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PROXIMITY DETECTION SHAPES UP GLOBALLY

The push for better worker safety solutions drives technological innovations

MINING & QUARRY WORLD

COAL INTERNATIONAL

2020 Media Pack





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Eskom powers up Unit 1 at Medupi station in South Africa

South African power utility Eskom announced that the last of its six new units at Medupi is generating coal-fired power and synched to the grid.

The Unit 1 at Medupi produced its first power at 190 MW. It is in the testing and optimization phase, which means that Unit 1 will deliver power intermittently for the time being and help bolster the grid.

The first synchronisation is a key milestone as the generation unit heads into commercial operation. The plan is to achieve commercial operation by November 2020.

"Delivering Unit 1 ahead of time is an indication that Team Medupi and its contractors are committed to deliver the project to the nation," Eskom COO Jan Oberholzer said in a statement. "This achievement signifies that Medupi is nearing its completion and is on track to reach commercialisation by the end of 2020."

Unit 1 at Medupi will eventually ramp up to full power of 800 MW.

Medupi is a dry-cooled coal-fired power station which originally achieved generation output from Unit 6 in 2015. Overall, the six units will generate up to 4,800 MW, according to reports.

The project is estimated to cost close to 200 bn South African rands, or close to $13 bn

PESB picks IAS officer Pramod Agrawal to head Coal India

Pramod Agrawal, a 1991 batch officer of the Indian Administrative Service (IAS) has been picked by the government head-hunter, the Public Enterprises Selection Board (PESB), as the new Chairman and Managing Director of Coal India Ltd.

Agrawal, currently Principal Secretary, Urban Development and Housing Department of Madhya Pradesh, is a post-graduate (M Tech) in Engineering.

The PESB recommendation will have to be ratified by the Central government.

Agrawal will succeed Anil Kumar Jha who is due to superannuate on January 31 next year.

The Kolkata-based Maharatna PSU is the largest coal-producing company in the world.

It is a holding company for seven wholly-owned coal producing subsidiaries and one mine planning and consultancy company spread over 8 States.

Seriti to acquire South32's South Africa Energy Coal business

Seriti Resources has signed exclusive negotiations to acquire South32's South Africa Energy Coal (SAEC) business following a competitive bid process.

South32 confirmed that Seriti will make an up-front cash payment under a deferred payment mechanism, pursuant to which both companies can share any commodity price upside for an agreed term.

According to Bloomberg the bid is said to be valued between $300m and $350m, although Seriti said that no figure has been discussed yet.

South32's share price has continued to plunge on the Australian Securities Exchange. Having started the week on A$2.82 a share the price has since fallen to A$2.46. This continues a general downward trend for the company, as it started 2019 on A$3.27 per share and peaked at A$3.95 on 27 February.

Seriti CEO Mike Teke said: "This is an exciting step forward for Seriti, and we look forward to continued engagement with South32 as we work together towards concluding a binding agreement.

"Should a sale agreement be reached, these assets would become a further important anchor of Seriti's domestically focused coal business.

"This would be further significant investment in the South African mining sector by South African investors, backed by a proven track record of responsible operation."

World's largest miner likely to keep dominating Indian market

The world's biggest coal miner is likely to hold on to its crown for now even as competition increases in India, which opened its doors to foreign miners to boost output and curb surging imports.

The South Asian economy will allow 100% foreign direct investment in mining and sale of coal, trade minister Piyush Goyal told reporters in a briefing, giving final shape to a reform he introduced as minister for coal in 2014. While that opens up the sector to private companies, both Indian and foreign, it will be a while before it reduces the dominance of monopoly producer Coal India Ltd., according to analysts with Emkay Global Financial Services Ltd.

India's coal demand is expected to rise with the addition of new thermal power plants and steel mills, making the nation a bright spot for coal miners in a world that is turning away from the dirty fuel. Still, difficulties in getting regulatory clearances, delays in land acquisition and shortages of railway rakes to haul the commodity may be a deterrent for foreign miners.

"We are still some time away from merchant coal mining given the overarching presence of Coal India," Emkay analysts including Vishal Chandak said in a note. "Once coal is mined, the new miner will have to compete with Coal India prices to sell or enter into long-term contracts for sale."

The state miner has a competitive advantage over other companies as it gets the mines for free, while others will have to participate in auctions to get access, raising their costs. Coal India rose as much 2.5% to 189.65 rupees and was trading at 188.75 rupees as of 1:56 p.m. in Mumbai recently, outperforming a 0.6% decline in the benchmark S&P BSE Sensex.

Germany approves aid for regions just before they go to polls

Germany's cabinet backed a draft law recently to funnel billions of euros in financial support to regions affected by plans to phase out coal, days before two of them hold crunch state elections.

The draft law envisages state aid totalling 40 billion euros ($45 billion) spread over the next 20 years, mostly to four regions affected by the plans to phase out coal by 2038 - part of Germany's transition to renewable energy, known as the 'Energiewende'.

Two of the states to benefit are Brandenburg and Saxony, which both held recent elections. Chancellor Angel Merkel's Chancellor Angela Merkel's conservatives and her Social Democrat (SPD) partners are expected to bleed support to the far-right.

A surge in support for the far-right Alternative for Germany (AfD) in the two former communist eastern states threatens to wreck Merkel's unwieldy right-left coalition government.

Polls show the AfD is running neck and neck with the SPD in Brandenburg, a state the Social Democrats have run since German reunification in 1990, and is a close second to Merkel's Christian Democrats (CDU) in Saxony.

The AfD has sought to attract voters in the poorer East by prioritising coal jobs above the environment.

Economy Minister Peter Altmaier, a close Merkel ally, said the exit from coal was needed to bring the opportunity for the affected regions to reinvent themselves while also helping to protect the climate.

"With today's law, we are paving the way for aid to flow quickly and for a successful structural change to take place," he said in a statement.

The other regions to profit most from the aid are the eastern state of Saxony-Anhalt and North Rhine-Westphalia in western Germany.

Production picks up for thermal power generation

A conveyor belt is running at full capacity at the Tokchon Area Coal-mining Complex.

The coal mining industry now concentrates on the preparations for production in winter while increasing the production of coal for thermal power generation.

Coal mines across the country have set it as the primary task to secure more coal beds by giving precedence to tunnelling and dynamically push ahead with it.

Projects are under way to develop new coalfields in the Puktanggol area of the February 8 Jiktong Youth Coal Mine and the Jolgol area of the Chonsong Youth Coal Mine. The coal mines have set an ambitious goal to tunnel over 1 000 metres a day in order to secure coal beds with rich coal deposits and carry out their assignments every day.

Coal mines also direct a great deal of energies to the mechanization and diversification of coal transport.

The Sochang Youth Coal Mine, Tokchon Coal Mine and Inpho Youth Coal Mine concentrate manpower and equipment to finish the construction of pits for conveyor belt in the shortest possible time. And many coal mines try to learn from the experience of the Chonsong Youth Coal Mine, which has diversified coal transport by using conveyor belt, cableway and coal wagon, to suit their specific conditions.

Meanwhile, all other coal mines are making preparations for the production in winter such as the maintenance and securing of equipment, materials and spare parts and the provision of favourable conditions for production.

The production of machinery and other equipment, large quantities of materials and parts has been organized and vigorously pushed ahead, including coal car, scraper conveyor of various kinds, loader and flexible shaft equipment.

Measures have been taken to secure enough props at mines while increasing their recycling rate.

A Chonsong-Songsan River gravity water drainage construction project is in full swing, whose completion will help several coal mines properly drain underground water flowing into pits without using equipment including pumps.

Two mines pull out hundreds of workers over mining equipment safety issue

The New South Wales Resources Regulator has escalated concerns about breathing masks that have resulted in the removal of hundreds of workers from two Illawarra underground coal mines.

Key points:

- South32 withdraws hundreds of workers from two coal mines over a safety equipment issue
- The NSW Resources Regulator is investigating the Dräger PSS 5000 Compressed Air Breathing Apparatus unit
- The mining union praised the miner for putting the safety of workers first

Recently, mining company South32 reported an issue with breathing sets supplied by German manufacturer Dräger.

As a result of the discovery, South32 made a decision to temporarily withdraw hundreds of underground workers from its operations at Appin and Dendrobium mines near Wollongong.

The regulator said the piece of equipment being investigated was the Dräger PSS 5000 Compressed Air Breathing Apparatus unit, which is designed to be used by mine workers in emergency situations including fires or explosions.

The miner said it identified a leak in the seal of the face mask during routine testing.

In a statement, South32 said staff safety was its priority.

"The safety and wellbeing of our people is paramount and we have voluntarily withdrawn our underground workforce at both mines," it said.

The miner said it did not expect any impact on shipping or production.

Andy Davey, district secretary of the Construction Forestry, Mining, Maritime and Energy Union, praised the miner for its response.

"South32 has done a tremendous job in putting the safety of the workers first and getting them out of the pit while they test all the units," Mr Davey said.

He said union members at other mines sites where the masks were used had raised concerns about the equipment.

"We have had a couple of phone calls with enquiries and we have run them through where we are at," Mr Davey said.

"Our district check inspectors have contacted each site and kept them all up to scratch with exactly what is going on."

The regulator confirmed the masks were used in a total of 12 of the state's mines.

Chief inspector of mines Garvin Burns said the mine and manufacturer were testing the equipment but were struggling to get a handle on the size of the problem.

"They are testing equipment in batches, based on when they were manufactured or serviced and if they find a fault in a batch, then they get that whole batch sent away," Mr Burns said.

"The key issue is actually understanding the fault that is leading to this leakage.

"They have offered up a number of possible causes, but we have nothing definitive in terms of the exact nature of the failure."

Mr Burns said suggestions the leak was linked to how South32 stored the sets in cryovac bags had been discounted by the supplier.

He said South32 had taken an extremely conservative approach and the regulator was monitoring the response of other miners who also used the equipment.

"We are watching closely what other operators are doing to try and understand why their approaches are different, because if we do feel people aren't serious about it, then they will leave us no option but to take the issue out of their hands," Mr Burns said.

"If we have any doubts that either the mining companies or supplier are not doing enough to fulfil their duties under the WHS Act then we may take further action to protect workers."

Fire and Rescue NSW confirmed its firefighters were equipped with Dräger self-contained breathing apparatus (SCBA) sets.

It said it was aware that issues had been identified by the mining industry and it was in consultation with Dräger.

It said it rigorously maintained and tested the SCBA sets to ensure they were safe for firefighters and had not experienced any similar issues with the Dräger PSS 5000 Compressed Air Breathing Apparatus units used in the mines.

Seriti bets on long-term reliance on coal for SA

CEO says coal producer is not an environmental denialist and alternatives will need to be phased in gradually

Seriti Resources, poised to become Africa's second-biggest coal producer, is betting that SA will rely on coal for decades even as Africa's biggest emitter of greenhouse gases implements carbon taxes and is under pressure to improve air quality.

The most-industrialised economy on the continent will soon release an energy blueprint to outline the sources it will get its power from in the future. The carbon tax, designed to incentivise a move away from the coal that accounts for almost all power generation, could eventually cost state-owned power utility Eskom about R11.5bn a year.

"When you operate in the coal-mining space the impression created is like you're an environmental denialist. We are not," Mike Teke, Seriti's CEO, said in an interview. "We operate in a developing economy" where alternatives will need to be phased in gradually, he said.

Some government forecasts are in line with Teke's view.

SA as a coal exporter remains from a cash-cost perspective very competitive versus its peers in Australia and elsewhere.

Seriti CFO Doug Gain

While coal-fuelled plants will decline to less than half of the country's total installed power generation capacity by 2030, it will still contribute more than 65% of energy production as the plants run around the clock, while renewables depend on sun and wind availability, according to a 2018 draft of the Integrated Resource Plan. A final version is expected within weeks.

Eskom's appetite for the fuel has not fluctuated much over the past decade, with the utility burning 116-million metric tons in 2018. The state company is facing growing competition from privately owned renewable power generation.

While Eskom is scheduled to close six of its 15 coal-fired plants by 2030 its two newest plants, which are yet to be completed, will produce 4,800MW each, placing them among the world's biggest coal-fired facilities.

Seriti is in talks to buy the South African coal assets of South32 to bring its production to about 50-million tons a year. It could potentially grow its customer base from one supplying Eskom's power stations to international clients as it will have the right to export 17-million tons of coal a year through the Richards Bay Coal Terminal.

"SA as a coal exporter remains from a cash-cost perspective very, very, competitive still versus its peers in Australia and elsewhere," said Seriti CFO Doug Gain.

Mike Tekel. Picture: Jeremy Glynn

Continental champion

Further expansion of the business may follow with multinational mining companies lightening their exposure to South African coal. More mines may become available, he said.

"We do see the multinationals looking to shorten their exposure to South African assets as other jurisdictions across the world become more friendly and more attractive and frankly easier to invest in," Gain said. "That brings to the secondary market, opportunities to acquire assets that are very well capitalised and very well run."

Seriti's growth plans include the development of the New Largo mine, an estimated 585-million ton coal resources located near Eskom's Kusile power plant, which could run until 2070.

Outside of the primary focus of domestic thermal coal and export options from South32 assets, Teke anticipates opportunities elsewhere in Africa and perhaps beyond.

"We want to build what we call a continental champion," he said.

Picture: Robert Tshabalala

Australia Bank forecasts modest recovery

National Australia Bank is forecasting steady growth in thermal coal prices though to July-September next year after a retreat in the current quarter, but prices are not expected to return to the levels seen earlier in 2019, National Australia Bank said in its monthly Minerals and Energy Outlook.

The Australian bank expects the FOB Newcastle price basis 6,000 kcal/kg NAR to average $68/mt over July-September, down from $78/mt in the previous quarter, then rise steadily to average in $78/mt FOB Newcastle over July-September next year.

Prices were then tipped to ease back to $70/mt FOB Newcastle by October-December 2021.

"It is unclear how strict is a proposed quota on Chinese coal imports [limiting the full year total to 281.5 m mt, the same volume as 2018] as this would result in a significant slowdown for the remainder of this year," the bank's analysts said in the report.

"India plans to cut coal imports by at least one third over the next five years, which would significantly reduce global demand over this period," it added.

Despite the forecast uptick over the coming quarters, prices are expected to remain well below the $95/mt FOB Newcastle averaged over January-March. In addition, the full year thermal coal price in 2020 is expected to be $76/mt, down from $79/mt in 2019, the analysts said in the report

Indonesia's decision to move capital to East Kalimantan could disrupt mining

Market sources expect some disruption to mining activity and stricter environmental standards after the Indonesian government picked the coal-producing region of East Kalimantan to host the country's new capital.

President Joko Widodo said recently the new capital would be in East Kalimantan province, which is home to several major thermal coal producers' mines, including Adaro and Indika.

The capital will be between the districts of North Penajam Paser and Kutai Kartanegar, near Samarinda City and the port city of Balikpapan. Both cities are strategic for coal and oil shipments, with Samarinda hosting Indonesia's main coal terminal while Balikpapan is the country's oil hub.

There is no detailed information on the development, but there is talks that mining could be affected, sources said.

"Some are worried that mining activities at the Paser area will be disrupted, and that some of the work contracts will not be extended," said an Indonesian producer.

"Right now we can't do much as we don't have much information," he said, adding that having government services in the province could help clean up the coal industry.

CLEANING UP

"For example, they might clean up illegal mining, and might have better work processes when it comes to collecting mining data, which is good for the industry as a whole," the producer said.

Other sources said that although they expect more environmental regulations, they do not foresee a major policy shift when it comes to the coal mining industry in East Kalimantan.

"I think the government will still need income from coal," a Singapore-based analyst said, adding that there could also be more environmental supervision in the province.

"Mining standard may [be] stricter there, but I don't think it's a big issue," he added.

Another Indonesian producer said other commodities, including steel, nickel and aluminum, would be required to build the new city.

"Domestic coal consumption will be boosted as energy demand will be ramped up, so this will help the coal industry in Indonesia remain attractive," he said.

According to Indonesian officials, construction of the new capital is expected to begin in 2021, and will be completed by 2024.

The relocation is said to help spread economic activity across the country and counter rising sea levels in Jakarta.

President Joko Widodo

Mine planning software in the coal sector

One of the oldest industries in the history of man, mining has evolved over the centuries. Gone are the days of canaries in cages, pick-axes, and candle-lit headlamps. With Global Positioning Systems (GPS) and automated machinery, today's operating mines are at the cutting edge of technology – taking the best of space-age advances to drive the industry. The role of the engineer in mining operations has evolved along with the industry. Today's mining engineer is the link between production and technical services, determining the direction the project will take, and how it will get there.

The mining engineer looks for processes, not independent solutions that link the computer model of the geology to the production crews who recover the reserve. These processes are integrated with each other in a flow – Geological Model to Mine Design to Mine Plan to Production Schedule to Mine Reconciliation. A well-integrated process flow allows the engineer to mesh and sequence steps in the process, maintaining the consistency of data that leads to meaningful results.

The engineer employs the software systems that are most in demand in the industry. Historically, geological modelling and mine design and planning have been packaged together, while scheduling, reporting, and costing were often done using spreadsheets or a separate package. Many packages attempted to bridge this division, but due to their inability to effectively meet the requirements of mining operations, no clear leader has emerged in scheduling software. However, as scheduling software developers delve into mine design, while modelling companies increase their scheduling capabilities and expertise, the playing field levels out.

The typical requirements for planning and scheduling a mine include:

1. The Resource and Geological Model as a starting point for engineering design and planning work. It is a geologist's interpretation of drill hole information, and allows the engineer to visualize and suitably design access to the ore and decide on the methodology to extract it. In particular, SRK's in-house expertise can provide 3D geological models on nearly every computer system used around the world.

2. The Engineering Model is the key component in the planning and scheduling process. It uses engineering parameters to determine the extent of the deposit and assess the mineable quantities and qualities of ore. It provides the practical, mineable interpretation of the geological model.

3. The Scheduling Model is the tool used to determine the rate, quantity, and sustainability of the engineering model. Adding this "time" component allows the engineer to calculate what practical production can be generated and maintained over the course of the mine's life. It pinpoints periods of stress, where parameters may need to be modified to continue effective operations, and alerts the engineer to make adjustments to designs and plans to accommodate deficiencies in mine production before they become operational or contractual problems.

SRK is proficient in using proven geological modeling and design packages. SRK Australia has demonstrated its expertise in using the following packages:

- Gemcom
- Surpac
- Vulcan
- Xpac
- Minescape
- Minesight
- Minex

The most commonly used software packages in geological modeling for coal are MineScape and Minex. SRK Australia's coal group adds Surpac to the mix to calculate the reserves and conduct mine planning and scheduling of mining activities.

With these resources available in-house, the SRK coal group can provide a full range of services to the mining industry that cover geological modeling, mine planning and scheduling, for both open pit and underground coal mining projects and operations.

UNDERGROUND MINING

Underground mining is the oldest method of mining coal. From the late 1970s to early 1980s open pit operations increased, achieving high quantities of production and lower production costs. However, today, with environmental considerations and the greater depth of coal seam deposits, underground mining is proving to be the more viable alternative.

Underground mining technology has experienced a revolution in the last few centuries, from pick-and-shovel mining to fully automated systems in every aspect of the process. This has not only improved productivity by

leaps and bounds but, more importantly, has significantly improved safety standards. Modern underground mines are highly mechanized as new technology continues to evolve.

This high level of mechanization must be accompanied by a high level of monitoring and reporting, as the investment in these systems is extremely costly. For example, the cost of a typical longwall installation could vary between A$100 million and A$300 million. Investments at that level must be supported by accurate geological data, resource and reserve estimation, mine planning and economic projections. The application of mine planning software systems contribute significantly to proving the economic viability of the mine, by handling large data sets with flexibility and speed. Using these tools engineers can assess the geological information, prepare 3D models of the seam, develop quality parameters and conduct structural interpretation. In turn, data is available for engineering and mine planning using specific modules for underground and open pit respectively. Engineers use these packages to calculate resources and reserves within mining parameters, such as method of mining, presence of structural interferences, quality parameters and seam extraction height.

Following the mine plan, the development and production quality parameters and seam extraction height can be scheduled to identify the achievable production rates and the optimum utilization of the available resources. These software packages and mechanized mining methods have improved the economics of underground coal mining operations, despite high capital investments.

OPEN PIT MINING

The old adage that "bigger is better" manifests itself in open cut mining for coal. In the last decade, open pit mining equipment has exploded in size and productivity. Coal mines have benefited greatly from the technology boom, as previously "unmineable" resources are now well within the capabilities of the new generation of equipment. Open pit coal mines are typically large, table-like, flat-lying deposits with minimal cover. Since coal is extremely susceptible to oxidation, the deposit must be thick enough to absorb a degree of oxidation without losing its economic value. The equipment used to mine the overburden must maintain a high level of productivity to ensure that such deposits can be mined economically.

Typically, it was assumed that open pit coal mines required dragline excavators – the massive slow moving machines that compensate for their ungainly movements with the sheer size of the bucket that moves waste material. Today, advances in truck and shovel technology allow quick-moving, extremely mobile fleets of hydraulic excavators, shovels, and haul trucks to reach, and even exceed, the productivity levels of draglines. Instead of tying up tens of millions of dollars in a single piece of excavating equipment, it is possible to obtain three or more excavators for the same price as a single dragline – and still maintain production levels, while increasing the availability and utilization of the fleet. Continued advances in technology successfully provide operators the tools to monitor fleet productivity and equipment performance that prevent breakdowns before they happen, ensuring that the open pit operations will continue to produce for years to come.

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Without leaving a trace

In the past, a coal-fired power plant was once in operation in the Belgian town of Flémalle. The coal residues are landfilled on a fly ash stockpile. Now, the stockpile is to be entirely emptied and the terrain transformed into a nature park. A BEUMER Group Pipe Conveyor is being used to transport the fly ash to the Maas river for shipment. The system has not only been adapted to operate along the steep mountains, but its enclosed design prevents the volatile material from coming into contact with the environment, while enabling a low-noise transport to the destination. This is important as the Pipe Conveyor passes over public motorways, railways and residential areas. This extraordinary project is characterised by the cooperation of the BEUMER Group team with the customer Tractebel Engineering (Group ENGIE). The transport of the fly ash is carried out in strict compliance with safety standards, taking into consideration environmental protection and the effect noise pollution has on the local residents.

The neighbourhood around the Belgian town of Liège is calm and picturesque with small villages along the Maas. The forests and landscapes are partly untouched and present a unique fauna and flora. Industrialisation started very early in the region of Wallonia, as coal was available in abundance. Even though the mines were closed years ago, there are still residues of slates and stones or bottom ash. For example in Flémalle, less than 20 km away from Liège: for approximately 50 years there are about two million cubic metres of the mentioned materials in a fly ash stockpile within proximity of the once largest coal-fired power plant. The stockpile is indeed surrounded by a wall, but according to a study, in the long run, it will represent a major threat for the local residents as it is displaced every year by several millimetres. In addition, the fly ash is an important additive in the manufacture of cement and concrete. It must be prepared to remove foreign substances such as wood or metal and to limit the grain size to 70 millimetres for the cement industry. In a project that is the only one of its kind in Europe, the Belgian power supplier Elektrabel commissioned its subsidiary Tractebel Engineering (ENGIE) to dimension and install a processing plant. The company offers engineering and consulting solutions for the energy and nuclear energy sector as well as for industry and infrastructure. It is planned to dissipate the complete stockpile in the next ten years, and to transform the terrain into a nature park, which will be developed according to the wishes of the local residents and authorities.

About two million cubic metres of fly ash are deposited in this stockpile in the Belgian town of Flémalle.

This is where the conveying begins. The material is transported from the stockpile onto the Pipe Conveyor.

PIPE CONVEYOR: THE ECONOMICAL ALTERNATIVE

Until then, the bulk material has to be transported to the Maas that is approximately two kilometres away (bee-line). However the terrain is very mountainous. The use of trucks would imply driving on public roads for long distances. This would have caused detours, slowed down transport times and raised costs. In addition, the environment would be harmed by exhaust gases, dust and noise. The project lead opted for the BEUMER Group Pipe Conveyor as economical alternative.

"To be able to support companies like Tractebel Engineering with turnkey solutions, we have bundled our comprehensive expertise worldwide spanning various industries and established different Centres of Competence", says Vincent Ferlay, Managing Director BEUMER Group France. "It includes also our Pipe Conveyor. This international team of BEUMER Group bundles the know-how and supports the Sales Department and the Project Management. With Tractebel ENGIE we have developed a solution adapted to the special routing and the ambient conditions", explains Ferlay.

DUST-FREE CONVEYING

The system supplier provided a conveying system with a centre distance of 1,800 meters. "Due to the system design and the required system capacity, we have designed the Pipe

The line runs across the open environment, over steep rocks. The Pipe Conveyor navigates these inclines and gradients.

The assembly work was demanding for BEUMER Group.

Special cranes and helicopters were used for the assembly work.

BEUMER Group installed a ship loader at the end of the conveyor line. It consists of a fixed boom with an extendable telescopic belt conveyor. Every day, 2,000 tons of fly ash are loaded on a ship.

Conveyor with a diameter of 260 mm," explains Ferlay. The conveyor transports 300 tons of fly ash per hour at a speed of 2.3 meters per second. Most importantly though: the enclosed transport of this machine protects the environment from the dry and dusty material. This was an important requirement for the construction of this solution to be approved in the first place. "The project planning absolutely had to guarantee a safe transportation of the material," reports Ferlay. "The fly ash had to be prevented from exiting or falling on the ground, even in the smallest

quantities", since the route passes public motorways, railways and residential areas. The noise emission played an important role too. "We had to minimise the noise to an extremely low level," he describes. The BEUMER Group team developed special sound-absorbing elements that were also used to enclose the Pipe Conveyor bridges. "Along certain line sections, the noise level had to be kept under 35 dB(A)," says Ferlay. This is also possible with special sound insulation, idlers and low-noise bearings.

The Pipe Conveyor transports fly ash across the open environment, navigates large inclines reliably and can be designed to accommodate tight curve radii. This is why only a few transfer towers are required, depending on the length of the conveyor, the terrain conditions and the curves. BEUMER Group can customise the conveying system to match the individual routing, thus protecting the environment and reducing the costs. The system supports are up to ten meters high. Durable conveyor belts guaranteeing tensile strength are used. BEUMER Group makes use of own dimensioning programs to determine the ideal belt design, thus enabling to analyse tractive forces but also forces which occur due to acceleration and deceleration – always taking into account the net weight of the belt and the transported material. This method also lets you calculate possible curve radii."This is particularly important for ascending and descending conveyors," describes Ferlay. For these types of projects, BEUMER Group also offers feasibility studies and profitability calculations. The colour scheme was selected so that the system blends in well with the environment.

EFFICIENT SHIP LOADING

The system supplier provided the turnkey system and all of the necessary components such as filters, strippers and dedusting units. The system provider also provided the engineering, automation and the steel structure, as well as loading systems: excavators load the material into hoppers and on vibrating feeders. From there it is transported to the feeding area of the Pipe Conveyor. BEUMER Group installed a ship loader at the end of the conveyor line. It consists of a fixed boom with an extendable telescopic belt conveyor. This way the ships are loaded efficiently. The ship loader is also equipped with a dedusting unit which keeps the process emission-free. Every day, 2,000 tons of fly ash are loaded on a ship and from there transported to a cement plant.

Interview with Vincent Lognay, project manager at ENGIE

Mr Lognay, how would you qualify the cooperation with BEUMER Group?

Vincent Lognay: The cooperation was based on trust right from the beginning. We were also convinced by the excellent price-performance ratio. The BEUMER Group team also took care of all other aspects of this project, including the compliance with official regulations and the particularly challenging assembly, sometimes across deep valleys.

How did BEUMER Group master these challenges?

Vincent Lognay: BEUMER Group deployed three teams. We needed a safe conveying system design, that would prevent any environmental impact and noise pollution during the bulk material transport, so in the first team employees of the local authorities worked in close cooperation with the BEUMER Group experts. The second team was made up of ten BEUMER Group employees that assembled the system, which presented itself as quite a challenge, in this picturesque, yet also quite hilly environment. Special cranes and helicopters were used for the assembly work. The system supplier assigned the third team for this: the Heliswiss International AG from Küssnacht, Switzerland. They provide transport and construction flights with heavy lift helicopters.

What were the biggest challenges during the installation?

Vincent Lognay: Extremely precise flight manoeuvres were necessary so that the technicians could safely assemble the elements suspended from the helicopter to the steel structure. In order to bolt the components together, the pilot had to guide them exactly over the bore holes of the connecting piece. The BEUMER Group employees were on platforms attached to cranes in heights of up to 45 metres. Very impressive. The entire jobsite team handled this task perfectly.

What was the time frame for this project?

Vincent Lognay: The work began in April 2016, commissioning already took place in October. BEUMER Group supplied everything from one single source. Interfaces could be omitted. Together we were able to comprehensively support the ENGIE Eletcrabel energy supplier.

Does this mean that the collaboration is now terminated?

Vincent Lognay: No, BEUMER Group's extensive Customer Support ensures a high level of system availability even after commissioning. If necessary, the BEUMER Group service staff will go to Flémalle in order to make the necessary adjustments and prevent malfunctions and machine breakdowns, which would lead to long downtimes.

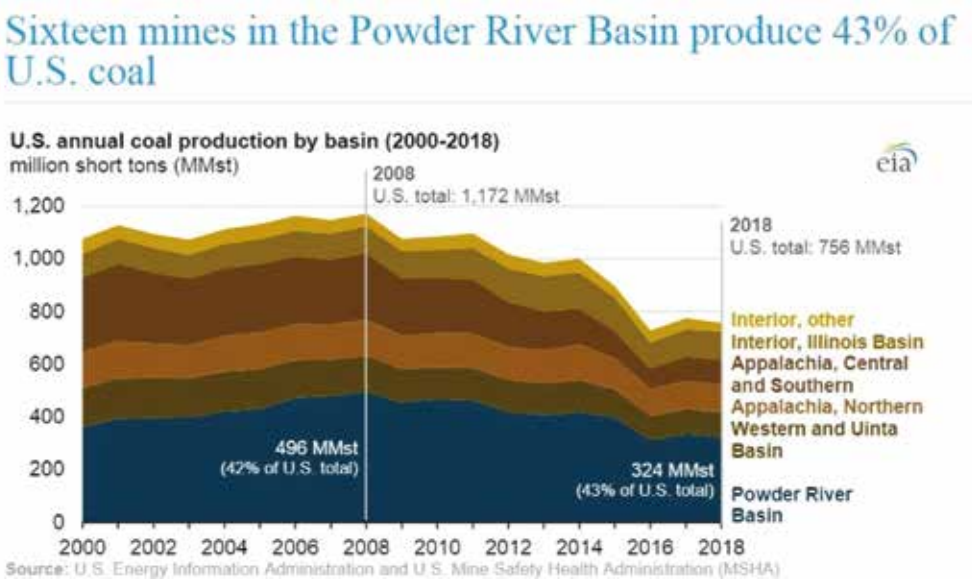
Vincent Lognay, Project director at ENGIE

Sixteen PRB mines produce 43% of US production

More than 40% of coal produced in the US comes from 16 mines in the Powder River Basin (Prb), which is primarily located in northeast Wyoming/southeast Montana.

Four companies collectively own more than half of those Prb mines, and those 10 mines produced 87% of the Basin's coal in 2018, the Energy Information Administration reports.

Two of those companies, Cloud Peak and Blackjewel, filed for bankruptcy this year. The two other companies, Peabody and Arch Coal, are proposing a joint venture that involves some of the Prb mines.



Most Prb coal for power generation

Most of the coal produced in the Prb supports electric power generation in the US Starting in the 1990s, many coal-fired power plants switched to subbituminous coal from the Prb, which has relatively low sulfur content, to meet tightening Clean Air Act emission standards.

By 2003, the Powder River Basin yielded more coal than the Appalachian coal basins in the eastern US, the Eia found.

Production peaks in 2008

Both US total coal production and Prb coal production peaked in 2008, and have since declined. Prb coal production reached a high of 496 m short tons (Mmst) in 2008, and fell to 314 Mmst in 2016, but has since increased slightly to 324 Mmst in 2018.

Coal use in the US electric power sector has decreased as overall electricity demand has remained relatively flat and other fuels – particularly natural gas and renewables – have gained market share.

Coal's share of the US electricity generation mix was 48% in 2008, and has since fallen to 28% in 2018.

Coal's share of powergen flat

The Energy Information Administration expects coal's share of power generation to be 24% in both 2019 and 2020. EIA forecasts coal production in the Western region, which includes Prb coal as well as coal production in the Rocky Mountains, will decline by 12% in 2019.

Declines in domestic coal consumption had been partially offset by rising demand for coal in export markets. Although most US coal exports are bituminous coal (used for steelmaking), the US has exported growing volumes of subbituminous coal from Prb mines to Asian countries for coal-fired power plants.

However, these volumes are relatively small – the US exported 7.7 Mmst of subbituminous coal in 2018, accounting for 7% of total US coal exports and 2% of total Prb coal production.

Prb mines using 67% of productive capacity

Coal mines in the Prb are only using about 67% of their productive capacity. Productive capacity refers to the amount of coal that mines could produce each year with their existing equipment.

Prb coal productive capacity peaked in 2010 at 575 Mmst and has since declined to 476 Mmst in 2018.

Prices for Prb coal have exhibited little volatility in the past decade. In 2008, the average annual selling price for Prb coal with a heating value of 8,800 British thermal units per pound was $13.31 per short ton, compared with $12.31 per short ton in 2018.

Transportation rates to deliver coal from Prb mines to power plants, mostly by railroad, now account for nearly 67% of the total delivered cost of the coal, compared with 56% in 2008.

South32

South32 is a mining company based in Perth, Western Australia. In 2018 the company had a revenue of just over $7.5bn and a net income of $1.3bn, achieving a profit margin of 17.64%.

The company operates coal mines across the world, being involved in 16 projects in South Africa, according to GlobalData. It also owns shares in other mining groups such as Arizona mining, paying over $80m in 2017 for a 20% share in the company.

It has been in talks to divest its holdings in South Africa since September 2018, with an estimated value of its entire operations in the country given as $800m.

Seriti, through its subsidiary Seriti Coal, operates three large-scale, opencast and underground coal mines in South Africa, namely the New Vaal, New Denmark and Kriel mines, which were acquired by Seriti from Anglo American in April 2017.

Seriti, along with its partners, plans to develop its New Largo project into an opencast coal mine that provides the baseload fuel requirements for Kusile power station.

Australia ranks no. 3 in world's biggest producer

Australia has ranked the country as the third largest exporter of fossil fuels in the world, next only to economic superpowers Russia and Saudi Arabia.

Australia is responsible for around 8% of all fossil fuel world exports in terms of carbon dioxide content, including owning nearly 75% of the global coal market, based on studies by The Australian Institute, which has conducted a strict monitoring of the country's measures to fight climate change.

While dissent in regulations and politics sometimes point to the country being to blame for 1.3% of global emissions in its own backyard, studies disclose that Australia is not actually a heavy producer of carbon dioxide by-products compared to other countries.

While the United States and China rank as the globe's leading greenhouse gas producers, the report by the Australian environment body emphasizes the role smaller fossil fuel exporters portray in the sale of fossil fuels to other countries. Australia, also listed as among the largest gas producers, supplies vast regions like Japan, South Korea, and even China.

The global fossil fuels market and export infrastructure plays a huge part in the lock-in that causes a rise in emissions, and the effect is usually take for granted in most climate change discussions, the Australian case study reveals.

Australia's coal exports have climbed more than 50% between 2000 and 2015, and currently, cover almost 31% of the world coal business. Exports of liquefied natural gas, for instance, has tripled in the same period to 7% and continues to grow.

In terms of pollution created by the country's domestic greenhouse gas, Australia produces 1.3% of the global emissions, the AI study confirms. Local emissions have also been on the rise during the past few months, as a volume of huge gas projects are developed, while new coal-fired facilities form the backbone of the country's power supply.

Being one of the prominent members of Pacific Islands Forum, Australia supported calls for other nations to create and publish long-term low emissions plans by 2020. Forum sources said this may include a determined approach and sincerity to hit the target of zero-emissions by 2050.

Meanwhile, Australian Prime Minister Scott Morrison bared that the country will reach its 2030 goal of cutting down carbon emissions it agreed upon in the Paris Agreement, although they have no clear agenda to hit this goal. Morrison's administration has been a staunch advocate of the fossil fuels industry, which includes supporting Adani Group's Carmichael Project, expected to open a new mining site Down Under.

China aims to shut 8.7 GW of coal power by year-end - regulator

China will aim to shut a total of 8.66 GW of obsolete coal-fired power capacity by the end of this year, its energy regulator said, part of its efforts to curb smog and greenhouse gas emissions.

The National Energy Administration didn't say how much of the target, equal to just under 1% of total capacity, had already been met.

All provinces and regions have been ordered to shut coal-fired power units with a capacity of less than 50,000 kW, the regulator said on its website on Sunday.

Larger units of up to 100,000 kW in regions covered by large-scale power grids will also be eliminated, along with those that have reached the end of their designed service period, it said.

Central China's Henan province, one of the country's most polluted regions, is under pressure to shut 1.6 GW this year, while southeastern Guangdong province near Hong Kong will shut 2.3 GW.

China has promised to ease its dependence on coal, it has also forced most of its coal-fired power plants to install ultra-low emissions technology in a bid to curb smog.

But while China has cut the share of coal in its total energy mix from 68% in 2012 to 59% last year, overall consumption has continued to increase and environmental groups estimate that it still has more than 200 GW of new coal-fired capacity in the pipeline.

The China Electricity Council, which represents the country's power industry, predicts that total coal-fired capacity could eventually peak at 1,300 GW, up from around 1,000 GW now.

Russian scientists find way to dramatically improve ecological situation around mines

Researchers from Russia's NUST MISiS National University of Science & Technology have found a way to dramatically reduce the spontaneous combustion of traces of coal found in dumps of waste rock by changing where these dumps are placed, thereby diminishing the risk of fire and improving environmental conditions in mining areas.

Known as 'tailings', the materials left over after the valuable ores have been extracted are often very difficult to extinguish once they catch fire, releasing toxic substances into the atmosphere for months or even years at a time. The situation is complicated by the fact that the waste products are most commonly dumped in canyons and ravines in geologically unstable areas, usually far away from any settlements and associated engineering facilities and infrastructure.

Dr. Adrian Batugin, a geophysicist and professor at the NUST MISiS' Institute of Mining, said that he and his colleagues have discovered that tailings in geodynamically active zones burn more often than those outside them.

This, he said, led him and his fellow researchers to a hypothesis about a connection between coal dump fires and these geodynamically active areas. This hypothesis "was based on the idea that, when located in this kind of highly permeable zone, air can penetrate to the bottom of a tailing from below, 'through' the zone, especially if it intersects with a nearby mine," the professor added.

Accordingly, by carefully studying a mining territory for geo-dynamically active areas using computer modelling, scientists are able to find suitable locations to dump tailings to reduce the risks of combustion, and the associated dangerous and ecological harm.

"Mines, their output, tailings, cities – everything is integrated in the natural geodynamic mobile system of the Earth's crust," Batugin said.

"Previously, it was thought that [human-made] systems could be considered 'stationary' on the geological time scale (given that the lifetime of a mine is insignificant compared to that of [naturally occurring] geological processes). Now, however, it has been established that there is an interaction of global and local processes, and this fact is recognised as the most important result of research in the fields of geomechanics and geodynamics. Accordingly, we are now able to retroactively see errors in the choice of engineering solutions," the professor added.

The NUST MISiS scientists are engaged in modelling the process by which air penetrates tailings in geodynamically active areas, and hope to study in more detail how a rise in temperatures impacts and hastens the processes of air movement inside mining waste products.

Approvals increase while china does climate pledges

China is sure it can continuously raise coal consumption and production while doing a significant reduction in its emissions.

To ensure pollution is controlled, "ultra-low emissions" technology is already a must in all-new Chinese coal power plants and is also getting included in mine zone regulations' improvement.

According to the government, by the end of 2018, 80% of the total coal-fired power capacity has an "ultra-low emissions" equipment, at 810 GW.

China also promised "the highest possible ambition" next year when it reviews the country's climate change pledges.

China aims to bring increasing non-fossil fuels in the country's energy mix to 20% by the end of the next decade.

Cutting coal use, in the long run, is part of China's climate, energy, and environmental goals.

However, a government agency recommends setting a cap on coal use in its 2021-2025 plan.

Still, construction of new coal mines increased in 2019 as Beijing sees coal consumption rising in the coming years even if it has measures on greenhouse gas emissions and smog.

The approval of 141 m tons of new annual coal production given from January to June is a drastic increase from the 25 million tons last year.

China made sure these newly approved mines are in the coal production "bases. " These bases include Xinjiang, Shaanxi, Mongolia, and Shanxi.

Senior energy analyst with Greenpeace, Lauri Myllyvirta is alarmed with "China's energy planning" that "seems to be driving at roughly maintaining current levels of coal output" which he says is difficult to accept considering "the goal of the Paris agreement (on climate change)."

He also stressed that since gas and oil consumption is "still increasing" then "coal use should start falling again."

China State Grid Corporation last month announced that total coal-fired capacity would peak at 1,230-1,350 GW. This is an increase of about 200-300 GW.

Likewise, a study published earlier this year also suggested China's climate, energy, and environmental targets would still allow another 290 GW of coal-fired capacity in the coming years.

Michelle Manook, chief executive of the World Coal Association, an industry lobby group, understands China's stand saying coal is still an important element in the world's change to cleaner energy. The focus, she said should be on lowering emissions rather than banning coal.

It's not about changing "from any one source of energy" but it's about moving to cleaner energy." And with" investment," coal will play "a significant role" she added.

India proposes legislative changes

In a first step that would partially blur the distinction between captive and commercial coal mining, India's Coal Ministry will amend mining legislation to enable companies free merchant sale of coal in the open market.

According to officials, the Coal Ministry will initiate amendments to the Mines and Minerals (Development and Regulation) Act (MMDRA) 2015 that will provide legislative backing to companies allotted captive coal blocks to offer the entire volume of coal produced for merchant sale.

However, the window for free sale of coal produced will differ between coal blocks allotted to private companies through the auction route and blocks allotted to government companies through the preferential allotment route.

In the case of captive coal blocks secured through competitive bidding at auctions by private companies, the latter will need to consume 75% of the production and can offer 25% for free sale. However, should companies be able to make out a case that its end-use plants are unable to consume the entire 75% of production, the balance can be offered to State-run miner Coal India Limited at a price notified by the latter.

Government companies allotted coal blocks through the preferential allotment route will get greater freedom under the legislative amendments and will be able to offer the entire production volume for free sale in the open market, at market determined prices, officials say.

The proposed amendments to the MMDRA 2015 will also ensure that mining leaseholders will not need to get mandatory environment clearances from the state government where mining blocks are located, with the Coal Ministry reckoning on a six- to twelve-month-reduced development time.

The Coal Ministry earlier this month announced the auctioning of 27 coal blocks for end-user industries alongside the allocation of 15 coal blocks to government companies under the preferential dispensation rules.

"At peak rated capacities, these 42 coal blocks will produce approximately 70-million tons a year," the Ministry statement announcing the auction said, adding that the auctioning would be conducted on the State-run MSTC's (formerly Metal Scrap Trading Corporation) electronic platform.

The tweaking of the mining legislation should be viewed against the backdrop of the government earlier this year approving a policy decision opening up coal mining for standalone mining companies. However, the auction of coal blocks exclusively for mining companies – domestic and foreign – permitting free sale of 100% of production and free pricing, was cancelled on an expected poor response from standalone mining companies.

Hence, the Coal Ministry feels that it will be a better alternative to permit free sale of coal by existing captive coal mining companies along with end-user industries and government companies, including state thermal power generators' free sale of coal from their assets, officials say.

Production at Minergy's Masama coal project in Botswana

Minergy Ltd has now removed over 2.2mln cubic metres of overburden at the 390mln tonne Masama coal project in Botswana, with production now getting underway in earnest.

The company is gearing up for a listing on the Aim market of the London stock exchange.

"We have come such a long way and are pleased with developments at the mine site," said Morné du Plessis, Minergy's chief executive.

"We are extremely excited about the future of the project, our ability to supply coal into the region, the highly experienced team responsible for executing the plan, as well as our capacity to contribute towards a viable coal sector in Botswana."

Mine infrastructure, including extensive civil work, power reticulation, water reticulation systems, access roads, weighbridges offices and workshops was completed earlier this year, and the mine box cut was ahead of schedule.

"During early July 2019, the plant had successfully passed both electricity connectivity and leak tests and we are pleased to report that it is now fully operational, producing saleable coal," du Plessis added.

Plant upgrades are ongoing to improve efficiencies and provide consistency in both product quality and sizing.

To date Minergy has extracted roughly 39,000 tons of coal. In excess of 340,000 tons are exposed in the pit, which only needs to be blasted and put through the plant. This equates to roughly three months of feedstock.

According to the mine plans, from August this year it is envisaged that Minergy will be mining 110,000 tons run of mine per month. The same quantities will be put through the washing plant and this should result in saleable coal of between 70,000 and 80,000, increasing to 100,000 tons per month next year.

It is envisaged that a steady state of operations will be reached in September 2019.

Demand for the product is high as a result of the short supply of coal specifically into the South African industrial market. It is believed that South African electricity generator Eskom will suffer a shortfall in coal supply of 470 million tons by 2030. Large players in the sector, Anglo American and South 32, are respectively withdrawing from the coal sector and disposing of their coal assets, meaning the supply will tighten even more.

Minergy is currently exploring various options for offtake, ranging from longer-term agreements for the finer duff product to spot deals for the bigger fractions.

The company has recently raised P90mln from the Botswana Development Corporation as well as from the Minerals Development Corporation of Botswana. The funding is sufficient to bring the mine into production.

Myanmar continues with plans

Coal-fired plants will continue to be in use despite objections by different groups on grounds of health and environmental pollution, Ministry of Electricity and Energy deputy minister U Tun Naing said.

He told the Amyotha Hluttaw, the upper house of Myanmar's national bicameral legislature, that the government intended to go ahead with the construction of coal-fired plants to address the energy shortage in the country.

"We're planning to go ahead with our plan to build coal-fired plants in partnership with private companies," U Tun Naing said at a meeting held on August 16 with the Amyotha Hluttaw.

He said that in its latest power mix plan, Myanmar will draw 33% of its energy needs from coal. "That's about 7,940 megawatts (MW) out of the total installed capacity of 23,594 MW," he said.

Meanwhile, 38pc will be supplied by hydropower, 20pc by natural gas and the remaining by renewable sources of energy such as solar power.

In comparison, under the country's Energy Master Plan published in 2014 to address energy shortfalls, coal will form 30pc of the energy mix by 2030. Hydropower had the biggest share at 57pc at the time, with the remaining generated by natural gas and renewable energy.

Despite the need for more energy to generate power, coal plants have faced difficulties operating due to objections by villagers worried about its health implications. Last year, the government scrapped a US$2.8 billion coal-fired plant to be built near the Karen State capital of Hpa-An by Toyo-Thai Co Ltd, a joint venture involving Thai and Japanese engineering and construction firms.

In 2014, a coal-fired plant operated by Wuxi Huaguang Electric Power Energy Co Ltd was shut down when it ignored a waste management request issued by the Ministry of Electricity and Energy. The request was issued after the ministry received complaints about the impact of waste from the plant on the surrounding environment.

But a year later, the plant recommenced operations after it pledged to upgrade the plant and conduct the necessary waste management procedures. Approved in 2002, the 120-megwatt Tigyit plant is Myanmar's first coal-fired power plant.

Detractors of coal-fired plants have noted that while coal remains a major source of feedstock for power plants, its use has gradually fallen. They have pointed out that Myanmar should leverage on its abundant hydropower sources instead of using coal.

U Ko Ko, Sagaing Region's Amyotha Hluttaw representative for constituency No. 8, backs a plan to generate up to 8,000 MW of electricity from coal-fired plants. The region is a major producer of coal, especially in the Kalaywa area, where coal-mining firms have been accused of polluting the environment.

"We can't be choosy about where the electricity comes from especially when it can benefit the country and people. It is not the time to say no to coal when only 35pc of our country's population have access to electricity.

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Experimental investigation on crack development characteristics in shallow coal seam mining in China

The development of cracks in mining is the scientific basis for the safety and environmental exploitation of shallow multiple seam. According to the "thickness of coal seam, interactive distance, and buried depth," four mining coal mines are selected in Shen Fu-Dong Sheng coalfield (SFDSC). To research the mining conditions of shallow coal seam under different base-load ratio mining conditions and different working faces by the physics simulation and in-sit measurement, the key roof caves are sketched by different colours. This study shows that the typical shallow coal seams in the thin overlying bedrock and thick loose sand layer (LSL) as well as the development of the setup entry cracks (SEC) is dominated by LSL arch damage. The surface cracks are almost directly above the setup entry. The flat seam mining and the SEC development is dominated by parabolic type. The surface cracks are located inside the setup entry. With the mining height increased typically in a shallow coal seam, the rate of crack development and the extent of damaged area increased significantly. The SEC and boundary cracks are fixed. The dynamic periodic cracks (DPC) show the ability of the strata to self-repair. During the multiple-seam mining, the above three kinds of cracks have the phenomenon of activation and development. Through the reasonable coal pillar distance arrangement, the development of boundary cracks can be effectively controlled, and the relatively uniform surface settlement and crack closure can be achieved. The purpose of reducing damage mining can also be achieved. Furthermore, it provides scientific support for the green mining in the shallow coal seam.

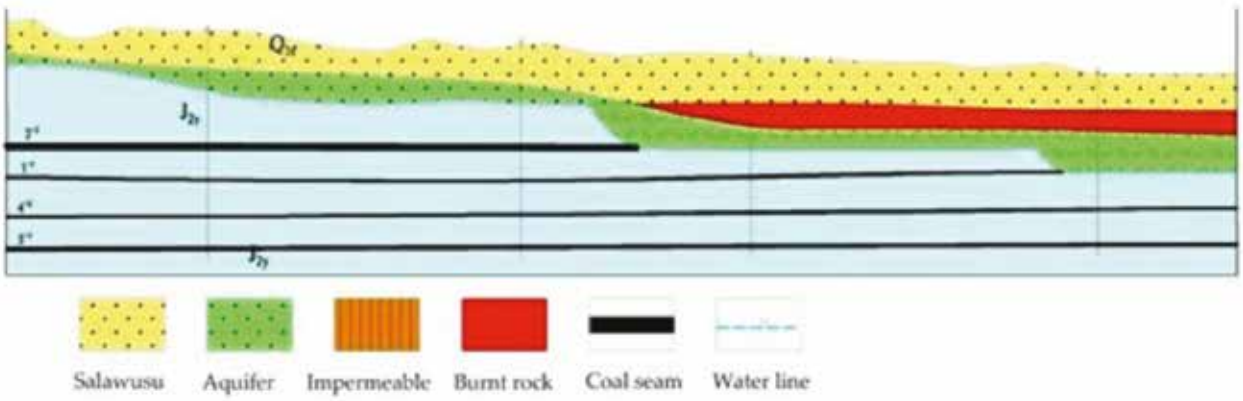


Figure 1: Sectional view of workable coal seams from Zhangjiamao Coal Mine in SFDFC, China.

INTRODUCTION

The Jurassic coalfield is located in northern SFDSC. The seams are generally characterized by shallow depth, is nearly horizontal, and has three to four workable coal seams. The interactive distance is about 20 to 40 m (**Figure 1**), so it belongs to the multiple-seam mining. With the continuous consumption of mineral resources, multiple-seam mining has become an inevitable trend. The realization of environmentally-friendly multiple-seam mining is a major topic in science mining in the shallow coal seam[1,2,3,4].

In recent years, domestic scholars have carried out extensive research on surface subsidence and ground cracks in shallow coal seam, and have become one of the new hot topics. Huang et al. [5,6] found that the load transfer effect under the thick LSL mining and the law of the key block load transfer is given. The stability of the water-resistant key strata in strip filling is an effective way to protect water mining. The height formula for the "upward crack" and "downward crack" of the strip filling water retention is given[7,8]. Liu[9,10] analysed the law of the dynamic development of mining ground cracks in shallow coal seam, and proposed corresponding treatment techniques. Hu *et al*.[11,12] conducted in-depth research on the distribution characteristics and development of subsidence ground cracks in shallow coal seam. Hu *et al*. pointed out the impact of mining on the surface environment is mainly subsided ground cracks and the edge cracks are the focus of restoration.

Fan[13,14] used remote sensing technology to study the distribution of ground cracks in the Yushenfu mining area and found the high-strength mining areas in the loess gully area have dense ground cracks and serious surface damage. Chen[15,16] studied the distribution characteristics and formation mechanism of surface cracks in the Shendong mining area, pointed out that surface dynamic tensile cracks appeared periodically with the advancement of the working surface, and stepped cracks appeared near the boundary of the working surface. The overburden stress distribution map is presented. Yu *et al*.[17,18,19] researched on mining cracks under different mining conditions. Peng *et al*.[20] conducted a large-scale three-dimensional physical similarity simulation experiment in order to explore the development mechanism of Xi'an ground fissure, which provided some enlightening significance for the mining engineering physical similarity simulation experiment to study mining cracks. Mao *et al*.[21] proposed the integrated management of coal mine spatial information, based on the "temporal" characteristics of coal mine data, expounding the importance of spatio-temporal synergy between underground and ground, and providing technical support for the dynamic study of surface cracks. Xu *et al*.[22] studied the caving pattern of overlying strata and determined the calculation method of fracture pathway parameters due to roof caving induced by coal mining. Zhang *et al*.[23] applied the geophysical-chemical properties of radon in mining engineering, and the field-measured results are good.

However, most of the above academics are based on the actual measurement and numerical simulation analysis of the shallow coal seam in the thick rock and loose layer. The study on the shallow buried thin rock and thick loose layer has not deepened. The secondary development mechanism of surface cracks needs to be improved in shallow multiple-seam mining.

Based on a large number of physical similarity simulation experiments, the law of crack evolution in shallow single coal seam under different base-load ratio mining conditions is investigated. Study on the secondary development law of cracks in multiple-seam mining, and the cracking field of repeated mining overburden is revealed. In addition, the coupling mechanism of surface cracks provides a scientific basis for the safe and environmentally-friendly mining in shallow coal seam.

PHYSICAL SIMULATION DESIGN AND METHODS

Experimental Design

Huang[24] proposed a scientific definition of typical shallow coal seam and near shallow coal seam. Characteristics of the typical shallow coal seam, the thin overlying bedrock and thick LSL, with the single key stratum, the roof is easily broken and the step is sinking. However, the near shallow coal seam has the thick overlying bedrock and thin LSL, with double or three key stratums. According to the ratio of thickness of coal seam and interactive distance, and whether the inter-burden contains key stratum, the shallow multiple-seam is divided two types including utmost closely spaced multiple-seam, and closely spaced multiple-seam. Combined with a large number of physical simulation in shallow coal seam and shallow multiple-seam mining, analyzed the physical simulation of the crack evolution law (PSCEL) of shallow coal seam mining.

Physical simulation experiments used similar principles to determine similarity constants, in order to simulate actual mining formations. Based on "thickness of coal seam, interactive distance, and buried depth," four coal mines are selected in SFDSC, and the parameters of coal and its roof and floor are listed in **Table 1**. Those values in **Table 1** were obtained from the experimental determination or from the references[1,7,8].

Methods

The physical similarity simulation experiment is convenient for people to intuitively acquaint and understand mining activities, and master the breaking law of mining on overlying strata. The main process is as follows.

First, the object of the physical simulation experiment is the prototype on site. According to the similarity theory, to satisfy the basic similar conditions (for example, geometric similarity, dynamic similarity and boundary similarity, etc.) in the simulation experiment body (for example: two/three-dimensional plane stress model frame, wind tunnels, sinks, etc.) to conduct the experiment to research the laws of the prototype[1,2]. Therefore, it is important to determine the geometric similarity ratio and select the appropriate model framework.

Table 1: The parameters of coal and its roof and floor of four coalmines.

Coal Mine (Working Face)	Lithology	Thickness (m)	Bulk Density (kg/m^3)	Young's Modulus (GPa)	Compressive Strength (MPa)	Cohesion (MPa)	Poisson's Ratio
Daliuta (1203)	Sand layer	45.0	2.25	0.18	7	0.02	0.4
	Fine sandstone	13.0	2.4	16.24	48	7.4	0.21
	Siltstone	6.0	2.4	9.83	36	7.2	0.14
	No. 1-2 seam	4.0	1.3	3.63	13	1.2	0.2
Huoluowan (22102 and 22104)	Muddy siltstone	13.8	2.14	7.29	29.6	4.9	0.33
	Medium quartz sand	7.30	2.65	19.24	85.7	12.8	0.15
	Muddy siltstone	2.67	2.14	9.63	29.6	4.9	0.33
	No. 2-2 upper seam	2.70	1.35	2.13	13.4	1.23	0.29
	Fine sandstone	4.24	2.40	14.45	45.7	3.3	0.21
	Quartz sandstone	1.88	2.65	20.29	83.7	13	0.13
	No. 2-2 seam	2.50	1.35	2.24	13.4	1.23	0.29
Zhangjiamao (15203)	Fine sandstone	1.19	2.23	15.89	51.7	1.56	0.35
	Siltstone	1.91	2.42	9.24	43.8	1.25	0.27
	Fine sandstone	1.67	2.21	14.33	48.5	1.56	0.35
	Mudstone	1.78	2.50	6.13	6.29	0.28	0.19
	Fine sandstone	2.6	2.21	14.45	32.3	1.56	0.34
	Mudstone	2.8	2.48	6.29	6.30	0.28	0.19
	No. 5-2 seam	6.1	1.32	3.45	12.8	1.35	0.26
Ningtiaota (N1114 and N1206)	Siltstone	6.7	2.42	12.05	35.3	0.65	0.32
	Medium sandstone	9.96	2.33	19.49	40.6	1.5	0.28
	No.1-2 seam	1.89	1.29	4.25	15.7	1.3	0.28
	Fine sandstone	2.85	2.23	9.53	25.6	1.2	0.27
	Fine sandstone	6.55	2.27	12.58	29.6	1.5	0.29
	Siltstone	3.8	2.44	11.22	46.0	0.9	0.30
	Fine sandstone	5.90	2.34	16.29	48.5	1.9	0.27
	Siltstone	1.0	2.40	11.24	45.3	1.2	0.30
	Fine sandstone	11	2.60	16.63	43.6	1.5	0.35
	Fine sandstone	2.16	2.30	16.63	45.6	2.2	0.27
	No. 2-2 seam	4.60	1.34	4.45	13.8	1.4	0.27

Second, based on the lithology in **Table 1**, the proportion of similar materials of each rock layer is determined, and the physical similar simulation experiment is laid forward. Generally, the aggregate selected from the rock layer is river sand, and the cementing material is gypsum and white powder. Impermeable clay or read clay was used to simulate the LSL and experimental oil was added to increase the viscosity. Then, we begin carrying out experimental excavation. All the experiments are excavated from left to right. In the process of mining, the total station and dial indicator are used to monitor the subsidence of overburden and surface. At the same time, select the appropriate fixed position. Use the high-definition camera to record the key experimental phenomena (**Figure 2**).

Lastly, the data of the experimental process is analysed and processed. The innovations in this experimental process are using the experimental photos taken by a high-definition camera taken at the same location, using AutoCAD software to sketch the experimental process.

This paper is based on the physical simulation experiment to investigate the crack development characteristics in shallow coal seam mining. Two aspects need to be explained.

1. The author focuses on the macroscopic crack development characteristics after the rock is mined and destroyed in this paper. There are some limitations in the existing experimental conditions and methods. It is impossible to simulate the micro-cracks, voids, and other structures inside the rock mass. In addition, the behaviour before and after the rock mass destruction is very complicated. Therefore, macro cracks and microstructures are not involved in this paper.

2. Table 1 shows the types of overburden mentioned are bedrock layer, red soil layer, sandy layer, and quicksand layer. According to the orthogonal experimental method, the authors made standard test pieces for different proportions, and carried out experiments on uniaxial

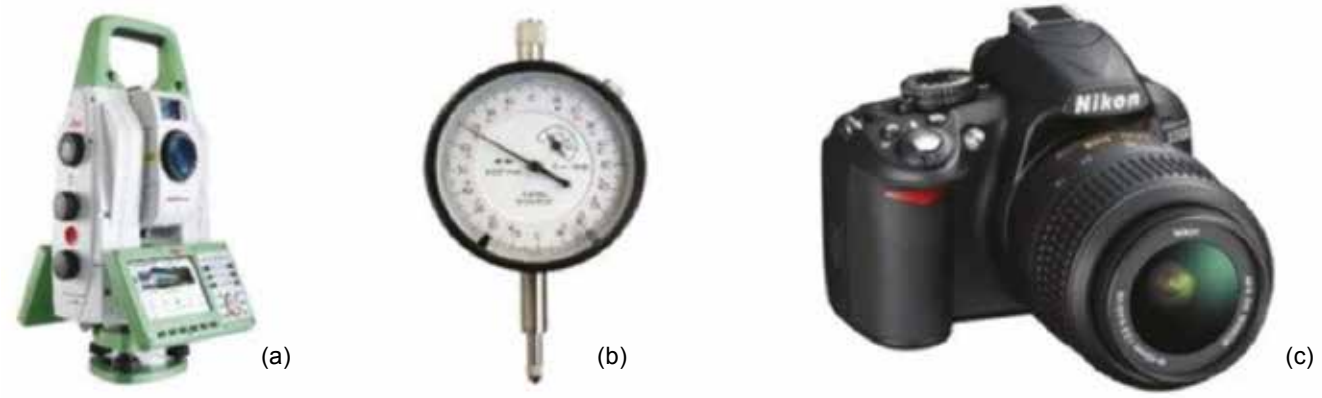


Figure 2: Monitor systems in physical simulation: (a) total station, (b) dial indicator, and (c) camera.

compressive strength in the laboratory. Based on the geometric similarity ratio, the intensity similarity ratio is determined, the result is obtained by the conversion of the intensity similarity ratio, which is compared with the strength of the corresponding layer of the prototype. The closest matching ratio number is selected to simulate the paving of each rock layer on the working surface to reduce the source of error in the experiment. With a large number of experiments, the authors used different aggregates and ratios to simulate the mechanical and structural characteristics of elastoplastic deformation or viscoelastic deformation characteristics of the rock (for example, red soil layer and the sand layer), and all of them achieved good experimental results.

EVOLUTION LAW OF CRACKS IN SHALLOW COAL SEAM

PSCEL of Typical Shallow Coal Seam

Taking the 1203 working face of Daliuta Coal Mine as the background, the No. 1-2 seam mines 68 m deep, the thickness of bedrock is 19 m and LSL is 45 m, and the mining height is 4.0 m. The geometric ratio is 1:100. When the face has advanced to 32 m, the roof caves for the first time, the thick LSL showed “loose arch” damage (**Figure 3**, black line) when advanced to 48 m. During the first periodical weighting, the LSL was still “arch” and the crack development height was 26 m (**Figure 3**, red line). When advanced to 64 m, the second periodical weighting, the “arch shell”-like separation zone is formed in the thick

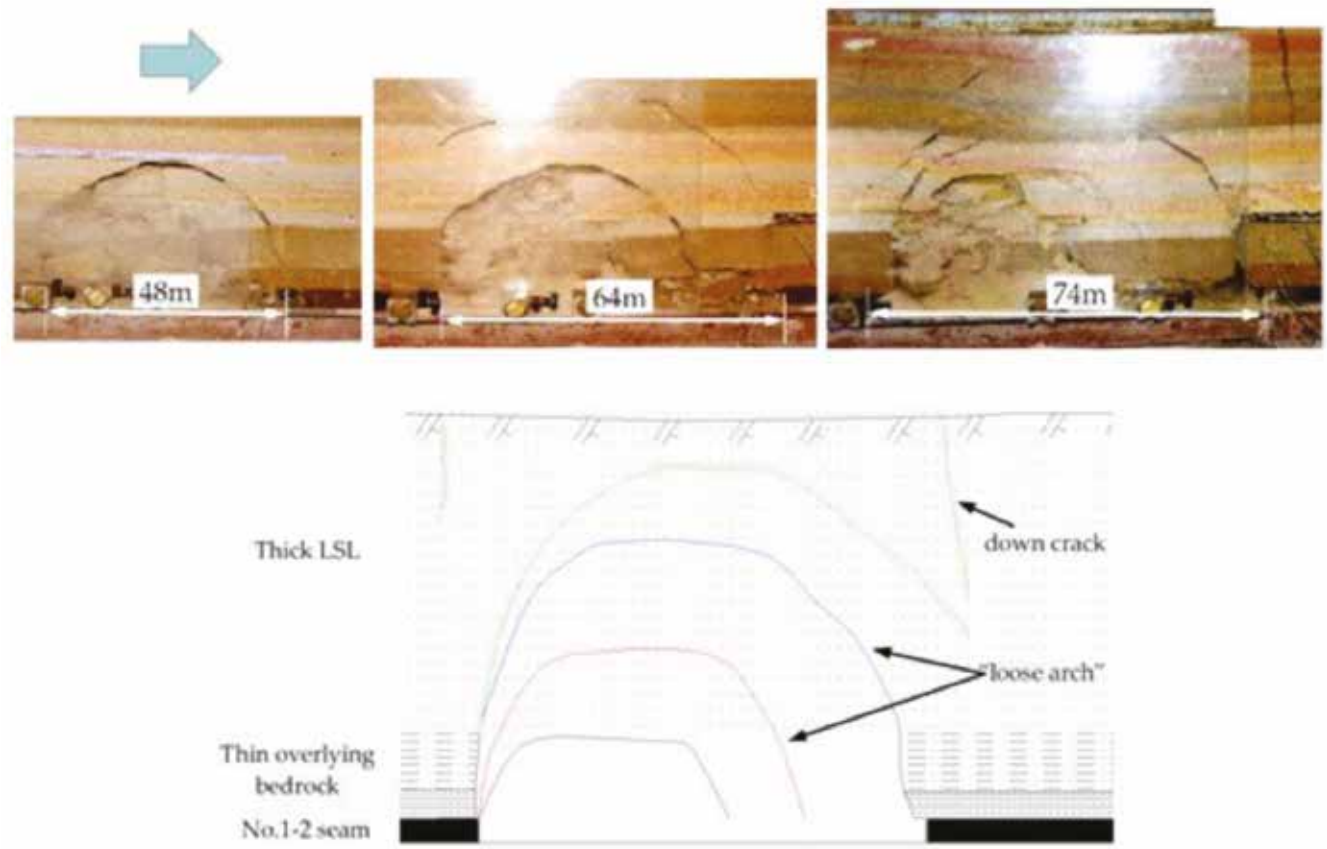


Figure 3: Sketch drawing of evolution of periodic cracks in mining.

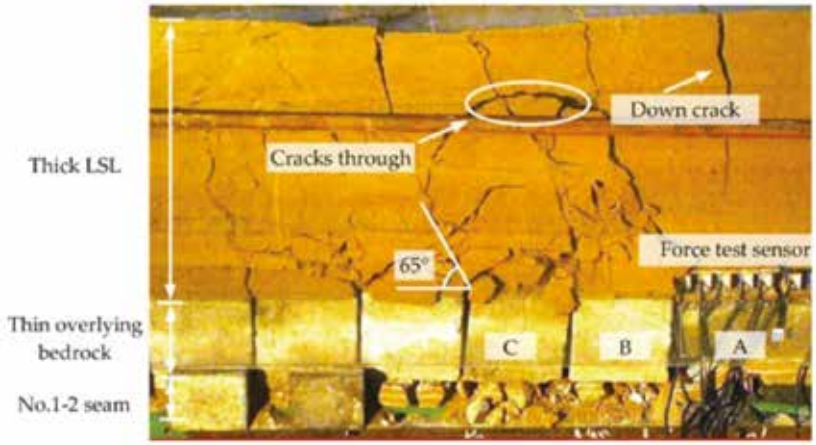


Figure 4: Periodic arc-shaped pillars and arching.

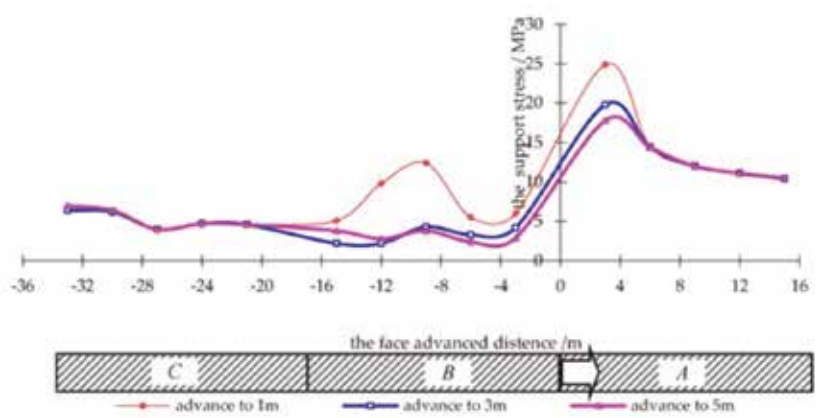


Figure 5: Key block dynamic load change in mining.

LSL (**Figure 3**, blue line). After reaching a full mining stage, the surface is generated in front of the coal wall. A physical simulation sketch of a typical shallow coal seam mining is shown in **Figure 3**. The sketch map of simulation is to sketch the fixed-point photographs in the simulation experiment frame one-by-one in sequence. Each color represents the crack of working face periodically falling at different times.

According to **Figure 3**, we found the cracks include upward cracks that develop from the bottom to the top, and down cracks develop from the top to the bottom. The upward cracks have SEC and DPC in the face, and the downward cracks have tensile cracks in the surface LSL or bedrock.

In the typical shallow coal seam mining process, the SEC increases with the face advanced distance. The roof breaking angle is about 65°. After full mining, the periodic segmentation of the roof plate shows the phenomenon of "secondary arching" in the curved rock pillars on the two broken rock blocks, and the surface steps sink down (**Figure 4**).

In addition, **Figure 4** shows the periodic cracks of the overlying strata in the thick LSL are periodically "arc rock pillars" and the height of the arc develops rapidly with the increase of the face advancing distance.

Figure 5 shows the critical value of the A key block support pressure is continuously reduced. The average load of the thick LSL on the B key block is reduced and the key block of C is not changed much, which indicates that the caving of thick LSL requires a certain time and process in the gob.

PSCEL of Nearly Shallow Coal Seam

Taking 22102 working face of Huoluowan Coal Mine as the background, the face is located in No. 2-2 upper seam, the seam buried depth is 115 m, the thickness of LSL is 27 m, and the thickness of overlying bedrock is 88 m, the mining height is 2.5 m, and the similarity ratio is 1:100.

The development of the overlying cracks in the experimental process of 22102 working face is sketched (**Figure 6**). The DPC in the subsidence basin are closed in the affected layer of the overburden structure, the surface settlement is slowed down, and the stratum presents a certain self-repair. During the process of advancing the working face, the overburden is still moving in the gob. The original separation or cracks has decreased or closed with the movement of the overburden. It could account for the stratum presenting self-repair characteristics.

PSCEL of Large Mining Height Cracks in Shallow Coal Seam

Under the large mining height face, the development height and width of the crack (including SEC and DPC) have a relationship with the mining height. Taking 15201 working face of Zhangjiamao Coal Mine as the background, the average buried depth is 120 m, the thickness of LSL is 50 m, the thickness of bedrock is 70 m, the mining height is 6.2 m, and the geometric ratio is 1:50.

Using the principle of controlling single variables in the physical simulation, the method of variable height of the slabs simulates the regularity of mining PDC under the mining height, which is 4 m, 5 m, and 6 m on the same model (**Figure 7**).

Figure 7 and **Figure 8** show the DPC evolution under different mining heights. The height is the only variable. As the mining height increases, the periodical weighting intervals and the range of cracks and the crack development speed grow.

In the actual mining process, the ground surface crack development law is observed manually. In the initial mining stage of the 6 m large mining height working face and the step type sinks. The surface damage is extremely serious. **Figure 9** shows the surface damage from the step cracks in the shallow coal seam mining. The coal mine ecological resources are threatened.

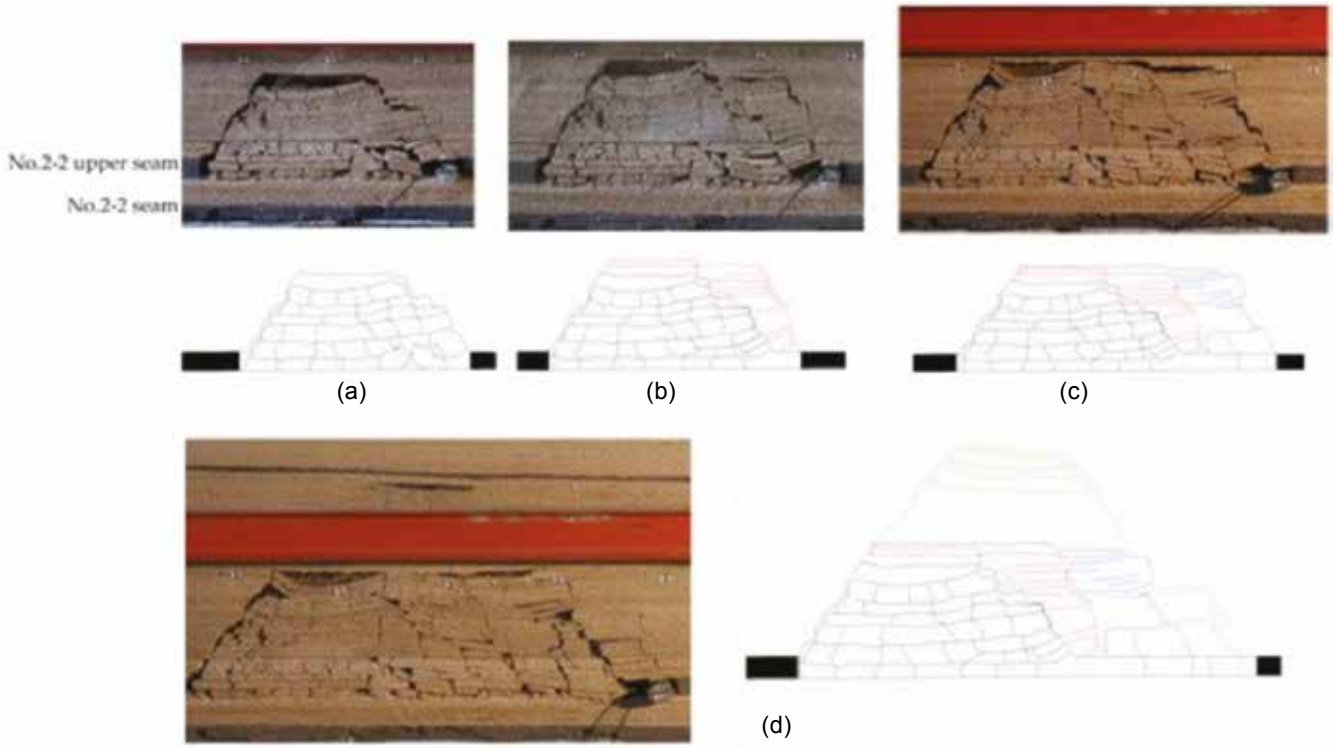


Figure 6: Crack development in different positions of 22102 working face: (a) advanced to 60 m, (b) advanced to 67.5 m, and (c) advanced to 80 m, and (d) advanced to 90 m.

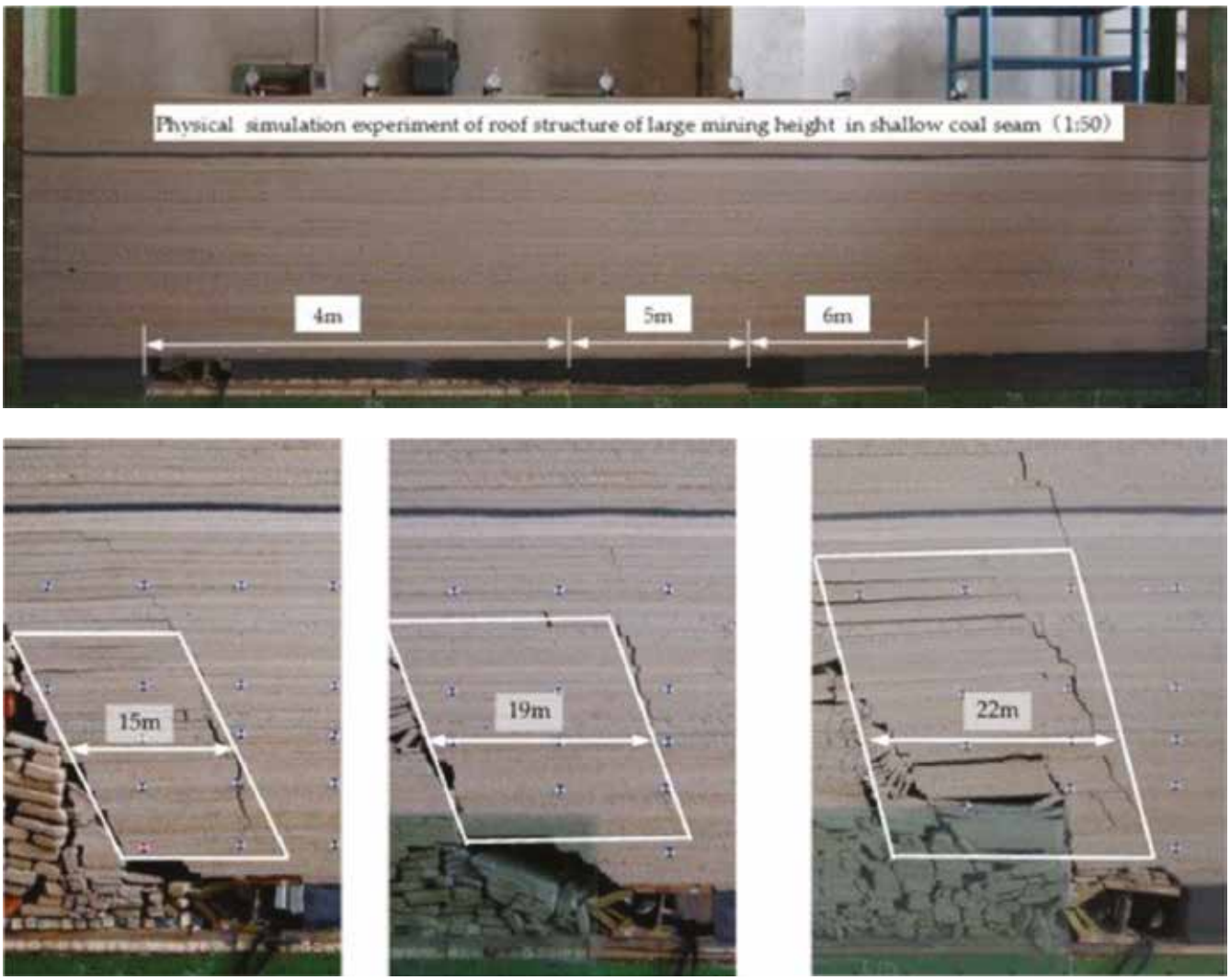


Figure 7: Simulated the mining height at 4 m, 5 m, and 6 m: (a) physical simulation model, (b) the mining height is 4 m, (c) the mining height is 5 m, and (d) the mining height is 6 m.

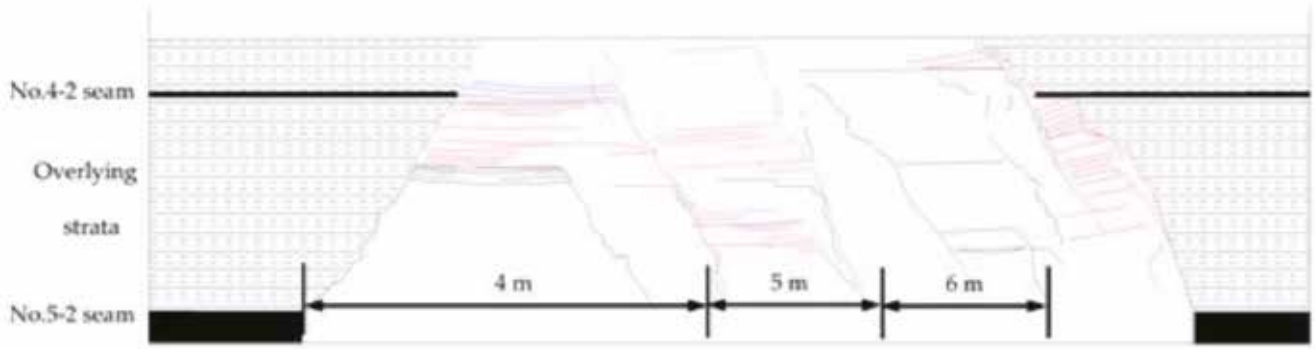
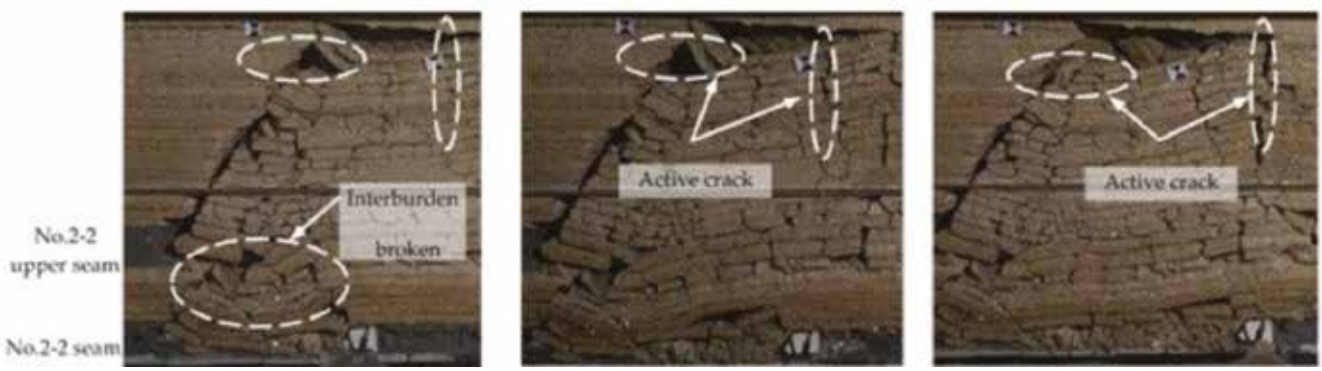


Figure 8: Sketch drawing of the dynamic periodic crack evolution under different mining heights.

Figure 9: Surface damage from the step cracks: (a) step crack, and (b) the height of step crack is 1.6 m.



(a) (b) (c)

Figure 10: 22104 working face activation cracks development schematic diagram: (a) advanced to 20 m, (b) advanced to 27.5 m, and (c) advanced to 35 m.

EVOLUTION LAWS OF CRACKS IN MULTIPLE-SEAM MINING

Through the physical simulation analysis of typical shallow coal seam and near shallow coal seam, it was concluded that different types of shallow coal seam mining have different development characteristics for SEC and DPC. In a typical shallow coal seam, the development of SEC are dominated, which leads to the failure of the LSL-like arch. However, the development of SEC is dominated by parabolic failure of rock layers in a nearly shallow coal seam.

PSCEL of Shallow Utmost Closely Spaced Multiple-Seam

Taking 22104 working face of Huoluowan Coal Mine as the engineering background, the face buried depth of 125 m and a mining height of 2.5 m is located in 2-2 coal seam and close to the upper coal seam gob of 5 to 7 m.

When the 22104 working face has advanced to 20 m, the inter-burden strata completely broke, which leads to the gob of the upper and lower working face is connected (**Figure 10a**). The broken roof caves massively for the first time and the activated crack height is 20 m. When the face advanced to 27.5 m, the height of the activated crack is 29 m, and the crack of the upper seam is widened (**Figure 10b**). When the face advanced to 35 m, the height of the activated crack reaches 34 m (**Figure 10c**).

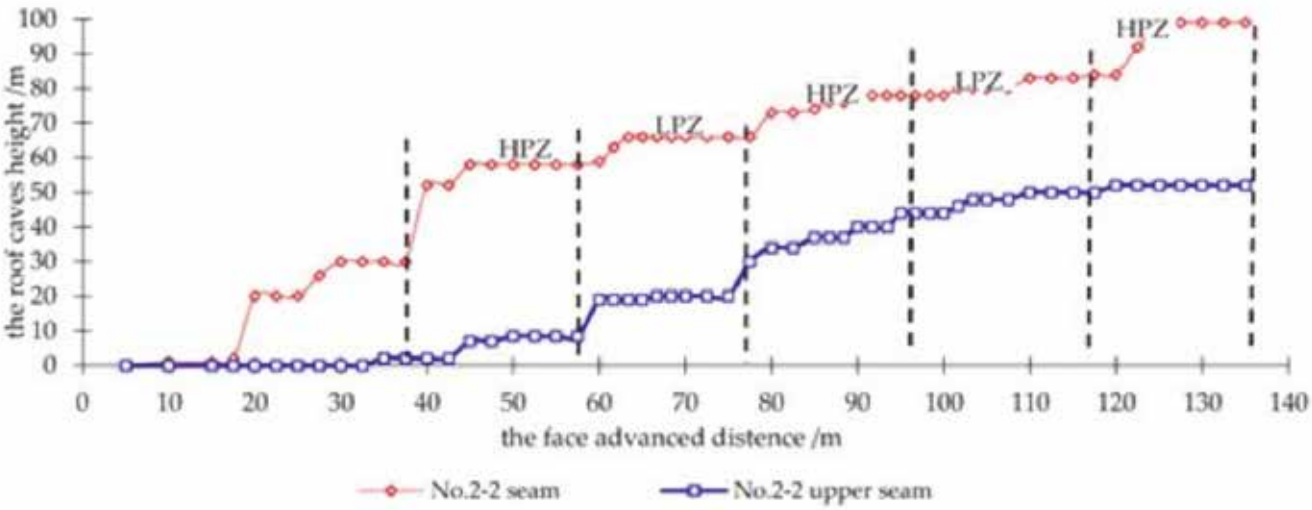


Figure 11: Advanced to 40 ~ 65 m high-pressure zone of the cracks activation.

As the face has advanced 38 to 58 m, the periodical weighting of the broken roof is about 5 to 7.5 m, the crack development speed of the overburden is significantly increased, and the average load of the simulated support is 7150 kN/frame. When the face has advanced 58 to 78 m, the crack development is not clear and the average load of the simulated support is 4810 kN/frame. The development speed and range of the activation crack lead to the "High Pressure Zone" (HPZ) and "Low Pressure Zone" (LPZ) as shown in **Figure 11**. According to **Figure 11**, when the lower seam roof caves height's slope increased more than the upper seam in multi-seam mining, it will cause the face HPZ phenomena.

When the mining reaches ultra-sufficient mining, the activation cracks in the overburden are developed, as shown in **Figure 12**. The SEC has developed on the surface, which forms the step crack shapes. The crack at the surface of the upper coal seam is reactivated, and the depth and width of the crack is increased.

The sketches of the crack activation and development process of the 22104 working face when entering and crossing the coal pillar are selected (**Figure 13**) and the width of the upper pillar is 25 m. Four colors represent four locations in the face. The black represents **Figure 13a**, the red represents Figure 13b, the blue represents **Figure 13c**, the green represents Figure 13d, and the physical simulation in different position's schematic diagram are shown in **Figure 13e–g**.

Figure 13e illustrates that the working face has advanced **Figure 13a,b**, the face entering the upper coal pillar (UCP) inverted trapezoidal affected zone, with the range and height of the coal pillar cracks (CPC) increasing. Compared with **Figure 13b,c**, the range and height of CPC grows insignificantly. However, the UCP inverted trapezoidal affected zone caved massively, while the face advanced after the UCP, as shown in **Figure 13g**. Combined with the production practice, the working face will occur in the midst of mine pressure in crossing the range of UCP.

PSCEL of Shallow Closely Spaced Multiple-Seam

The N1114 working face in No.1-2 coal seam (upper seam) and the N1206 working face in No. 2-2 coal seam (lower seam) of the Ningtiaota Coal Mine. The N1114 working face buried depth is 123 m, the thickness of bedrock is 81 m, the thickness of LSL is 42 m, and the height of mining is 1.75 m. The N1206 working face buried depth is 163 m, the thickness of bedrock is 121 m, the thickness of LSL is 42 m, the mining height is 5.46 m, and the geometric ratio is 1:200.

Since the N1114 working face has advanced to 55 m, during the main roof first weighting, the crack height was 18 m. When the face advanced to 74 m, the main roof first periodic weighting and the crack height was 26 m. As the face advanced to 97 m, the height of the crack was 43 m. When the face advanced to 110 m, the height of the crack was 46 m (**Figure 14**).

The No.1-2 seam was excavated in the model. The seam included the N1114 working face and the N1115 working face, their width is 245 m and the coal pillar is 20 m. The "W" type surface subsidence line is shown in **Figure 15**. When the working face of the lower seam has advanced

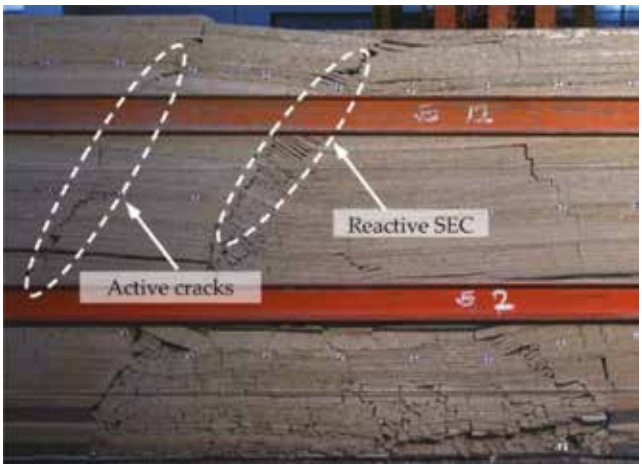


Figure 12: Development of cracks in overlying strata after supercritical mining.

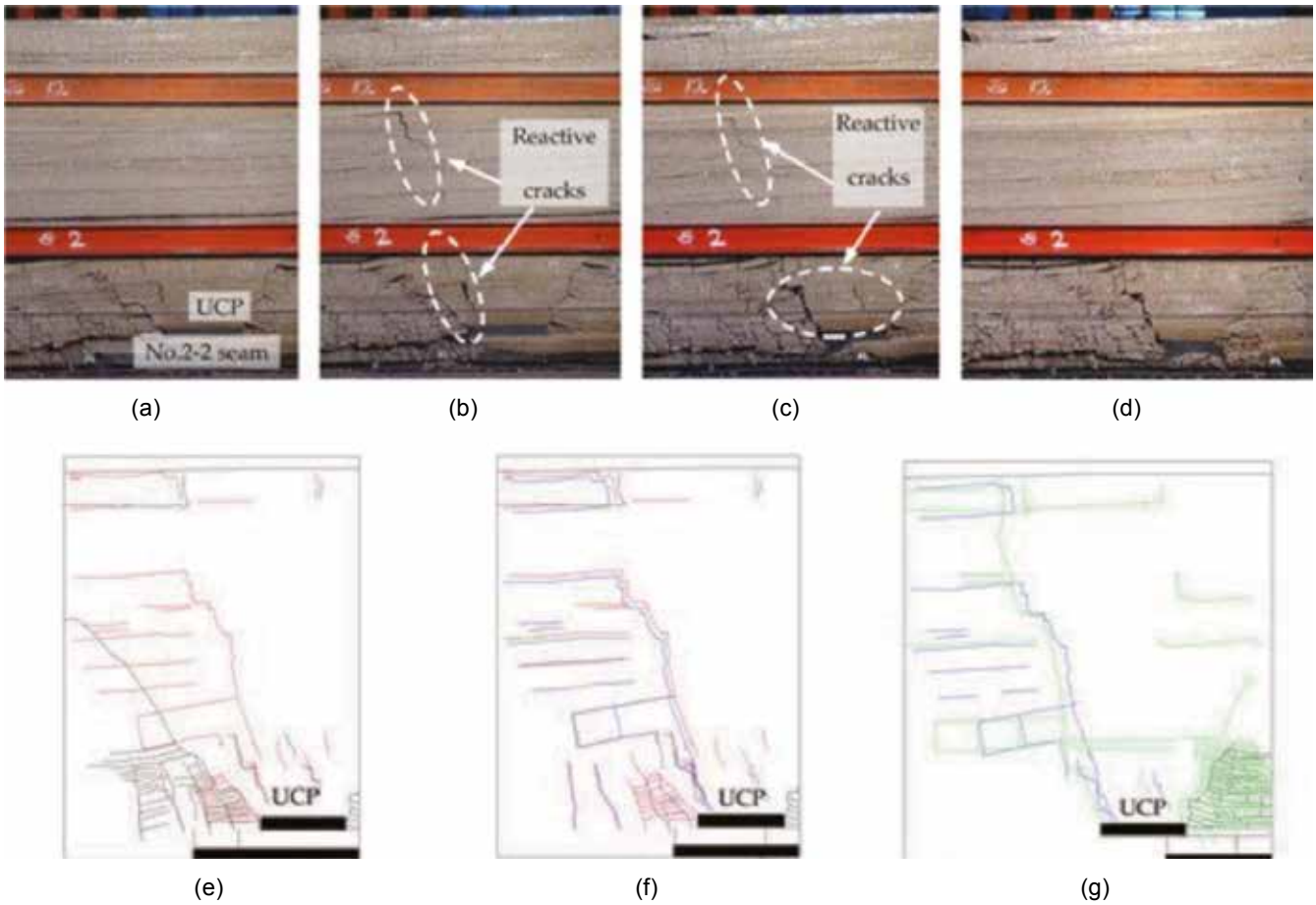


Figure 13: CPC activation schematic diagram: (a) 20 m from the UCP left side, (b) 10 m from the UCP left side, (c) before 10 m from the UCP right side, (d) behind 20 m from the UCP right side, (e) comparative positions (a,b), (f) comparative positions (b,c), (g) comparative positions (c,d).

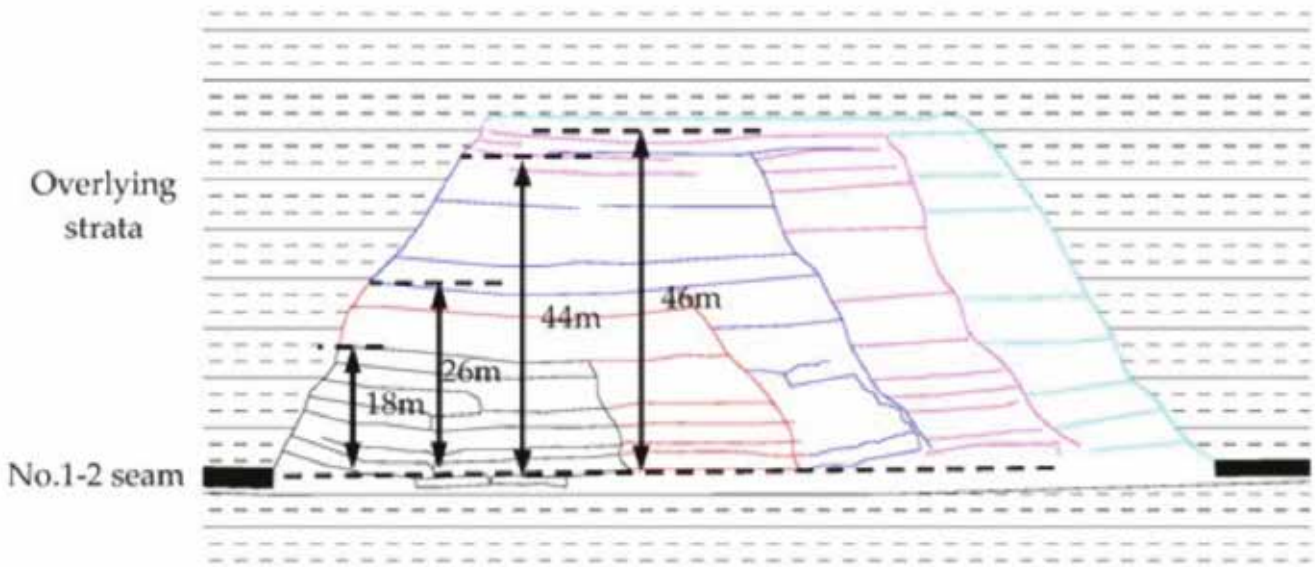


Figure 14: Sketch drawing of evolution of DPC in N1114 working face mining.

to the range of the section coal pillar by the upper seam, due to the influence of the section coal pillar the surface subsidence value is smaller than other locations.

Figure 16 shows the DPC activation of the schematic diagram in the face advanced in different locations. The black lines represent the first weighting. The DPC height is 29 m. The red lines represent the first periodic weighting. The DPC height is 56 m with inter-burden bedrock completely broken, and the activated upper and lower gobs are through. The blue lines represent the second periodic weighting. The activated crack height is 94 m. When the face has advanced to 130 m, the green lines represent the fourth periodic weighting and the activated crack height reaches 163 m.

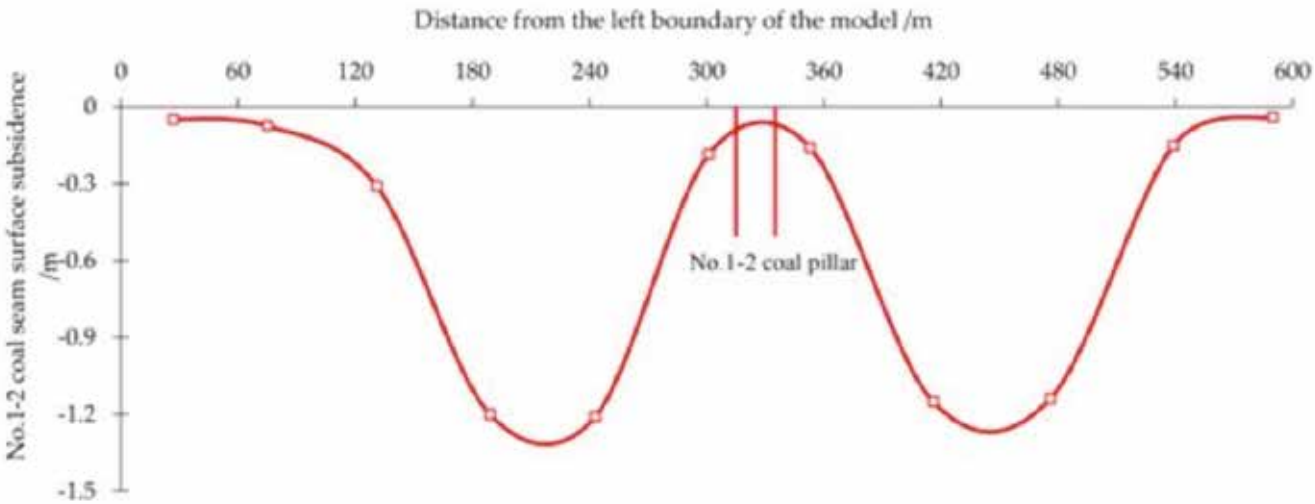


Figure 15: Surface "W-shape" subsidence curve after 1-2 coal seam physical simulation mining.

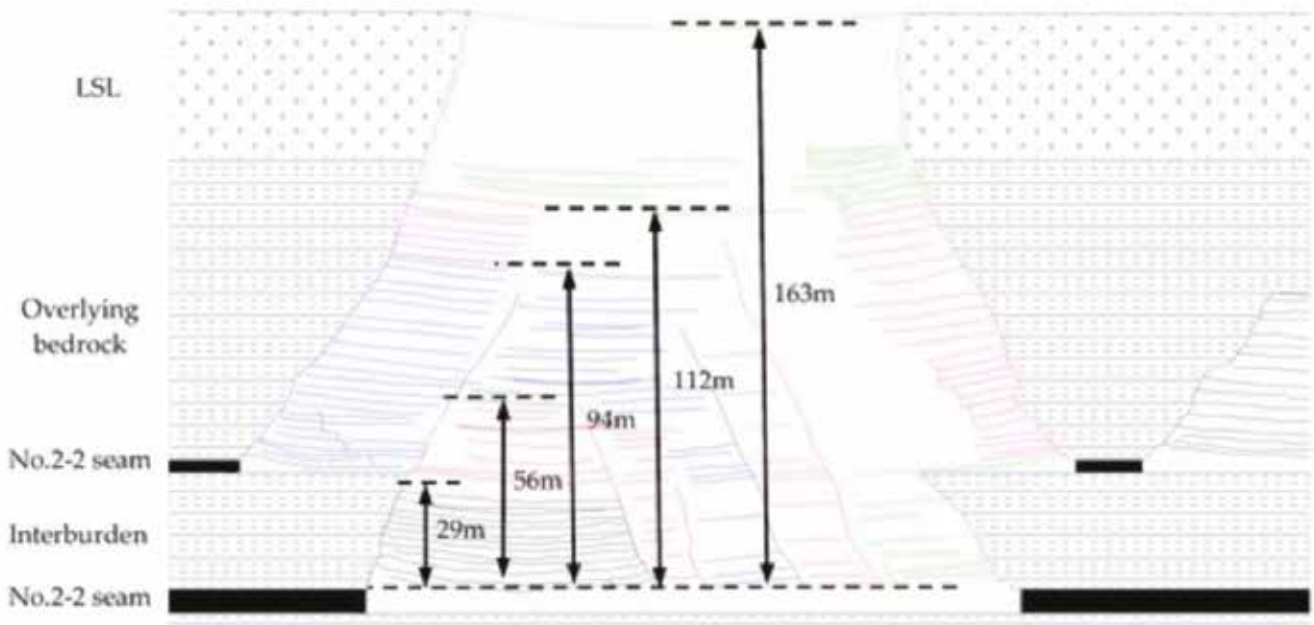


Figure 16: Figure 16. N1206 working face DPC activation development schematic diagram.

Combined with field measurement, when the upper seam working face has mined finished, the fixed crack was selected for observation in the overlapping area of the N1114 and N1206 working faces, as shown in **Figure 17a**. With the mining of the lower seam, when the working face has advanced to the fixed crack location, the crack width increased (**Figure 17b,c**).

When the face enters and across the UPC (**Figure 18**), the CPC is gradually activated before the coal pillar enters the coal pillar, the width of the coal pillar crack increases, and the surface subsidence increases. After the coal pillar, the "inverted trapezoid" body structure of the pillar is completely sunk, the activated CPC are closed again, and the surface subsidence is reduced.

When the 2-2 seam (lower seam) has mined, compared with the surface subsidence value of the 1-2 seam (upper seam), as shown in **Figure 19**. **Figure 19** shows the coal pillars can effectively reduce surface subsidence, for example, the corresponding surface subsidence value of the No.2-2 coal pillar is 2.59m and the No.1-2 coal pillar is 2.84m, however, the maximum value of surface subsidence is 4m. Separately reduced 1.41m and 1.16m.

EFFECT OF COAL PILLAR GROUP STRUCTURE IN MULTIPLE-SEAM MINING

The coal pillar is ensuring the stability of the roadway during the mining process in the lower seam while the stability of the coal pillar mainly affects the stability of the upper seam gob. However, in multiple-seam mining, the size, location, and stability of the coal pillars have a direct impact on the layout of the lower coal seam face.

Figure 20 shows the reasonable coal pillars spacing in the multiple-seam mining and can reduce the surface uneven subsidence. Based on the physical simulation of the Ningtiaota coalmine, when the 2-2 coal pillar is separated from the 1-2 coal pillar by 40 m, and the 3-1 coal pillar is separated from the 2-2 coal pillar by 80 m, the surface sinks evenly.

Figure 17: Field measurement of DPC: (a) the upper seam working face has mined finished, (b) the lower seam working face has finished with the same location, and (c) the lower seam working face has advanced through the position of DPC.

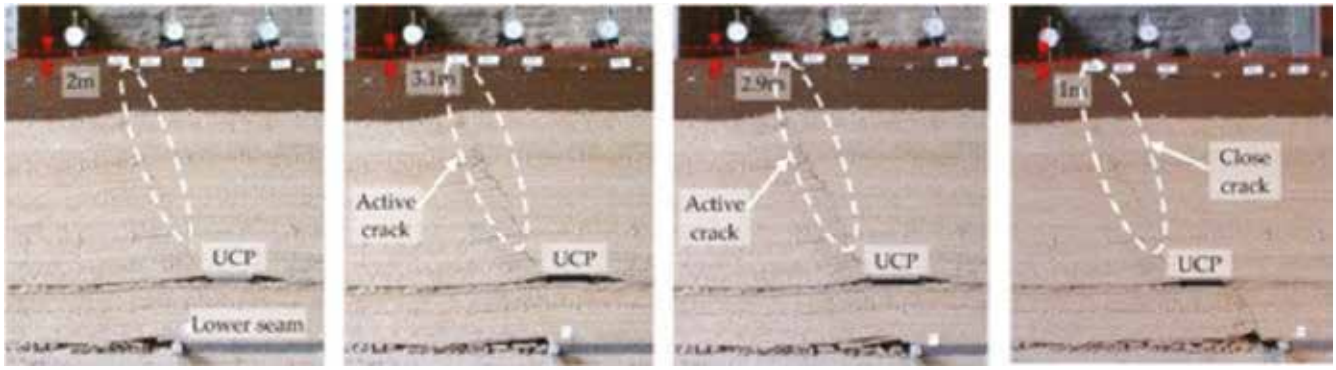


Figure 18: Distance from the center UCP: (a) 10 m, (b) aligned pillar, (c) 0 m, and (d) 40 m.

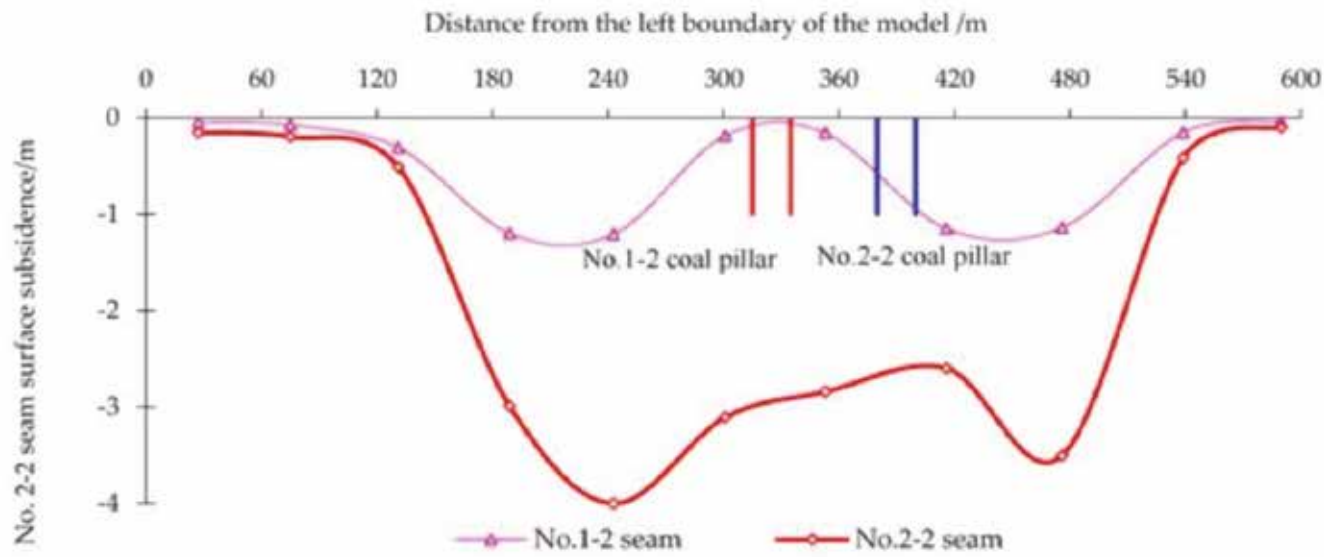


Figure 19: Surface subsidence of 2-2 seam from the physical simulation mining.

Table 2 and **Figure 21** present the position of the coal pillar, which corresponds to the minimum value of the absolute subsidence value, and the subsidence of the affected area of the coal pillar "inverted trapezoid" slows. The absolute subsidence value of the surface are roughly equal, and the rational self-repair of the overlying strata can be achieved through reasonable coal pillar spacing.

According to "Deformation Monitoring and Subsidence Engineering"[25], the length and width of the gob reach and exceed 1.2H-1.4H (H is buried depth) is the sufficient condition for critical mining. When the shallow multiple-seam mining in the Shenfu coalfield, the face has reached supercritical mining. The remaining coal pillars are the main reason of an uneven surface settlement. The author believes that the reasonable coal pillar spacing is arranged by the "inverted trapezoidal" structure formed by the UCP in the uneven settlement area, combined with the distribution range of the coal pillars in the floor stress, with the structural effect of the coal pillar group, and the width of the surface

Table 2: Absolute subsidence value and factor in coal pillars position after multiple-seam mining.

	Coal Seam	No.1-2 Coal Pillar	No.2-2 Coal Pillar	No.3-1 Coal Pillar
Absolute Subsidence Value/m	No.1-2 seam	0.18	1.20	1.21
	No.2-2 seam	2.98	1.85	2.79
	No.3-1 seam	2.05	2.18	1.49
	Total	5.21	5.23	5.29
Absolute Subsidence Factor/%	No.1-2 seam	0.06	0.64	0.64
	No.2-2 seam	0.65	0.40	0.60
	No.3-1 seam	0.75	0.80	0.54

crack, the drop gradually decreases or closes and the surface subsidence basin increases. This realizes the self-repair of the ecological environment in the mining area and achieves the goal of green mining.

CONCLUSIONS

Through physical simulation and measurement, the SEC development is dominated by sand-arched failure, and the surface crack is almost directly above the setup entry in typical shallow coal seam mining. However, in near shallow coal seam mining, the SEC development is dominated by parabolic damage, and the surface crack is located inside the setup entry. As the mining height increases, the crack growth rate and extent of damage increase significantly.

The overlying bedrock cracks in shallow coal seam mining are divided into two types: upward crack and downward crack, according to the development direction. According to the development position, they are divided into three kinds: SEC, DPC, and boundary crack. The temporary DPC generation and closure shows the ability of the formation to self-repair. The permanent fixed crack is the main object to be controlled in a production practice. However, the quantitative analysis of the development of activated cracks needs further improvement during the repeated mining of shallow multiple seam.

The coal pillar of the multiple seam is the main reason for the uneven settlement of the surface. Through reasonable coal pillars spacing, the relatively uniform settlement of the surface and the overlying bedrock cracks can be controlled. The self-repair and green mining of the ecological environment in the mining area can be realized.

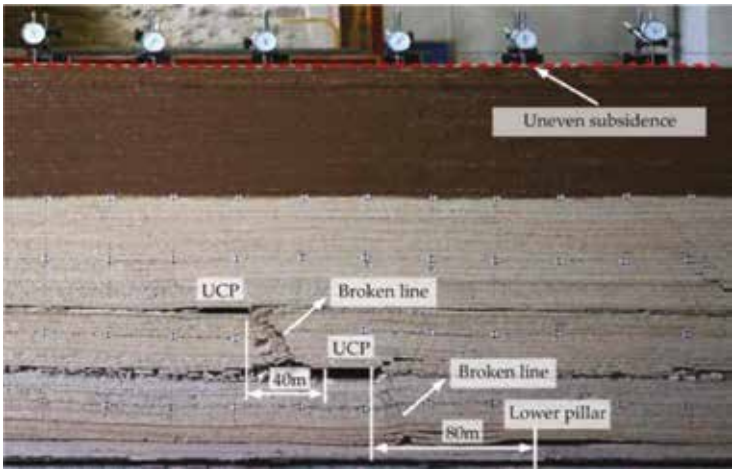


Figure 20: Surface subsidence uniformly with reasonable coal pillars.

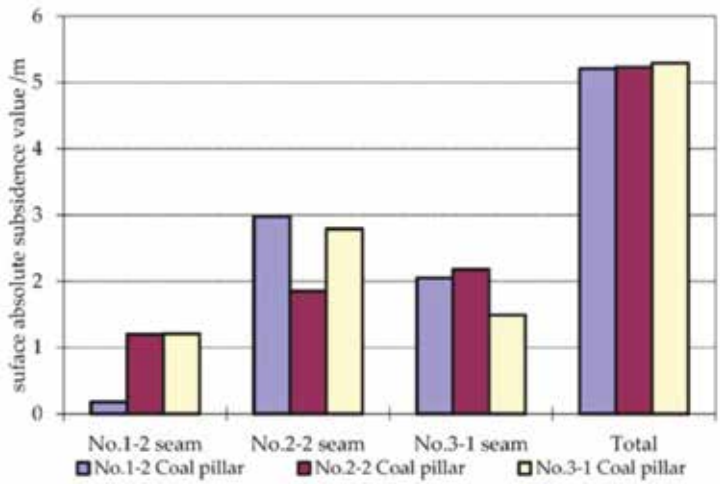


Figure 21: Absolute subsidence value in coal pillars position after multiple-seam mining.

REFERENCES

1. Huang, Q.X. *Study on Roof Structure and Ground Control in Shallow Seam Longwall Mining*; China University of Mining and Technology Press: Xuzhou, China, 2000.
2. Wang, S.M.; Huang, Q.X.; Fan, L.M.; Wang, W.K. *The Key Technology of Water Conservation Mining in Fragile Ecologically Mining Coal Resources*; Science Press: Beijing, China, 2010.
3. Qian, M.G.; Miao, X.X.; Xu, J.L.; Cao, S.G. On Scientized Mining. *J. Min. Saf. Eng*. 2008, **25**, 1-10.
4. Qian, M.G.; Xu, J.L.; Wang, J.C. Further on the sustainable mining of coal. *J. China Coal Soc*. 2018, **43**, 1-13.
5. Huang, Q.X.; Zhang, P. Study on dynamic load distribution on key roof blocks of under thick sandy soil stratum. *Chin. J. Rock Mech. Eng*. 2004, **23**, 4179-4182.
6. Huang, Q.X. Study on loading distribution law on key roof and its structure upon mining face under thick sandy layer. *J. China Univ. Min. Technol*. 2005, **34**, 289-293.
7. Huang, Q.X. Research on roof control of water conservation mining in shallow seam. *J. Min. Saf. Eng*. 2017, **42**, 50-55.
8. Huang, Q.X.; Zhang, W.Z. Mechanical model of water resisting strata group in shallow seam strip-filling mining. *J. China Coal Soc*. 2015, **40**, 973-978.
9. Liu, H.; He, C.G.; Deng, K.Z.; Bian, Z.F.; Fan, H.D.; Lei, S.G.; Zhang, A.B. Analysis of forming mechanism of collapsing ground fissure caused by mining. *J. Min. Saf. Eng*. 2013, **30**, 380-384.

10. Liu, H.; Deng, K.Z.; Lei, S.G.; Bian, Z.F.; Chen, D.Y. Dynamic developing law and governance standard of ground fissures caused by underground mining. *J. Min. Saf. Eng*. 2017, **34**, 884-890.
11. Hu, Z.Q.; Wang, X.J.; He, A.M. Distribution characteristic and development rules of ground fissures due to coal mining in windy and sandy region. *J. China Coal Soc*. 2014, **39**, 11-18.
12. Hu, Z.Q.; Long, J.H.; Wang, X.J. Self-healing natural restoration and artificial restoration of ecological environment for coal mining. *J. China Coal Soc*. 2014, **39**, 1751-1757.
13. Fan, L.M.; Zhang, X.T.; Xiang, M.X.; Zhang, H.Q.; Shen, T. Characteristics of ground fissure development in high intensity mining area of shallow seam in Yushenfu coal field. *J. China Coal Soc*. 2015, **40**, 1442-1447.
14. Fan, L.M.; Ma, X.D.; Li, Y.H.; Li, C.; Yao, C.W. Geological disasters and control technology in high intensity mining area of western China. *J. China Coal Soc*. 2017, **42**, 276-285.
15. Chen, J.J.; Zhu, L.J.; Yan, W.T.; Wang, M.Y. Analysis on distribution characteristic and formation mechanism of surface fissures caused by high intensity mining. *J. Saf. Sci. Technol*. 2015, **11**, 96-100.
16. Chen, J.J.; Zou, Y.F.; Guo, W.B. Study on the Relationship Between Subsidence Coefficient and Mining Degree Under A Thick Alluvium Stratum. *J. Min. Saf. Eng*. 2012, **29**, 250-254.
17. Kang, J.R. Analysis of effect of fissures caused by underground mining on ground movement and deformation. *J. Rock. Mech. Eng*. 2008, **27**, 59–64.

Fan, G.W.; Zhang, D.S.; Ma, L.Q. Overburden movement and fracture distribution induced by longwall mining of the shallow coal seam in the Shendong coalfield. *J. China Univ. Min. Technol*. 2011, **40**, 196-201.

19. YU, X.Y.; Li, B.B.; Li, R.B.; Duan, W.S.; Liu, P.L. Analysis of mining damage in huge thick collapsible loess of western China. *J. China Univ. Min. Technol*. 2008, **37**, 43-47.
20. Peng, J.B.; Chen, L.W.; Huang, Q.B.; Men, Y.M.; Fan, W.; Yan, J.K.; Li, K.; Ji, Y.S.; Shi, Y.L. Large-scale physical simulative experiment on ground-fissure expansion mechanism. *Chin. J. Geophys*. 2008, **51**, 1826-1834.
21. Mao, S.J.; Yang, N.S.; Gao, Y.Q.; Zhang, P.P.; Wu, D.Z. Design and key technology research of coal mine distributed cooperative "one map" system. *J. China Coal Soc*. 2018, **43**, 280-286.
22. Zhang, W.; Zhang, D.S.; Wu, L.X.; Wang, H.Z. On-site radon detection of mining-induced fractures from overlying strata to the surface: A case study of the Baoshan Coal Mine in China. *Energies* 2014, **7**, 8483-8507. [CrossRef]
23. Xu, D.J.; Peng, S.P.; Xiang, S.Y.; He, Y.L. A novel caving model of overburden strata movement induced by coal mining. *Energies* 2017, **10**, 476. [CrossRef]
24. Huang, Q.X. Ground pressure behavior and definition of shallow seams. J. Rock Mech. Eng. 2002, 21, 1174-1177.
25. Deng, K.Z.; Tan, Z.Q.; Jiang, Y.; Dai, H.Y.; Shi, Y.; Xu, L.J. *Deformation Monitoring and Subsidence Engineering*; China University of Mining and Technology Press: Xuzhou, China, 2014.

NEWS, PLANT AND EQUIPMENT

Tata Steel plans to enter merchant mining

Global steel major Tata Steel is considering merchant mining as a new business vertical that will leverage its existing expertise in captive iron-ore and coal mining.

"It is important for us to look at mining as a new business area. This is what we are evaluating just now to see how we can get into mining as business and focusing on India," Tata Steel executive director and CFO Koushik Chatterjee said in response to queries from shareholders recently.

He said that Tata Steel would float a separate company to undertake its planned merchant mining projects across the country. However, no plans to venture overseas were officially announced.

The planned foray into commercial mining is part of the larger consolidation exercise taken up by Tata Steel to streamline its businesses under four verticals – steel production, downstream value additions, mining, infrastructure and utilities.

The global steel producer with production capacities of about 33 m tons is planning to enter commercial merchant mining at a time when the Indian government has opened up commercial coal mining for private miners and even liberalised rules for operating captive coal mines, enabling a miner to offer part of production for free merchant sale.

The entry into merchant mining was a logical step to extend its internal mining operations, considering that it was the second largest iron-ore miner after State-run NMDC with captive iron-ore assets across the eastern Indian states of Odisha and Jharkhand, where its main steel producing mill was located. The steel producer also produces ferro- alloys, chromite and manganese largely for consumption at its steel mills.

According to company records, Tata Steel produced 23.3 m tons of iron-ore from its captive mines during 2018/19 and 6.54 m tons of coal. The steel producer was almost fully self- reliant in iron-ore from its captive mines, which provided it with raw material security and cost of production advantages, while its captive coal mines met about 27% of the requirements of its steel mill blast furnaces.

Chatterjee said that Tata Steel was currently evaluating a number of iron-ore mines in Odisha that were slated to be put up for auction as their existing lease were expiring in March 2020.

Mining work begins in Thar Coal Block-I

A Chinese power company, Shanghai Electric, has mobilised its machinery and begun mining work in Thar Coal Block-I for the development of the mine and installation of the 1,320 MW coal-fired power plant.

Sindh Energy Minister Imtiaz Shaikh, Board of Revenue Senior Member Qazi Shahid Pervez, Principle Secretary to CM Sajid Jamal Abro, Energy Secretary Musadiq Khan, Finance Secretary Hassan Naqvi, Additional Secretary to CM Shuhab Qamar and other relevant officials.

In response to a query, Shaikh told the CM that Shanghai Electric has also begun work on developing a coal mine to generate 7.8 m tonnes of coal annually.

The CM was informed that around 600 families would be displaced due to the coal mining and installation of the power plant. The CM directed Shaikh to ask the Chinese company to construct a residential colony for the affected families. "The colony must have good houses, paved roads, school, park, mosque, temple, playground, and small market," directed the CM. He gave the example of the Suneri Dars village constructed by the Sindh Engro Coal Mining Company (SEMC) for displaced people of Block-I. According to the CM, the model village school there was flourishing with even those children who had not been enrolled before attending the school.

The CM approved the appointment of Shaikh as the chairperson of SECMC and also appointed him as the chairperson of Thar Foundation to ensure corporate social responsibility.

Paringa sets sales record

Coal miner Paringa Resources has reported a record sales quarter in the three months to September, with sales revenue reaching A$5.7 m.

Coal shipments during the September quarter also increased to 136,000 t, compared with the 26,000 t shipped in the June quarter, as production from the Poplar Grove operation, in western Kentucky, continues to ramp up.

Paringa told shareholders that further increases in coal sales were expected in the December quarter, as Poplar Grove production continues to increase.

PARINGA RESOURCES LIMITED

Cost savings buoy Coal India's operations

Coal India Ltd's first-quarter numbers were decent, but still fell marginally short of the Street's expectations. This resulted in the stock correcting about 1.6% recently when most front-line metal and mining stocks staged a smart recovery.

Part of the reason was a dip in realizations in the preceding quarter, which muted revenue growth. However, compared to the year-earlier quarter, realizations were higher by about 4%. On the other hand, realizations from e-auction sales were lower by about 10% year-on-year.

This kept revenue growth soft at about 3.6% year-on-year. Thankfully, a control on costs and lower raw material consumption increased Ebitda by 16% year-on-year in the June quarter. Ebitda stands for earnings before, interest, tax, depreciation and amortization.

Coal India shut down some of its old mines to improve productivity and also cut back on additional expenses.

As a result, Ebitda margins received a fillip coming in at 26.5% in the June quarter, as against 23.5% in the year-ago period. However, point to note, that this is lower sequentially than the 28.8% margins seen in the preceding March quarter.

The Street has been looking for signs of improvement in the miner's coal production and sales numbers. On that score, production of raw coal in the first quarter remained the same as last year at 137 million tonnes (mt). Sales volumes, too, were a drab at 153 mt.

The management had indicated earlier that production volume would be around 660 mt in FY20. Going by the current run rate, Coal India will need to produce about 169 mt of the fuel per quarter over the next three quarters, which means a significant ramp-up.

Going ahead, though, Ebitda growth, and cash flows could remain steady. "Ongoing efficiency measures and continued growth in volumes (our estimates 5-6%), should drive 5% EBITDA compounded annual growth rate over FY19-21, despite the high base of FY19," said a Motilal Oswal Financial Services Ltd note.

Yet, the Coal India stock has been struggling. Since the beginning of the year, the stock has corrected about 17%, despite carrying a dividend yield of about 8%. The company, though, continues to generate good cash flow.

However, earnings growth expectation remains soft. An overhang has been government divestment, which will increase the available free-float.

Not surprisingly, analysts have trimmed their valuation expectations. "Taking cognizance of divestment risk and muted earnings growth, we trim exit multiple to 8.5x (earlier 10.0x FY21E EPS)," said analysts at Edelweiss Securities Ltd in a recent note to clients.

Though, any ramp-up on production and sales by Coal India will be seen as a positive.

The times they are a changing

At this year's China Coal Exhibition Coal International will be celebrating its 25th anniversary since its entrance as the first ever English coal journal to be represented in China and whom subsequently went on and still produces a Chinese language issue for the exhibition year on year.

Trevor Barratt Coal Internationals Managing Editor and owner comments at the many changes that have taken place over the years.

"To say how things have changed from the plethora of International longwall equipment suppliers plying their wares with not a single Chinese equivalent in sight 25 years ago is an understatement. A lot of name changes have occurred along the way and many partnerships have been formed with local participation. Chinas coal industry thirst for new technology was in abundance and with the help of some keen photography it would not be long before they produced their own equivalent equipment versions. Albeit first attempts were not up to the quality of their international counterparts but would still find their way into the local market and indeed find some export potential. This thirst for better quality equipment would lead to many worldwide manufactures now being owned by Chinese companies. HOW THINGS HAVE CHANGED"

INNOVATION

Fast forward to 2019 and it's clear that the country is making technology innovation a major, major priority having become a leader in research and development in multiple industries and the mining industry is no exception with the introduction of the Longwall Top Coal Caving method of mining proving a masterpiece of ingenuity that would present opportunities for other longwall producers worldwide, particularly in Australia.

LONGWALL TOP CAVING –THICK SEAM MINING

The top-coal caving mining method, developed steadily in the past two decades, has now become the main method for thick seam coal mining in China. In recent years, the core research areas in the top-coal caving mining are the mechanisms of top-coal caving and the improvement of top-coal recovery ratio. Notwithstanding is the need to address all the relevant safety problems that can arise during production that all need to be resolved.

INTRODUCTION

In China there is an abundance of thick coal seams. These account for about 45% of the total national coal reserve. In recent years, about 44% of coal production come from these thick seams. Several years ago, thick seams were mostly mined with a longwall slicing method which presented many safety issues. When the first slice is mined, a large amount of gas is emitted and flows from the following slices to working face. As a result, the specific methane emission is often doubled and gas control becomes more difficult. This slows down face advance speed and restricts coal production.

When a seam is mined repeatedly, it provides a favorable condition for spontaneous combustion of residual coal in goaf. When a thick seam is mined with a longwall slicing method, spontaneous combustion occurs frequently and thick coal seams become unminable. However, experiences in the field has shown that longwall top-coal caving (LTC) method can solve the above mentioned safety problem using longwall slicing and still remains highly productive.

In 1982, China introduced its first. LTC method. Although the first test face (Puhe Coal-mine of Shenyang Mining Bureau in 1984) was not successful, it has subsequently been applied successfully in steeply inclined thick seam in Meihekou Coal-

mine of Liaoyuan Mining Bureau and Liudaowan Coal-mine of Urumchi Mining Bureau. In 1990, LTC was successfully tested in a flat-pitching seam at Luan Mining Bureau and Yangquan Mining Bureau, achieving 140,000 mt in a single month. Since then LTC was adopted in many mines in China. Today, the production of a LTC working face under favorable geological conditions exceeds 2 Mt annually. For instance, in Yanzhou Mining Bureau's Dongtan Coal-mine, its LTC face produced 4 Mt coal in one year, with per man-shift at 208 tones. Now, LTC can also be applied in many difficult mining conditions: thick seams with soft roof and floor, tight roof and seam, high slope angle, large gas content (even with potential for gas outburst), susceptibility to spontaneous combustion, or even with thin coal seams.

Because LTC is very different from longwall slicing method, so are some of the challenges during a mine disaster and many safety problems tnust be resolved. What's the characteristic of gas mission and gas outburst in LTC comparing with longwall slicing? Can LTC be used to mine seams with large gas content or liable to gas outburst? What's the difference in spontaneous combustion between LTC and longwall slicing? How could spontaneous combustion be prevented in LTC working face? What measures should be taken to control coal dust in LTC working face? In this paper, authors will review the practice of mine disaster prevention of LTC in China.

CHARACTERISTICS AND PREVENTIVE MEASURES OF GAS EMISSION AND OUTBURST

Characteristics of Gas Emission in LTC Working Face

The LTC system mines the entire coal seam in one pass. Its gas emission characteristic are different from longwall slicing method as follows:

The specific methane emission is less. In longwall slicing method, when the top slice is mined, gas in following slices enter into working face. The working face in the first slice has the largest gas emission, becomes less in following slices. **Table 1** shows data from the Luling Coal mine of Huaibei Mining Bureau. This thick seam is mined in 4 slices, about 60% of gas is discharged during the first slice.

In the LTC method, the overall thickness of seam is mined once, so that the specific' gas emission is even and much less than that of first slice working face, because the speed of the face advancing is slowed down.

Table 1: Gas emission proportion in each slice.

Number of slice	1	2	3	4
Gas emission proportion/%	43-75	12-24	9-17	8-16

The absolute methane emission is also increased because of two reasons. First, the production of LTC working face is 2~5 times as that of slicing working face. Second, the LTC method mines the entire seam in one pass so that decompression area becomes greater, height of cracked zone is increased, and more gas in adjacent seams may gush into working face.

There are more methane accumulation spots. Methane accumulation 'occurs not only at the upper (or bottom) corner of the face like in slicing working face, but also around caving orifice and above support canopy. **Figure 1** shows explosive gas near the working face is in zone D.

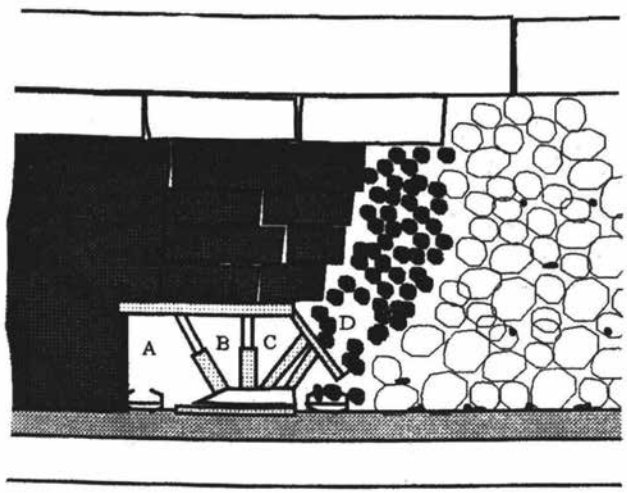


Figure 1: Methane distribution in face

Gas emission is uneven during the mining operation. There are methane in high concentrations above the support, it flows out during the caving process or support movement, so the methane concentration varies following the mining process. The factor of gas emission varies is between 1.2 and 1.4, some times even over 2.0.

Methane distribution in the face area is uneven, too. As shown in **Figure 1**, the mining face can be divided into three parts: A, B and C. In zone A, the rate of airflow is the greatest, with about 70% of the air quantity passing through, resulting in the lowest methane concentration. In zone C, the space is smaller and ventilation resistance is high, and only less than 10% of the air quantity pass through. Methane emission from goaf and caving coal come into it, so that the methane concentration in zone C becomes higher than zone A and B. The wetland concentration in zone B will be between zones A and C. Zone D does not belong to working face, but it is in the area above the caving orifice. In zone D, gas concentration may be in an explosive region. It flows with caved coal into face space and increases methane concentration in the working area.

GAS OUTBURST IN LTC WORKING FACE

Factors that affect Gas Outburst

Generally, a soft coal seam will be more susceptible to methane outburst. With the slicing method, tow pick headings are disposed in the floor and connected to haulage entry with oblique headings. To drive oblique heading needs to uncover the seam and thus increases the possibility of gas outburst. For instance, in Luling Coal, there have been 19 gas outbursts in history, 17 of them took place while the seam was being uncovered by driving oblique headings.

In LTC method, pick headings are not needed. There are no oblique headings, and gas outbursts caused by uncovering seam can be removed. When using LTC method, there is a greatly concentrated stress area will form in coal seam

immediately ahead of the face, and peak abutment moves farther away from face. The cracked zone in coal seam ahead of the face expands, which make the gas release easier and gas pressure gradient lower. Therefor, LTC tends to inhibit gas outburst. In several mines, LTC has been successfully used to mine the thick seams that are susceptible to outburst, after gas drainage.

However, since the air intake road and air return road are located at the bottom of coal seam in a LTC system. The gravitation of coal above the road enhances the possibility of gas outburst.

METHANE EXPLOSION PREVENTION MEASURES

Gas drainage

Gas drainage is an essential method to prevent a methane explosion. It discharges the methane and thus reduces gas pressure. Gas drainage methods can be divided into three kinds: predrainage, gas drainage during mining, and gob gas drainage. All drainage methods used in slicing method can also be used in LTC. For the three methods, it has been proven that drainage during mining is more efficient in a LTC face than in slicing face. The cracked zone ahead of the LTC working face is greater, which make the gas drainage easier. In some mines, most gas emission comes from adjacent supper seams.

There is a method that can efficiently reduce the gas emission from adjacent upper seams. As shown in **Figure 2**, this method is to drive a heading (along seam strike or dip direction) or drill a large-diameter hole in roof strata. Gas is drained out from the heading or through the hole.

Mining the Protective Seam

In regions where not all seams are gassy, then the seams without the possibility of gas outburst is mined first, this will de-stress the seam, thus facilitates methane drainage to reduce the possibility of gas outburst. This method has been used in China since 1958, and has been proven as an efficient and economic method to prevent gas outburst. However, there are areas where all seams are gassy or this "protective" seam may be so thin that it is not economically minable. This method is rarely applied on a LTC working face.

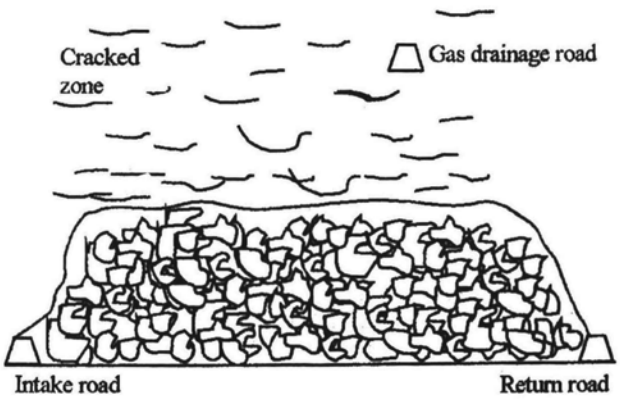


Figure 2: Gas drainage road along the seam intake

In some mines, there is only one thick seam with large methane content. In order that LTC is safely used, the top slice of seam is still mined with longwall slicing method. The drawback is that the top slice face can't work regularly, resulting in reduced production which affects the regular production of LTC face.

Modification of Ventilation System

In U form of ventilation system, in order to reduce the methane concentration in return air to below the allowable value (1%), the air quantity of face is estimated as:

where
Q = air quantity of face, m^3/min; K = gas emission

Equation 1

$$Q = \frac{K \cdot Q_o}{C =} = \frac{K \cdot q_o \cdot A}{1440\ C}$$

uneven factor; Q_o = mean absolute gas emission, m^3/min; C = allowable methane concentration in air, %; q_o = mean specific gas emission, m^3/t; A = mean productivity of face, t/day.

The air quantity is restricted by the maximum of airflow 4 mls. If the cross section of roadway equals to $6m^2$, the maximum air quantity is 1,440 m^3/min, which requires that the absolute gas emission be less than 10.3 m^3/min, and specific gas emission be 10 m^3/t, giving a maximwn production face 1481 t/day. In order to maximise the high productivity in a TLC system, proper measures for efficient gas drainage and ventilation system be taken.

Since 1992, E form ventilation system (**Figure 3**) has been used in many mines. This system is formed by increasing a gas drain based on the U form system. The gas drain is a heading located at the top of the coal seam. The horizontal interval between it and return airway is 10-20m. There is no person and any kind of equipment in it. It is over the face and the air in it comes from the air leakage in goaf and broken coal above the powered support with high concentration of methane. The methane concentration in the gas drain should be no more than 3%, which has been operating satisfactory up to present. The purpose for this system is to control methane concentration at the upper corner of face.

SPONTANEOUS COMBUSTION PREVENTION MEASURES

Spontaneous Combustion in LTC

The LTC system has a much higher production and thus takes a shorter mining period seam than the slicing system. After mining, the goaf can be closed in time. The spontaneous combustion is a slow process of oxidation and accumulation of heat. For example, in third mine of Yangquan Mining Bureau, the No. 15 seam was mined with slicing system with 3 slices. The shortest period from mining the first slice to combustion is 24 months (incubation period). It takes 40-50 months for all 3 slices to be mined out. There have been 17 cases of spontaneous combustion in slicing system. With the LTC

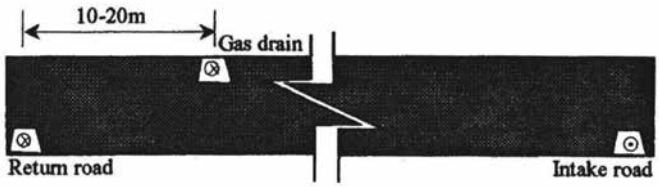


Figure 3: The E form ventilation system

system, it takes only 13 months to mine the same full thickness in a face. The goaf is sealed in 15 months, so that the possibility of spontaneous ignition is greatly reduced.

The LTC system reduces the air leakage, which is the major cause of spontaneous combustion. In the longwall slicing system, 90% of the spontaneous combustion takes place in the lower slices. After the first slice is mined, the rock in goaf is bulky. The air can pass through goaf from the oblique headings connected with intake air pick heading to the oblique headings connected with return air pick heading. After coal roads of lower slice are driven, the air can be leaked from intake entry to return entry through goaf. The goaf of upper slice is oxidised for a long time, the spontaneous ignition may take place in the front and rear areas of the lower slice face. In the LTC system, there are no pick or oblique headings. There is no such leakage in the slicing system, and the possibility of spontaneous combustion is reduced.

It is easier to seal the goaf in LTC system. In the slicing system, pillars around rise or dip is acted by concentration stress repeatedly. There are more cracks in pillars, which make it difficult to seal the goaf. A great amount of spontaneous combustion is caused as the air leaks through pillars. In a LTC system, the pillars are affected by concentration stress only once, pillars keep their integrity and goaf can be sealed tightly. Hence, there is less spontaneous combustion in pillars and goaf.

However, in LTC system, coal headings are located along the bottom of the seam, the possibility of roof-fall and rib fall is increased; There are air leakage in roof-fall spot and cracks around roads, which makes the spontaneous combustion in coal seam around road or in goaf as the coal with high temperature left behind face possible.

The recovery rate of coal is lower in the LTC system, and the loose coal in goaf may induce spontaneous combustion as well.

It is also possible that the 8-10m top-coal in the region between the start line and stop mining line along advancing direction is not entirely caved down, and it will be left in goaf. It is easy to induce a spontaneous combustion if the goaf could not be sealed tightly.

Spontaneous Combustion Prevention Measures

Experience in the field has shown that the following measures are effective in preventing spontaneous combustion:

To Increase Face Advance Rate

The goaf can be divided into 3 zones according to the stages of spontaneous combustion: cooling zone, oxidation zone and asphyxia zone. The larger the oxidation zone is, the longer it will be for coal to oxidise and heat to accumulate, thus increasing the likelihood of a spontaneous combustion. Increasing the face advancing rate makes the oxidation zone smaller and reduces the possibility of spontaneous combustion.

To Inject Nitrogen into Goal. Nitrogen with over 99% purity is injected into the goaf through the pipe buried beforehand in goaf along the intake airway.

To Use Oxidation Retarding Agent. In China the agents generally used are $MaCl_2$, $CaCl_2$, and soluble glass.

To Inject the Mud Slurry. To inject the mud slurry is a common and efficient technique to prevent spontaneous combustion in China.

To Reinforce the Coal around the Coal Roadway. Filling the gap between the roadway support and the coal wall reduces the air leakage in the surrounding coal.

Fireproof and Extinguishing by Balancing Pressure. Decreasing the air pressure difference around the goaf can prevent the air leakage in goaf, and to prevent spontaneous combustion.

DUST CONTROL TECHNQUE

In China, the dust concentration exposed by worker is restricted by the national standard, but the safety rules and regulations do not forbid that workers to stay in the return air. The LTC system is another dust source, because caving process produces dust. The dust concentration in LTC working face is higher than regular longwall working face, so the LTC system requires more stringent practice to control dust. In China the following measures have been used to control dust.

- Instead of high caving gate supports, the low caving gate supports are widely used.
- Dust control by water-cloud should be enhanced. Sprayers beneath the forward canopy are installed to contain the dust produced by shearer drum. Sprinklers are installed on the gob shield, which automatically spray while moving support or caving top-coal. Sometimes the wetting agent is dissolved in water to increase the effect of dust control.
- Preliminary infusion in seam is widely used in China.
- The new dust arresting devices are being researched.

EPILOGUE

The LTC system has been developed rapidly in China in recent 15 years. The research of safety measures of a LTC system has obtained some achievements. The characteristics of safety problem in a LTC system has been basically identified. Many efficient measures are taken to prevent methane explosions, spontaneous combustion and dust. In this past 15 years, there have not been any serious accidents that have taken place in any LTC system in China.






Time to go electric

A Vision for a Sustainable Battery Value Chain in 2030, a report announced recently by the World Economic Forum's Global Battery Alliance highlighted its implications for the mining sector. By 2030, the report found, batteries can bring down emissions by 30% in the transport and power sectors; create 10 million jobs and add $150bn to the global economy and; provide electricity to 600m people.

In order for that potential to be achieved, the metals and mining sector has a prominent role to play, be that through the responsible provision of key materials, the creation of safe and sustainable jobs and measures taken to benefit the environment and eliminate child and forced labour.

Commenting on the publication of the announcement, Benedikt Sobotka, CEO of Eurasian Resources Group and co-chair of the World Economic Forum's Global Battery Alliance, said: "The vast potential of the global battery sector transcends boundaries across economies, industries and geographies. Harnessed appropriately, it may help meet the 2°C goal of Paris Agreement and create millions of safe jobs but also alleviate poverty and tackle ethical issues in the most vulnerable communities. This opportunity should be seized upon but, as this landmark report highlights, it is only through coordinated, collaborative action that we can achieve our collective global sustainability ambitions."

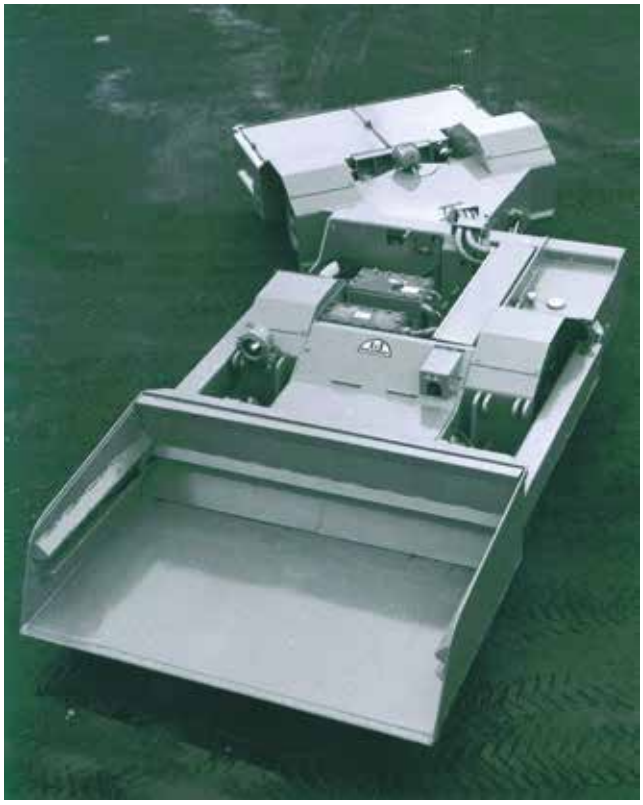
MINING INDUSTRY PLAYING ITS PART

In the wake of the mining downturn, the industry seems to have now recovered to re-affirm its place as a major driver of some of the world's largest economies. The coming years will reinforce this position as hundreds of projects or expansions develop into the next generation of mines. Now global industries demand for fully battery-powered vehicles for underground mining applications is very highly anticipated in the coming years as mining organisations are working towards environmentally friendly and efficient machinery in their workplace. A lot of equipment used in the coal industry lends itself to future innovative battery operations as is being witnessed now in room and pillar operations.

IN THE PAST

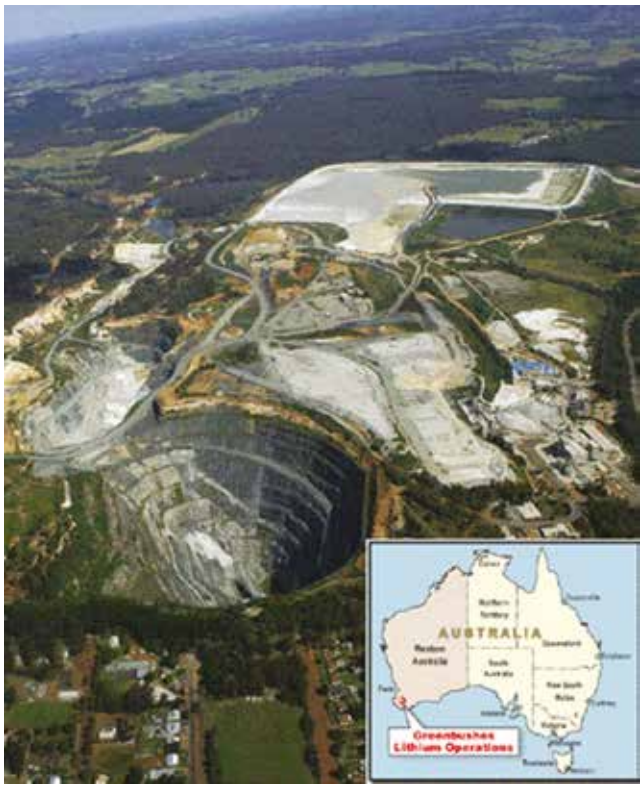
The year was 1968, and USA company S & S Machinery Co. was in its infancy. It was that year that S & S introduced its first battery-powered scoop. The product would change immensely over the next 25 years, but S & S's dominance in battery-powered equipment would not. With as high as 80% of the market share in battery-powered mining equipment, S & S became one of the most successful companies the mining industry has ever seen. With immensely popular battery tractor, scoop, and hauler models, the Simmons name became synonymous with battery-powered equipment throughout the coalfields, and even the world.

Battery powered mining vehicles have continued to evolve, but it is only in recent years that large-scale adoption of the technology is either being considered or has already been adopted. Recent reports would indicate that the market for underground mining machines is still in the beginning stages of a paradigm shift that will ultimately see battery-powered equipment make its diesel competition obsolete. The tipping point where everyone has decided that, in future, they will use battery-driven zero emissions equipment has not yet been reached. Most major mining companies will currently only purchase zero-emission equipment for underground operations, however, as new technology evolves a shift to surface operations also seems imminent.



S&S First Battery Powered Scoop

Battery technology is ideally suited for underground mining and the speed of adoption will be driven by the mines' comfort level with the technology and the OEMs' ability to deliver a solid product that will operate for a full shift [As previously stated battery electric vehicles (BEV) are not some new phenomena and the use in coal mines worldwide were developed back in the 1960s. Room and



Overview and location of Greenbushes Operations

Pillar operations in the USA, South Africa and Australia in particular have been utilising the use of BEV's for many years. Most projects found that not only were they cleaner, they outperformed the equivalent diesel vehicle both in hill-climbing and top speed capability.

Today the initiative to create battery operated equipment has been driven by new innovative developments in battery technology. This has made it possible to create powerful and productive equipment with zero emissions. The difference being is the latest innovations in battery technology has reached new heights as can be witnessed by the now large-scale production of electric cars worldwide and the ongoing development of Lithium resources with Australia being the current world leader in lithium production. Australia has the Greenbushes, which is the world's largest known single lithium reserve. Companies are also looking at restarting lithium production at Mt. Cattlin in Western Australia. Unlike the second largest producer Chile whose lithium is found in brines below the surface of salt flats, Australia extracts lithium from traditional hard-rock mines and exports a proportion of it to China and other Asian countries. The majority of China's lithium comes from the Chang Tang plain in western Tibet. China has to fully ramp up its lithium extraction as the need for the metal rises. The Atacama salt flat is Chile's most significant source of lithium production. Chilean mines feature the largest confirmed lithium reserves in the world. By some estimates, the country hosts five times more lithium than Australia.

Lithium is abundant; it hasn't been mined in large quantities until lithium-ion batteries grew in demand. Studies in geology prove that there is no alarming shortage of lithium at the level of the Earth's crust. Indeed, almost three quarters of total lithium supply has come from brine (salt lakes) and is now described as white gold by many countries, add new future hardrock mines into the equation and the future for Lithium mines certainly looks rosy.

Managing Editor Trevor Barratt takes a look at such developments that continues to show how battery powered equipment is becoming more innovative. A lot of equipment used in the industry lends itself to future battery operations and it seems the sky is the limit. Companies nowadays are developing and offering complete lines of battery-powered scoops, diesel-powered scoops and tractors, multipurpose vehicles, longwall shield haulers, roof bolters, maintenance vehicles and continuous miners and haulage systems. As the future of mining goes, some companies are taking the bull by the horns and integrating new innovations to help mining companies in the most productive, most efficient, and safest way possible. Battery-powered equipment could be just what the doctor ordered.

CAPITAL INVESTMENT

One of the biggest problems with switching from diesel-driven equipment to a new electric fleet is the significant capital investment required. In the typical cyclic nature of the industry an economy dealing with lowered commodity prices places pressure on new purchases. While most mines slow down on their spending, the long-term benefits of investing in a clean, green and modern range of electrically driven

underground equipment may outweigh the short-term cash outlay. Directly driven mine machinery (ie. power from an AC feed) has advantages, but there is a serious disadvantage in areas where mobility is required. It is these areas specifically where battery driven, and hybrid units come to the fore.

With the cost of batteries and other storage systems being driven down by other sectors, the cost of converting to BEVs in underground mines is reducing. In addition, the electric vehicle market is developing and producing batteries with increased energy density and of the size and shape suitable for low profile mining traction units. The cost of batteries specifically designed for transport is decreasing rapidly, and charging regimes have been developed which allow rapid recharge of batteries. A further development is the use of hybrid mining propulsion units, which can be adapted to a wide variety of underground operations.

Traditionally, underground mobile equipment in the mining sector has relied on diesel engines which release emissions, and therefore must be ventilated via costly systems. While there are already electric scoops and trucks in underground mines consuming around 80% of diesel fuel underground, some of these units have to be tethered via an electric cable, limiting their limited range and creating other operating challenges.

As major manufactures of underground diesel and electric loaders continue to introduce and indeed showcase their latest innovations at major exhibitions worldwide the emphasis has now definitely shifted to the design of underground loaders, and their battery power capability, being driven by new developments .All the obvious benefits with battery power add up to something that might not be as obvious, like a reduced environmental footprint, higher worker satisfaction, and a better standing in the greener community's mindset. Additionally, as diesel engines are replaced with battery electric solutions, underground mines will produce less heat, noise and exhaust gases, including diesel particulate matter. Thus, the innovative technology will result in decreased mine ventilation needs, which are currently a significant cost factor in deep and complex underground mines.

Of course, when implementing a new technology there is always a lot of questions and concerns from the customers and end users. How safe is a battery machine and will it perform? What's the business case for implementing battery machines instead of diesel machines? The aim within any project is to clarify all these issues and convince the customers that this is the future and the technology is now available now to implement.

Although some coal mining companies have installed various BEV's at some stage, they are yet to follow in the footsteps of Newmont Goldcorp, which presented its Borden Lake gold project as the world's first all-electric underground mine in northern Ontario, Canada. The company's project is a key part of Goldcorp's plan to increase production by 20% by 2021

To help realise its plan of building Canada's first all-electric 'mine of the future', Goldcorp teamed up with technology leaders Sandvik Mining and MacLean Engineering to provide a suite of new innovative technologies that will power all aspects of the mine's operation. These range from

Arial photo of Borden Lake

The newly arrived Scooptram ST14 Battery and Minetruck MT42 Battery at Agnico Eagle's Kittilä mine

battery-powered underground vehicles, drilling and blasting equipment, to electric bolters and personnel carriers.

A 40 metric tonne battery-powered haul truck, which will eliminate all greenhouse gases (GHG) associated with the movement of ore and waste rock, is nearing commercial production. The company predicts that this will translate into a 50% reduction in the estimated GHG emissions associated with these activities (equivalent to 5,000 tonnes of CO2 per year) in a mine of a similar size.

TAKING ADVANTAGE

Leading equipment manufacturers are certainly taking advantage of the demand for battery electric mining equipment for example less than a year after Swedish company Epiroc's launch of its new generation equipment, the company has won orders for those machines from customers in several countries including Finland, Australia and Canada.

In Finland, Agnico Eagle Mines Limited ordered in the third quarter 2019 the Boltec E Battery rig for use at the Kittilä gold mine. Several orders from other companies have been booked in previous quarters for battery electric versions of the Boltec rock bolting rig, Boomer face drilling rig, Scooptram loader and Minetruck hauler.

In addition, Agnico Eagle Mines is already testing several Epiroc battery-powered machines at Kittilä as part of the Sustainable Intelligent Mining Systems (SIMS) project. SIMS, where Epiroc is serving as coordinator, is part of Horizon 2020, the European Union's most extensive research and innovation program ever. A Boomer E2 Battery has been operating for some months at Kittilä, and in August a Minetruck MT42 Battery and a Scooptram ST14 Battery also arrived at the mine as part of the SIMS project.

"We see very strong customer interest for our new battery electric mining machines," said Helena Hedblom, Epiroc's Senior Executive Vice President Mining and Infrastructure. "The technology is now well established, and more and more mining companies are realizing the significant benefits that come with using electric machines instead of diesel. We are proud to spearhead the mining industry's drive toward a fossil-free future."

The benefits include improved health and safety, lower total cost of operation and higher productivity. The advantage is especially significant for underground operations where mining companies traditionally must invest heavily in ventilation to air out the diesel fumes.

"The Boomer E2 Battery has been performing very well and a diesel engine has not been missed," said Jari Kolehmainen, Production Manager at Agnico Eagle Mines. "Operator feedback has been positive, and we are looking forward to expand our fleet with more electrically powered equipment in the near future. Therefore, we are also very excited to be testing the battery powered mine truck and loader. These tests are giving us the confidence to be a successful early adopter of this new and exciting technology."

Epiroc launched its first battery electric machines in 2016. In November 2018, the company unveiled its new generation consisting of 14 and 18-ton loaders, a 42-ton truck and a mid-sized drilling family including face drilling, production drilling and rock reinforcement rigs. Epiroc aims to be able to offer its complete fleet of underground mining equipment as battery electric versions by 2025.

IntelliZone provides a safer environment for miners without compromising productivity. Shaped zones conforming to the mobile equipment's shape can be precisely established.

Proximity detection shapes up globally

In the past two years, laws requiring coal mines to have proximity detection on mobile machinery have been instituted in the U.S. and South Africa. These new mandates are putting a global spotlight on the need for worker safety solutions. The product selected most often to meet these deadlines, Matrix's IntelliZone, has recently received IECEx approval. This system is now available in the Australian market and expanding to other countries worldwide.

IntelliZone warns personnel if they are in close proximity to mobile machinery or entering an unsafe working area. Its control system interfaces with machinery, providing the ability to slow down or stop a machine should personnel move into Warning or Shutdown Zones designated around it. Unlike bubble-zone systems, IntelliZone's proprietary shaped-zone technology allows mines to set custom perimeters around the machines, minimizing nuisance alerts and allowing increased productivity for mines. The system also enables zones to expand and contract based on a vehicle's speed and direction and only into the path of travel, instead of overlapping into crosscuts or cutouts.

"Precise worker location teaches support personnel where to position themselves to be clear of danger and allow the equipment to do its job," said David Clardy, president of Matrix. "IntelliZone operating data from the last 10 years indicates little-to-no drop in production while providing outstanding worker benefits."

CELEBRATING 10 YEARS OF INNOVATION

Originally introduced to the American market in 2009, IntelliZone was the culmination of a three-year effort to create a next-level proximity detection system for underground mines. When the patent was approved for IntelliZone's proprietary technology, for the first time, ultra-precise tracking and the ability to define customized shaped zones around each machine was available. This X,Y tracking was revolutionary in the mining market, particularly for MSHA-approved systems.

Before IntelliZone was introduced, only "bubble" zone technology was available. These football-like shapes expand wider as the machine's zones extend forward, detecting workers on the sides or in crosscuts who are actually in a safe location. In contrast, IntelliZone's SharpZone technology enables precise worker location around a piece of equipment.

In 2013, Matrix introduced IntelliZone Gen 2, which delivered increased range allowing for use on faster moving vehicles, provided a reduction of electrical noise interference and included a number of features to minimize nuisance trips. An in-cab display for visual indication of zone breaches was

also added as well as visual and audible zone alerts on the wearable locator. To ensure system reliability on equipment, components are integrated into the machine and kept inside the machine frame, which means that cables are protected and not exposed.

Because Matrix is focused on continuous innovation, it has recently introduced a number of new features allowing for additional signal diagnostics, machine angle detection and reduced EMI interference. Matrix will soon be releasing a Status Screen that provides detailed on-board diagnostics, critical for quick troubleshooting and maintenance, and a new longer-range driver for higher speed applications.

Today, IntelliZone can be found on continuous miners as well as many other mobile machines in underground mining environments, including shuttle cars, roof bolters, LHDs (load haul dumps), battery-powered scoops and battery haulers. The system has also been successfully installed on articulating haulage. In addition to coal mines, IntelliZone is being used in a variety of soft rock mines and tunneling operations.

"Shaped zones are data-proven to provide a safer work environment underground without a lot of nuisance trips or slow-downs," said Brian Jones, director of Business Development. "And IntelliZone's robust component construction provides greater uptime in the toughest environments."

SAFE PRACTICES

IntelliZone not only provides proximity warning and equipment shutdown when necessary, the system is primarily intended to enhance miners' awareness of potentially dangerous areas around working machinery and instill safe operating practices. Ultimately, IntelliZone's components, durability and reliability provide the lowest cost of ownership in coal mine proximity detection. Its suite of exclusive features balances safety and production, its precision raises a mine's safety factor, and it is now IECEx-approved.

IECEX APPROVAL

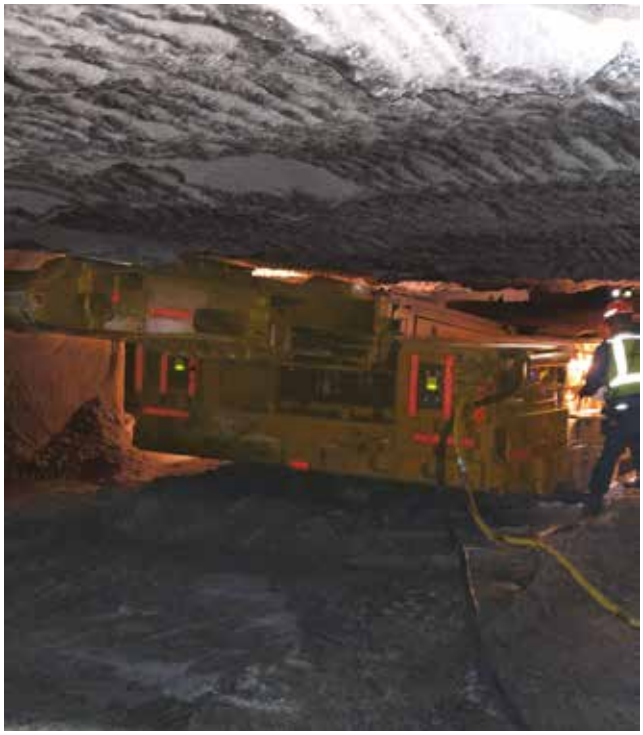
IntelliZone's IECEx approval was acquired from the Department of Industry's Mine Safety Technology Centre in Thornton, NSW, Australia. This certification allows Matrix to enter the Australian marketplace and sell worldwide in other countries that follow IECEx standards. IECEx is the IEC system for certification to standards relating to equipment for use in explosive ("Ex") atmospheres.

Green Zone

Yellow (Caution) Zone

Red (Stop) Zone

ntelliZone components are designed to last longer in the harsh operating environments of underground mining.



IntelliZone works in all underground mining environments and can be installed on any type of mobile equipment – standard or articulated.

MATRIX DESIGN COMPANY

Matrix is a safety and productivity technology leader for underground mining and industrial applications. Its innovative product line includes systems for proximity detection, communications and tracking, atmospheric monitoring, lighting and cameras.

Since 2006, Matrix's core business has been mining safety. The company designs, manufactures, sells and supports a range of cost-effective new-tech products. While best known for its IntelliZone proximity detection system, Matrix has expanded beyond the underground coal mining industry and now sells into industrial markets globally. Today, the company has introduced – and continues to launch – suites of leading-edge products that help its customers operate more safely and productively.

Headquartered in Newburgh, Indiana, Matrix has offices in Lexington, KY, Johannesburg, South Africa and service locations throughout its mining regions, as well as distribution partners around the globe.

Two IntelliZone systems can combine to create, in this example, a Loading Mode zone where an operator can move closer within a green zone during offload. The CM and Shuttle Car systems will precisely track all worker locations within the zone's set-up.

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