

Booming pink gold



Paul Moore looks at the ongoing hive of activity in the potash market, from both majors and juniors, that is proving highly prospective for the key shaft sinking groups, EPCMs and continuous mining machine manufacturers

The potash market continues to boom, through established expansions to major existing operations owned by PotashCorp, Uralkali, Belaruskali, Mosaic, Israel Chemicals and others to new greenfield projects such as K+S Potash Canada's Legacy and BHP Billiton's Jansen in Saskatchewan; to Vale's Rio Colorado in Argentina. There are also a whole host of juniors looking to get into the sector, not only in Canada and the US but globally, including South Boulder Mines with its Colluli project in Eritrea to MagIndustries Mengo in the Republic of Congo. The issue with potash mines is that they generally require major shaft development as well as extensive lateral underground development, that involves huge initial costs – usually several billion dollars – and as much as 8 to 10 years before the owner sees any positive cashflow. This is one of the reasons why the market is controlled by a relatively small number of players as to develop a new potash mine is a long and expensive process. As a bulk material it also means getting access to transport infrastructure – generally a freight rail line. Unfortunately this also means that many of the projects being advanced by juniors will never reach production.

Russia's Uralkali now vies for top position with PotashCorp in potash reserves and annual production capacity; and the group has major expansion plans. Expansion and modernisation of its existing production facilities will add 4.5 Mt of potash production capacity to Uralkali's total. Further to this, the Ust-Yayvinsky and Polovodovsky projects include the construction of two new mines which, when they reach full

capacity, will increase Uralkali's potash production by 5.3 Mt. The launch of new projects will make up for the gradually depleting ore reserves of the Berezniki-2 mine as well as increase potash production capacity. In total, as a result of the large-scale investment program, Uralkali will increase its production capacities over ten years to 19 Mt/y of potash as KCl. The expansion project envisages replacement of old hoist machines which will allow the company to increase the capacity of Berezniki-4 mine from 14.5 to 20 Mt/y of potash ore. The Ust-Yayvinsky project focuses on construction of a new mine with two shafts of 8 m in diameter and the capacity for 11 Mt/y of potash. Potash ore extracted from the Ust-Yayvinsky block will be processed at Berezniki-3 plant. The mine will produce its first ore in 2020.

A core technology market

From an equipment technology standpoint, potash, sometimes referred to as "pink gold", represents the most important market for continuous mining machines after coal by some margin. As such the use of longwalls, continuous miners, roadheaders and borer miners tends to be overshadowed by the coal industry, as does the importance of potash mining to shaft sinking specialists, especially as it often involves specialist ground freezing techniques. Deilmann-Haniel Shaft Sinking GmbH (DHSS), now part of the Redpath Group, concluded a contract to sink two freeze shafts for the new Ust-Jaiwa mine for Russian potash producer Uralkali in late December 2011. The contract is worth approximately €215 million

Sandvik MF320 borer miner operating at Uralkali

and will be performed through the Russian subsidiary Deilmann-Haniel Schachtstroj. The construction period is approximately 5.5 years. PotashCorp has teamed up with joint venture partners, Redpath and Thyssen Mining, who together form Associated Mining Construction (AMC) for the first new potash mine shaft in Saskatchewan, Canada, in over forty years – the Scissors Creek project. The statement said: "AMC draws upon the experience of both parent companies and their subsidiaries to provide solutions to what have proven to be some of the most complex shaft sinking projects in the world. Due to the nature of the deposit, the PotashCorp Scissors Creek shaft must be sunk through layers of unconsolidated water bearing strata. Therefore specialised ground freezing techniques are utilised, along with complex high pressure shaft liners." Other key players in potash shaft sinking include the UK's Alan Auld Engineering, DMS Mining Services in Canada, Shaft Sinkers in South Africa, CDM Smith and others. The scale, scope and cost of the potash projects means it is also attractive to EPCM companies such as AMEC, Hatch and SNC-Lavalin.

Key machinery suppliers

Longwall mining of potash is conducted in a similar manner to coal mining with longwall equipment, though there is the advantage that there are not the same hazards found in coal mining such as rock bursts and methane



Manufacturer of the leading Ural 10R and 20R range of potash mining machines, Russia's Kopeysk celebrated its 70th anniversary in 2011

concentration. However, dust tends to be more of an issue and is one of the main challenges that the equipment manufacturers have to face in the potash industry. Traditional water cooling systems cannot be used in potash mines therefore cooling systems tend to have to work in closed circuit. Because of the faster advance of the longwall, the canopies and other elements of roof supports undergo significant attrition, therefore the materials used must be very robust. Perhaps unexpectedly, there is no problem of corrosion with potash – as the salt coats and therefore to some extent protects the equipment.

Companies in Poland's Famur Group specialise in manufacturing equipment for hard coal longwall mining but in their long history the companies have been also producing and delivering machines for potash mines. Since 1992, Famur shearer loaders and Fazos roof supports have formed a major part of the equipment fleet at Belaruskali's mines in Belarus. Fazos alone delivered over 2,300 roof supports. Belaruskali also uses longwall equipment from Caterpillar and Eickhoff.

The machines produced for Belaruskali were customised for those operations. The hardness of the ore required greater installed power in the cutting arms of the shearers, while the cutter motors' planetary gearboxes were equipped with additional cooling systems. The cutting drums also had a special arrangement of the pick system. The shearers were also equipped with dust reduction systems, consisting of fans and dust sucking units, and the sensitive elements of the shearer were additionally covered for enhanced protection.

In total, Famur delivered eight longwall shearer loaders (types: KGS-570/2B/Sol, KGS-570/KGS-800S/2BP, KGU-310/Sol) to the potash mines in Soligorsk. Fazos delivered 2,387 roof supports (types: FAZOS-09/15,5-Oz, FAZOS-15/31-Oz-SOL, FAZOS-16/24-Oz, FAZOS-08/13-POz, FAZOS-09/15-POz, FAZOS-16/24-POz, FAZOS-13/20-POz, FAZOS-23/36-Pp, FAZOS-35/43-Pp, FAZOS-22/34-Pop).

A new product from Famur is its mining system for thin coal seams, known as FL 13/19. It includes the longwall shearer FS200, powered roof supports, armoured face conveyor and beam stage loader with a lump crusher. With adjustments, the company believes the system is also very applicable to potash mining.

Caterpillar, through its purchase of Bucyrus is now a major supplier of equipment for potash mining, including continuous miners and longwall systems. The successful operation of a first 30M4-NP continuous miner (Caterpillar CM345 N) delivered in 2004 to Agrium's Vanscoy potash operation, led to an order for a further three units, which were delivered by August 2010. Extensive modifications were incorporated by a team of engineers working closely with the customer for over two years.

One of the major challenges was to convert the cooling system from a glycol to oil system to allow operation of the miners in very hot conditions. The cooling system also had to be redesigned to fit within the same footprint, while at the same time easing the transition from flat ground to a grade during uphill mining to avoid ground contact, as all three continuous miners will be cutting extensively on grades of up to 20°. Other changes include voltage-segregated electrical enclosures, a new control system, modifications to the frame, new cover layouts, and a new layout of the operator's cab. The customer requested an electrical control system that operators were familiar with and that would facilitate operator access to individual components. With a modular design, the control system also allows growth to accommodate future functionality. A completely new cover package was implemented for the continuous miners to accommodate the new electrical and cooling systems.

The custom machines weigh in at 74.84 t and can mine seams of 1.8 to 4.63 m. Caterpillar states that other features that contribute to the success of the machine include increased brake capacity with faster set and release times to facilitate operation on steep grades; improved

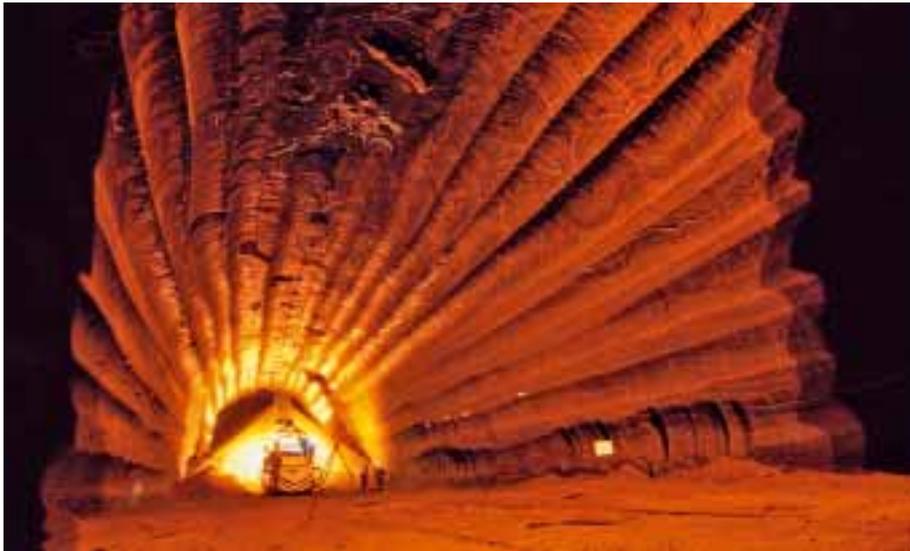
geometry to prevent material accumulation and to ease transition to and from steep grades; a modular design to comply with mine-site restrictions for hoist capacity and shaft dimensions; non-XP electrics and enclosures; and a 4,160 v input voltage to replace the standard 995 v supply.

There are also other equipment suppliers for which potash is an important market. Salzgitter Maschinenbau AG (SMAG) manufactures and sells automated specialist drilling vehicles specifically made for potash and salt mining, but increasingly used in oil shale extraction. Its products include the GB 280 S large-bore drilling vehicle. The GB 280 has three independent drilling drives, which in each case propel a drill rod with a diameter of 280 mm. The maximum drilling depth is 7,500 mm. Even on rough surfaces a movable rod guidance system in the front area of the machine provides optimal rod guidance. Extendable crossbeams make it possible to drill 6 horizontal holes in parallel positions. With the optional vertical level control system installed it is possible to drill 12 holes in one drill set up. A central chain drive is used to feed the drilling drives and an electronic feed

control system prevents the drill drives from overloading and/or deadlocking the drill rods.

Rock pressure can reduce the lifetime of tunnelled sections particularly in potash and salt mines. Paus has recently designed the Slot Cutter PLS 10, a rubber-tyred and all-wheel-driven loader designed to minimise floor convergence and track construction underground. With its cutter, users have the option of cutting tension relief slots into the roof with a continuous nominal depth of 1.8 m and a thickness of 0.15 m. This process is a major contributor to improving roof and impact safety. The machine can be used in tunnels up to 2.8 m wide with a maximum height of between 2.4 and 3.2 m. The vehicle is also fitted with a shield to push fallen rock to the side in the same process.

The cutter is equipped with a 69 kW Deutz diesel engine. Power is transmitted from the



Uralkali is looking to produce its production capacity for potash to 19 Mt/y

cutting chain to the boom by means of the hydrostatic drive. A dual rotary mechanism ensures slots can be cut at any position across the cross-section of rock. During cutting, the vehicle is moved by a 30 kW engine, which enables users to make very precise adjustments from the cabin. The cutting speed is 1 metre per minute. A 76 kW engine and torque converter with a Clark powershift transmission is also used for transport within the mine. The machine is also equipped with a motor cable reel with some 300 m of cable, giving the vehicle maximum freedom of movement.

The driver's cabin on the Paus Slot Cutter is fitted with a protective floor and roll-bar. Maximum sight is ensured by a 180° rotatable driver's seat and double driving platform when moving forward and reversing. There is now no need for turning manoeuvres in narrow mines and tunnels, as the driver can turn the driver's seat towards the opposite driving platform and exit the tunnel in reverse. The monitoring equipment for both directions enhances driving safety. The all-wheel-driven vehicle has a sturdy modular framework construction and hydraulically-supported articulated steering.

Joy Global estimates that it has delivered over 70 machines to potash mining operations, including continuous miners, battery haulers/shuttle cars, feeder breakers and flexible conveyor trains (FCTs). Continuous miners have been used in potash operations for many years, however, Joy argues that in recent years their size, weight and motor power has enabled them to consistently produce at high enough rates to make them consistently more economic when compared to more traditional drill and blast methods. The company estimates that the productivity of continuous miners has more than tripled in the last ten years. This

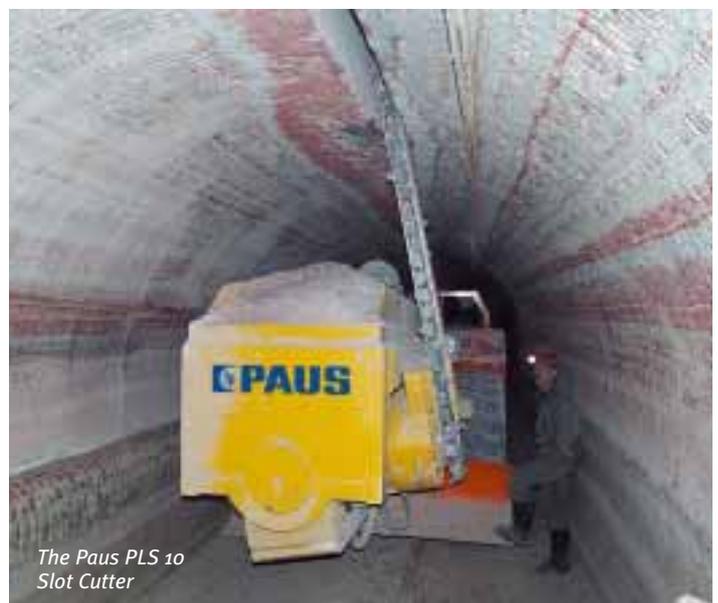
increase is due to higher capacity equipment, increased power, high voltage, increased reliability and utilisation coupled with better infrastructure, improved mine planning and layouts and better roof control. Potash mines using Joy continuous miners include ICL's Boulby mine in the UK and Intrepid Potash in New Mexico.

For the industrial minerals market, Joy offers the 12HM (hard rock miner) series continuous miner. Within the series is the 12HM36, the largest and most powerful drum type continuous miner manufactured. Utilising common continuous miner components, but designed to meet specific applications, the 12HM continuous miners are successfully operating in trona, gypsum, potash and salt mines around the world. The basic elements of each continuous miner are similar in design, following field proven philosophies perfected by Joy over the years. Each machine employs Joy's multi-motor concept with outboard access to motors, gear cases, controllers and other major components.

The philosophy calls for the isolation of major components for easier troubleshooting and maintenance. The continuous miners use individual motors with direct drive transmissions to power the cutter, traction, gathering and hydraulic systems. This permits service or repair quickly and easily, thus reducing downtime and maintenance costs. The group also

offers longwall systems for industrial minerals operations. Joy's latest innovation in this area is its Advanced Shearer Automation (ASA) system, which results in the optimisation of longwall production cycles and mining safety, according to coal customers in the US, Australia, and China. Joy Global states; "These operational gains, which also contribute to lower operating costs per tonne, stem from new shearer steering technologies which allow the programming of fully-automated cutting sequences, including gate-end turnarounds. End user benefits include controlling the shearing machine with a single operator, positioned upwind with less dust and noise exposure; achieving consistent extraction heights and cutting methods between shifts; and allowing the ability to manage shearer speed while easily accessing valuable system performance data at the mine surface." Joy ASA productivity features, such as gate-end turnarounds, are the result of very specific software enhancements, new sensor technologies, and the sharing of data between the shearer, powered roof supports, and face conveyor sub systems. The initial cutting profiles and extraction heights are defined by the use of a software utility called the Graphical Offline Planner. With this configuration, the shearer automatically replicates the face profile until seam conditions change – at which time, the operator has the ability to override control of the roof drum which records the changing roof horizon. By utilising this new roof horizon data, the remainder of the cutting sequence is fully automated per the predefined extraction heights. This advanced level of automation enables the most efficient cycle times possible, while providing day-to-day consistency.

Joy's licence with CSIRO has enabled Joy to integrate CSIRO's Landmark Face Alignment System into Joy's longwall automation platform,



The Paus PLS 10 Slot Cutter

further boosting performance capacities by automatically maintaining alignment of the AFC with the coal seam, a production advantage that minimizes downtime by eliminating the need to manually straighten the face. This alignment is achieved through the use of an inertial navigation system (INS), which is located in the shearer controller, and is used to track the position of the shearer as it traverses the face, measuring the face straightness. This information is transmitted to a server where the data is compared to a predetermined model of the seam. The server then issues recommended corrections to the powered roof supports, instructing the system how far to advance on subsequent cycles, which allows proper alignment with the coal seam. Joy shearers equipped with the Landmark Face Alignment System are currently available in the US and Australia.

Caterpillar has also announced its next generation EL3000 longwall shearer, which features a state-of-the-art communication system for advanced automation and monitoring. The Caterpillar longwall system includes personnel proximity detection and underground cameras that can be linked to a surface monitoring centre. In underground rubber tyred equipment, new additions include the new AD60 underground truck, with 60 t capacity, and the new R3000H underground loader, with a 20 t capacity.

Borer miners

Borer miner machines in trona or potash are typically used to drive entries up to a total length of 1,500 m in a number of passes, using an extensible belt conveyor arrangement. The resulting room width can be as large as 22 m. The height, depending on the seam conditions, can also be mined in multi-pass operation. A typical application in higher seams sees the machine advanced through the panel on the first pass and operated with a bridge conveyor on the second pass. This application repeats the sequence a second time by taking two additional passes at a lower level. The average result is a room height of approximately 4.5-5 m, depending upon ground conditions and seam thickness. Finally, there are also applications where cascading mobile-bridge-conveyor concepts are used. These are particularly suitable for the 3 m and higher seam heights.

The development of boring-type continuous miners began in the 1950s. Two machines were built by the Marietta Manufacturing in West Virginia. The Marietta Miner, as this machine was called, was mounted on tracks and fully mobile. The original machines were rail-mounted and could only cut a short distance before the machine would have to be backed

away from the face and additional track installed. Successful use of these machines in coal led to their ultimate application into trona and potash in the 1960s. The interest in this type of machine among the US coal miners became ever greater. The Clarkson Division of National Mine Service purchased the rights to manufacture the Marietta Borer and improved the design by increasing the installed power. In 1969, legislation in the US stopped the Marietta Miner from being used in underground coal mines, due to the fact that many of the new roof control and ventilation requirements could not be met with Marietta machines. National Mine Service started with designing and manufacturing larger, heavier, and more

powerful machines for mining trona, potash, and salt. In 1959, the first non-coal Marietta Miner was delivered to a trona mine in Green River, Wyoming. In 1965, machine specifications were introduced for Canadian potash mines. Since then, many miners have been delivered ranging in profile dimensions of 2.1 m high by 3.6 to 4 m wide; to 3.3 m high by 5.5 m and 6 m wide. The largest machine was the Marietta Borer type 780AW-4, a four-rotor machine that cut a profile 2.5 m high by 7.8 m wide. These miners range in weight from 68 t to 225 t and have a total installed power of 560 to 1,400 kW.

Sandvik bought the rights to the Marietta Borer and set about updating the design for production at its Zeltweg, Austria location. This

International Mining Editor Paul Moore and Publisher John Chadwick go the extra mile to report on real mines and mining projects globally, in addition to the major tradeshows and exhibitions. So far from 2011 to early May 2012 alone, visits have included the following:

Country	Operations reported on
BRAZIL	Samarco (iron ore) Anglo American Barro Alto (nickel)
BULGARIA	Chelopech (gold)
CANADA	IAMGOLD Westwood (gold)
CHILE	Anglo American Los Bronces (copper)
CHINA	SD-Mining Sanshandao (gold) SD-Mining Xincheng (gold) Xinjulong Jonggu (coal)
CZECH REPUBLIC	OKD CSA (coal)
FINLAND	Northland Resources Kaunisvaara (iron ore) Dragon Mining Orivesi (gold)
GERMANY	GEOMIN Erzgebirgische Kalkwerke (marble)
IRELAND	Boliden Tara (zinc)
POLAND	NWR Debiensko (coal)
RUSSIA	KRU Taldinski (coal)
SOUTH AFRICA	Frontier Zandkopsdrift (rare earths)
SPAIN	Iberpotash Cabanasas (potash)
UK	Galantas (gold)
USA	Stillwater Mining (platinum/palladium) Peabody Energy NARM (coal) Peabody Energy Rawhide (coal)





An Eickhoff SL500 longwall shearer at Belaruskali

project ultimately saw the development of the MF420 Sandvik Borer Miner, which was based on the design of the well proven Marietta Borer Miner 1012. It was presented to potential customers in early 2010. The MF420 has a total weight of 250 t and a total installed power of 1,630 kW. The cutting unit is driven by two 448 kW motors for the rotors and three 160 kW motors for the top and bottom cutting drum, providing the power to continuously produce 24 t of potash ore per minute. When developed, the machine was the world's largest self-propelled underground mobile mining machine. With the high cutting power it is also the most powerful and most productive machine on the market. The MF420 Borer Miner is. Several of these machines have been in operation for decades in a number of Canadian Potash mines.

The Borer Miner MF420 is a boring type, variable height and width-machine which cuts and delivers material to auxiliary haulage equipment in a truly continuous operation. The machine may be used to drive entries, mine rooms and extract pillars as rapidly as haulage equipment can remove material to the main haulage way. The instantaneous advance rate of the machine can be as high as 0.5 m per minute.

The addition of cutter drums to the cutting concept is one aspect of the new generation of Borer Miners, and provides a number of advantages, including the ability to make a sharp corner between roof and rib; reducing the major cause for breakdown and wear on standard machines (the trim chain); less power requirement and higher penetration rates; reduced fines; and increased manoeuvrability to follow the seam as well as negotiating gradient changes better.

In August 2011, Sandvik Mining and Construction entered into an agreement with BHP Billiton for the conceptual design of a mechanical cutting system for use at the Jansen

project. The project located near Saskatoon, Saskatchewan Canada will employ Sandvik Borer Miners designed and developed under the agreement. This has led to the development of the Borer Miner MF460, a design upgrade of the MF420 with an extended range in cutting height for following the seam variation at the Jansen project. The proposed Sandvik Borer Miner design originates from the well proven EIMCO 1012 operating at the Lanigan mine, which has also operated at the former Potacan mine. The emphasis of this new development is the integration of well proven technology into a machine which eliminates the bench cut in a variable seam and incorporates an intelligent control system to steer the machine in seam with the target to automate the cutting process. Smart diagnostics will assist in improving reliability as well as machine utilisation. The MF460 consists of two main function assemblies, the cutting and conveying system and the tramming unit. The cutting and conveying system is connected to the tramming unit with the thrust posts and the trim cylinders, enabling the cutting and conveying unit to be adjusted in height as well as in tilt and roll. The tractor frame supports the entire weight of the machine and transfers this weight to the crawler chains through bogie wheels. The weight of the rotor drive gear case, conveyor assembly and main frame is supported by the tractor frame through the front and rear trim cylinders. The cutting forces are transferred from the cutting elements through the thrust posts into the tramming unit.

New mining approaches

A paper at the 2012 MassMin conference authored by RWTH Aachen University and K+S AG attended by *IM* discussed the development of mining concepts for cutting technology in semi-steep deposits. The major problem in

deposits with an inclination of 20 to 60° is that the dip is often too steep for the conventional use of mobile equipment or regular belt conveyors on the one hand; while on the other hand they are not sufficiently steep enough for gravity flow. To use mobile equipment involves the challenge is to find a suitable mine design and reduce the inclination in mine roadways to an acceptable level. In order to do so, different alternative mine designs were developed and discussed.

Drilling and blasting is still the most widely applied extraction method in German potash mining, but applications of cutting technology come increasingly into focus due to technological advancements and consequently increases in productivity. The development of a continuous mining system for semi-steep potash seams is part of a strategic research project, which currently is being conducted by the Institute of Mining Engineering I (BBK I) at RWTH Aachen University in cooperation with salt and potash mining group, K+S AG.

One theoretical example of a panel layout in a semi-steep deposit was presented with an average inclination of 25°. The general mining direction is downwards and access to the panel is provided by an entry drift, with an inclination of the roadway of 13.5°. At the end of this entry drift the actual panel layout starts. Within the panel the inclination of the main production drift (mains) is reduced to 8.5°. For layout purposes and in order to stay within the panel, the direction of the mains changes every 500 m. Fully-loaded standard mobile haulage equipment can operate economically up to this dip of the mains. The main extraction takes place in horizontal rooms/stopes with a length of some 500 m, starting from the mains. The development of the mains and the mineral extraction in the horizontal rooms/stopes are carried out simultaneously. The mineral is extracted by means of a continuous miner and is then transported to a feeder breaker by means of underground trucks.

An alternative option to mineral transport within the potash seam would be the development of a separate horizontal haulage level underneath the deposit, thus necessitating the integration of ore passes between the seam and the haulage level. However, the roadways required would most probably have to be developed in surrounding rock, which usually would be uneconomical.

It was also ultimately recommended for cost reasons to use drilling and blasting technology for the development of the mains and cutting technology for extraction in the rooms/stopes. *IM*