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Mining Engineers' Association of India
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this issue contains...

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President's Message.....

Economic and Health effects of the Covid-19 pandemic have been very significant. Individuals, households, small businesses, large Corporates and Government have all been impacted albeit in differing ways. However, the longer the pandemic - and the associated conditions therewith - persist, the greater the strain on the financial position of all the constituents of the economy.

The crisis - as with all such events - has shown us new opportunities as well. The digital revolution that was creeping on to us has now been speeded up manifold. Even Businesses such as Mining- unlikely beneficiaries of this revolution - have also learnt to adapt and use this technology to serve their customers. This represents a microcosm of India's entrepreneurial energy - from industrial equipment to capital goods - every industry is adapting to conserve resources, stay relevant and grow.

Friends, August 2021 marks the last month of my tenure as MEAI president. I would like to wholeheartedly thank each member for their contribution and help MEAI rise to new heights during this time with their sincere efforts. Although the tenure was mostly disrupted because of the pandemic, we learnt to cope up with the situation and instead learned the digital way of working. The National Council meetings and several knowledge enriching webinars were conducted digitally. This ensured the functioning of the Association smoothly.

The continuous engagement of the team led to acceptance of the much awaited CRIRSCO Framework for Reserves and Resources Reporting by the Government. The efforts of the International Affairs Committee helped to increase the visibility of MEAI overseas and in receiving approval of SME for RCP class of NACRI to be recognised as Competent Persons under the provision of SME Guide for Reporting Exploration Results, Mineral Resources and Mineral Reserves.

Imparting knowledge and training has been one of the prime objectives of MEAI. In this line, the training conducted by NACRI and MEAI has been applauded all over. The Training Development Committee had taken an excellent initiative in organising Certificate Programs with Arizona University for MEAI members and we are on the verge of signing an MOU with them.

With deep regret and sorrow, I mention that we lost our beloved Joint Secretary cum Treasurer, Mr. K.U. Rao and Office Assistant Ms Jyothi Spandana during the pandemic. Their passing away has created a void in our Association and we would always remember them with a deep sense of gratitude.

The much-awaited "Senior Citizens Welfare Scheme" was conceptualised and rolled out to support the part medical expenditure needs of our senior members, who have given distinguished service to the Association during their tenure.

The list of wonderful works done is endless and so is the contribution of the members. It gives me pleasure to inform the members that during last month, Delhi Chapter elected its new Chairman and I along with the MEAI fraternity wish the Chapter good luck in their endeavours. The Webinar on "Updates on Mineral Legislation in India" organised by Bangalore Chapter saw a wide participation by members. Also, the E-voting of MEAI National Council Elections for the term 2021-2023 concluded successfully.

Any Association would look up to the mentors and senior members for guidance, which is more so for an Association of our size and spread. I am indebted to our seniors and past presidents for their guidance and support and look forward to their continued guidance to my successor.

I also take this opportunity to urge all readers to continue to take guard against the pandemic.

Sanjay Kumar Pattnaik
President

Mining Engineers' Association of India

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EDITOR'S DESK

Dr. P.V. Rao
Editor, MEJ

Blockchain technology emerged as an important enabler in the application of SEG principles to achieve sustainable mining. It will have a massive impact in all areas of mining viz. from exploration and resources to the supply of metals to industrial and retail customers. In view of its impact on the mineral sector, it may be meaningful to appreciate how blockchain technology could transform the mining sector.

Blockchain technology can be a pivotal tool in sustainable mining supply chains due to its ability to track the financial, environmental, social and regulatory criteria of a project from the moment an operation begins to when an end user receives the product. It is an invaluable tool for identifying the provenance of a mineral and tracking its path from its source to its ultimate destination. It increases trust, security, transparency, and the traceability of data shared across a business network and delivers cost savings with new efficiencies.

Blockchain is a system of recording information in a way that makes it difficult or impossible to change, hack, or cheat the system. It is essentially a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain. Although the mechanics of blockchain are extremely complex, the basic idea is simple: to decentralize the storage of data so that such data cannot be owned, controlled or manipulated by a central actor. A change in data of any block changes its hash and to tamper the network, one has to change the information in the whole chain. Consequently, it becomes nearly impossible to break security.

This would improve transparency, clarifying the origin of minerals and tracking all the steps up to the final customer.

Blockchain technology could provide benefits to the mining sector by having a strong impact in engineering, construction and handover of mine sites, compliance and mining lease management, and supply chain. It can be used in making transactions traceable during the complex processes of managing regulations and standards, and ensuring trust and work compliance. It is useful in compliance and mining lease management, facilitating the workflow and visibility of documents, e.g. by improving the traceability of reserve estimation for stock exchange reporting. It can be applied to the supply chain, to track materials in particular, from the blocks of ore to the concentrate and metal. It helps streamline the entire process by cutting out all intermediaries and lengthy procedures, thereby the burden of unnecessary time delays.

This would improve transparency, clarifying the origin of minerals and tracking all the steps up to the final customer.

While blockchain application in mining may present various benefits, there are also limits to its use. Business processes can be transformed only if a number of conditions are met, such as the creation of a broad network of transactions and willingness of participants to provide true information on what and when and – by doing this – to stick to the digital database as the only source of trust. The inherent challenge of this system is how to ensure that the data uploaded is correct and reflects the truth. This challenge of how the off-chain and on-chain worlds can be linked is called the "oracle problem." Blockchain oracles can be trusted organizations that verify the validity of the information before it goes onto the blockchain. As a multi-party system, blockchain databases need to be managed by all participants in accordance with the common rules, and this raises issues about who should take the lead.

Mining companies that embraced the digital transition have recorded improvements in terms of safety, sustainability, productivity and profits. Blockchain is at the heart of the digital transition and has the potential to transform businesses and the whole of society, not only the mining sector. With its capacity to provide security and transparency in business transactions, as well as to record changes to documents and business agreements, blockchain technology has extremely useful applications in mining. Manufacturing companies like Apple are concerned about the source of minerals and have decided not to use minerals coming from conflict zones, from mining companies with underpaid labour and poor environmental standards.

Europe-led global certification scheme for raw materials is the first global certification scheme ensuring consistent standards of environmental, social and economic impact throughout the entire raw materials value chain. The certification process will be carried out using a private blockchain while its verification and search will be available on a public blockchain. Owing to their complex and encrypted, distributed nature, blockchains can be slow and cumbersome.

- Editor

NEWS FROM THE MINING WORLD

➢ CHART: Study predicts over 400% increase in copper, lithium, nickel battery demand

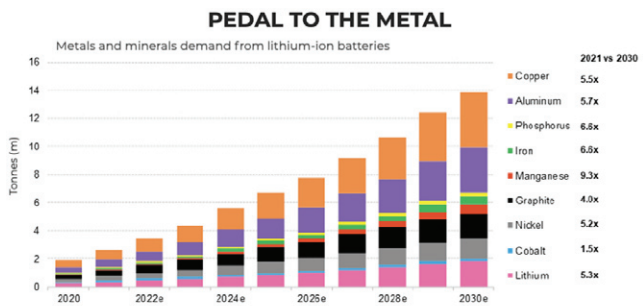
BloombergNEF has upped its predictions for annual demand for lithium-ion batteries by more than a third from its previous forecast on the back of expectations for rapid growth in the passenger vehicle segment.

BNEF predicts annual demand for lithium-ion batteries will pass 2.7 terawatt-hours per year by 2030 – a 35% increase from the analytics company's forecast made last year. Passenger vehicles will represent 72% of the overall market as sales race to 14 million by 2025 from just over 3 million last year.

BNEF expects China to extend its lead in the battery supply chain — particularly processing and refining. The country accounts for almost half of new lithium hydroxide projects coming online this year and has 55% of the world's nickel sulfate market and 80% of the global market for cobalt sulfate, according to the report.

The Asian nation also accounts for 95% of the world's manganese sulfate production and almost all of the graphite used in producing materials for anodes. Despite its dominance in the supply chain, the electric car market is expected to grow fastest in Europe with Germany expected to represent 40% of total sales by 2025 versus 25% for China.

"Diversifying the global supply chain would require significant investment from regions such as Europe and North America."



Source: BloombergNEF. Note: Metals demand occurs at mine mouth, one-year before battery demand. All metals expressed in metric tons of contained metal, except lithium, which is in lithium carbonate equivalent (LCE).

Chemistries

BNEF says automakers wary of rising raw materials costs could switch to lithium iron phosphate (LFP) batteries, which are significantly cheaper to manufacture but come at the expense of lower range. This would enable the electrification of transport to continue unabated, says the firm:

"LFP's share of stationary storage deployments in 2030 jumps to 53% in this outlook from 23%, at the cost of the highest nickel chemistries."

Lithium

BNEF believes lithium carbonate and hydroxide should be sufficiently supplied until at least 2025, but hydroxide could face a shortage by 2027, as demand for high nickel chemistries surges:

"One key risk is that some 35% of the projected supply growth from now until 2025, will come from integrated spodumene-to-hydroxide converters in Australia. "These projects are expensive and have a history of delays. Should the commissioning of these Australian converters be delayed there may be a shortage of hydroxide by 2025." Lithium prices have been on a tear this year, with carbonate climbing 71%, hydroxide 91%, and spodumene feedstock 58%. BNEF expects all prices to continue their rally but gradually plateau as more supply comes online through 2022.

Nickel

The nickel sulfate market is expected to remain balanced in the medium term and in the near term prices should hover around the $18,000 a tonne mark:

"Domestic demand in China was relatively low as some automakers are shifting to LFP chemistries. This will have limited impact in the adoption of nickel-rich battery cathode chemistries, and as such, the nickel sulfate market may slip into a 128,000 metric ton deficit as early as 2024. "At the start of the year, BNEF predicted that the nickel market will move into a two-tier system for nickel pricing to further incentivize investment into additional Class 1 battery-grade nickel supply. At the end of the first half of 2021, there have been no concrete developments toward this much-needed change in the dynamics of pricing in the nickel market."

Cobalt

BNEF expects the cobalt market to move into a small surplus of around 3,300 tonnes this year on the back of increasing large-scale and artisanal mining production. The DRC is responsible for some two-thirds of global output, which is predicted to rise to about 166,434 tonnes in 2021.

From above $50,000 a tonne in March, a two year high, cobalt metal prices could average $45,000 per tonne by the end of the year: "With the market projected to be relatively in surplus this decade, BNEF expects prices will hold at an average of $44,000 per ton up to 2025."

Manganese

Manganese production in top producer South Africa in April more than tripled as covid disruptions eased, but BNEF says mining operations in the country are plagued by challenges associated with haulage, electricity reliability and port operations.

The manganese battery supply chain will experience the strongest growth through 2030, with the market increasing in size by a factor of more than 9. Manganese sulfate prices have risen 30%, from $867 per tonne in January to $1,128 in June, and are expected to continue to strengthen over the course of the year: "With the manganese sulfate market currently projected to be in a deficit, prices are likely to rise to support new refinery projects in order to meet demand by 2024."

Graphite

Graphite demand from lithium-ion batteries, according to BNEF, is set to grow by 37% year on year to just under 447,000 tonnes in 2021, increasing fourfold by the end of the decade. Commercial vehicles will represent the fastest growth, with year-on-year demand doubling in 2021.

MINING.com Editor | June 30, 2021

➢ Western Australia plans world's biggest renewable energy hub

Albany wind farm in Western Australia. (Stock image.)

An international consortium plans to build what would be the world's biggest renewable energy hub along the south coast of Western Australia.

The Western Green Energy Hub (WGEH) would stretch across 15,000 square km, an area bigger than the size of greater Sydney, and could produce up to 50 gigawatts of energy. The A$100 billion ($75bn) project would also convert wind and solar power into green fuels like hydrogen. The project's 50GW capacity compares to the 54GW of generation capacity of all the coal, gas and renewables plants in Australia's energy market, which includes all states except Western Australia and the Northern Territory. The country's largest coal plant generates just 2.9GW.

The group behind the proposal, including Intercontinental Energy and CWP Global, said the green hydrogen market will be worth $2.5 trillion by 2050. Both companies are already involved in the Asian Renewable Energy Hub, another contender for the world's largest green power site that was rejected by Australia's environment minister last month. Hong Kong-based InterContinental is also seeking to develop a green hydrogen project in Oman.

The project, to be built in conjunction with Mirning Green Energy Limited, would be developed in three phases to produce up to 3.5 million tonnes of green hydrogen or 20 million tonnes of green ammonia each year. The proposal would be innovative not only in the scale of green energy produced but also in the model of partnership with the Mirning people, who are the traditional owners of the land, the companies said.

The wind and solar generation would be located across the Shires of Dundas and the city of Kalgoorlie-Boulder, with the complementary nature of windy nights and sunny days providing an expected 70% capacity factor. The state government has committed more than A$35 million towards developing a renewable hydrogen industry.

Cecilia Jamasmie | July 13, 2021

➢ Alrosa unveils new diamond tracking method

The physical nano marking is a three-dimensional code linked to the Alrosa' Provenance platform, offering in-depth information about the diamond's origin and characteristics. (*Image courtesy of Alrosa.*)

Alrosa (MCX: ALRS), the world's top diamond miner by output, has begun offering a new laser-marking technology that allows customers to trace rough and polished stone from the mine to the jewellery store.

Unlike traditional laser engraving, the 'nano mark' is only visible with a special scanner and it is impossible to be destroyed or polished off as it applies to the atomic structure of the diamond.

Oleg Kovalchuk, a researcher at the Alrosa Institute in Siberia, says the method recreates the process that occurs in diamonds for millions of years.

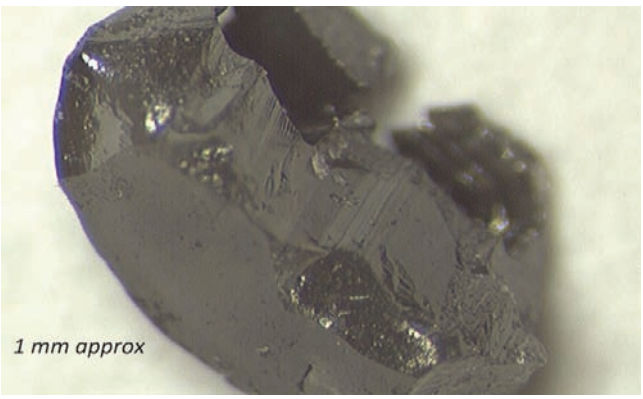
The company's physical nano marking is a three-dimensional code linked to the Alrosa' Provenance platform. It offers in-depth information about the diamond's origin and characteristics, as well as a unique identification number, photo, video and details about how it has been cut. Scientists believe that, as the technology evolves, it is likely to become an important way of embedding large amounts of data within the diamond, including media files, images and music.

Rival De Beers uses an end-to-end diamond blockchain program to track diamonds, which Alrosa tried out in 2018. Soon after, the Russian miner also developed its own program to allow buyers to track the diamond's history in detail, using an identity number and electronic and video passports.

The company is not the only one applying nanotechnology. In February, New York-based Nano Innovator Holdings (NIH) unveiled a prototype platform for end-to-end identification of rough and polished diamonds using the technology. Both Alrosa and NIH's solutions do not change the diamond's clarity or colour, as per The Gemological Institute of America (GIA) grading standard.

Cecilia Jamasmie | July 6, 2021

➢ Rare diamonds show life-giving elements present on Earth soon after it formed



One of the 2.7-billion-year-old diamonds used in the research. *(Image by Michael Broadly, courtesy of Goldschmidt Conference)*.

Ancient diamonds studied by a group of French and Canadian researchers revealed that the presence of life-giving elements in sufficient quantities appeared soon after Earth formed, and has remained fairly constant ever since. In detail, volatile gases conserved in diamonds found in ancient rocks indicate that the basic chemical composition of the planet's atmosphere, which makes it suitable for life's explosion of diversity, was laid down at least 2.7 billion years ago and hasn't changed much since.

In a presentation at the Goldschmidt Conference, research lead Michael Broadly, from the University of Lorraine, explained that volatiles such as hydrogen, nitrogen, neon, and carbon-bearing species are light chemical elements and compounds that can be readily vaporized due to heat or pressure changes. Yet, they are necessary for life, especially carbon and nitrogen.

On Earth, volatile substances mostly bubble up from the inside of the planet and are brought to the surface through incidents such as volcanic eruptions. According to Broadly, knowing when the volatiles became present on Earth's atmosphere is key to understanding when the conditions were suitable for the origin and development of life, but until now there has been no way of understanding these conditions in the deep past.

"Studying the composition of the Earth's modern mantle is relatively simple. On average the mantle layer begins around 30 kilometers below the Earth's surface, and so we can collect samples thrown up by volcanoes and study the fluids and gases trapped inside," the scientist said.

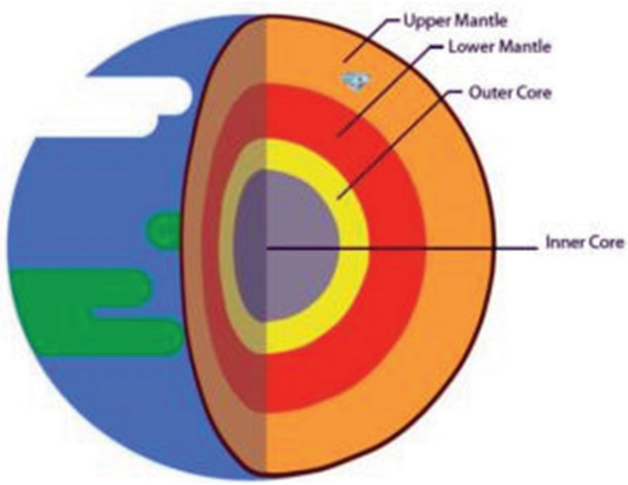


Diagram of the Earth's layers, showing the position the diamonds were formed in the Upper Mantle. *(Image by Michael Broadly, courtesy of the Goldschmidt Conference)*.

"However, the constant churning of the Earth's crust via plate tectonics means that older samples have mostly

been destroyed. Diamonds however are comparatively indestructible, they're ideal time capsules." The rare, fibrous diamonds studied by the researcher and his team were trapped in 2.7-billion-year-old highly preserved rock from Wawa, on Lake Superior in Canada.

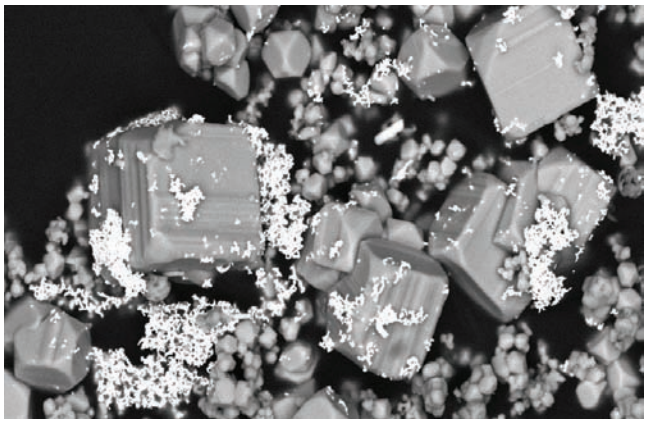
To analyze their composition, the group heated them to over 2000 degrees Celsius to transform them into graphite, which then released tiny quantities of gas for measurement. The team then measured the isotopes of helium, neon, and argon, and found that they were present in similar proportions to those found in the upper mantle today.

This is what allowed them to conclude that there has probably been little change in the proportion of volatiles generally and that the distribution of essential volatile elements between the mantle and the atmosphere is likely to have remained fairly stable throughout most of Earth's life. The mantle is the part between the Earth's crust and the core, and it comprises around 84% of the planet's volume.

"This was a surprising result. It means the volatile-rich environment we see around us today is not a recent development," Broadly said. "Our work shows that these conditions were present at least 2.7 billion years ago, but the diamonds we use may be much older, so it's likely that these conditions were set well before our 2.7 billion year threshold."

MINING.COM Staff Writer | July 13, 2021

➢ Why gold loves arsenic



Scanning electron microscopy photomicrograph showing gold microparticles (bright color) deposited with pyrite crystals from a hydrothermal solution in a laboratory experiment. Such experiments simulate the formation of gold deposits in nature. *(Image by Maria Kokh and Gleb Pokrovski, courtesy of the Goldschmidt Conference)*.

An international team of geochemists discovered why gold is concentrated alongside arsenic, a phenomenon that explains the formation of most deposits of the precious metal.

In a presentation at the annual Goldschmidt Conference organized by the Washington-based Geochemical Society, the researchers explained that even though some gold is found in the form of nuggets, an appreciable amount is bound up with iron and arsenic-containing minerals such as pyrite and arsenopyrite. These minerals act like a sponge and are capable of concentrating gold up to 1 million times more than is found elsewhere in nature. But when it is bound with something else, gold becomes invisible to the naked eye. This is why the scientific team studied the action of the gold-concentrating minerals using an intense X-rays beam produced by the European Synchrotron (ESRF) at Grenoble in France.

They found that when the minerals are enriched with arsenic, gold can enter mineral structural sites by directly binding to arsenic, forming, chemically speaking, Au(2+) and As(1-) bonds. This process allows gold to be stabilized in the mineral. However, when the arsenic concentration is low, gold doesn't enter the mineral structure but only forms weak gold-sulphur bonds with the mineral surface. "Our results show that arsenic drives the concentration of gold. This arsenic-driven gold pump explains how these iron sulphides can massively capture and then release gold, thus controlling ore deposit formation and distribution," lead researcher, Gleb Pokrovski, said at the conference.

"In practical terms, this means that it will make it easier to find new sources of gold and other precious metals, which bind to arsenic-containing iron sulphides. It may also open the door to controlling the chemical reactions, and if we can improve gold processing, we can recover more gold." Pokrovski said that the new model identifies, at an atomic level, why gold tends to be found with arsenic. This means that scientists can now explore if there is anything they can do to prevent this in order to minimize the health risks that the carcinogen metalloid poses to gold miners.

"Geologists, as well as prospectors, have long known that gold can be associated with arsenic-rich minerals, and over the past few decades, others have quantified this association," Jeffrey Hedenquist, a leading expert on epithermal gold systems and professor at the University of Ottawa, said at the event. "The findings of Dr. Pokrovski and his team now help to explain why we see this association, caused by an atomic-scale

attraction between gold and arsenic, with this marriage arranged by the structure of certain minerals."

MINING.COM Staff Writer | July 8, 2021

➢ **No bids for over 70% of Indian coal mines up for auction**

In the first coal mining auctions for the private sector without restrictions on end-use of the fuel conducted last year, there were no bids for nearly half of the 38 mines.

India received no bids for 48 of the 67 mines up for sale as part of its plan to open up coal mining to private companies, reflecting little investor appetite for a sector clouded by environmental concerns and low margins.

Prime Minister Narendra Modi last year offered financial incentives to the private sector and removed restrictions on the end-use of the fuel in a bid to reduce imports and make India a net coal exporter.

India has the world's fourth largest coal reserves and is the second largest coal consumer, importer and producer. In a statement released late on Friday after a deadline for the submission of technical bids, the coal ministry said only 19 of the 67 mines had drawn interest. "Four of these mines are coking coal mines and the remaining 15 fifteen mines are non-coking coal mines," the ministry said.

REUTERS | JULY 09, 2021

➢ **Australia must weigh climate change in mine approvals — court**

Australia's government has been ordered to consider risks carbon dioxide emissions pose to young people when approving new coal mines or expansions to existing ones, the federal court said on Thursday. The case, brought by eight students and an octogenarian nun, centred on Whitehaven Coal's planned expansion of an operation in New South Wales. The project aims at producing as much as 10 million tonnes a year of mostly metallurgical coal, used in steel-making.

The Vickery open-cut coal mine. (Image courtesy of Whitehaven Coal.)

While judge Mordy Bromberg had dismissed the original claim seeking to stop expansion of coal mine operations, Thursday's judgement could set a precedent for all fossil fuel projects in Australia, the world's second-largest coal exporter by volume.

Climate advocates hailed the decision, adding there should be "no moral, legal or rational way" environment minister Sussan Ley could now approve Whitehaven's expansion of its Vickery coal mine. They noted Bromberg s verdict will have implications beyond coal as it specifies a duty of care in relation to "emissions of carbon dioxide into the Earth's atmosphere". That means it could apply to any project with a significant emissions footprint that required Environment Protection and Biodiversity Conservation (EPBC) Act approval.

Minerals Council of Australia chief executive Tania Constable backed the Vickery project, which could still be approved by Minister Ley. "Projects like these are a vital part of Australian mining, which continues to produce some of the best quality raw materials in the world enabling economic development and rising living standards abroad while supporting jobs and communities at home," she said in a statement.

Lawyer David Barnden, who represented the students, said the ruling brings hope and anticipation of "a better, and responsible decision making by government." He added the ramifications for the minister are now very clear.

Whitehaven Coal said it had nothing to add to its previous statement, issued in May, as "today's orders really just [to] formalize the previous outcome". Also in

(Continued on Page 29

NO DIAMONDS, YET SHINE

Abid Mohiyuddin

Can you imagine the blood-red hue of a Ruby, the deep blue hue of a Sapphire, golden hue of a yellow Sapphire - all three varieties of mineral Corundum. Deep green glitter of an Emerald, sea- blue colour of an Aquamarine, yellow color of a Heliodor, lovely pink of a Morganite, or a colourless, glossy and sparkling Goshenite (*varieties of mineral Beryl*)?

Imagine the double-colour effect of an Alexandrite (*greenish or bluish green in daylight and purplish or reddish in artificial light*). "Asterism" or "Chatoyancy" showing light playing on the polished convex surface of mineral "Chrysoberyl", appearing just like the EYE of a CAT! (a rare phenomenon of certain gemstones). B*oth "Alexandrite "and "Cat's Eye" are varieties of mineral Chrysoberyl*.

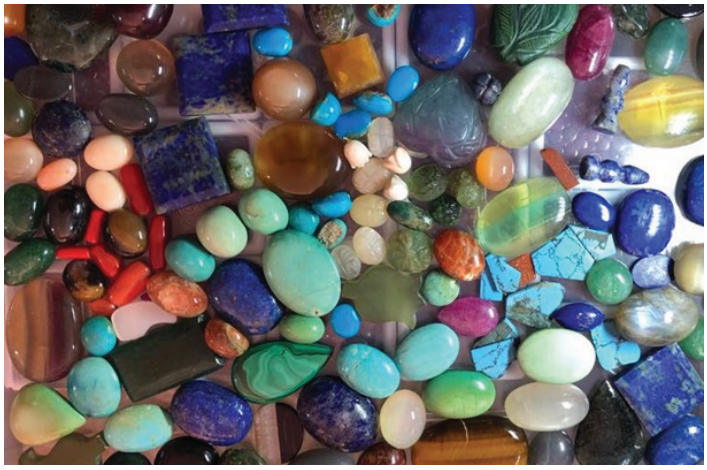
A host of other semiprecious stones like Garnet (*Staurolite*), Quartz, Moonstone, Sunstone, Labradorite (*varieties of mineral Feldspar*), Diopside, Enstatite, Sillimanite, Kyanite, Kornuperine, Tiger stone etc. also show the "Cat's-eye" or a "4-ray Star effect" or simply a sheen or fluorescence or a shiny silk-like reflecting surface, whereas RUBY and SAPPHIRE show a clear and perfect "6-ray star" shimmering on the convex surface of the stone, an apt example of "Asterism".

Can you imagine the triple colour effect (*Trichroism*) of a Tourmaline or a double colour effect (*Dichroism*) of a Cordierite or iolite - that appears like a blue Sapphire from one angle and grey from another? Double colour effect (*yellow and violet colour*) of an "Ametrine" (*a variety of amethyst-quartz*)?

Image: Lapis Lazuli (Indigo Blue with golden specs), Fluorite (Striped Yellow & Green), Corals (White & Red), Turquoise (Greenish & Bluish)

Continue to imagine the depth of colour of a natural fine violet or pinkish violet colour of an Amethyst, varying deep-blue tinged Tanzanite or hues of red, orange, green, crimson, scarlett or the many other colours of "Garnets" or sky blue and the many lovely colours of Aquamarines, Zircons, Fluorites (*having multiple colour layers*), golden yellow, lemon yellow and blue of a Topaz or Citrine. Jasper, Bloodstone, Carnelian and various colours of Agate, Onyx, Sardonynx or peacock green hue of a Peridot (*mineral Olivine*) or Sea-blue or greenish blue colour of a Turquoise or beautiful indigo blue colour of a Lapis Lazuli (*mineral Lazurite*), which has beautiful, shiny and glittering specs of Pyrites (*an ore of Copper that glitters just like gold!*) and is called "Fools Gold". Greenish blue color of Malachite (*an ore of copper*), rare and lovely lilac colour of Kunzite (*mineral Spodumene*) or the play of colours of an "Opal" (*a variety of mineral Quartz, which is the only gemstone with the rare quality of reflecting various colours from its polished, convex surface*).

Many other gemstones like Moonstones of various colours or Labradorite, Diopside, Kyanite, Beryl, Kornuperine, Tiger Stone, Rose Quartz etc., also show strong iridescence or chatuancy or a sheen on the polished convex top.



A White Zircon, Snow White Tourmaline, fascinating, eye-catching Sphalerite (*an ore of metal Zinc*) or a Sphene, (*which appears like a rare, sparkling, yellow Diamond*) outshine Diamonds in brilliance as they have a higher Refractive Index* (*R.I., viz., the quality to throw back light that falls on its surface*) especially Sphalerite, which has four times higher R.I. than a Diamond (*highest for any natural gemstone ever known*).

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These are all natural gemstones, each with their unique, inherent appearance and uncanny beauty - mindboggling creations of mother nature. The rare and lovely colours and combinations (*one feels that the colour is coming somewhere from inside*), the brilliant contrasts and formations have fascinated man from time immemorial to become a source of inspiration - leading him to explore nature's hidden treasures in the Earth's crust. History has recorded innumerable instances of man holding gemstones as objects of faith, believed to have mystic and healing powers, as part of religious rituals, for investment purposes and in many instances, as proud possessions, attaching immense sentimental value to them. Science claims such beliefs as superstitions and modern science discards them saying such beliefs are myths and bigotry. One cannot stop appreciating mother nature's magnificence.

Gemstones, Diamonds included, are minerals which occur either as loose pebbles in the earth's crust, or embedded in solid rock, either in cavities or as part of the rock or other minerals. Diamonds occur both as loose crystals and pebbles in black or blue soil called Kimberlite pipes (*large black soil heaps inside the crust of the earth, vertically or horizontally placed formations, which sometimes are very shallow and sometimes very deep, due to volcanic activity that occurred billions of years ago*).

Image: Different kinds of Rubies

Diamonds are said to be the costliest among gemstones. Rarity of occurrence and exclusive appearance of certain other gemstones like Rubies, Sapphires, Emeralds, Cats-Eyes, Alexandrites, Yellow Sapphires, Pearls and other "RARE" stones which are unique, outbeat a Diamond in many respects. For instance, a fine Diamond may have an instant sparkle and brilliance, may have a high Refractive Index, may command a fancy price in the market for it's attributes including size, color, cut and other qualities, but do you know that a good "pigeon-egg sized" (or a little bigger) clear Ruby, if found without a "flaw" or "inclusion", and with all the qualifications of a "good rare ruby", viz., depth of color, (*fresh, pigeon-blood color regarded as the best*), transparency, lustre etc., would be invaluable i.e. cost a fortune?

To substantiate this, it was quoted in 2012 that a Burmese Ruby weighing only 32.08 carats (*approximately 6.5 grams*) was auctioned in Sotheby's in Europe for a whopping $6.7 million (more than Rs.500 crores). Bigger rubies if found, will have a value which is beyond one's imagination and could be an astronomical sum. You may find hundreds of large sized Diamonds all over the world but a flawless big Ruby with all the rare "qualifications" is yet to be found and has not been recorded in history.

Image: Ruby Cabochons

The biggest ruby of historical importance is the **Timur Ruby,** which weighs 361 carats (*72 grams*), which again is a "Spinel Ruby" with many flaws (*Common variety of ruby, which differs from a real ruby, as it is "singly" refractive while a real ruby is "doubly" refractive, and the hardness of which is more than a spinel Ruby and which commands a much lesser value compared to a real Ruby*). Another beautiful ruby (*only of its kind – "rare", weighing 101 carats, viz., 20 grams*) - is displayed in the American Museum of Natural History, New York, which is claimed to be the rarest of rare rubies, of a big size and impeccable quality. That said, this fine, unique ruby also has flaws or inclusions. These inclusions, in the shape of needles of mineral "Rutile" (*Titanium*) or "Haematite" set in a definite pattern naturally inside the crystal, form a "six-ray star" on cut and polished convex surface of the gem. It is a rare phenomenon, described earlier, called Asterism. Many big size rubies found embedded in royal crowns and jewelry, finger rings, armbands, headgear, amulets, swords, daggers, royal robes and thrones in many popular museums across the globe, and many with the rich and Royal families of India, Europe, Russia, Iran, Afghanistan and elsewhere are mostly "Spinels" and not invaluable "Rubies", it is established.

Diamonds occur in many colours like red, blue, green, orange, pink, yellow, etc. but white Diamonds are abundantly available and most sought after. Coloured Diamonds are rare, if big,

i.e. more than 5 carats (*1 gram*), and command a price much higher (*thousands of times*) than whites due to their rarity of occurrence and are called "fancy Diamonds". To quote a recent instance (*November 2020*) a rare, pink Diamond was auctioned for a whopping $26.6 million (*about Rs. 2000 crores*) at Sotheby's Geneva. Mined in Russia the Diamond was described as a true wonder of nature. Blue Diamonds (*Blue Jägers*) are also very rare, and if found, will command great value.

Geologists and scientists have carried out extensive work in solving the mysteries surrounding minerals and gemstones. Every gemstone is either a mineral or a group of minerals occurring in nature in the Earth's crust. These are available from the surface of the earth mostly in weathered and metamorphosed, highly decomposed rocks and natural habitats, sometimes at shallow depths and sometimes at greater depths. Gold is also generally available at great depths from the Earth's surface (*as deep as 14,500 feet and beyond, in India and Africa*) ingrained in solid rocks (*popularly known as champion gneiss rock in Kolar Gold Fields, Karnataka, India*).

History has recorded more than 2,500 different types of minerals and gemstones out of which only about 180 types of gemstones and about 50 or 60 ornamental stones are popular, and a very few are seen in conventional jewelry.

Nine gemstones, as per Indian mythology and scriptures "Navaratana" i.e. nine precious gems known to man of prehistoric times - Diamond (*Heera or Vajra*), Ruby (*Manikya or Kempu*) Emerald (*Panna or Pachche*), Sapphire (*Neelam or Neela*), Cat's-Eye (*Lahsania or Viyduria*) Hessonite (Gomedha or Gomedhika), Yellow Sapphire (*Pukhraj or Pushparaga*), Coral (*Moonga or Haavala*) and Pearl (*Moti or Muthu*) are held sacred. Each gem is associated with a planet and is to be worn as a Birthstone as per one's star sign. Though Corals and Pearls are got from oceans (*Coral Reefs and Pearl Oysters*), they are wrongly classified as gemstones. Many other gemstones seen in jewelry are mostly semiprecious and set in silver and other cheaper metals, worn as fancy or costume jewelry.

Every gem, either precious or semi-precious, differs in its chemical composition, physical appearance, method of formation (*crystal system*), colour, hardness, specific gravity etc. Crystal system is a vital tool for recognizing and identifying a gemstone. Impurities or inclusions in a gemstone are sometimes a clue to the place of its origin (*country*), experts claim.

Image: Navaratna (9 Gems revered in Hindu Mythology)

The presence of a small quantity or trace of other minerals like Iron, Manganese, Chromium etc. or impurities and inclusions of other minerals can alter the colour, quality, commercial value and demand of a gemstone.

In South India, semi-precious Rubies, Star Rubies and various other semi-precious stones occur in abundance. Precious variety of Ruby, Star Rubies, Cats-Eye, Alexandrites, Aquamarines, Tourmalines, Pinkish Violet or Lilac-coloured Amethysts and Garnets also occur but are scarce. There are three so-called 'Corundum Belts' along which these stray pocket deposits of Ruby corundum occur. They run from village to village, state to state, extending to long distances and in some places, suddenly vanish, and take a deep plunge and emerge elsewhere; a characteristic feature of certain minerals.

There are no regular mining activities or methodical mining in this sector even in Tamil Nadu, Andhra Pradesh or Kerala where these "Mineral Pockets" occur. The villagers make a neat ransom, whenever they come across such chance find deposits with the support of local authorities.

Semi-precious stones of good quality, like Sphene, Tourmalines, Kornuperine, Diopside, Garnets and various coloured moonstones occur abundantly in Karur and other adjoining areas and forests of Tamil Nadu. Andhra Pradesh and Karnataka also produce many gemstones, mostly

Semi precious Rubies and Star Rubies from hundreds of locations. Precious stones of good quality Cat's-Eyes, Alexandrite, Rubies etc. are found in Vizag and adjoining areas of Andhra Pradesh. An ornamental/semi-precious stone used for making objects of art, curios, Buddha heads, animals, birds and other carvings known as Aventurine (*Fuchsite quartzite*) commercially called "Green Quartz" (Markaz) or "Indian Jade" occurs in many colours (mostly light green) in abundance in Karnataka. Aventurine is found in very few countries in the world and India (*Karnataka in particular*) is the leading supplier of this popular stone. Many believe Green Aventurine to have occult powers and healing properties and is in demand in many foreign countries as well.

Image: Diopside (Black 4 Line Star), Malachite (Turquoise Green Square), Star Ruby (Brown with 6 Ray Star)

Thiruvananthapuram in Kerala has been a hunting ground for world class Chrysoberyl "Cats-Eye", (*true honey colour, transparent with very sharp and distinct iridescence or sheen, just like the eye of a Cat!*), the gem more expensive than Diamond.

There are references that more than 50,000 workers were working for Diamonds in the areas (*now Andhra Pradesh*), right along the Krishna, Pennar and Godavari river valleys, during the 14th century (*Kakatiya Dynasty*), 15th through 18th centuries (*Qutub Shahi and Bahamani Kingdom, and the Nizams*) . A large area known as "Golconda Sultanate" (Qutub Shahi Kingdom) was supposedly the prime source of Best Diamonds other than many adjoining areas popular even today for "chance finds". During pre-monsoon showers (*in Kollur, Vajrakarur, Kalyan Durg, Pennkonda, Gutti and many other towns and villages of Guntur, Krishna and Kurnool districts*) people walk with their head bowed towards the ground, always in anticipation of a "chance find" and making a fortune out of it as first rains bring up fresh soil while the dust settles down. It is not unusual to pick up a Diamond by some fortunate person, year over year.

Sunstone, Agate (Buddha Head), Aventurine (Laughing Buddha and Elephant)

Until about 180 years ago, our country was the only source of Diamonds to the whole world. Most of the historical Diamonds, "rarest of rare" on all parameters viz., size, quality, colour, value etc., are from India, known to the world as " Golconda" area-Diamonds (*Some Diamonds were also found in a small town known as "Panna" in Madhya Pradesh for long*). Qutub Shahi Dynasty named their kingdom as Golconda Sultanate. A large number of Diamonds were taken away from India, references of which are found in history. To name a few, Daryaaye Noor (*182 carats, 36.2 grams*), Akbar Shah (*73.6 carats, 14.2 grams*), Nizam and Jacob (*184 carats, 37 grams*), Great Moghul (*280 carats, 787carats originally*), Noor-ul-Ain (*60 carats, 12 grams*) Archduke Joseph Diamond (*78.54 carats, 15.74 grams*), Florentine yellow (*137.27 carats, 27 grams*), Blue Hope (*67 carats, 13.5 grams*), Princedia (*140 carats, 28 grams*) and the list is endless. Kohinoor Diamond, originally weighing more than 600 carats, recut thrice to improve its appearance it is claimed, tops the list (*current weight 191 carats, 38.2 grams*).

The Nizams last possessed these mines and workings until the Britishers occupied India in the 18th century. They were the richest kings of their times in the world after Moghuls and Rajputs and owned the Diamond areas and mines and had profound knowledge of Diamonds and precious stones and all the Royal jewelry they possessed were masterpieces of antique jewelry, replicas of ancient historical masterpieces studded with invaluable Diamonds and precious gems (*efforts of master craftsmen who were their subjects and craftsmen who were from friendly neighbouring countries*).

Image: Pearls and other various gemstones

Image: Citrine (Golden Topaz), Amethyst (Purple Faceted), Heliodor (Yellow Beryl)

The Britishers it is claimed, exploited the Nizams, promising them arms and ammunition in exchange of Diamonds, Precious Gems, Antiques and Antiquities. After invading India, they spoilt these mine workings by unsystematically and haphazardly working to gain maximum benefit from minimum investment (*typical rat mining as is known*) even while extracting gold. Huge pits and wells were dug and the debris was left as-is, to move and attack the next prospective spot.

Today, India produces a small quantity of Diamonds (*mostly industrial Diamonds from Panna valley of Madhya Pradesh*) and commercial exploration of precious Diamonds from the famous Golconda and other popular areas of Andhra Pradesh has come to a standstill since centuries. Diamonds were found in many locations in Africa, Brazil, Australia, China only about 180 years ago. Presently, 35 countries now have Diamond mines. Russia and Africa (*Botswana*) top the list of producers. A very large-sized Diamond, as large as 3106 carats, 620 grams , named “Cullinan” Diamond was mined in 1905, and many other huge size Diamonds such as “Excelsior” (*199 grams, 995 carats*), “Star of Sierra Leone” (*968.9 carats, approx. 195 grams*), The “Golden Jubilee, a deep golden yellow colour Diamond (*545.6 carats, 109 grams*), “The incomparable,” *890 carat, 178 grams*), “The Centenary” (*273.8 carats, 599 grams*), “The Jubilee” (*245.35 carats, 49.07 grams)*,“The De Beers” (*originally 428.50 carats, 85.7 grams*) etc. have also been mined. The list is never ending.

The De Beers Group is the leading Diamond company since 1888 and controls most of the world production and Diamond business. India, of late, has tied up with other countries like France, Australia, USA etc. and is exploring the old areas and prospecting for new occurrences.

Image: Various Gemstones

The author is a mining engineer/consultant and gemmologist with over 50 years of experience and has worked and visited various mines of minerals and gemstones. A gem merchant himself, with a vast collection of gemstones, minerals, specimens and curios, can be contacted for free consultation and knowledge sharing. Interested readers can reach out via abid.mohiyuddin@icloud.com *to receive a video made from his personal collection/rare books/magazines/journals and periodicals.*

Pictures of gemstones are from the author’s personal collection.

UNDERSTANDING THE BEHAVIOUR OF BLAST-INDUCED GROUND VIBRATION AT TUNNEL FACE USING STATISTICAL REGRESSION ANALYSIS AND BLASTWARE SOFTWARE (PART-II)

Bhukya Naveen Kumar*, Dr. Bhanwar Singh Choudhary*

4. FIELD STUDY:

4.1. INTRODUCTION.

For the study, data were collected from the underground Mine-A.

Mine is located in the Cuddapah basin's southwestern corner, close to the Archean basement. The uranium mineralization in this area is hosted by a thick pile of carbonate rock (Vempalle formation). Purple shale, massive limestone, intraformational conglomerate, dolostone (uriniferous), shale, and cherty limestone make up the Vempalle formation. The marker horizons are an impersistent conglomerate and a purple shale band that occur immediately below and above the mineralized rock, respectively. The formation's general strike is WNW-ESE, with the amount of dip varying between 15° and 17° due to N22°E.

The ore body is fairly continuous along its entire strike length of 6.6 km and extends uniformly downdip to a depth of 275m. Two parallel ore bands, known as the hang wall lode and the footwall lode, with average widths of 3.2 m and 2.5 m, respectively, are tabular, strata bound, and non-transgressive, with little variation in grade and thickness along strike and dip direction. These two bands are separated by a 1.5 m to 3 m wide lean zone. The host rock is quite capable.

5.2. DRILLING AND BLASTING:

The mine is being worked by horizontal slice/ strip blasting in stope and solid blasting in the development of heading. Details of drilling and blasting operations are described below:

5.2.1. Drilling:

A jumbo drill of 45 mm diameter is being used to drill blast holes of 3.4m in length. The drilling pattern is burn cut in the development heading.

5.2.2. Blasting:

All the 15 trial blasts utilized an electric initiation system. The delay numbers used for the blasting were 0,1, 2, 3, 4, 5,6,7,8,9, 10, and 11 of long delay (100ms interval) between each set of holes to fire. The firing sequence with delay is shown in Fig. 18.

Blasting was carried out using cartridge explosives (40mm x 200mm (390gm)). The average power factor achieved was 0.8 to 1.1 m^3/kg depending on the formation (compact /cracked), type of initiation sequence, and other blast design variations.

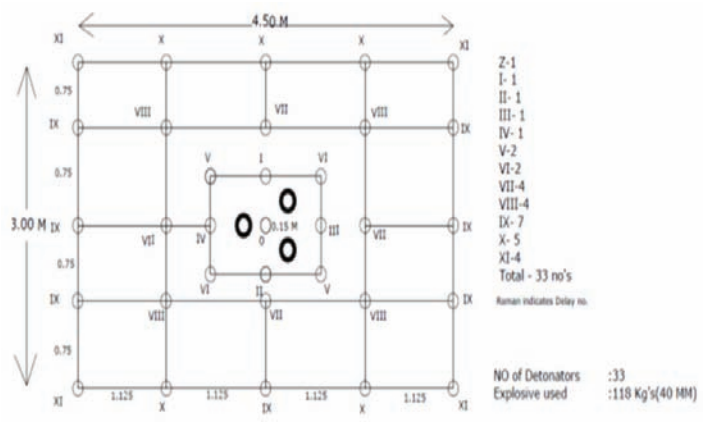

Fig. 18. Drilling and firing sequence.

4.2. FIELD DATA AND ANALYSIS:

A total of 15 blasts were performed and results are recorded carefully.

The predictor equation of the United States Bureau of Mines (USBM) is commonly used for blast-induced vibration prediction. The equation is an empirical relationship between the maximum explosive weight per delay for blast (MCPD), the distance (D) of the monitoring station from the blast face, and the peak particle velocity (PPV). This equation 8 is site-specific and can be described by two-site constants derived from blasting data regression analysis as shown in Fig 19.

Where, PPV is the Peak Particle Velocity (mm/sec), SD is the Scale Distance (D/Q^1/2) (m/kg^1/2), D is the distance of the monitoring station from the blast face (m), Q i s the Maximum Quantity of charge per delay for blast (MCPD) (kg), 779.32, -1.902 are the site law constant and site law exponent respectively.

The data from the case study mine's ground vibrations have been grouped for statistical analysis along with its Coefficient of Determination, which is shown in Fig.19.

Similarly, the equation is an empirical relationship between the total amount of explosives used for blast (TCPR), the distance (D) of themonitoring station from the blast face, and the peak particle velocity (PPV).

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Table: 2. Details of blast observation for different charges and distance of monitoring station from blast face in development face.

Sl. No.	Max. Charge per delay (MCPD), Kg	Total Charge per Round (TCPR), Kg	Distance (D), m	Scale Distance for MCPD	Scale Distance for TCPR	PPV, mm/s
1	7.02	40.17	50	18.87	7.89	11.2
2	14.04	69.42	45	12.01	5.40	17.9
3	21.06	100.23	50	10.90	4.99	15.6
4	21.06	117.39	35	7.63	3.23	29.2
5	16.38	65.6	76	18.78	9.38	1.99
6	32.76	65.6	87	15.20	10.74	2.05
7	32.76	65.6	131	22.89	16.17	1.2
8	49.14	110.14	270	38.52	25.73	0.77
9	49.14	110.14	63	8.99	6.00	4.32
10	14.04	75	53	14.14	6.12	5.16
11	18.72	110.14	137	31.66	13.05	1.09
12	21.06	117.55	40	8.72	3.69	11.4
13	32.76	131.2	80	13.98	6.98	4.91
14	16.38	81.51	45	11.12	4.98	3.98

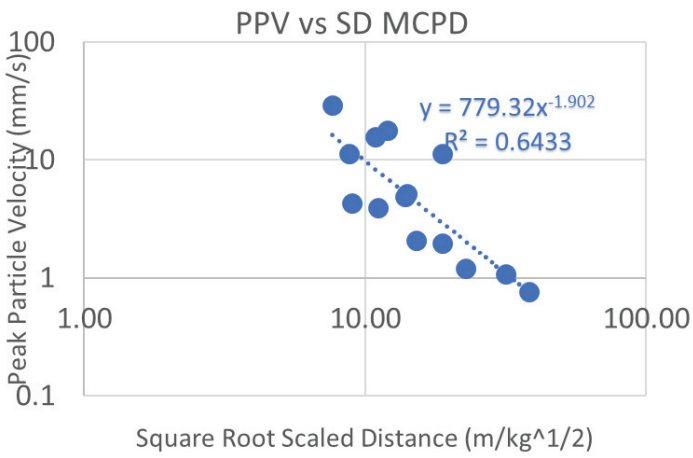

Fig 19. PPV versus the Scaled Distance (MCPD).

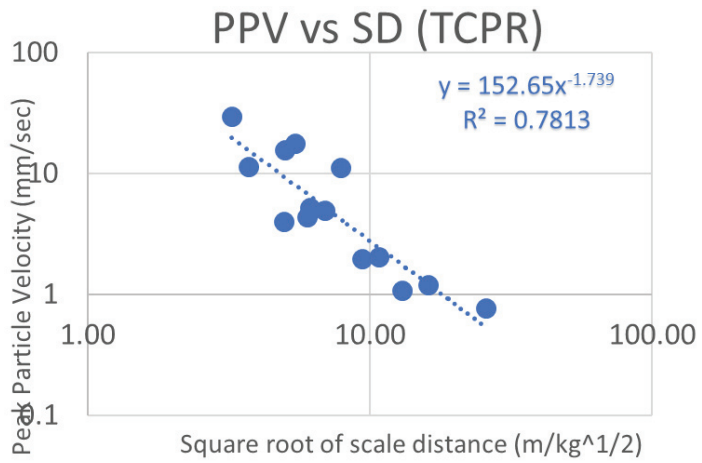

Fig 20: PPV versus the Scaled Distance (TCPR).

This equation 9 is site-specific and can be described by two-site constants derived from blasting data regression analysis along with its coefficient of determination as shown in Fig 20.

4.3. STATISTICAL ANALYSIS APPROACH:

4.3.1. Multivariate linear regression:

To relate PPV with blast design parameters, multivariate linear regression was used with Microsoft Excel's Data Analysis tool kit. The multiple coefficients of correlation (R) value in the regression performance are 0.55, which is a much lower value. Since the probability value (P-value) for a charge per delay, average explosive in a hole, and total explosive is all greater than 0.1, this regression analysis is not considered to be appropriate for blast-induced vibration prediction.

4.3.2. Multivariate polynomial regression:

Correlating single-variate polynomial regression for each variable has been used to approach multivariate polynomial regression. Except for charge per delay and total explosive charge in a blasting round, single-variate regression trends display a correlation coefficient below 22% for most variables. As a result, this regression analysis was not taken into account.

4.3.3. Statistical regression analysis:

The best result for vibration prediction is statistical regression, which is consistent with the results of most researchers. The statistical regression is used in the USBM predictor equation. The statistical regression data was chosen to predict blast-induced vibration and to optimize blast design parameters for day-to-day blasting operations in compliance with statutory requirements. To maximize the overall explosive charge for a blasting round and the charge per delay, logarithmic regression analyses were used.

Blast-induced ground vibration is influenced by several factors, including blast design parameters, rock parameters, and blast propagation media. Rock parameters include rock weight, elastic modulus, Poisson's ratio, and other uncontrollable natural phenomena. Blast-induced vibration propagation media involve the rock properties of the surrounding rock mass between the blast face and the structure. It could include geological features such as discontinuities, joints, and certain surface features such as ponds and rivers. In nature, this parameter is also uncontrollable.

The number of holes, hole diameter, hole depth, explosive column length, total explosive charge in a hole, total explosive charge in a blasting round, the charge per delay, initiation device, and distance of the structure from blast face is all blast design parameters. Most blast design parameters, except explosive charge and distance from the blasting faces, are constant for smaller mines or blasting activities.

As a result, the USBM predictor equation has been generally accepted as a site-specific blast vibration predictor because it takes into account explosive charge and blast's face distance from the structure. However, blast design parameters in large mines can vary depending on site conditions and equipment availability. In this case, the regression analysis technique is critical for predicting blast-induced vibration with a coefficient of correlation between actual scale distance and predicted scale distance is for a maximum charge per delay is 0.87 and for a total charge per round, it is 0.91.

Table: 3. Statistical regression output for PPV prediction using hole distance of monitoring station from blast face, and maximum charge per delay as parameters.

Sl. No.	Distance (D)	PPV mm/sec	Scale Distance (MCPD)	Scale Distance (TCPR)	95% Scale Distance (MCPD)	95% Scale Distance (TCPR)
1	50	11.2	18.87	7.89	18.87	7.89
2	45	17.9	12.01	5.40	12.01	5.40
3	50	15.6	10.90	4.99	10.90	4.99
4	35	29.2	7.63	3.23	7.63	3.23
5	76	1.99	18.78	9.38	18.78	9.38
6	87	2.05	15.20	10.74	15.20	10.74
7	131	1.2	22.89	16.17	22.89	16.17
8	270	0.773	38.52	25.73	38.52	25.73
9	63	4.32	8.99	6.00	8.99	6.00
10	53	5.16	14.14	6.12	14.14	6.12
11	137	1.09	31.66	13.05	31.66	13.05
12	40	11.4	8.72	3.69	8.72	3.69
13	80	4.91	13.98	6.98	13.98	6.98
14	45	3.98	11.12	4.98	11.12	4.98

Where, PPV is the Peak Particle Velocity (mm/sec), SDis the Scale Distance (D/Q^1/2) (m/kg^1/2),

However, blasting data used for this empirical relation have variations in parameters like distance of the structure from blast face, the maximum charge per delay (MCPD). So, USBM predictor equations that have been developed for the developing tunnel blast design have been presented in Eq. 10 using Microsoft excel statistical regression analysis as shown in Fig. 21.

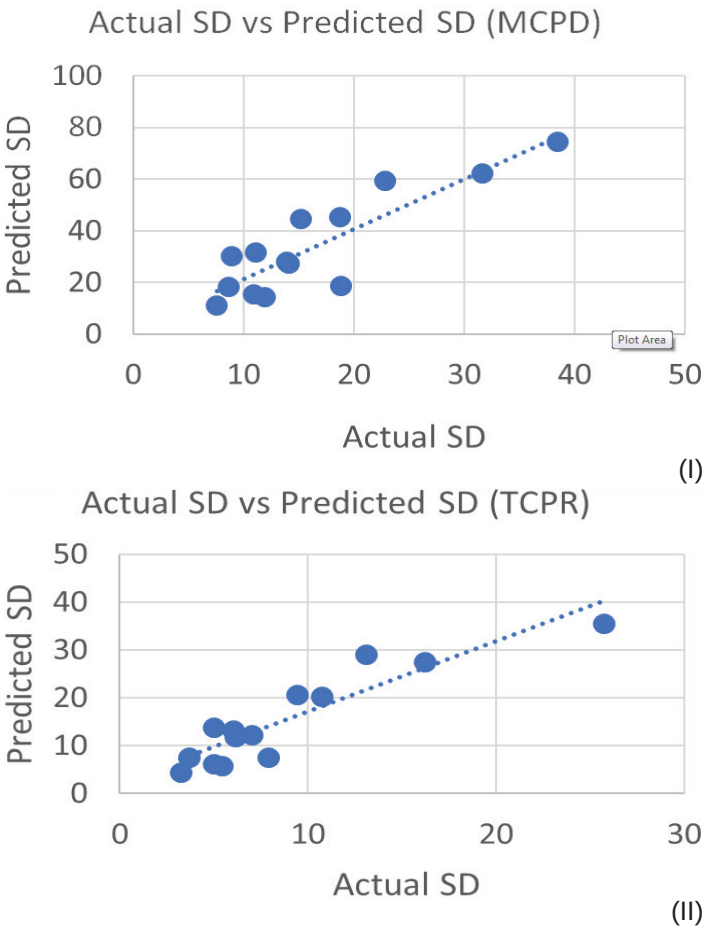

Fig 20: Correlation coefficients between actual and predicted Scale distance for MCPD (I) and TCPR (II)).

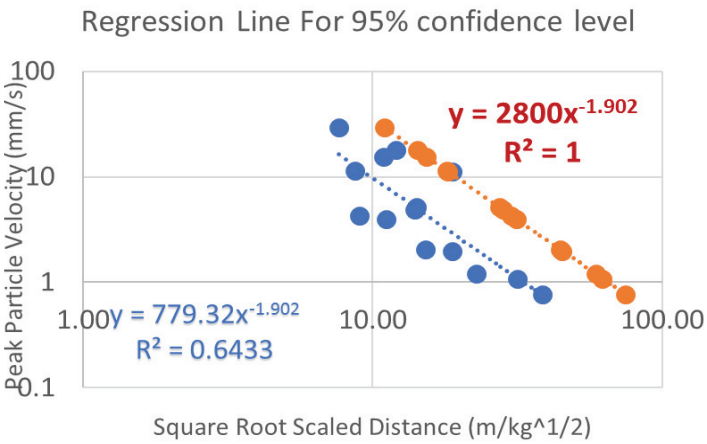

Fig 21: Regression line for 95% confidence level for PPV vs scale distance (MCPD).

A confidence line is based on the "rule of thumb". It states that in a normally distributed large population approximately 68% of the members lie within one standard deviation of the mean, whereas 95% of the members lie within two standard deviations.

A 95 % of the confidence interval is a unit of data within which can be 95% certain that the true population mean is contained. Strictly speaking, a 95% confidence interval means that we were to take 14 sets of data and compute a 95% confidence interval for each sample, then approximately 13 of the 14 confidence intervals will contain the true mean value.

Where, PPV is the Peak Particle Velocity (mm/sec), SD is the Scale Distance (D/Q^1/2) (m/kg^1/2),

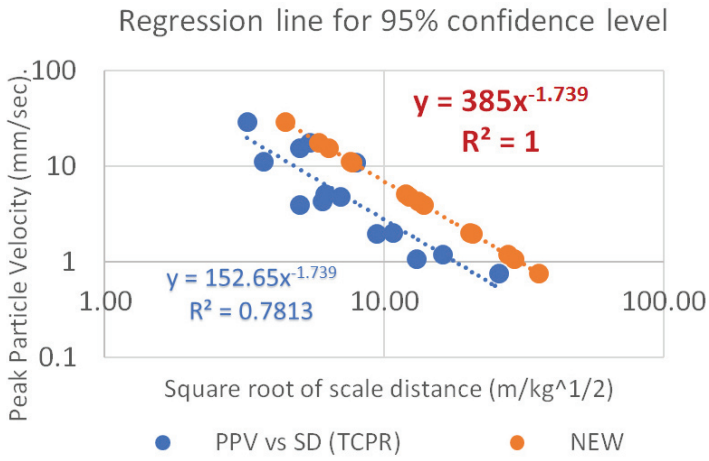

Fig. 22. The regression line for 95% confidence level for PPV vs scale distance (TCPR).

Similarly, USBM predictor equations for the distance of the structure from blast face, Total charge per round of blast (TCPR) have been developed for the developing tunnel blast design have been presented in Eq. 11 using Microsoft excel statistical regression analysis as shown in Fig. 22.

4.4. OPTIMIZATION OF MAXIMUM EXPLOSIVE CHARGE PER DELAY (MCPD) LOGARITHMIC REGRESSION:

The regression analysis has been performed to optimize the maximum charge per delay for the blast. A probability value analysis of the variables shows that PPV is dependent on the charge per delay, and distance of monitoring station from blast face. Regression output has been presented in Table 3. The predictor equation based on Statistical regression output is shown as Eq. 10.

The establishment of a site-specific predictor equation has resulted from regression, as discussed in section regression. The blast design parameters for the Mine-A production face were optimized using this equation. To protect nearby structures from blast-induced vibration, blast design parameters are optimized. The Directorate General of Mines Safety circular No. 7 of 1997 specified standards for the maximum permissible blast-induced vibration for the Indian situation.

Table.4 summarizes this suggestion. Based on the frequency of ground vibration, the shown norm indicates a blast vibration threshold limit.

Table: 4. Suggested blast vibration standard as per circular 7, 1997, DGMS India.

Type of structure	Dominant excitation frequency		
	< 8 Hz	8–25 Hz	> 25 Hz
(A) Buildings/structures not belonging to the owner			
1. Domestic houses/structures (Kuchcha, brick, and cement)	5	10	15
2. Industrial building.	10	20	25
3. Objects of historical importance and sensitive structures	2	5	10
(B) Buildings belonging to owner with limited span of life			
1. Domestic houses/structures	10	15	25
2. Industrial buildings	15	25	50

The majority of blast vibration was registered at dominant peak frequencies below 8 Hz and as well above the 25 Hz, indicating that blast architecture for day-to-day blasting should be configured to keep blast vibration within 5 mm/s, 10mm/s, and 15mm/s around surface structures not owned by the owner, as per DGMS norms (Directorate General of Mines Safety 1997).

For this reason, the observed frequency of blast-induced ground vibration has been plotted and is shown in Fig. 23.

Minimizing the Maximum charge per delay. An empirical equation 12 has been developed using statistical regression analysis to Optimize theMaximum charge per delay.

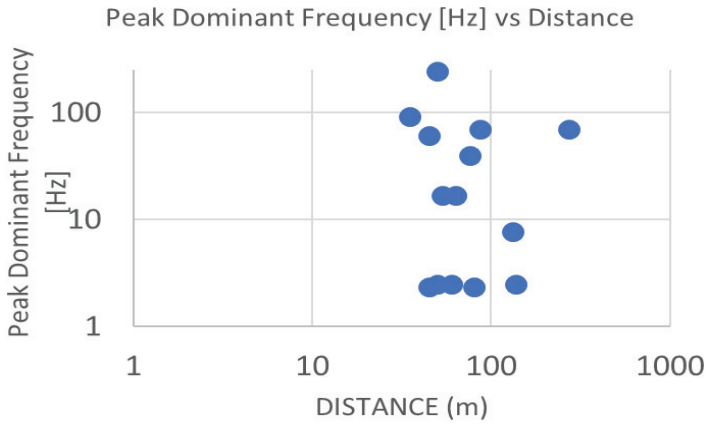

Fig. 23. The plot of recorded peak dominant frequency vs distance.

Hence for the design of blast of Mine-A where Blast hole diameter and Blast hole length are constant as per the equipment available in the mine. So, to minimize the blast-induced ground, the quantity of explosives should be reduced.

Hence, Eq.12 has been recommended for day-to-day blast optimization at the site considering the minimum possible combination of variables affecting blast-induced vibration.

WhereQ is the maximum charge per delay of the blast (MCPD) (kg), PPV is the Peak Particle Velocity (mm/sec), D is the distance of the structure from the blast face (m).

This equation is site-specific and valid only for Mine-A. Using the above equation predicted maximum charge per delay is calculated as shown in table 5.

Table: 5. Recommended blast design parameters and Maximum charge per delay (kg) for day-to-day blasting at Mine-A

Hole diameter (mm)	Length of the hole (m)	No of holes (No's)	Distance from structure to the blast face(m)	Maximum charge per delay (kg)		
				> 8 Hz	8Hz - 25Hz	<25Hz
				5 mm/s	10mm/s	15 mm/s
44	3.4	33	50	3.22	6.68	10.23
44	3.4	33	100	12.89	26.71	40.92
44	3.4	33	150	29.00	60.11	92.07
44	3.4	33	200	51.56	106.86	163.67
44	3.4	33	250	80.55	166.97	255.74
44	3.4	33	300	116.00	240.43	368.26
44	3.4	33	350	157.89	327.26	501.25
44	3.4	33	400	206.22	427.44	654.69
44	3.4	33	450	261.00	540.98	828.59
44	3.4	33	500	322.22	667.87	1022.96

4.5. OPTIMIZATION OF TOTAL EXPLOSIVE CHARGE PER ROUND (TCPR) USING LOGARITHMIC REGRESSION:

Similarly for the design of blast of Mine-A where Blast hole diameter and Blast hole length are constant as per the equipment available in the mine. So, to minimize the blast-induced ground, the Quantity of explosives should be reduced i.e., Minimizing the Total charge per delay. An empirical equation 13 has been developed using statistical regression analysis to Optimize the Maximum charge per delay. Hence, Eq.13 has been recommended for day-to-day blast optimization at the site considering the minimum possible combination of variables affecting blast-induced vibration.

Where, Q is the total charge per round of the blast (MCPD) (kg), PPV is the Peak Particle Velocity (mm/sec), D is the distance of the structure from the blast face (m).

This equation is site-specific and valid only for the Mine-A. Using the above equation predicted Total charge per round of blast is calculated as shown in table 5.

6. GROUND VIBRATION PREDICTED EQUATION BY BLASTWARE:

Blastware Graph menu has commands for scaling distance analysis on the file currently open in the Scaled Distance window. Square Root, Cube Root, and Air Blast are all

Table: 6. Recommended blast design parameters and Total charge per round of blast (kg) for day-to-day blasting at Mine-A.

Hole diameter (mm)	Length of the hole (m)	No of holes (No's)	Distance from structure to the blast face(m)	Total charge per round of blast (kg)		
				> 8 Hz	8Hz - 25Hz	<25Hz
				5 mm/sec	10 mm/sec	15 mm/sec
44	3.4	33	50	16.92	37.54	59.85
44	3.4	33	100	67.67	150.17	239.39
44	3.4	33	150	152.25	337.88	538.62
44	3.4	33	200	270.67	600.68	957.55
44	3.4	33	250	422.91	938.56	1496.18
44	3.4	33	300	609.00	1351.53	2154.50
44	3.4	33	350	828.91	1839.58	2932.51
44	3.4	33	400	1082.66	2402.72	3830.22
44	3.4	33	450	1370.24	3040.94	4847.62
44	3.4	33	500	1691.66	3754.25	5984.72

available from the Graph menu. The Square Root command plots the regression line for square root scaled distance on a graph as shown in Fig. 24.

The graph (Fig. 24) which is drawn from Blastware software gives us a prediction equation for a maximum charge per delay (MCPD) based on the data which we have entered into the software. The predicted equation is shown in Eq. 6.1.

Similarly for the total charge per round of blast (TCPR) is shown in Fig 25 and the predicted equation is shown in Eq. 15.

6.1. Optimizing Maximum charge per delay (MCPD) and Total charge per round (TCPR) of the blast using Blastware.

Various tools, based on the scaled distance analysis, are available under the Tools menu to measure charge weight, safe distance, and other variables. The Scaled Distance

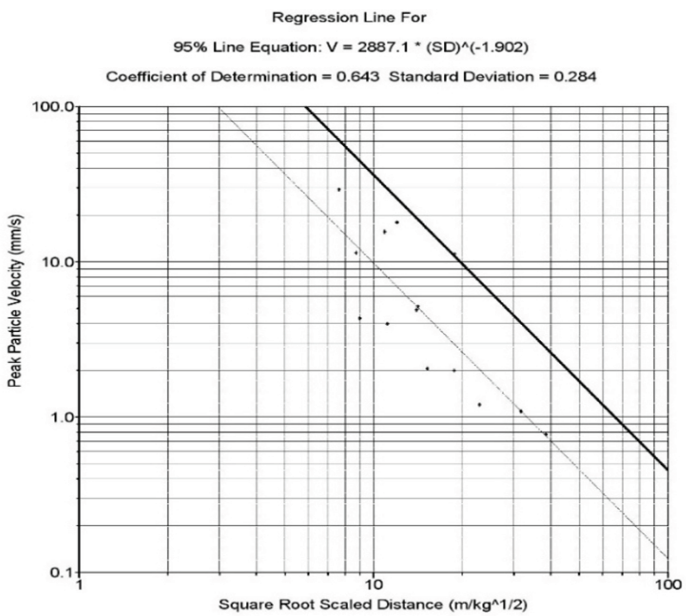

Fig 24: Regression line for 95% line using Blastware (MCPD).

Calculator is called by the Calculator order, and it allows us to perform a variety of calculations based on a trust level graph. This allows us to get accurate details about the blast site. Input the PPV and incremental distance values from the DGMS (Table 4.) into the corresponding boxes, and the results will be displayed automatically.

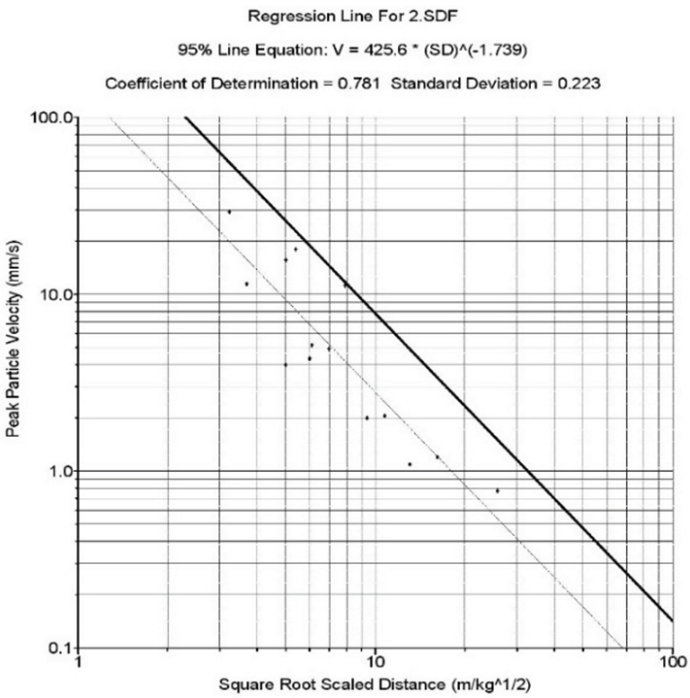

Fig 25: Regression line for 95% line using Blastware (TCPR).

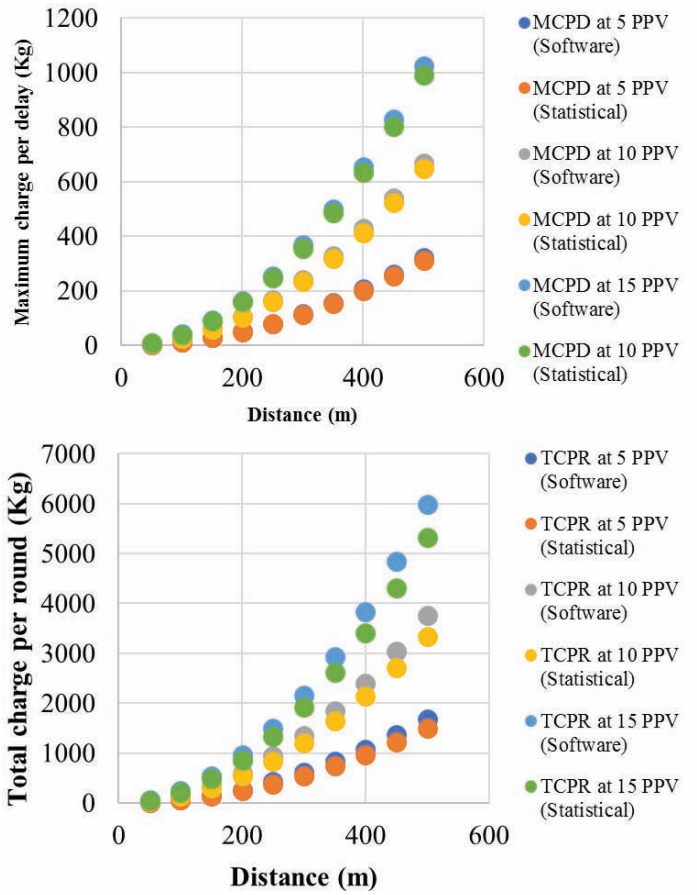

Fig 26:Polt between statistical regression analysis results and Blastware predicted results

Table: 6. Predicted maximum charge per delay (kg) from the statistical analysis and Blastware model.

Distance	STATISTICAL ANALYSIS			BLASTWARE RESULTS		
	Maximum charge per delay (kg)			Maximum charge per delay (kg)		
	> 8 Hz	8Hz - 25Hz	<25Hz	> 8 Hz	8Hz - 25Hz	<25Hz
	5 mm/sec	10 mm/sec	15 mm/sec	5 mm/sec	10 mm/sec	15 mm/sec
50	3.22	6.68	10.23	3.11	6.46	9.898
100	12.89	26.71	40.92	12.47	25.85	39.59
150	29.00	60.11	92.07	28.06	58.16	89.08
200	51.56	106.86	163.67	49.88	103.4	158.4
250	80.55	166.97	255.74	77.93	161.6	247.5
300	116.00	240.43	368.26	112.2	232.6	356.3
350	157.89	327.26	501.25	152.8	316.6	485.0
400	206.22	427.44	654.69	199.5	413.6	633.5
450	261.00	540.98	828.59	252.5	523.4	801.8
500	322.22	667.87	1022.96	311.7	646.2	989.8

Table: 7. Predicted Total charge per round (kg) ofthe blast from the statistical analysis and Blastware model.

DISTANCE	STATISTICAL ANALYSIS			BLASTWARE RESULTS		
	Total charge per round (kg) of the blast			Total charge per round (kg) of the blast		
	> 8 Hz	8Hz - 25Hz	<25Hz	> 8 Hz	8Hz - 25Hz	<25Hz
	5 mm/sec	10 mm/sec	15 mm/sec	5 mm/sec	10 mm/sec	15 mm/sec
50	16.92	37.54	59.85	15.07	33.44	53.31
100	67.67	150.17	239.39	60.27	133.8	213.2
150	152.25	337.88	538.62	135.6	301.0	479.8
200	270.67	600.68	957.55	241.1	535.0	853.0
250	422.91	938.56	1496.18	376.7	836.0	1332.7
300	609.00	1351.53	2154.50	542.4	1203.9	1919.2
350	828.91	1839.58	2932.51	738.3	1638.6	2612.2
400	1082.66	2402.72	3830.22	964.3	2140.2	3411.8
450	1370.24	3040.94	4847.62	1220.4	3708.7	4318.1
500	1691.66	3754.25	5984.72	1506.7	3344.0	5331.0

From tables (6, 7), the predicted maximum charge per delay and Total charge per delay are compared. The result is shown in the table where we can find the difference is very less and the coefficient of correlation is around 98% is shown in Fig 26. From this analysis for the blast purpose of the Mine-A, can use the predicted charge for their blast design.

7. CONCLUSIONS:

Prediction of blast-induced ground vibration is a key concern for blast designers to optimize blast design parameters. Statistical regression analysis could be an effective tool to design a blast with PPV of recorded blast vibration. This paper dealt with the establishment of a Statistical regression equation for the prediction of blast vibration at the tunnel face. This approach considered various constant blast design parameters like diameter of the hole, length of the hole, and the number of holes and Changing with the quantity of explosive per delay as well as for round of blast.

Prediction of ground vibration has been done by different analyses like Multivariate linear regression, Multivariate polynomial regression, and Statistical regression analysis but in Multivariate linear regression, the multiple coefficients of correlation (R) value in the regression performance are 0.55, which is a much lower value. Since the probability value (P-value) for a charge per delay, average explosive in a hole, and total explosive is all greater than 0.1, Multivariate regression trends display a correlation coefficient below 22% for most variables. So, it is done by Statistical regression analysis and got the coefficient of correlation between actual scale distance and predicted scale distance for a maximum charge per delay is 0.87 and for the total charge per round, it is 0.91.

A site-specific predictor equation to predict PPV has been established considering blast design parameters like the number of blast holes, hole diameter, total explosive charge in a blasting round, and distance of vibration monitoring station from blast face. Another predictor equation considering maximum charge per delay as one of the parameters has been established. Design parameters have been optimized keeping the PPV limit up to 5 mm/s, 10mm/s, and 15mm/s as per DGMS standard for the safety of surface structures not belonging to the owner with the frequency of blast vibration. A prediction has been done using Blastware for the MCPD and TCPR and also compared results of software and statistical analysis. The results are more accurate and closer to each other with a correlation coefficient of 98%. Optimum blast design has been suggested for solid blasting in the development of heading at mine for various distances of surface structures from blast faces.

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OBITUARY

Shri Ashok Kumar Singh Nirala
(5.1.1972 - 5.7.2021)

Shri Ashok Kumar Singh Nirala was born on 5.1.1972 at Village-Etawan Noniyan Bigha, Thana-Nabinagar, Dist.- Aurangabad (Bihar). He was a life member of Ahmedabad Chapter (LM no. 4059/AMD).

He did Diploma in Mining from Government Polytechnic Nagpur in the year 1991 and did BE (Mining) from College of Engineering, Chandrapur in the year 1997.

He joined GMDC Ltd. in the year of 2008 at Lignite Project Panandhro. Later in 2016 he was transferred to Lignite Project Umarsar and subsequently transferred to Gadhsisa project in 2019 as a Mines Manager of Mothala Balachod Bauxite Mine.

Shri Ashok Singh is survived by his wife Mrs. Sandhya Singh, daughter Shree Singh and Son Aayu Singh. The members of MEAI pray for the departed soul rest in peace and express their deepest condolences to the bereaved family members.

(Continued from Page 13)

May a ruling in The Hague ordered Royal Dutch Shell to cut emissions faster than planned and currently there are about 1,800 climate litigations pending around the world, according to Columbia Law School's Sabin Center for Climate Change Law.

The environment ministry said it would challenge the court ruling, without specifying details of the issues the government will contest. The federal court's ruling comes on the heels of a report showing that emissions from coal mined in Australia, but exported and burned overseas, were almost double the nation's domestic greenhouse gas footprint in 2020.

The study by energy industry consultancy group Kayrros showed the Bowen Basin, which straddles the border between the states of New South Wales and Queensland, released an average of 1.6 million tonnes a year of methane in 2019 and 2020. Australia's total emissions in 2020 were 499 million tonnes, government data shows. The government is resisting international pressure to commit to net zero emissions by 2050 and has ruled out charging polluters by setting a price on carbon.

Cecilia Jamasmie | July 8, 2021

MEAI NEWS

BELLARY-HOSPET CHAPTER

Minutes of Executive Committee & Chapter Development Committee Meeting held at sums office on 15-07-2021 at 06.00 pm

The following Executive & Chapter Development Committee Members attended the meeting:

1. Sri. K. Madhusudhana - Vice President-I, MEAI
2. Sri. K. Prabhakar Reddy - Chairman
3. Sri. S.H.M Mallikarjuna - Secretary
4. Sri. R. Prakash Babu - Joint Secretary
5. Sri. Jagadeeshwar S.M. - Treasure
6. Sri. P Srinivas Rao - Council member
7. Sri. J. Sreekanth - Executive member
8. Sri. Gopal Joshi - Executive member
9. Sri. Y.V.R. Krishna Reddy - Executive member

Development Committee Members

10. Sri. Chandrashekar Halli
11. Sri. P. Venkateshwara Rao
12. Sri. M. T. Jagadisha
13. Sri. S. Ravindra

Following Points Were Discussed During The Meeting

1. Sri. K. Prabhakara Reddy, Chairman, BH Chapter Welcomed all the members for the meeting and presented the points for discussion.
2. Sri. K. Madhusdhana & Sri. K. Prabhakara Reddy discussed in detail with the forum about the program of conducting the National Council Meeting, National AGB Meeting & National Seminar on the theme of "The Mining – Present & Future Prospects" on 20th and 21st August 2021 at Hotel Hampi International Pvt. Ltd, Hosapete.
3. Accordingly, approval from the Head Office of MEAI is required to be taken. Forum discussed and decided to select 10 authors to present the papers in the seminar on various topics.
4. Shri. K. Prabhakara Reddy informed the difficulties faced by individuals in the region in getting the First Aid Certificate for appearing Examinations conducted by DGMS. The matter was discussed with DGMS and NMDC Officials for making necessary arrangements in getting First Aid training and get approval from the statutory authorities.
5. Shri. Mallikarjuna S.H.M, Secretary, BH Chapter proposed vote of thanks to the members.

RAJSTHAN CHAPTER-UDAIPUR

Report of Technical talk on 17th June, 2021 at 4.00 - 5:00 pm

Rajasthan Chapter-Udaipur on 17.6.2021 organized a virtual visit of Gamsberg Mine of Vedanta Zinc Inc, South Africa through a power-point presentation. Virtually around 100 and physically 10 mining engineers, geoscientists, stakeholders participated in this unique knowledge sharing event on overseas mining operation of global benchmark.

At the outset, Shri YC Gupta, Chapter Chairman welcomed all the members, speaker Sh LS Shekhawat, Head of Business, Vedanta Zinc International, South Africa and his team who offered to present a valuable talk on Gemsberg Mine of South Africa. He also appreciated the courage of women mining engineers who have been given important responsibility by HZL.

Felicitation of India's 1st two women Mining Engineers

On this occasion, former National President Shri Arun Kothari and former chapter chairman Shri SS Rathore honored women First-Class Mines Manager Ms Yogeshwari Rane & Ms Sandhya Rakastala by presenting a scarf, shawl & Certificate to appreciate and congratulate the efforts made by them.

Dr SK Vashisth, National Council member of MEAI introduced the women Mining engineers from M/s Hindustan Zinc. Ms. Sandhya Rasakatla schooling in Montessori High school in Bhupalapalli in Telangana and intermediate in Narayana Jr college in Hyderabad, B.Tech (Mining) from Kothagudam school of mines Telangana region. She joined HZL organization in 2018 as a GET in Mochia Mines. She passed first class Mines Manager certificate of competency 2021 and recently posted at Zawarmala mines and holding the charge of Mines Manager.

Ms. Yogeshwari Rane schooling from Shri Ram High School, Goa and B.E Mining from Goa College of Engineering in

2015. She is topper of batch 2014-15. She has joined Vedanta in July, 2015 Iron ore Goa Mines. She has worked at Sesa Goa for three years in multiple operations. She joined HZL in 2018 in the Planning Deptt of Rampura Agucha U/G Mines. After due permission of women employment in mines by the Govt. she worked as shift engineer at Rampura Agucha U/G Mines. Currently she is working in Kayad Mines as Head Planning & Development, HZL.

Sh AK Kothari, Former President MEAI, Presenting of Certificate to Ms Yogeshwari Rane Head Mine Planning, Kayad Mine-HZL.

Dr SS Rathore, Ex-Chairman, Presenting of Certificate to Ms Sandhya Rasakatla, 1st Mine Manager Zawarmala Mine-HZL

"Virtual visit of Gamsberg Mine of Vedanta Zinc Inc (S. Africa)"

A presentation was given by Shri LS Shekhawat, Business Head, of Vedanta Zinc International, S Africa, from Udaipur and his team member from Planning, Project & Mill joined from the Site. Vital insights viz R&R, exploration status, mining operational details, Concentrator plant, tailing dam, Environment measures for protection were covered.

Dr SK Vashisth, introduced Shri LS Shekhawat, Business Head of Vedanta Zinc International and Recipient of "**National Geoscience award**" 2016 for contribution in the field of Mining Technology, systematic mine planning & mines safety. He started his career with Hindustan Zinc Limited at Rampura Agucha Mine in year 1990 as a Mining Engineer and has worked his way to become the COO-Mines during the year 2014 and Director Operations (Mines & Smelters) in Jan 2019.

Presentation of Sh LS Shekhawat, Head of Business, Vedanta Zinc International, South Africa.

At the outset Sh LS Shekhawat introduced Vedanta as contributor of 8% global zinc production, second larger zinc mine, one of the largest power producers, top 20 independent energy & power company globally (Cairn Oil & Gas); Contribution of >25% to India's current domestic crude oil production, larger Aluminum Producer in India, US $ 40 M on communities impacting 3.1 million people globally. Vedanta Zinc International is the largest Zinc producer in Africa. Integrated Mining & refinery operations across southern Africa are as follows:

1. Gamsberg Mine (South Africa) with the capacity of 250 KTPA
2. Black Mountain Mine (South Africa)

   U/G (Zinc, Lead, Silver and Copper deposit) Plant capacity of 75 KTPA Zn)
3. Skorpion Zinc (Namibia) – The operation for 2.5 KTPA

Mining operations at site being fully mechanized, using state-of-the-art technology besides best-in-class equipment. The key highlights are:

1. Gamberg mines are in the Northern Cap province of South Africa. It was acquired by Vedanta from Anglo Americans in 2011.
2. Gamsberg will exploit one of the largest known, undeveloped zinc ore bodies in the world and comprises an open pit mine and a dedicated processing plant. The Current Capacity of the mines is 4 MTPA ore production with future expansion to plan in phase manner.
3. The mine has over 250 Mt R & R with grade ~6.5% with further upside potential. It contributes 31% of the African Zinc R & R. The cut of grade is 2.5% and metal content in tailing is 1.5%. Stripping ratio is 1:9.8.
4. Gamsberg ore body comprises Magnetite Ore Zone, Pyrrhotite Ore Zone and Pyrite Ore Zone.
5. Mining is 100% outsourced

6. Geotechnically it is equipped with SSR, Geomos & INSAR technology with advanced electronic drilling & blasting technologies.
7. One of the most advanced digitalized mines using latest technologies like “Mine RP”, “APC in Mill” & Fully automated robotic assay lab.
8. Gamsberg Processing Plant is the largest single stream Zinc Concentrator of 4 MTPA with Wood grove flotation technology.
9. The HDPE lined Tailing Storage Facility is 1st of its kind in South Africa.

World class arrangements have been made for the safety of the mine. Simultaneously, many steps have been taken for the environment protection. Shri Shekhawat said that in South Africa, entrepreneurs, public and concerned departments fulfill their responsibilities well and are aware about the environment. South Africa's mining industry is world renowned for its use of high-end technology. Mining industries are the main source of income in South Africa. During the question-answer period at the end of the presentation, Shri Shekhawat answered all questions effectively.

Questions were raised like ROM Grade, cut off grade, stripping ratio, tailing grade, separation of magnetite, depth of exploitation, ecology of area for which Shri LS Shekhawat replied technically and upto the satisfaction of Questioners. Shri AK Kothari, Former President MEAI thanked Shri LS Shekhawat and his team for a nice presentation. He also honored him by garlanding with shawl and uparna.

Felicited of Sh LS Shekhawat, Head of Business, Vedanta Zinc International, South Africa by Sh AK Kothari, Former President , MEAI

Vote of thank was given by Dr SS Rathore, former Chairman of the chapter. He thanked Shdi LS Shekhawat and his team for their technical presentation. He also thanked both the women mining engineers and offered best wishes for success in mining profession. He also thanked all participants and organizers for the efforts made in conducting this virtual visit successfully.

(L-R) Sh Pravin Kumar- HZL; Sh MS Paliwal Secretary; Ms Yogeshwari Rane Head Mine Planning, Kayad Mine-HZL; Ms Sandhya Rasakatla, I st Mine Manager Zawarmal Mine-HZL; Sh LS Shekhawat Head of Business Vedanta Zinc International South Africa; Sh AK Kothari Former President-MEAI; Dr SS Rathore Ex-Chairman & Sh RC Purohit, Executive Committee Member at MEAI Office, Rajasthan Chapter-Udaipur.

The programme was coordinated by Shri MS Paliwal, Secretary of the Chapter.

A wide publicity of the program was made through print media through coverage in local newspapers, social media among the students, members and the entrepreneurs, and stakeholders.

VERAVAL-PORBANDAR CHAPTER

Workshop on New Format of Mining Plan

A workshop was conducted on 23.06.2021 on New Format of Mining Plan amongst the fraternities of mining industries of Gir-Somnath District.

With reference to CCOM Circular No.1/2021, DT. 07.06.2021 new format on Mining Plan was introduced among mining fraternity over the old appraisal of mining plan guidelines of 2014. The programme was organised with the association of M/S GHCL, Sutrapada and V-P Chapter maintaining all COVID Guidelines with strictly keeping social distance, using mask and Namaskar sanskar for one hour duration. In all 20 delegates joined the programme from various mineral based industries, small mine owners, geologists, mining engineers etc of Gir-Somnath District. Shri Ajay Kumar Jain, Head Mineral Resources , Ambuja Cement & Chapter Chairman, Shri Manish Kumar Yadav, Mines Head of GHCL & Vice Chairman (MEAI VP Chapter) were present with their team .The programme covered the new mining plan format in Excel format with nine chapters covering all the points given in the template. Apart from this discussion, queries related to Star Rating were also solved. The format was distributed through email, WhatsApp among attendees. The workshop concluded with Vote of Thanks proposed by Shri Manish Kumar Yadav.

CONFERENCES, SEMINARS, WORKSHOPS ETC.

ABROAD

23-24 Aug 2021: **ICCGG 2021 - International Conference on Computational Geology and Geosciences** in Rome, Italy. For more details, please visit: https://waset.org/computational-geology-and-geosciences-conference-in-july-2021-in-rome

23-24 Aug 2021: **International Conference on Geology, Mineral Exploration and Mining ICGMEM** in Rome, Italy. Website URL: https://waset.org/geology-mineral-exploration-and-mining-conference-in-august-2021-in-rome; Contact URL: https://waset.org

29 Aug - 02 Sep 2021: **APCOM Conference**. Misty Hills Country Hotel, Conference Centre & Spa, Johannesburg, South Africa.

12th Sep 2021: **International Conference on Geological and Environmental Sustainability (ICGES-21)** in Kuching, Sarawak, Canada. Contact Info: Phone: +91 8870915303; Email: info@scienceleagues.com

13-15 Sep 2021: **MINExpo International 2021**. MINExpo INTERNATIONAL covers the entire industry - exploration, mine development, opencast, underground mining, processing, safety, environmental improvement, and more. Las Vegas Convention Center, 3150 Paradise Rd, Nevada, 89109, United States. For details contact +1 (202) 463-2639; MINExpo@nma.org

20-21 Sep 2021: **ICGG 2021 - International Conference on Geochronology and Geography** in Toronto, Canada. For more details, please visit: https://waset.org/geochronology-and-geography-conference-in-september-2021-in-toronto

21-22 Sep 2021: **Africa Mining Summit**. Phakalane Golf Estate Hotel & Convention Centre, Golf Drive Phakalane Phakalane, Gaborone, Botswana

28-29 Sep 2021: **New Leaders Conference 2021**. Online conference organized by AusIMM Brisbane, Australia

6-7 Oct 2021: **ICEGGE 2021 - International Conference on Engineering Geology and Geomorphology Engineering** in Beijing, China. For more details, please visit: https://waset.org/engineering-geology-and-geomorphology-engineering-conference-in-october-2021-in-beijing

13-16 Oct 2021: **Bauma Conexpo Africa**. Gallagher Convention Centre, 19 Richards Dr, Halfway House, Midrand, South Africa

18-19 Oct 2021: **ICEG 2021 - International Conference on Earthquake Geology** in Rome, Italy. For more details, please visit: https://waset.org/earthquake-geology-conference-in-october-2021-in-rome

18-22 Oct 2021: **International Mineral Processing Congress**. **CTICC** (Cape Town International Convention Centre), Convention Square, 1 Lower Long Street, Cape Town, South Africa.

21-22 Oct 2021: **ICRSSGA 2021- International Conference on Remote Sensing Sensors for Geoscience Applications** in Athens, Greece. For more details, please visit: https://waset.org/remote-sensing-sensors-for-geoscience-applications-conference-in-october-2021-in-athens

25-27 Oct 2021: **International Mining and Resources Conference (IMARC)** where Global mining leaders connect with technology, finance & the future. Melbourne showgrounds, Australia. For details contact connect@imarcglobal.com; Australia: +61 (0) 3 9008 5946

Oct 2021: **Southern African Rare Earths International Conference**. The Canvas Riversands Conferencing, 8 Incubation Drive Riverside View Ext 15, Fourways, Midrand, South Africa.

3-4 Nov 2021: **International Conference on Mineral and Mining Engineering ICMME 2021**. Cape Town, Cape Town, South Africa

8-10 Nov 2021: **Iron Ore Conference 2021**. Online conference organized by AusIMM Perth, Australia

8-9 Nov 2021: **ICEGGP 2021 - International Conference on Environmental Geology and Geological Problems** in Istanbul, Turkey. For more details, please visit: https://waset.org/environmental-geology-and-geological-problems-conference-in-november-2021-in-istanbul

17-18 Nov 2021: **Cement Business & Industry Africa (CBI Africa)**. Leading cement conference & exhibition. Johannesburg, South Africa. Venue to be announced.

18-19 Nov 2021: **International Conference on Mining Geology, Exploration and Mining ICMGEM** in Singapore, Singapore. Website URL: https://waset.org/mining-geology-exploration-and-mining-conference-in-november-2021-in-singapore; Contact URL: https://waset.org

2-3 Dec 2021: **ICRMGEA 2021 - International Conference on Rock Mechanics for Geotechnical Engineering Applications** in Tokyo, Japan. For more details, please visit: https://waset.org/rock-mechanics-for-geotechnical-engineering-applications-conference-in-december-2021-in-tokyo

6-7 Dec 2021: **ICCGM 2021 - International Conference on Computational Geosciences and Mathematical Modelling** in Kuala Lumpur, Malaysia. For more details, please visit: https://waset.org/computational-geosciences-and-mathematical-modelling-conference-in-december-2021-in-kuala-lumpur

6-8 Dec 2021: **International Future Mining Conference 2021**. Online conference organized by AusIMM Perth, Australia

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