustainable Water Management (ICSWM)**. Cebu City, Philippines. Website URL: http://conferencefora.org/Conference/30610/ICSWM/

15-16 Apr 2022: **International Conference on Mining Geology and Rock Excavation ICMGRE** in Cape Town, South Africa. Website URL: https://waset.org/mining-geology-and-rock-excavation-conference-in-april-2022-in-cape-town; Contact URL: https://waset.org

19-20 Apr 2022: **International Conference on Exploration and Mining Geology ICEMG**. Paris, France. Website URL: https://waset.org/exploration-and-mining-geology-conference-in-april-2022-in-paris

22-23 Apr 2022: **International Conference on Mining and Mineral Technologies ICMMT**. Tokyo, Japan. Website URL:https://waset.org/mining-and-mineral-technologies-conference-in-april-2022-in-tokyo; Contact URL: https://waset.org

3-4 May 2022: **International Conference on Mining Technologies and Sustainable Systems ICMTSS**. Rome, Italy. Website URL: https://waset.org/mining-technologies-and-sustainable-systems-conference-in-may-2022-in-rome; Contact URL: https://waset.org

4-5 May 2022: **Minesafe International Conference 2022 (#minesafe2022)**. Perth, Australia and online. Contact AusIMM. T: 1800 657 985 or +61 3 9658 6100 (if overseas)

11-12 May 2022: **Gold Plant of the Future Symposium**. Blue Mountains, Australia and online. Contact AusIMM. T: 1800 657 985 or +61 3 9658 6100 (if overseas)

20-21 May 2022: **International Conference on Recent Advances in Mining Technologies ICRAMT**. Berlin, Germany. Website URL: https://waset.org/recent-advances-in-mining-technologies-conference-in-may-2022-in-berlin; Contact URL: https://waset.org

24-25 May 2022: **International Conference on Mining and Mineral Processing ICMMP**. Montreal, Canada. Contact URL: https://waset.org. Website URL: https://waset.org/mining-and-mineral-processing-conference-in-may-2022-in-montreal

3-4 Jun 2022: **International Conference on Trends in Web Mining**, Information and Knowledge Extraction ICTWMIKE. Rome, Italy. Contact URL: https://waset.org. Website URL: https://waset.org/trends-in-web-mining-information-and-knowledge-extraction-conference-in-june-2022-in-rome

29-30 Jun 2022: **Mining World Congress**. London, United Kingdom. Website URL: https://miningconferences.org/; Program URL: https://miningconferences.org/agenda/; Contact URL: https://miningconferences.org/contact-us/; Contact E-mail: info@miningconferences.org

21-22 Jun 2022: **Open Pit Operators Conference 2022 (#openpit2022)**. Perth, Australia and Online. Contact AusIMM. T: 1800 657 985 or +61 3 9658 6100 (if overseas)

18-20 Jul 2022: **International Conference on Design Methods in Underground Mining ICDMUM**. Dubai, United Arab Emirates. Website URL: https://waset.org/design-methods-in-underground-mining-conference-in-july-2022-in-dubai; Contact URL: https://waset.org

19-20 Jul 2022: **International Conference on Land Reclamation in Mining Areas ICLRMA**. Copenhagen, Denmark. Website URL: https://waset.org/land-reclamation-in-mining-areas-conference-in-july-2022-in-copenhagen; Contact URL: https://waset.org

9-10 Aug 2022: **International Conference on Green Coal Mining Technologies and Techniques ICGCMTT**. New York, United States. Website URL: https://waset.org/green-coal-mining-technologies-and-techniques-conference-in-august-2022-in-new-york; Contact URL: https://waset.org

12-13 Aug 2022: **International Conference on Mining and Mineral Technologies ICMMT**. Venice, Italy. Contact URL: https://waset.org. Website URL: https://waset.org/mining-and-mineral-technologies-conference-in-august-2022-in-venice

21-23 Aug 2022: **IMPC Asia-Pacific 2022**. Melbourne, Australia and Online. Contact AusIMM. T: 1800 657 985 or +61 3 9658 6100 (if overseas)

14-15 Sep 2022: **Lithium Battery and Energy Metals Conference 2022**. Perth, Australia and Online. Contact AusIMM. T: 1800 657 985 or +61 3 9658 6100 (if overseas)

10-12 Oct 2022: **Australian Mine Ventilation Conference 2022**. Gold Coast, Australia and online. Contact AusIMM. T: 1800 657 985 or +61 3 9658 6100 (if overseas)

21-22 Oct 2022: **International Conference on Mineral Processing and Mining ICMPM**. London, United Kingdom. Website URL: https://waset.org/mineral-processing-and-mining-conference-in-october-2022-in-london; Contact URL: https://waset.org

18-19 Nov 2022: **International Conference on Underground Mining Methods and Applications (ICUMMA)**. Singapore. Website URL: https://waset.org/underground-mining-methods-and-applications-conference-in-november-2022-in-singapore. Program URL: https://waset.org/conferences-in-november-2022-in-singapore/program.

29 Nov - 1 Dec 2022: **AusRock Conference 2022**. Melbourne, Australia and Online. Contact AusIMM. T: 1800 657 985 or +61 3 9658 6100 (if overseas)

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TATA STEEL

#WeAlsoMakeTomorrow

TATA

#SteelFact

Globally, extensive

afforestation

programmes are converting mines into habitats for local wildlife

Source: World Steel Association

*Currently, an area of 563 hectares is covered via afforestation in our mining locations.

Data as on October 2021

We are ensuring that the natural ecosystem in our mining locations is preserved. We have progressively implemented Biodiversity Management Plans at all our raw material locations in order to ensure no net loss in biodiversity.
Sure, we make steel.
But #WeAlsoMakeTomorrow.

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