



## EDITORIAL

### Tough times, but prepare for the upturn!

**OUR CUSTOMERS HAVE** been forced into mining more difficult resources as the easily available ones have been stripped. This means digging deeper into the earth which is more expensive, dangerous and time consuming.

In addition to the tough tasks of drilling and extraction, the mining industry is confronted with other challenges such as the impact of their operations on the environment, increased regulations and the rising costs of mining.

Mining companies are clearly doing their best to manage productivity and improve efficiencies, and at Atlas Copco we have an important role to play in developing the technology that will help our customers achieve these goals.

One example is the Explorac 100, a new exploration drill rig which has been launched to meet demands for personal safety and environmental care. It offers the efficiency and performance required by contractors, such as fast setup and drilling speeds, easy maintenance, reduced noise levels and enables the collection of high quality samples that geologists need.

On top of that, we can provide a complete solution for reverse circulation drilling, including drill rig, compressor, booster and drill string, making it easy for our customers to deal with just one supplier.

Another example of how new technology can reduce costs as well and improve the environment is the new Green Line range of electric mining vehicles which you can also read about in this issue.

At Atlas Copco we believe that there is always a better way. We also believe that by investing in new technology you will not only be able to tackle today's tough challenges, you will also be getting well prepared for the upturn.

**VICTOR TAPIA**  
President, Atlas Copco  
Geotechnical Drilling  
and Exploration.



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Tel: +46 (0)19 670 70 00.

**PUBLISHER** Paula Blamberg,  
e-mail: [paula.blamberg@se.atlascopco.com](mailto:paula.blamberg@se.atlascopco.com)

**EDITOR** Terry Greenwood, e-mail:  
[terry@greenwood.se](mailto:terry@greenwood.se)

**ADVISORY BOARD** Ulf Linder, Lars Bergqvist

**EDITORIAL PRODUCTION & DESIGN**  
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### TRADEMARKS AND REPRODUCTION OF ARTICLES

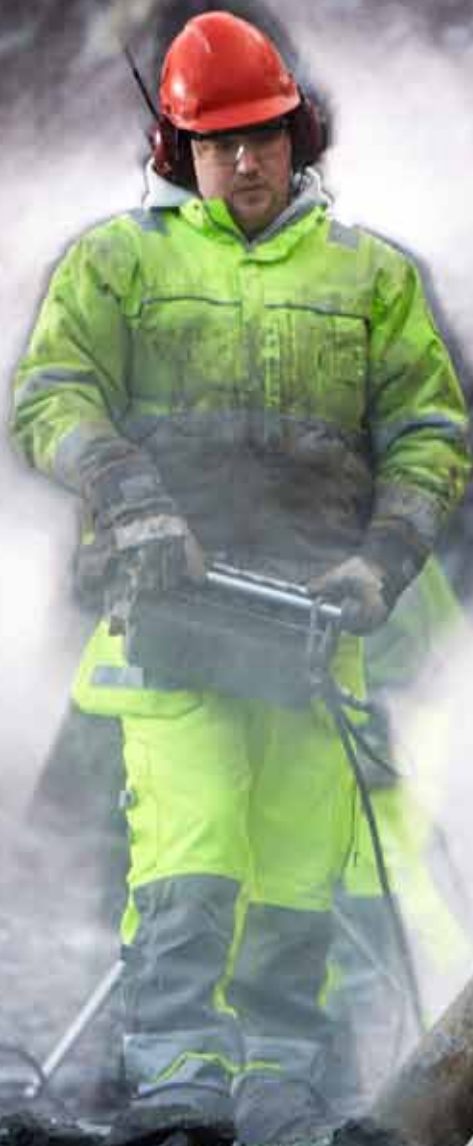
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**Atlas Copco**

# GOOD AS GOLD



## **New exploration rig makes grade control easy and safe**

The largest pure gold mine in northern Europe, Björkdalsgruvan, expects continued strong demand and is gearing up for future production using the new, compact Explorac 100 drill rig.





*Compact yet mighty: The new Explorac 100 performs RC drilling at Sweden's Björkdalsgruvan, the largest pure gold mine in Northern Europe. The rig's automatic rod handling system and teleremote control panel keep drillers out of harm's way.*

» **W**hether in good or bad times, few global commodities capture the imagination like gold. And despite the drop in prices this year, mines are expecting demand to remain stable.

Among the mines whose operations are thriving is the Björkdal mine, or Björkdalsgruvan as it is known locally, tucked away in the deep forests of northern Sweden some 40 km northwest of the town of Skellefteå.

Since prospectors first struck gold here in 1983, the mine has witnessed a near continuous expansion, and modern mining equipment increasingly plays a key role in maintaining high productivity levels.

Quality is equally important and following the mine's acquisition in 2012 by Canada's Elgin Mining Inc., a grade control project was initiated to plan for future blast holes that would help determine the path

for up to five years of continued production.

During an initial six month period, geologists and drillers came together to track the ore which is found in veins that extend like a spider's web through a rock mass with high quartz content.

#### **RC drilling – road to expansion**

Styrud Arctic, based in the town of Kiruna, is a leading RC drilling contractor in the region and saw a golden opportunity to provide rock samples in the form of chips using the latest exploration technology – the Explorac 100.

This newly launched reverse circulation (RC) drill rig from Atlas Copco is designed to deliver maximum performance and reliability while minimizing manual tasks.

Björkdalsgruvan has both open pit and underground operations. The open pit stretches over 50 hectares while the

underground operation reaches a depth of 305 m and extends over nine levels. The combined annual production is 1.3 Mt of ore which yields 1.3 tonnes of gold or 4 kg per day.

#### **Gold standard for safety**

The Explorac 100 is a new generation exploration rig and replaces the Explorac R50, a workhorse that has been familiar to miners for more than 30 years. It is an extremely compact rig – just 7 800 mm long, 3 000 mm wide and 2 300 mm in height – and features a labor saving rod handling system.

“Safety is the first thing our customers ask us about today,” says Joakim Kemi, Project Manager at Styrud Arctic, who supervised the testing of the Explorac 100 with the aim to update the company's fleet.

“The rig has an automated rod handling system which has enabled major improvements. It greatly reduces manual work and thereby the risk of accidents as our operators don't have to use a crane to lift and mount the drill rods which weigh 78 kilos.”

The Explorac 100 is a far cry from how gold was graded in the pioneering days of the Klondike. It drills 140 mm diameter holes to a precise depth of 32 m. It is operated by a team of three with one man for each task; drilling, rod handling and ore sampling. A cyclone unit mounted on the rig

“ Safety is the first thing our customers ask about. This rig reduces the risk.

**Joakim Kemi** Project Manager, Styrud Arctic





Upper photo: A protective cage boosts safety for the operators. Lower photo: Using the blow-down system to eliminate excess water, and thereby the risk of contaminating samples.

The art of grade control: Identical sample fines weighing 2.5 kg are a prerequisite for accurate analysis.

delivers one ore sample per meter. These are carefully collected in bags, separated into boxes according to a numbering system and delivered to the company's onsite geologist before being sent on for further analysis.

### Identical samples

A crucial part of the operation is to achieve near-identical samples. These should preferably weigh 2.5 kg for accurate analysis.

According to Andreas Hansson who operates the Explorac 100, the team achieves a production rate of three to four holes per day resulting in 90–128 sample fines, which well exceeds the required two holes per day.

"This can vary from week to week," he says. "We've recently had a lot of excess rain and groundwater to deal with which is a challenge, both in terms of drilling and sampling, as getting water in the cyclone will contaminate the samples."

In order to prevent the risk of mixing new and old samples in the cyclone, extra precaution is taken to eliminate water by using the rig's powerful blow-down system before each new drill rod is connected.

Hansson continues: "The Explorac 100 has excellent hydraulics and is also energy efficient. We typically run the engine at 1 500 rpm and diesel consumption is about five liters per hour, which is very low. It's also a quiet machine which makes it nice to work with, especially here at

Björkdalsgruvan which is the best work place I've had," he says.

The low noise emission is the result of a fully enclosed power pack design that holds a Tier 3A diesel engine (82 kW at 2 200 rpm). For each 32 m hole, 11 drill rods are required and the automated rod handling system does the job well, operated from a second control panel.

### Smooth operation

Hansson adds: "The machine took some getting used to but now we've got a really good work flow. The mast is made for angled drilling at 45 degrees and we usually take it to an upright position when changing the bit."


Another main design feature is the mechanized breakout system with its hydraulically operated key suitable for 4.4", 4", and 3.5" drill pipes. Apart from eliminating the use of handheld keys when replacing the drill bit, a new safety cage reduces any risks of injury.

Lena Printzell, Open Pit Geologist at the mine, coaches the drill team on a daily basis and monitors their progress. Using 3D computer software for orebody analysis, she collects data based on the amount of gold, minerals and quartz found in each sample.

"We use RC drilling after mucking and blasting but we're not actually doing exploration. Grade control is about obtaining more

information about the ore that we want to extract, so it is very important that the drill team is careful and precise in their work."

That, she adds, involves being certain that each sample corresponds with a given hole depth. "Without accurate samples, the entire hole is wasted."

Having previously drilled 150 m holes in the South Wall section of the mine, the Explorac 100 will return for long hole drilling sooner than planned. Project Manager Kemi concludes: "We've spent 600 hours testing this rig and I think it's a good and reliable machine. It provides a safer and more controlled environment for our operators, and it's also easy to load onto a truck thanks to the compact size." 

### YOUNG STAR IN RC DRILLING

The Explorac 100 is a compact, low emission rig with an automated rod handling system and a mechanized breakout table for increased safety and efficiency. Presented on a crawler chassis with remote control, it is suitable for both RC and down-the-hole drilling (DTH) applications, at depths of 100–200 m.



Scan the code for more information on the Explorac 100

# DRIVING THE FUTURE OF ROCK SUPPORT

## Now Atlas Copco broadens range to offer cutting edge shotcreting technology and equipment

Atlas Copco's recent acquisition of shotcreting specialist MEYCO of Switzerland has broadened the company's range to include advanced shotcreting knowhow and the market's widest range of mobile shotcreting equipment for underground applications. The acquisition places Atlas Copco at the forefront of this important technology and lays the foundation for the development of new shotcreting solutions.



With MEYCO now a part of the Atlas Copco Group, miners and tunnelers worldwide have easy access to the expertise and equipment required for superior shotcreting services.

This development is especially important for all underground mining and construction companies as the role of advanced shotcreting is increasing to meet higher demands for durability, safety, low risk to health and

“ Now we will be able to take a greater role at the forefront of this technology.



Pauli Arenram General Manager of Atlas Copco MEYCO.



*Suprema: For conveying and spraying of wet mix shotcrete and pumping of concrete.*



*Piccola: Designed for processing dry mix shotcrete according to the widely used rotor principle.*

negative impact on the environment.

Experts also believe that sprayed concrete techniques will play an even greater role in underground rock reinforcement as mines go deeper and safety regulations grow stricter, both for miners as well as tunneling engineers.

Working together with BASF Construction Chemicals, MEYCO's former owners, Atlas Copco aims to drive the future development of this technology with the focus on new solutions.

### Internationally recognized

The acquisition of MEYCO, whose knowhow and products are internationally recognized, puts Atlas Copco in a unique



*Potenza: Mobile unit for spraying of concrete.*



*Cobra FB4: An electro-hydraulic unit, specially designed for the mining industry.*



*Versa: Compact and versatile for maximum mobility in constricted tunnels, cross passages and winding drifts.*



*Poca: The most compact mobile unit on the market for professional concrete spraying.*



*Oruga FBS: Mobile spraying manipulator unit for mechanizing and automating concrete spraying.*



*Roadrunner: Sprays wet concrete and the only MEYCO unit which can be transported on ordinary roads.*

position to take the lead in this field.

Pauli Arenram, newly appointed General Manager of Atlas Copco MEYCO says: "For many years this company has been instrumental in providing cutting edge technology for shotcreting in tunneling and mining. Now, as a part of Atlas Copco, we will be able to take a greater role at the forefront of this technology with new methods, innovative equipment and application expertise. Through these solutions we aim to set new standards of safety and efficiency in tunneling and mining."

Tom Kurth, Marketing Manager, adds: "We are excited to see the possibilities offered by Atlas Copco to bring this innovative equipment into new underground

markets outside of Europe, which in the past was not easy due to the size of the after sales organization at hand.


"The synergies, particularly in engineering and procurement are obvious and will help to shorten the time to market for our new products in the pipeline. On the other hand, the MEYCO range will support the Atlas Copco offering in that we now can be a one-stop shop for all the activities and work processes at the tunnel face."

### **Comprehensive range**

The newly formed Atlas Copco MEYCO is based in Winterthur, Switzerland, and offers a comprehensive range of carrier-mounted concrete and stand alone spraying equip-

ment including spraying arms, pumps and dosing units as well as solutions for TBMs (Tunnel Boring Machines). The company also has in-depth knowledge of concrete technology and chemicals due to its long association with the chemical industry.

In addition, all spray concrete can be applied with MEYCO Logica, the company's unique robotic sprayer.

Until now, MEYCO equipment has mainly been available in Europe, Asia and the Middle East. From now on, it is available worldwide through Atlas Copco Customer Centers. 

*See MEYCO in Action in New York, page 9. See also Technically Speaking, page 16.*







# AT LAST! »»

## A new subway line for the Big Apple

They've waited patiently for almost a century, but now, at long last, New Yorkers are to get a new subway extension that will ease overcrowding and congestion on the city's transport system.

M&C goes beneath the streets of The Big Apple to meet the tunnelers working on the first stage of the new Second Avenue line.

UP TOWN TRAINS

DOWN TOWN TRAINS

# Tough challenge below the streets of Manhattan

It has been described as the most complex subway project in the world in the heart of one of the most densely populated cities on the planet. New York's long-awaited Second Avenue extension is all that and more.



*A major challenge: Workers set up the compact FlexiROC T30 in the access shaft at the north end of the 86th Street project.*



*The only way is up: After blasting, all of the muck was hoisted to the surface in boxes at the rate of 700–1 000 tonnes per day.*

» **N**ew York's long awaited Second Avenue subway extension is now well under way on Manhattan's East Side and will be a welcome addition to the city's mass transit system.

The first decision to build the new line was taken as long ago as 1920 and ever since then the project has been repeatedly postponed due to a long series of events ranging from The Great Depression through World War II to a prolonged series of financial and political obstacles.

In recent years however, renewed efforts to get the project back on track have succeeded and New Yorkers will finally get their much needed subway – although not before 2019.

The new line under Second Avenue will ultimately be 8.5 km long, running from 125th Street in uptown Manhattan all the way down to Hanover Square in the financial district. Along the way, there will be three new stations – at 96th Street, 86th Street and 72nd Street – plus several branches linking to other sections of the city's transport systems.

All in all, the project will cost a staggering USD 17 billion, but considering the

relief it will bring (more than 4.3 million people ride the NY subway every day), most people agree that it will be money well spent.

## First phase on track

Among the many contractors engaged in the project is Skanska USA and Traylor Brothers who have teamed up to excavate two construction shafts, North and South, and a rock cavern in between which will eventually house the new 86th Street station.

For the drilling operations, the team is using state-of-the-art equipment from Atlas Copco. This includes a FlexiROC T30 R surface rig (formerly known as ROC D3), two Boomer E2 C tunneling rigs and shotcreting equipment from Atlas Copco MEYCO.

The work began with the sinking of a 10 m x 7 m shaft where the FlexiROC T30 was used to great advantage. Thanks to the rig's compactness, the operator was able to rotate the rig within the extremely confined space to drill the 45 mm blast holes. In addition, the excellent boom coverage meant that the rig did not have to be frequently moved on the benches.

Dust was a major issue, but the contractors

kept it well under control with the help of the FlexiROC's dust control unit as well as blast mats and steel curtains to contain the flyrock and constant water spraying to dampen down the work areas.

Another challenge was to underpin the high rise building on the east corner of Second Avenue and 83rd Street. As a part of this building is directly above the future portal to the 86th Street Station, it had to be underpinned before excavation of the construction and escalator shafts could begin.

Tom O'Rourke, Skanska's Project Manager, said: "It was very close work at times. We had to watch the overhead utilities and surround everything in blast mats. Some blasts were as small as two meters by two meters in diameter."

After drilling its holes, the FlexiROC rig was hoisted from the shaft for blasting and then, after mucking out and scaling of the walls, it was lowered back into the hole to start drilling the next round.

## Drilling the crown

Once at the bottom of the shaft, the next challenge was to start drilling the crown of the cavern with the Boomer E2C tunneling



*Benching the North Shaft: A Boomer T1 D had to be used to expand the lower level of the shaft to create sufficient space for the Boomer E2 C (above) to start vertical drilling.*

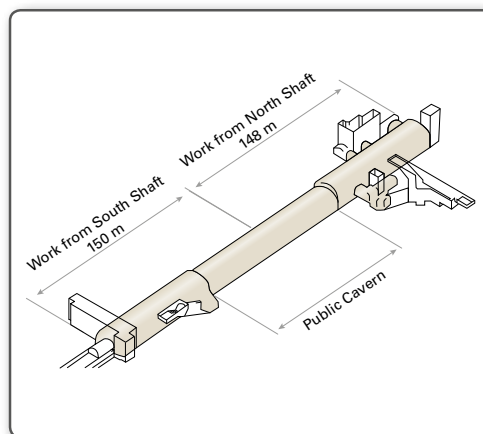
rig. However, there was not enough room to set it up at the right angle and a second Atlas Copco rig, a Boomer T1 D, was brought in to open up the shaft's lower level in order to expose the top heading of the cavern.

The Boomer T1 D is normally used in narrow-vein mining applications and is compact and versatile. It has a carrier length of 4.8 m and a boom length of 4 m with the BMH 2825 feed system. It can also be used with the BUT 4B heavy duty boom system which provides a 900 mm extension and a 1 500 mm feed extension. Furthermore, the feed rollover is a full 360 degrees with a boom swing angle of 30 degrees which allowed good maneuverability.

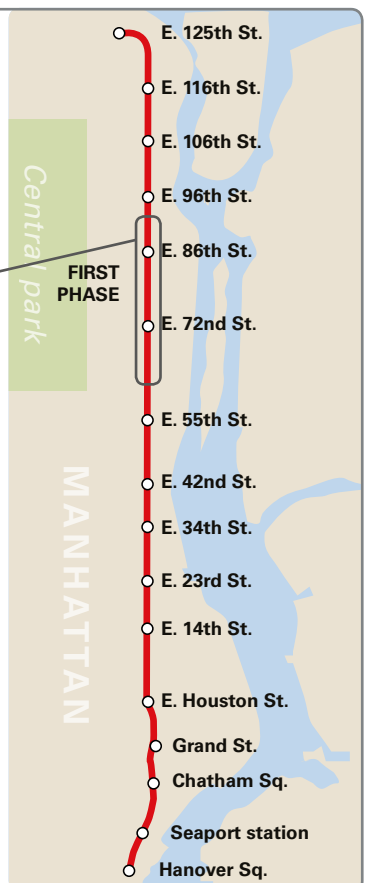
The rig was used to drill short cuts at 90 degrees into the shaft wall and it took several rounds before the area was big enough for the Boomer E2 C. In addition, the shaft floor had to be lowered by about 3 m, and slightly angled, to enable the boom to reach the cavern's top heading. After blasting, the Boomer E2 C could finally be lowered into position.

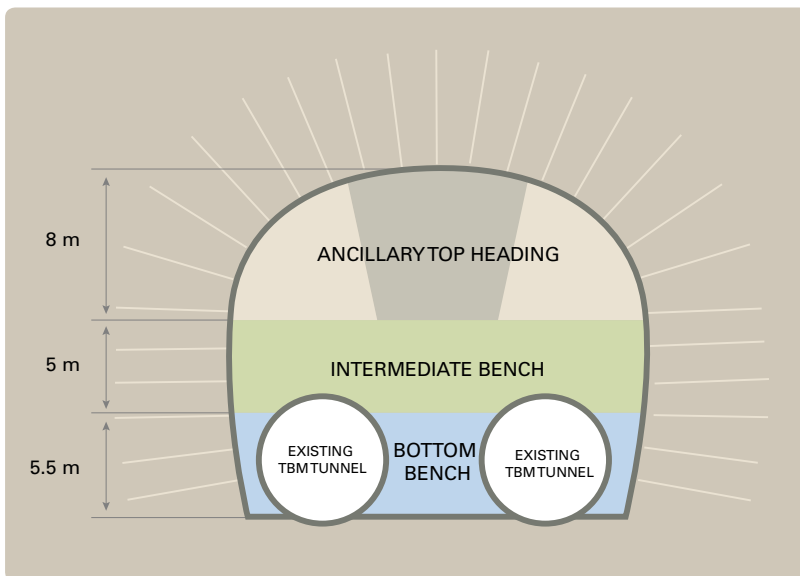
The cavern is located under Second Avenue with the crown only 12 m below street level and with an overhead rock cover of approximately 9 m. It will be 286 m

*Skanska-Traylor's assignment: The project involves two access shafts, a huge rock cavern in between the shafts to eventually house the new 86th Street subway station, plus a range of auxiliary excavations.*



*The route: The Second Avenue subway will run from 125 Street in East Harlem down to Hanover Square in the financial district and incorporate three new stations – at 96th, 86th and 72nd Streets. Scheduled to be opened in 2019, the new subway will reduce overcrowding and delays on the Lexington Avenue line, improving travel for both city and suburban commuters, and provide better access to mass transit for residents of the far East Side of Manhattan.*





Cross section of the cavern construction for the new 86th Street Station showing the existing TBM tunnels.



Setting up: The Boomer E2 C during the drilling of the cavern's top heading.

long and has ancillary sections at each end, 74 m and 88 m long, with a so-called Public Cavern in between, 124 m long. The ancillary caverns were excavated by top heading, intermediate bench and bottom bench (*see cross section above*).

The Public Cavern, being 3.6 m lower at the crown, was excavated as a top heading and bottom bench only. The top headings were split into a center pilot and two side slashes which were followed by the bench excavation.

The top heading center pilots were 7.3 m high and the total width of the cavern is 21 m. Two Boomer E2 C rigs were used, one operating from the North shaft and the other from the South Shaft and mucking was carried out by wheel loaders bringing the muck from the face to the shaft area and thereafter hoisted in boxes up to street level.

### Squeezing in the Boomer

The Boomer E2 C was used to drill most of the blast holes in order to remove 140 000 m<sup>3</sup> rock (108 000 m<sup>3</sup> the cavern with a further 32 000 m<sup>3</sup> from the escalator tunnels and all other underground excavations)

and was also used for drilling bolt holes.

But calculating how much space was needed in the shaft to get the Boomer in place presented the biggest challenge. Kip McCalla, Atlas Copco Area Sales Manager, says: "Having the dimensions of the rig and hole were not enough. We needed to know how the rig would react when articulating the booms in the shaft."

Joe Mela, Atlas Copco Area Salesman, was on site when the Boomer E2 C made its descent. "It was very, very tight and seemed like there was barely a coat of paint to spare," he says. "The crew really showed their expertise in getting the rig into position."

Lars Jennemyr, Skanska Director of Underground Tunneling Operations, shared the sentiment: "We knew the Boomer would be able to drill within the area but making that happen was critical. By sending our crews to Atlas Copco's Clarks Summit location, they were able to practice the maneuver repeatedly with the Boomer to get the routine down."

Jennemyr explains: "When the booms travel up and down vertically, they spread

wider from the center. By repeating this action and studying the booms' movements the crews were better able to understand what would happen in the shaft."

Once the Boomer E2 C was installed in the tunnel, face drilling advanced steadily and on schedule throughout the drilling part of the project," said O'Rourke.

The cavern advanced on three faces starting with the top heading, then the bench drilling. The center face of the top heading was drilled up to 7.3 m wide at the crown and 5.5 m to 6 m high on each side. Some 120 to 150 holes were drilled for the center and 70 to 90 holes for the sides. The tunnel face advanced 2.5 to 3.5 m with each round.

The rock here is competent Manhattan schist and granite with wide fracturing and is easily drilled. Typically, the drilling progressed at the rate of 3 m/min.

More than 210 people were on site during M&C's visit. Boomer operator Sean Keeffe has worked on several different Boomer models and said he especially likes the controls of the Boomer E2 C. "I think the controls are smoother and the Rig Control System makes it really easy to drill the pattern," he said.

The process for each drill pattern started with surveyor Paul Stogner. Skanska Superintendent John Kierman explained: "Paul navigated the entire cavern. He would set up the transom and line up the first hole. It would go pretty fast from there."

Stogner said: "It takes about two minutes for me to set up and locate the first hole. The driller would line up the rig and set up on the first hole and drill the pattern according to the computer's direction."

“ We knew the Boomer would be able to drill in the area, but making that happen was critical.

Lars Jennemyr Director of Underground Tunneling Operations, Skanska



*History in the making: Members of the Skanska-Traylor team with NY City contract tunnelers (known locally as Sandhogs) pose for a picture during construction of the new Second Avenue subway beneath the streets of Manhattan. In the background, the Atlas Copco Bommer E2 C drill rig which was lowered from street level to excavate the cavern for the new 86th Street station.*

Drill operator Kevin Mari has worked on three projects in New York City using the Boomer E2 C. He says he appreciates the BUT 45 boom rotation device which allows 190 degrees of rotation in both directions. "I like having the steel on top because it's easier to see and line up," he says.

Atlas Copco made a variety of consignment bits, steel and adapters available so that the crew had access to whatever they needed. The primary bit used was a 48 mm T32 flat face ballistic bit, although a range of sizes were available for the various drills and formation transitions.

The drill steel used was R32 × T38

Hex rod with a 57 mm coupler and R32 × T38 round rod. Both were available in 3 – 4.8 m lengths with round rod in 5.5 and 6 m lengths. A shank adapter for the T38 was necessary for the COP 1838 rock drills used on both the FlexiROC T30 and the Boomer E2 C drill rigs.

#### **Round the clock schedule**

The engineers worked round the clock, five days a week in three shifts – the first shift for drilling, charging and blasting, the second for mucking and scaling and the third for bolting, shotcreting and initiating the next cycle.

O'Rourke said: "The same process was

carried out with each slash; drill, blast, muck, bolt, shotcrete. For various reasons, the plan wasn't always followed but we tried to keep it consistent. It was an intense five-day schedule. If we were drilling on one face, we'd be mucking on another and loading on the third."

The plan was originally set up to drill benches with horizontal blast holes, but once they tried benching vertically with success, that's the way the project continued with both the FlexiROC and the Boomer. The benches were blasted in 4–5 m rounds and the muck from the first bench dropped into the existing TBM



*Reinforcing the rock: Using Atlas Copco MEYCO's Suprema spraying equipment, three layers of shotcrete were applied, two layers of a fiber reinforced mix including a superplasticizer, before and after bolting, plus a third non-fiber coating prior to the installation of a PVC water membrane. Together, the layers formed a minimum thickness of 250 mm overall.*

» tunnels from where it was hoisted to the surface in connection with the excavation of the second bench.

### The MEYCO factor

Rock stabilization was carried out with 6 m resin rock bolts above the springline. Working from the rigs' service platforms, the bolts were placed in a 1.8 m pattern and pre-stressed to 133.5 kN. Six meter dowels were installed below the springline in a grid pattern of 1.8 m vertical by 3.5 m horizontal.

Shotcreting was done in three phases using shotcrete and equipment from Atlas Copco MEYCO. Before bolting, the specifications called for a layer of steel fiber reinforced shotcrete with a minimum thickness of 50 mm. After bolting, a further layer of 100–150 mm of steel fiber reinforced shotcrete was applied. Lastly, a smooth coating without fiber and with a minimum thickness of 25 mm was applied to cover the fibers before the PVC water membrane was installed.

Gary Almeraris, Project Executive Manager, explained: "The key to shotcreting is high quality, not high quantity of the mix. We used 400 bar steel fiber reinforced shotcrete with a superplasticizer. An accelerator was added to give rapid support in just 10 hours and full support after 28 days. Every day, 60 to 90 m<sup>3</sup> was sprayed using two Suprema shotcrete pumps and two Potenza spraying robots.

Almeraris commented: "With the MEYCO we could spray 18 cubic meters an hour with the guys in the cavern communicating with the guys on the surface by radio." A tender on the Suprema pump unit on the surface controlled the ready-mix trucks so that the Suprema operators knew when the material was ready. "We applied shotcrete 80 to 100 mm at a time with a minimum of 175 mm overall. One layer could go on right after the other, and there was not really any waiting. The MEYCO equipment worked really well."


Throughout the project an Atlas Copco service technician was on site, day and night – Jim Mattila on the day shift and Scott Streichenwein on the night shift. Almeraris said: "The support we received from Atlas Copco was unbelievable. They were with us all along the way. Whenever we needed them, they were there – really part of the team."

### On schedule

The project has continued on schedule with the removal of the muck from the downtown streets being the most complicated part of the project. Each day between 7 am and 10 pm a total of 40–60 muck boxes were hoisted up the shafts to the surface and loaded onto dump trucks to be hauled away.

Much of the drilling and blasting on this section is now complete and in a few months the cavern will be down to the final invert level. Then the construction of the

cast-in-place concrete lining of invert, walls and arch concreting will begin. Lastly, the escalator and adit tunnels will be completed and the project will be handed over to the city's Metro Transit Authority by September 2014 for track laying, mechanical and electrical installations.

This first section of the new line, between from 96th St. and 63rd St., is due to be opened in December 2016 and carry some 200 000 passengers per day. 



*Total concentration: MEYCO operators apply the final layer of shotcrete to a wall using the Suprema machine's remote control.*







# WALLS

*More than meets the eye: The typical gray shotcrete used to reinforce mine and tunnel walls. Today, due to its high capacity, only the wet mix method is used in tunnels for which MEYCO robotic equipment (right) is ideally suited.*

and tunnelers to reduce the effort of installing wire mesh, thus saving a considerable amount of time and money.

The thickness of the shotcrete layers varies, depending on the mix type and the project requirements, but this is normally up to 50 mm for wet mix and 30 mm for dry mix in one path. In many cases though, thicker application is required which means that multiple layers have to be applied.

A great many parameters are taken into account when matching shotcrete to different applications. These include sand/aggregate grading, cement type and amount, hydration control of admixtures, type of plasticizers/superplasticizers, workability, accelerator type, temperature, pulsation, nozzle systems, to name a few.

Safety is obviously a major consideration in tunneling but so is speed and cost. Each operation in the tunnel has to be carried out as quickly and as efficiently as possible. The faster the contractor can apply the shotcrete the better it is for the overall economy of the project, and the more likely that the contractor will meet the contracted

completion date. Similarly, the more shotcreting time can be reduced, the faster the advance, thereby reducing the costs for tunneling.


## Shotcrete of the future

These days, wet mix is now used exclusively in tunneling thanks to its high capacity. On large tunnel profiles such as highway tunnels, up to 24 m<sup>3</sup>/h of wet mix can be sprayed, whereas the dry mix method would only give a maximum of 10 m<sup>3</sup>/h.

In this context, MEYCO equipment is extremely economical. Due to a patented control system on the concrete pumps, it gives less waste material, known as “rebound”, and uses less chemical accelerator thanks to highly accurate dosing systems. Moreover, robotic units keep operators out of danger zones and ensure optimal spraying parameters such as distance of spraying nozzle to rock strata and a consistent spraying angle of 90 degrees, which reduce rebound and give full coverage of rock strata. Robotic equipment also lessens the dependency on skilled operators.



It is true to say that shotcreting is a science in its own right and an indispensable element of modern rock support technology in all subsurface construction. However, the technology is far from complete and the drive to develop new innovations in this field are intensifying. In the future, leading shotcrete specialists, including Atlas Copco MEYCO, will develop new methods and products to further increase functionality, performance and safety.

I believe their success will have a major impact as mines go deeper and tunnels are increasingly driven through weaker rock strata and in increasing length. 



Tom Kurth is Marketing Manager at Atlas Copco MEYCO, the international shotcrete equipment specialist, based in Winterthur, Switzerland. He has more than 20 years of experience working with shotcreting technology and application machinery.

*Family business: PerfoChile's Operations Manager Osvaldo Carmona Morales on site with the RD10+. Morales, who is the son of Osvaldo Carmona Vergara, the company's founder, visited the Atlas Copco factory in Garland, Texas, together with Business Development Manager Eduardo Eguillor, prior to the delivery of two new RD10+ rigs.*





# A PERFECT plus for PERFOCHILE

## Reverse Circulation specialist relies on RD10+ for mineral exploration

Exploration contractor PerfoChile is known for its work with reverse circulation and diamond core drilling. That reputation has just been given three extra plus points.

Chile produces more than one third of the world's copper and also has an abundance of gold, silver and iron and exploration drilling is continuously under way to find more hidden treasures.

Among the many contractors who provide these drilling services to the nation's mining companies is PerfoChile, a contractor with a widespread reputation for reverse circulation (RC) and diamond core drilling as well as blasthole drilling.

Most of the company's contracting work is done in northern Chile and the company calculates that it has drilled more than seven million meters since it was founded some 30 years ago.

A more recent milestone is that the company has also commissioned a new Atlas Copco RD10+ RC drill rig – the fourth such rig in its equipment fleet. This large-hole rig is a typical hydraulic, top-head drive drill that produces 445 kN of pullback force and 13 560 Nm of torque.

By way of contrast, the majority of exploration contractors in Chile are focused on core drilling, which is a slower process than RC drilling, and, PerfoChile says, less cost effective.

PerfoChile was founded in 1984 by Osvaldo Carmona Vergara, a former mine superintendent, and today, besides a modern drilling fleet, the company also has service workshops in Santiago, Antofagasta and Pozo Almonte.

The company typically drills holes 300–700 m deep, depending on the terrain. "With exploration drilling there's no defined drill pattern," says Carmona Morales, who now runs the business. "Sometimes the holes will be one kilometer apart, others 500 meters apart, and some can be much closer. It's wherever the geologist decides."

According to Carmona Morales, the RD10+ has at least 90 percent availability and typically performs at a high level. "We prepare the rig before the job, and if something were to happen to the rig we'd have to put all of our resources into that rig to get it running again," he says.

With a three-man crew consisting of one driller and two drill helpers, PerfoChile works three shifts per location, including a relief shift. Typically each shift includes time for breaks, set-up and maintenance. Most jobs consist of eight to 10 holes,

usually drilling a total of 3 000 m per month.

Carmona Morales said they even hit a total of 5 000 m in one month for a client who needed 10 holes drilled to a depth of approximately 500 m.

The holes are typically 146 mm in diameter and about 400 m deep, using a down-the-hole hammer.

The great majority of Chile's mining takes place in the Norte Grande region, bordering Peru to the north, and the Atacama Desert. Working in rugged, remote locations requires PerfoChile to set up camp for each job. And the compact design of the RD10+ is ideal for working in such remote locations.

Carmona Morales says: "It enables us to go to the mountains, and you need a big space to drill deep holes. It's also compact which means we can travel on the freeways and the highways. Our country is very, very long so sometimes you need to drive 1 400 kilometers from Santiago to another city."

With inevitable travel between jobs, the ability to go anywhere at anytime without a great deal of support along the way is crucial. It takes approximately on average three truck loads to move from site to site.

"We use one compressor and booster, a truck for rods, and another truck for fuel. We use trailers for a camp, too," says Carmona Morales.

PerfoChile drillers have become expert RD10+ operators – both inside and outside the country. Some of them helped with the setup and training of an RD10+ that was shipped to a customer in Brazil. This shows the strong relationship between PerfoChile and Atlas Copco.

Eguillor says: "There's a lot of continuity, confidence, and loyalty between what was Ingersoll Rand and what is now Atlas Copco." It's this confidence that ensures they will most likely continue as partners well into the future.

“The RD10+ is a compact rig and performs with an availability of at least 90 percent.”



Carmona Morales Operations Manager, PerfoChile



Carefully selected: The Girodrill EVO drills a marble block at the Pinoso quarry in Alguena. Above, Quarry Manager Jesús Pérez de la Muela (right) with Fernando Menendez, Atlas Copco's Business Line Manager in Spain.

# PRODUCTIVITY

## written in stone

**The story of the drill rigs that met the high demands of a world leader**

Levantina of Spain – the multinational producer of natural stone – has increased productivity at its Pinoso limestone quarry in Spain with a drill rig fleet from Atlas Copco.

In the international dimension stone industry, Levantina of Spain is a well known name. The company operates more than 60 quarries, including the largest marble site in the world, El Coto Crema Marfil in Pinoso, Alicante.

Since it was founded in 1959, Levantina has grown continuously and has undergone significant international expansion. Today it has a global presence and is regarded in the dimension stone industry as a benchmark for quality, innovation, technology and sustainability.

As part of its sustainability strategy, Levantina insists on using the most advanced technology available to extract the stone blocks and process products with the emphasis on energy efficiency, saving and recycling water and respect for the environment. As a result, all of the equipment used

at its quarries is carefully chosen to meet these criteria.

The company's Pinoso limestone quarry in Alguena near Alicante in southern Spain is a typical example. It is one of the biggest quarries of its kind in the world producing more than 1 000 m<sup>3</sup> of stone per day with a workforce of 250 and a fleet of four drill rigs from Atlas Copco.

### Productivity boosters

These rigs, from the Perfora range, now a part of the Atlas Copco Group, include a Girodrill EVO and a Girodrill 200, the latter clocking up more than 2 000 hours in just over seven months. Not only are they fast and efficient, they are run autonomously which has significantly contributed to the quarry's productivity.

Quarry Manager Jesús Pérez de la

Muela explains: "We've seen an increase in our productivity thanks to these machines. As they have their own compressors we can use a small pneumatic hammer to open the drilled benches, making it completely autonomous. No other supporting equipment is needed to start drilling the blocks.

"In addition, all rack movements are controlled by remote radio control for added safety. This has increased the production cycle by about 20 percent and the noise levels are much better as well."

Inclined benches can be dangerous to work on with pneumatic drills. The Girodrills, each of which can easily match the performance of three pneumatic rigs, are equipped with a multiple positioning movement, allowing for safe bench drilling even in difficult working conditions as well as at night.

José Deltell, Levantina's Production Manager, adds: "A big advantage with the Girodrill is its self-sufficiency. I don't



*With 250 people working two shifts a day, the Levantina quarry in southern Spain produces as much as 1 000 m<sup>3</sup> of limestone per day. A fleet of Perfora Girodrill drill rigs recently helped to raise productivity here by 20 percent.*

need other equipment to support it or to run hoses to supply it with air. The production to consumption ratio has been much improved. Earlier, to achieve this level of production we needed about twelve drill rods per month. Now, with the Girodrill, we only need two to produce the same amount.” With the cost of drill steel averaging 75 euros/unit, savings are substantial.

Deltell continues: “We achieve very high levels of productivity with 1 600 to 1 700 linear drilled meters in two eight hour shifts. And that’s more than seven hours of productive drilling out of the eight hours that the engine is running with a fuel consumption of just 105 to 110 liters!

“These are very profitable figures. We can produce eighty cubic meters per day with just one machine so we are extremely satisfied.”

### Expanding the fleet

Levantina now plans to increase its capacity even further by adding more Perfora rigs to the fleet. The company plans to order three

more units in 2013 followed by another five in 2014.

Meanwhile, tests are being carried out with a Perfora SpeedCut wire saw. These are also proving positive, achieving 21 m<sup>2</sup>/hour compared to the 10 to 13 m<sup>2</sup>/hour of previous equipment. If these early results continue, Levantina plans to extend SpeedCut technology to other quarries in the group.

Quarry Manager de la Muela concludes: “We are always looking to increase productivity and we trust the Perfora range from Atlas Copco to bring to us the best equipment for exploring the dimension stone industry.”

### Footnote:

In February 2012, Atlas Copco made a major commitment to the dimension stone industry (DSI) with the acquisition of the Italian specialist Perfora, a company that manufactures and sells DS cutting and drilling equipment. Perfora is a leading supplier in this segment, with a strong customer focus and high quality products. As part of the Atlas Copco Group, Perfora is now a global supplier of tailor made equipment for dimension stone producers.



*Smooth operation: Using the Girodrill 200 with remote control.*

Levantina owns and operates 63 quarries in Spain, Portugal and Brazil. It has nine factories, 35 distribution centers and 1 700 employees worldwide. The company offers an extensive range of natural stone products including marble, granite, limestone, onyx, travertine and slate. More than two million tonnes of raw materials are extracted annually, of which 1.4 Mt is marble from the Crema Marfil quarry, the largest in the world. These materials are used for construction projects of all types such as shopping malls, public buildings and hotels.





*Leif Kemi, Production Manager at Svappavaara mine: "Most of our operators were very impressed."*



*Outstanding job: The new FlexiROC 45 logged 12 500 drillmeters with a fuel consumption of just 20.5 liters per hour. In its folding boom version the rig is equipped with the COP 2560 and in its fixed boom version with the more powerful COP 3060 for deeper, straighter and larger holes.*

**TEST DATA**

Engine hours: 500  
Impact hours: 200  
Meters drilled: 12 500  
Hole diameter: 89 mm  
Average depth: 15 meters in iron-rich rock  
Fuel consumption: 20.5 l/h  
Engine RPM: During drilling 1 200, during tramping 600, during idle 900

# AS GOOD AS NEW!

## Meeting market demands for remanufacturing

Atlas Copco's remanufacturing services are being developed and expanded across the globe to meet increasing demands for reconditioned components or even entire drill rigs, loaders and trucks. For equipment owners, reman solutions is the perfect way to maximize assets and cost flexibility.

The remanufacturing of key components on mining equipment is in increasing demand and Atlas Copco has responded by further developing these services at multiple locations around the world.

At a time when mines are looking to increase availability at the same time as they need to keep costs down, remanufacturing has emerged as a valuable, short term option.

Remanufacturing, not only of key components but even of entire products, offers important advantages for mining companies. For example:

- having a single-source supplier to remanufacture the parts and support the product ensures quality workmanship and components
- in many cases, remanufactured components come with the same warranties as new products or extended warranties
- mines remain operational and productive and get more time to consider an investment in new equipment
- the cost of remanufacturing is substantially lower than the cost of a comparable new product.

To meet the upward demand for these services, Atlas Copco Service is strengthening

its remanufacturing capability at dedicated "reman" facilities.

### Setting the standard in Garland

**THE CITY OF GARLAND** in Dallas, Texas is the U.S. location for remanufacturing equipment components, and is also the base for the manufacture of Atlas Copco's Pit Viper and DM drill rigs. The processes and procedures developed here serve as the the standard for all other Atlas Copco reman centers around the world. The Garland Reman Center has come a long way since its startup in 2009. After a major expansion in 2012, the 3 700 m<sup>2</sup> facility is now equipped with state-of-the-art tools and testing equipment.

“Remanufacturing solutions give customers peace of mind that components will always be available.”

**Bill Xuan** Reman Solutions Product Manager, Atlas Copco Service



These include Atlas Copco's industrial tools and hydraulic testing tools for all products after remanufacturing.

In its five work bays the Center mostly remanufactures pumps and motors, but also rotary heads, airends, cylinders and drives. More than 180 spare parts are in stock to support component remanufacturing for hydraulic components alone.

The next phase of the Center's evolution will add repairing rock drills and remanufacturing axles and transfer cases, all with OEM parts to precise OEM specifications.

When a major component needs remanufacturing, it first goes through a visual inspection by local certified technicians. A part that has a major failure such as a housing crack is not considered a candidate for remanufacturing. Once a component







**Remanufacturing in action:** *This rotary head from a Pit Viper 351 drill rig will be completely restored and reassembled using new genuine parts and applying the latest engineering specifications and factory upgrades.*

qualifies for remanufacturing, it is sent to Garland in purpose-built boxes.

Each component that arrives in Garland goes through a specific 15-step process that includes inspection, disassembly, cleaning, upgrading, parts replacement, assembly and testing. Each component leaving the Center will have an OEM quality certificate and traceable information, including serial number, parts numbers and inspector signatures.

That component stays in the Atlas Copco engineering and logistics information management system throughout its life.

Bill Xuan, Reman Solutions Product Manager at the Garland Center, points out that the greatest cost related to customers' productivity is downtime.

"Being down greatly outweighs the cost of the component itself, and a remanufactured component is even more cost effective

with the same quality level as new," he says. "Having remanufacturing solutions for our customers allows them the peace of mind that major components are always available off the shelf. In addition, having a single-source supplier and OEM guaranteed remanufactured components along with continued service creates harmony in using Atlas Copco equipment."

These remanufacturing solutions from **>>**



*Remanufacturing in the USA: The process begins with the cleaning of all components before moving on through the five remanufacturing work bays. The procedures and processes developed in Garland set the standard for Atlas Copco Reman Centers worldwide.*

» Atlas Copco offer customers smart and sustainable options for service. With Customer Centers around the globe, Atlas Copco is within easy reach. Service is flexible and can be suited to each customer's needs, whether it is 24 hour technical support, routine maintenance, repairs, remanufacturing or service programs that use Atlas Copco's expertise to manage equipment fleets.

"Our goal is to be flexible in how we help customers and share knowledge," says Xuan. "Atlas Copco has a good understanding of the customers' operations and their industry and how to maximize the performance of their equipment."

"Atlas Copco's technicians at the mine can monitor the part's life from installation to removal. Scheduled replacement means there is no downtime outside routine maintenance. We can look ahead for optimum planning for the customer, or just provide service as needed."

Sylvia Havre-Carter, Operations Manager at the Garland Center says: "We have had a great many components come in here. If we have a quality core, we can return it to original condition with our highly qualified technicians following our strict processes."

The Center applies the latest engineering specifications to each component to ensure that it is brought back to OEM specifications. Sometimes, remanufactured components are even better than the originals as they receive the latest factory upgrades.

The Center uses high-end Tensor

electronic assembly tools along with bar code embedded work orders. The intelligent tools and interactive software tracks and controls specifications of work performed, which ensures that everything meets OEM specifications down to how each bolt is tightened. Once assembled, products are rigorously tested on state-of-the-art test benches.

Havre-Carter continues: "With OEM certified and knowledgeable technicians using advanced equipment, along with our assurance processes we certainly deliver quality. We guarantee genuine OEM parts will be used on remanufactured components while offering a full Atlas Copco warranty."

According to Havre-Carter, the customer can realize direct savings of 30 to 50 percent on remanufactured components, and considering the availability and reliability of Atlas Copco reman components, even greater savings can be realized in terms of labor, logistics and inventory.

"We are continually focusing on improvements to our processes. Each technician has years of experience working on these components and the step-by-step processes we've put in place only make us better as a team," Havre-Carter adds. "We take ownership of each component and we are totally committed to quality."

## 24 hour service in Satpayev

**THE REMAN CENTER** in Satpayev, Kazakhstan, is the most recent Center to join the global Atlas Copco network. It is a typical example of how Atlas Copco is investing in helping customers to find local solutions that reduce their operational costs while maintaining the same OEM quality.

Opened at the end of 2012, it took only one year for the Center to reach a world class standard of safety and engineering.

“Our Reman service is by far the most beneficial service we offer to our customers.”



**Danila Praporschikov** Service Operation Performance Specialist, Atlas Copco Service

*World class engineering in Kazakhstan: From top, reconditioning gears; the team outside the modern Reman Center in Satpayev; checking the OEM specifications in the database.*

The Center was developed to serve several major mines including Zhomart, Vostochniy (East) and Zapadniy (West) which are owned by Kazakhmys, one of the world's leading copper producers.

Together, these three mines are at work round the clock, seven days a week, and use more than 100 units of Atlas Copco equipment. The Satpayev Center is conveniently located only 15 minutes' drive from the most remote mine in the Zhezkazgan area and two hours away from Zhomart, which is also in operation seven days a week.

Under the terms of the service contracts at the mines, all equipment must be kept fully operational with a guaranteed availability rate. The Center's team of 10 engineers remanufactures axles, transmissions, cylinders, up boxes, drop boxes as well as COP rock drills.

Danila Praporschikov, Service Operation Performance Specialist and member of the Atlas Copco team developing reman practices worldwide, says: "What's so special about the Satpayev Center is that the best practices of Atlas Copco's other large remanufacturing centers, including set-up, lay-out, operating procedures, and workflows have all been implemented here.

"In my view that was a revolutionary approach and as such I feel justified in describing the Satpayev Center as truly innovative. Remanufacturing of components is by far the most beneficial service we offer to our customers. Only the components where the cost of reman is not more than 60 percent of the cost of new component qualify."

### **OEM quality guaranteed**


The Center offers its customers the same warranty for remanufactured components as it does for new components. Mechanic Sergey Sukhomyro, is justly proud of the work done here. "I evaluate the level of our work as being very high quality," he says. "We use advanced tools and professional testing panels. The workflow is specified in a 15-step procedure which describes all of the necessary actions in detail.

"This system guarantees that all components will undergo comprehensive



inspection, diagnostics and upgrades and that they will be remanufactured to the Atlas Copco OEM quality level."

Anuar Basbayev, Business Line Manager, for Atlas Copco Service, Central Asia, says: "We always pursue a better way to support our customers and with this great project

which we have achieved within one year, we are able to offer OEM specification remanufactured components locally and continuously help customers to lower their operation costs. With our ongoing efforts, I am sure that more customers will benefit from this project very soon." 

# NORTHERN shines bright

LKAB's Malmberget iron ore mine in the far north of Sweden is now making its mark on the future of underground long hole drilling.

The early morning coffee has just brewed. The air conditioning is perfect. Ergonomic office chairs and comfy footwear await the operators who are about to start another shift. This is life in the world of automation at Malmberget.

Located about 5 km from the town of Gällivare in Sweden's far north, Malmberget, or The Ore Mountain, is one of two iron ore operations run by state-owned LKAB, and is now a model of modern mining, not least for its automated, long hole drilling.

The control room at the 1 000 m level, with its computer monitors on the walls and desks, joystick controls, keyboards and data servers, reflects the progress that has been made here. It was recently set up to track and manage the performance of a new fleet of automated drill rigs that are in continuous operation, all year round.

For this task, three operators working seven day shifts, are in charge of two drill rigs each. They drill 115 mm diameter blast-holes in drifts 5.5 m wide x 5 m high. The team is led by Bengt Anttila, Production Supervisor, South Section. Anttila has more than 40 years of experience at Malmberget and has witnessed many of the mine's development milestones, among them the transition to large scale, sublevel



At a safe distance: The Malmberget control room where each operator is in charge of two Simba drill rigs. Here, Production Supervisor Bengt Anttila checks data logs from the night's drilling.

caving in the 1980s, and the introduction of automated production drilling in the mid 1990s.

He explains: "We have been working very closely with our sister mine, the Kiruna mine, which has been a forerunner in automated drilling. When the first projects started, Kiruna already had automated skips and rail transport. Malmberget followed their example in 1997 when we took delivery of the first BK drill rigs."

BK was the name given locally to the first automated Simba W462 rigs which were developed together with Atlas Copco, marking the beginning of a long lasting

cooperation. (The "W" is for Wassara, the highly efficient, water powered DTH hammer).

## New phase in progress

LKAB adopts a zero tolerance approach to injuries and the planners at Malmberget, which has 1 300 employees, do their utmost to reduce the number of miners working in hazardous areas. This, in turn, has been a driving force in the development of automated drilling, coupled with the need for extreme precision in long hole drilling.

Now the mine is in the middle of another transitional phase consisting of a generation shift towards younger operators with a flair for technology, and a major equipment upgrade by replacing the "BK" fleet with six new Simba WL6 C rigs.

Apart from being more powerful, the Simba rigs offer a wide range of new features including what the miners call "full fan" automation. Not only that, the rigs are equipped for teleremote operation using a new data system and interface, taking operators out of hazardous mining areas.

This capability has enabled Malmberget

“ Preventive maintenance is the most important factor for a high level of automation.



Bengt Anttila Production Supervisor, South Section, Malmberget Mine

# STAR



*Automation in action: One of six new Simba WL6 drill rigs at work in the Alliansen orebody at the 1 022 m level in the Malmberget mine.*





Above, operator Andreas Larsson during one of the few occasions he goes into the drift to reposition the rig for the next fan of blastholes. Right, the Simba WL6 C in full fan drilling mode, drilling 30 m long holes at the center of the fan and 17 m holes on the sides.

» to follow in the footsteps of its sister, the Kiruna mine, where full fan drilling with Simba rigs and teleremote operation has already proven its worth.

Continues Anttila: “We knew that this would probably be the most challenging year so far in the history of Malmberget as we were not allowed to lose any drillmeters during the transition. As a result, we had to replace the old rigs step by step while trying to maintain production rates day and night.”

During M&C’s visit to the control room at the 1 000 m level, one of the six new Simba rigs was drilling into the Alliansen orebody at the 1 022 m level. The mine

had achieved full fleet capacity and it was expected that the new fleet would result in a production increase of 20%.

#### It’s all in the fans

Malmberget has about 20 orebodies extending across an area of 2.5 km x 5 km, of which 12 are mined, most of them consisting of magnetite ore.

Upward drilling with full fan automation is provided by the Simba rig’s computerized Rig Control System (RCS), operating in the ABC Total mode, enabling drilling to be carried out throughout the night when no personnel is present in the mine.

The typical length of the drifts is 85 m which allows for around 25 fans. Each fan consists of 8–10 holes and is drilled 3–3.5 m apart, with a double fan drilled close to the footwall to enable maximum ore recovery. The holes are typically 45–47 m long and are drilled with a maximum deviation of 1.5% with 115 mm diameter bits and 2.3 m long drill rods.

“We can drill 55 meter holes but we rarely go beyond 50 meters,” says Anttila. “For blasting, it is crucial to get the holes absolutely straight, which the Wassara hammer helps us with, but the angle of drilling also determines the material flow. We drill at 80–85 degrees and 85–90 degrees for the final double fans.”

At the 1 022 m level, the Simba WL6 C is drilling 30–47 m holes at the center of the fan and 17 m holes on the sides, using a 115 mm drill bit with a rotation speed of 80–90 rpm for suitable fragmentation. The penetration rate is 0.8 m/min.

The holes are charged with emulsion explosives and blasting takes place every night between midnight and 2 am. Three fans are typically blasted per round with

“ Our aim is not to just monitor the rigs but to get a full overview of production rates.



Magnus Abrahamsson Project Manager, Automation, Malmberget



Photo: Fredric Alm

View from the air: LKAB's Malmberget mine above the Arctic Circle in northern Sweden.

each fan yielding approximately 6 600 tonnes of ore.

### Preventive maintenance is key

Malmberget has a full service agreement with Atlas Copco for all of its production drill rigs and the service team was due to move from premises in Gällivare into one of the main workshops in the mine.

Although full fan automation enables drilling to continue through the night – adding significant value in terms of production meters – downtime is more costly than conventional mechanized drilling where an operator can immediately attend to an issue. However, in the case of breakdown during the day, service personnel can be on site within 30 minutes, but only if needed.

Anttila says: “Preventive maintenance is the most important factor for a high level of automation in mining. Comprehensive schedules, routines and checklists are a must. Without them, automation will not work. The problems we have with the rigs are often small things like dirt jamming up the stinger feeders, easily fixed by a driller on site with a few tools in his belt and by flushing, but it’s not easy if no one is there.”

Another important task is to stockpile parts ordered in advance, and to inspect the equipment before service. “We have a set schedule whereby inspections of the equipment are carried out on Mondays and spare parts are sourced during the week, with service being performed on Fridays,” says Anttila.

Since Malmberget took delivery of the sixth Simba WL6 C rig the operators in the control room have been refining their skills to meet a strict production target of 350 drillmeters per rig, per 24 hours. This is equal to 2 100 m per week.

Operator Andreas Larsson, who has two years of experience in production drilling at the mine, adds: “The new system gives you the feeling of being in complete control.

We set the drilling parameters before we leave at night and then check all the logs in the morning to see if there have been any errors, and if necessary we follow up with troubleshooting.”

Teleremote allows the rigs to be operated with the aid of continuous video supervision and a laser guidance system. The operators have access to the same information that is shown on the rig’s monitors. At Malmberget, the system is used for rigs located 1 to 6 km from the control room. Communication is via both LAN and WLAN and the rigs’ interface, known as Rig Remote Access (RRA), enables the seamless transfer of drill plans, log files and messages to the rig’s control system.

### Increased safety

By increasing the level of automation, Malmberget has increased safety by minimizing the exposure of its personnel to danger in the production areas. However, there are still situations when operators need to be in the drift, for example to reposition the rigs for the next fan or to deal with stoppages. For this reason, the rigs have motion sensors that immediately shut down the drilling if someone gets within a radius of two meters.

“This is the tricky aspect of automated drilling,” says Anttila. “As long as the drilling goes smoothly there’s not much to

worry about. But when something happens to the rigs, a broken hose or if the drill string gets jammed, it is vital that the operator has the experience to make a 30 second risk analysis before entering the drift.”

Also on the operator team is Fredrik Bäck. He says: “Being in the control center you absolutely get a sense of working in the mine of the future. It’s the best job you can have underground.”

### The IT challenge

Among the biggest challenges for mines seeking to bring automation to their operations is to set up IT systems that can be applied to a variety of equipment and different software. At Malmberget, this task is approached with the same dedication as the day-to-day drilling, blasting and hauling. For the time being, Malmberget’s priority is to expand WLAN communication in all areas of the mine and further develop the monitoring capability for production drilling.

Magnus Abrahamsson, Project Manager, Automation, says: “Our aim is to develop the systems so that operators in the control room can monitor not just the performance of the individual rigs but also get a full overview of production rates. We also want to enable instant connection with workshops so that operators can show production data to service personnel in order to solve problems as efficiently as possible.”



Teleremote technology: Above left, the drill plans for the Simba WL6 C rigs as they appear on the operator console. Right, the screen setup that monitors the progress of each rig in the mine.

Many of us share the same vision. We see fleets of drill rigs, loaders and trucks running unmanned, monitored from a remote location by just a few people. But how close are we to a fully automated mining industry? M&C talks to **Brian Fox** for an update.

# Insight On **AUTOMATION**

**Q. What is Atlas Copco focusing on right now in terms of automated systems?**

**A.** We use our Rig Control System (RCS) CAN-bus control system as our base platform, so the first step is integrating RCS on machines that require advanced technology. From here, we can add automated functions such as drilling, leveling and rod changing along with wireless communications and data systems. We have teleremote control and semi-autonomous capability on many of our surface drills and underground loaders, face drills and long-hole drill rigs. Our focus is now on autonomous operation of surface drills and multiple semi-autonomous LHDs which provide automated tram and dump with teleremote loading.

Automation is a high priority in our company and we feel like we are at the forefront of mining technology. The key for us is to move at a pace that we can support with reliable systems and competent people in the right locations.

**Q. Is it technically possible to automate all mining equipment?**

**A.** Technically, yes. The question is to what level do you need to automate. “Autonomous” means different things to

different people. On a basic level, a drill is running autonomously if it can tram itself and drill a hole. But to truly run without human involvement, it must be able to work with changing bench conditions and know where people and other equipment may be. It must analyze the condition of the bit and change it automatically. It must sense the amount of dust and optimize the amount of water needed to control it. As technical challenges become more complex, a decision must be made as to whether the benefits are worth the cost.

**Q. What drives automation in mining?**

I see four primary drivers; safety, productivity, qualified labor and production costs. With regard to safety, teleremote and autonomous operation ultimately move the operator away from potentially dangerous areas. When it comes to productivity, declining ore grades and increasing strip ratios require more material movement and mining new deposits in increasingly difficult locations. Autonomous operation will increase the utilization of machines and production will be more consistent, making planning much easier.

Finding qualified labor is a key concern today. As mining migrates toward remote locations, getting competent labor to operate mines is becoming increasingly difficult. Remote operation reduces the number of operators on site, which also results in fewer people to transport and house. Finding people that can work with data and networks should prove easier than finding traditional operators, as the new generation is exposed to and educated in new technology.

In terms of production costs, we see that mining costs have increased rapidly due to higher steel, fuel and labor costs. Smart machines will use less energy and have lower maintenance, repair and consumables costs, and fewer will be needed due to increased utilization.

But the big impact will come from executing processes as designed, for example, drilling holes in the planned location and using the information obtained from the machines such as rock hardness and mineralization as a means of optimizing fragmentation and ore routing. This will provide savings in downstream mining and processing costs.

**Q. Why hasn't automation been developed faster in the mining industry?**

**A.** First off, automated machines in a factory setting are designed to operate in a confined, controlled environment. In surface or underground mining, you have many pieces and different types of equipment interacting with ever changing geological and environmental conditions.

Secondly, there hasn't been an urgent demand from customers. Safety is one of the drivers, but mining companies have done a great job of developing strong safety cultures and have trained their people to assess and mitigate risks using



*Automated operations: Remote controlled and semi-autonomous LHDs are an increasing sight in underground mines.*





*Brian Fox is Vice President, Marketing - Automation, within Atlas Copco's Mining & Rock Excavation Business Area.*

traditional equipment and processes. The safety performance trend is positive, but we're approaching the point where equipment must be automated to further improve. From a productivity standpoint, miners have been able to meet demand through more machines and manpower.

**Q. If advanced technology needed is available now, what's holding it back?**


**A.** The technology available today is impressive, but it has to be safe and reliable and must show a good return on investment. Anyone who has been in the industry awhile will remember the buzz created at MINExpo

1996 around autonomous haul truck testing. Yet here we are, over 15 years later, and while some autonomous trucks are in operation, it is not widespread. Why? I believe it is a combination of reliability of the technology paired with the difficulty of integrating the machine with the worksite network.

Also, holding things back is the challenge of justifying automation. Without long term test results to look at, it is tough to make the large financial commitment for automated machines and the necessary infrastructure and operating procedures to support them. However, many successful tests are underway and as a result I think

we'll see a rapid expansion of automation in mining in the next few years.

**Q. What are the three most important areas that mines should be addressing?**

**A.** The three areas to focus on would be networks, data and training. To be ready once autonomy starts taking off, mines need to hire and develop people who understand wireless networks and data systems. Without the ability to transmit and utilize information from the machines, there will be little benefit. It is important to get a headstart in this area so that implementation is smooth when automated machines become available. 

# AUTONOMY in the

## Chile's copper giant Codelco puts Scooptram ST14 to the test

Codelco, the world's largest copper producer, has recently concluded trials focusing on semi-autonomous loading as a means of further increasing safety and productivity at the Andina Mine in Chile. M&C reports on the findings.



**W**ith safety and productivity demands growing year on year, coupled with the need to go deeper in order to reach new orebodies, mines are increasingly looking for ways to excavate ore without putting people at risk.

Over the last decade, remote controlled drill rigs and LHD vehicles have been gradually introduced in a number of mines and autonomous mine trucks are now also available on a global scale (see *Greening The Industry*, page 15).

However, although autonomous operations are still far from commonplace, some visionary mining groups see automation technology as a long term investment and are making positive contributions.

Among these is the giant copper producer Codelco of Chile, whose Andina Division recently carried out two trials centered around the use of semi-autonomous, underground loaders. The trials were conducted at Andina Division's block caving operation

located 140 km northwest of Santiago and about 4 000 m above sea level in the Cordillera mountains.

### Commitment to health and safety

Like many mining companies, Codelco is committed to health and safety and is justly proud of its low accident rate – less than three lost time injuries per million worked hours – which is an impressive figure considering it has a workforce of some 16 000 employees.

The company says it recognizes that health and safety is directly linked to growth. For this reason decided to investigate the benefits of semi-autonomous loading by launching comprehensive trials with state-of-the-art, remote controlled equipment, complemented with autonomous guidance systems.

Semi-autonomous loading allows for an underground loader to complete a full load-haul-dump cycle with an operator needed only for the “load” part of the cycle. This

is accomplished using tele-remote controls from an operator station located at a safe distance from the vehicle.

The mine's equipment fleet consists of 14 LHDs and nine trucks provided by various suppliers, but for the trials, it chose to use Atlas Copco's 14 tonne Scooptram ST14. This LHD has all the modern features of the manually operated version but with the addition of a high-tech automation kit that incorporates various sensors, control algorithms and a wireless communications system. Communication between the loader and the control room is facilitated by the mine's Wireless Local Area Network (WLAN) and an overland fiber optic link.

The project represented two unique milestones for the Andina Division:

- never before had a 14 tonne vehicle been used in areas of the mine where only 10 tonne equipment is traditionally used
- the operators chosen for the trials were the youngest ever to operate heavy equipment at Codelco
- the operator control room was located about 80 km from the mine in Los Andes, enabling the operators to live and work in their home town, far from the tough mining environment.

Comments Marcelo Prado, Project Manager for Codelco: “This was a very bold and exciting project for us. We initially used four young operators, two men and two women, who were not more than 22 years old. They had no previous

“After these trials we view the Scooptram system as very promising with a lot of growth potential.”



Marcelo Prado Project Manager, Andina Division, Codelco

# Andes



*Joystick competence: During the trials, operators learned to control the LHDs from a control room in their home town of Los Andes, 80 km from the mine. Pictured here with Project Manager Marcelo Prada are, from left, Miguel Careño, Valentina Reinoso and Bastian Salas.*



*Tomorrow's LHD operators: A total of six young operators were engaged by Codelco for the semi-autonomous loading trials. From left, Karen Jimenez, Felipe Quezada and Valentina Reinoso.*

mining experience – just the ability to handle computers and software programs and excellent motor skills using the joysticks, which are just like those on the vehicles' operation consoles.”

Neither had the operators been employed by Codelco before and were recruited after passing tests to prove their PC competence and, in particular, their joystick skills when playing games on PlayStation.

### Three-phase project

The project was divided into three phases with Phase Zero signalling the installation of the control room in Los Andes and the necessary automation infrastructure in the mine itself. Reconstruction work also had to be carried out in the fairly narrow drift in order to allow the Scooptram S14 to perform at its best in terms of speed and mobility.

The next phase consisted of production start-up and operator training. This began with 5 x 2 day shifts, ramping up to 4 x 4, and as operators progressed, to 4 x 4 (day and night) or two 12 hour shifts making the operation continuous.

During this phase, the responsibility for the various loading operations in the mine was determined according to the progress of each operator. It was estimated that one operator would be sufficiently trained after 500 loading cycles in order to work alone for one shift. The first phase was concluded with a change of location, from Drift 71 to Drift 79, as Drift 71 did not have any turning

points which caused unnecessary delays.

The third phase, which extended over a period of five months, focused on testing the performance of the semi-autonomous loading system in a real production environment, with KPI (Key Performance Indicators) objectives based on those typically achieved with standard, manually operated machines.

During this phase, Codelco's Institute of Innovation and Investigation for Mining and Metallurgy (IM2) was given the task to guide the production and manage the key variables such as performance, cycle time, tonnage, actual hours, and so on.

Two new system operators were also added to the team and reached the same level of proficiency as the original operators after a very short training period. Throughout the trial, the mine was supported by an experienced Atlas Copco operator who made numerous visits to conduct operator and systems training.

### Autonomous beats manual

The trials were carried out for approximately one year and showed conclusively that semi-autonomous loading can be used successfully at the Andina mine. From February 2012 until the trials ended in December, the average ore production increased from 44 850 tonnes per month to 80 000 t/m, representing 340 to 415 tonnes per hour. The best monthly production figure was 133 000 tonnes which exceeded the

normal monthly performance per shift or month using manually operated LHDs.

### Growth potential

Prado says he is pleased with the results and points out that although Codelco has been working with semi-autonomous LHDs for almost 10 years, this was the first time it had tried Atlas Copco's automation system.

“My impression is that the application of the automation system provided for the Scooptram ST14 is excellent,” he says. “It is a very logical system which makes its operation simple and safe. We see it as very promising system with a lot of growth potential.”

Prado also stresses that the trials proved that young operators with good motor skills but no mining experience can be trained for automation tasks. “That was an important milestone for us,” he says, adding “I congratulate the Atlas Copco Chile team and the factory for their efforts and commitment to achieve success with this application.”

Further development of autonomous mining technologies continues – a process that Prado says Codelco broadly supports.

He concludes: “We must work today on tomorrow's processes, not only to develop the technologies but also the people that will be needed to apply them. We hope that Atlas Copco will continue its development work in order to achieve the best possible performance and I have no doubt that it will contribute to a significant change in mining activities.”

**Sustainable productivity in mining is largely a question of how vital resources are utilized. The use of electricity instead of diesel is a major step in the right direction.**



*Rolling out The Green Line: There are seven mine vehicles in the range, two trucks, four LHDs and an electric generator.*

# Greening the mining industry

## Electric vehicles for loading and haulage lead the way underground

**E**nergy supply is one of the biggest challenges currently facing the underground mining industry as mines step up efforts to cut costs and increase efficiency.

The cost of diesel fuel is one the biggest issues, followed by the cost of energy to power the ventilation systems needed to evacuate the exhaust fumes from diesel powered equipment.

However, the future is now looking greener with the introduction of a new range of electric powered trucks and loaders from Atlas Copco. Appropriately called The Green Line, the range comprises a total of seven mine vehicles – two trucks, four LHDs and a trailer-mounted generator.

### Trucking with trolleys

During normal operation, the Minetruck EMT35 and EMT50 are powered up and down the ramp by an overhead, electrified trolley rail. In areas where there is no access to a trolley rail, the truck disengages itself from the trolley and activates a small, 80 kW onboard diesel engine.

This engine, which uses only 10% of the fuel used by a large diesel engine, is powerful enough to power the truck into the correct position for loading or dumping and also to return it to re-engage with the trolley rail.

Using this technique, diesel emissions and exhaust fumes are drastically reduced. And not only that, the empty trucks traveling

down the ramp also generate electric power which is used to replenish the mine's electricity grid. This is achieved by the truck's high efficiency electric motors with their direct axle drive and minimal transmission losses, together with a regenerative braking system. In this way, a considerable amount of the energy that is consumed by the fully loaded trucks going up the ramp is regenerated by empty vehicles going down.

It is also believed that these extremely low levels of emissions can reduce the cost of powering ventilation systems by up to 90% while still maintaining ventilation mining standards.

Apart from the environmental improvements and the cost savings, the trucks are twice as fast on a 15% gradient when fully loaded than any diesel powered equivalent, meaning that fewer trucks are required to transport the same volume of material.

### Electric Scooptram

Green Line loaders are based on the successful Scooptram platform but are now powered entirely by high efficiency electric motors. Consequently, these LHDs, with a capacity range of 3.5–14 tonnes, consume less energy and generate less heat and noise than diesel versions, resulting in lower running costs, less environmental impact and a better working environment.

It is estimated that these electric LHDs – Scooptram EST2D, EST3.5, EST1030 and EST14 – reduce energy consumption


by about 70% compared to comparable diesel powered loaders. Furthermore, they can be run on renewable energy such as wind or hydro power and maintenance is also greatly reduced.

The most innovative part of the LHD package is the Scooptram's unique cable reel management system. Cable is expensive and is exposed to high wear and tear in underground mines on conventional electric loaders. Green Line loaders solve this problem with a patented Low Tension System which makes it possible to keep a 3–400 m cable constantly under control.

### Portable generator

Transporting the loaders to wherever they need to be in the mine is also no problem thanks to a unique trailer-mounted generator system.

The Gentrail GT325, specially designed for the underground environment, simply hooks up behind the loader and provides all the power it needs for tramming to different load/dump sites or the service workshop. And once a loader has reached its destination, the generator is simply unhooked, parked or towed away.

By replacing diesel powered equipment with electric powered equivalents, it is clear that mines can realize huge potential savings at the same time as they benefit from a better working environment, with the added bonus of increased job satisfaction and lower staff turnover. 

# Australia's got a crush on **POWERCRUSHER**

**Modern stone producers upgrade to meet high demand**



*Fleet of power: At the Boral recycling site at Kooragang Island, MES has installed both a Powercrusher PC 6 and PC 21 mobile crushing unit as well as an HCS 5515 screening unit.*

Atlas Copco's range of mobile stone crushers and screeners is rapidly becoming an established feature of modern aggregate and stone production in Australian quarries.

Over the past 18 months, an increasing number of quarries in Australia have installed new, high quality crushers and screening equipment in order to handle increasing demands for aggregates and stone products.

One of the latest companies to choose this equipment from Atlas Copco is the prominent New South Wales contractor Mining & Earthmoving Services (MES).

Part of the diversified RTC Group, MES has recently commissioned a new fleet comprised of a Powercrusher PC 6 and PC 21 track-mounted, crushing and screening units plus a Powercrusher HCS 5515 mobile double-deck screening unit and will add a Powercrusher HCS Grizzly in the Fall 2013.

## **Versatile setup for recycling**

The machines all operate at a Boral recycling site at Kooragang Island, north of Newcastle, where MES has a contract to produce gabion materials (rock filled cages, cylinders or boxes for construction purposes) and other recycled stone products.

Andy Graham, Atlas Copco's product manager in Australia, explains: "The

Powercrusher PC 6 jaw crusher and a screening unit are used in the production of gabion drainage wall materials. When they go onto other products they add the PC 21 cone crusher into a closed circuit so they can reprocess quite a lot of their rock to get fines and small products.

"It's an extremely versatile set-up in terms of the throughput range and the spread of different products they are able to produce. We are seeing strong interest in these products in what is a very competitive segment of the overall construction equipment market."

Graham adds that Australian quarries feel confident in the Atlas Copco brand which is known and trusted across the country.

The Powercrusher mobile range, which has a throughput rating of up to 350 tonnes per hour, is ideally suited to smaller scale screening, crushing and material movement projects. And when it comes to the mining sector, the focus is on the 55 tonne capacity Powercrusher thanks to its mobility in the support of haulage roads and general infrastructure.




*Confidence in the brand: Jason Hassler, MES Crushing and Screening Manager.*

## **Quattro Movement advantage**

A well documented feature of the Powercrusher jaw crusher is its unique Quattro Movement, which allows the jaw to move in a figure-eight motion, increasing the feed capacity and producing a "post-crush" at the outlet.

This enables the Powercrusher to produce considerably higher percentages of cubic stone and the wear over the jaws is more consistently spread, ensuring maximum lifespan.

The units are also extremely easy to transport, set up and maintain. As Graham says, "You can basically drive these machines onto a job site, back them off the truck, park them up, hit a button and you are crushing rock before you know it."

The Powercrusher mobile range is marketed directly through 16 Atlas Copco customer centers across Australia together with full after sales service support. 

# Bauma's spotlight shines on drill rig innovations

**GERMANY** Five features of Atlas Copco's Boomer E-series of underground drill rigs caught the attention of the enthusiastic crowds at the recent 2013 Bauma trade show in Munich. These included the new COP 4038 and upgraded COP 1800+ series of rock drills, an upgraded Rig Control System and Underground Manager program as well as a new Dry Drilling System.

At 140 Hz, the new COP 4038 is said to be the fastest rock drill ever made (*read more, page 8*). The COP 1800+ series, on the other hand, is the next generation of the COP 1800, retaining all of its superior performance parameters while increasing the recommended

service interval by up to 50 percent. This provides lower running costs, higher machine availability, increased safety and enhanced environmental sustainability. It looks the same on the outside, but on the inside, extensive engineering and design work has been carried out



to ensure superior service and operation. Maria Pettersson, Research and Developer at Atlas Copco



*Eyecatchers at Bauma: Top, the new 1800+ rock drill. Below, from left: the water free Boomer XE3 C; the new suction nozzle around the rig's drill string; the new RCS system console with touchscreen and Underground Manager software.*



## Long term commitment for India's expansion



*New equipment for a new mine: Hindustan Zinc's Rampura Agucha open pit, located in northwestern India, is going underground with Atlas Copco equipment.*

**INDIA** Atlas Copco is to supply mining equipment to Hindustan Zinc for the development of an underground mine in Rampura Agucha, northwestern India.

The equipment package, which also includes a service commitment for five years, is scheduled for delivery during 2013 and includes long hole drill rigs, face drilling rigs and mine trucks.

The order reflects a 30 year long relationship between Atlas Copco and Hindustan Zinc, a subsidiary of Vedanta Resources PLC.

Bob Fassl, Business Area President, Atlas Copco Mining and Rock Excavation Technique, says: "This shows the importance of consistent and committed delivery to the customer. We feel very proud of Vedanta's confidence in our abilities to provide equipment and service that will help them boost their productivity."

Rampura Agucha Mine is an open pit which was commissioned in 1991 and is today one of the largest lead/zinc deposits in the world with a metal content of about 14 percent and production of more than 6 Mt per year.

The underground mine is expected to be opened in 2014 with a planned production capacity of 3.75 Mt/year.

### IN BRIEF

#### New hammer for exploration drillers

Atlas Copco Secoroc has developed a new hammer for exploration drillers using reverse circulation drill rigs.

The new RC 40 is designed for hole sizes of 125–140 mm (5–5.5 in) in a variety of conditions, from hard rock to flooded. It is also 34 percent shorter and 20 percent lighter than other comparable hammers on the market.

In addition, the RC 40 hammer can be serviced more quickly, making it a smart choice for increased performance and reliability in remote, greenfield exploration operations.

The hammer's modular system features a one-piece sample tube that can easily be changed without opening the hammer. By matching the RC 40 to Atlas Copco's DR102 and DR115 drill pipes, exploration drilling can be carried out to depths in excess of 600 m.



## WHERE TO FIND US

Please contact your local Atlas Copco Customer Center.

**ALBANIA**, Tirana, +355 682 061 618. **ALGERIA**, Zeralda, +213 (0) 21 32 83 25 / 26/27. **ANGOLA**, Luanda, +244 929 303 139. **ARGENTINA**, Buenos Aires, +54 (0)11 47172200. **AUSTRALIA**, Blacktown, +61 (0)2 9621 9700. **AUSTRIA**, Vienna, +43 (0)1 760120. **BELGIUM**, Brussels, +32 (0)2 689 0511. **BOLIVIA**, La Paz, +591 (0)2 21 12000. **BOSNIA AND HERZEGOVINA**, Sarajevo, +387 33 674 391. **BOTSWANA**, Gaborone, +267 395 9155. **BRAZIL**, São Paulo, +55 (11) 3478 8200. **BULGARIA**, Sofia, +359 (0)2 489 3178. **BURKINA FASO**, Ouagadougou, +226 5036 5610. **CAMEROUN**, Douala, +237 76308451. **CANADA**, Sudbury, +1 (0)705 673 6711, North Bay, +1 (0)705 4723320. **CHILE**, Santiago, +56 (0)2 4423600. **CROATIA**, Zagreb, +385 (0)1 611 1288. **CHINA**, Beijing office, +86 (0)10 58706200, Nanjing, +86 (0)25 8696 7600. **HONG KONG**, +852 2797 6600. **COLOMBIA**, Bogotá, +57 (0)1 419 9200. **CYPRUS**, Nicosia, +357 (0)22 480740. **CZECH REPUBLIC**, Praha, +420 225 434 000. **DR OF CONGO**, Lubumbashi, +243 (0) 991 004 430. **DENMARK**, Glostrup, +45 4345 4611. **EGYPT**, Cairo, +202 461 01 770. **ESTONIA**, Vantaa (Finland) +358 (0)20 718 9300. **FINLAND**, Vantaa, +358 (0)20 718 9300. **FRANCE**, Saint Ouen l'Aumône, +33 (0)1 3909 3222. **GERMANY**, Essen, +49 (0)201 21770. **GHANA**, Accra, +233 0302 7745 12. **GREAT BRITAIN**, Hemel Hempstead, +44 (0)1442 22 2100. **GREECE**, Koropi, Athens, +30 (0)210 349 9600. **INDIA**, Pune, +91 (0)20 3072 2222. **INDONESIA**, Jakarta, +62 (0)21 789 0550. **IRAN**, Tehran, +98 (0)21 6693 7711. **IRELAND**, Dublin, +353 (0)1 4505 978. **ITALY**, Milan, +39 02 617 991. **JAPAN**, Tokyo, +81 (0)3 5765 7890. **KAZAKHSTAN**, Almaty, +7 727 2588 534. **KENYA**, Nairobi, +254 (0)20 6605 000. **KUWAIT**, East Ahmadi, +956 2398 7952. **SOUTH KOREA**, Seoul, +82 (0)2 2189 4000. **LATVIA**, Vantaa (Finland), +358 (0)20 718 9300. **LITHUANIA**, Vantaa (Finland), +358 (0)20 718 9300. **MACEDONIA**, Skopje, +389 (0)2 3112 383. **MALAYSIA**, Selangor, +60 (0)3 5123 8888. **MALI**, Barmako, +223 73 29 00 00. **MEXICO**, Tlalnepantla, +52 55 2282 0600. **MONGOLIA**, Ulan Bator, +976 (0)11 344 991. **MOROCCO**, Casablanca, +212 522 63 4000. **MOZAMBIQUE**, Maputo, +258 823 08 2478. **NAMIBIA**, Windhoek, +264 (0)61 2613 96. **NETHERLANDS**, Zwijndrecht, +31 (0)78 6230 230. **NEW ZEALAND**, Auckland, +64 (0)9 5794 069. **NIGERIA**, Abuja, +234 7068 6212 53. **NORWAY**, Oslo, +47 6486 0300. **PAKISTAN**, Lahore, +92 4235 749 406. **PANAMA**, Panama City, +507 2695 808, 09. **PERU**, Lima, +51 1 4116 100. **PHILIPPINES**, Manila, +63 (0)2 8430 535 to 39. **POLAND**, Raszyn, +48 (0)22 5726 800. **PORTUGAL**, Lisbon, +351 214 168 500. **ROMANIA**, Baia Mare and Bucharest, +40 262 218212. **RUSSIA**, Moscow, +7 (495) 9335 552. **SAUDI ARABIA**, Jeddah, +966 (0)2 6933 357. **SERBIA**, Belgrade, Phone: +381 11 220 1640. **SINGAPORE**, Jurong, +65 6210 8000. **SLOVENIA**, Trzin, +386 (0)1 5600 710. **SOUTH AFRICA**, Witfield, +27 (0)11 8219 000. **SPAIN**, Madrid, +34 (0)9 162 79100. **SWEDEN**, Stockholm, +46 (0)8 7439 230. **SWITZERLAND**, Studen/Biel, +41 (0)32 3741 581. **TAIWAN**, Taoyuan Hsien, +886 (0)3 4796 838. **TANZANIA**, Dar es Salaam, +255 222 86 1570. **THAILAND**, Bangkok, +66 (0) 3856 2900. **TURKEY**, Istanbul, +90 (0)216 5810 581. **UNITED ARAB EMIRATES**, Dubai, +971 4 8861 996. **UKRAINE**, Kiev, +380 44 499 1870. **USA**, Denver, Colorado, +1 800 7326 762. **UZBEKISTAN**, Tashkent, +998 71 120 4635. **VENEZUELA**, Caracas, +58 (0)212 2562 311. **VIETNAM**, Binh Duong, +84 650 373 8484. **ZAMBIA**, Chingola, +260 212 31 1281. **ZIMBABWE**, Harare, +263 (0)4 621 761.

For more information visit [www.atlascopco.com](http://www.atlascopco.com) or contact Atlas Copco AB, SE-105 23 Stockholm, Sweden. Telephone: +46 (0)8 743 80 00. [www.miningandconstruction.com](http://www.miningandconstruction.com)


Roctec, says: "Dynamic modelling of the rock drill was used for the "detective work" to understand and find improvements for this rock drill. The development of the improvement solutions were then verified in laboratory tests."

The upgraded Rig Control System (RCS) provides an operator system in which all functions are grouped in blocks for easy navigation within the system. Together with a new touch screen display, operation is streamlined and the training time for new operators is reduced.

There are two multifunctional joysticks, with primary functions for drilling, located at the top of the joystick. This allows the operator to focus on drilling instead of searching for functions on the keyboard or display.

The Underground Manager software which supports all Atlas Copco underground rigs takes planning and evaluation to a higher level. The easy-to-use interface contains a new drill plan generator, complete 3D view of the tunnel, smart interpolation of contours, and an improved log and report function.

Lastly, Atlas Copco is now able to deliver a three-boom face drilling rig that is totally water free thanks to a new Dry Drilling System. Now available on the Boomer XE3 C, this system makes

use of compressed air to keep the hole free from cuttings and has a suction nozzle around the drill string to eliminate dust. The system is ideal for projects where water is scarce or where it is not possible to use water due to rock conditions. 



### Out now! New edition on surface drilling and crushing

Atlas Copco has published the 5th edition of its popular reference book on Surface Drilling and Mobile Crushing. The book's 204 pages are packed with fascinating articles that trace the evolution of surface drilling technology coupled with on-site case studies showing modern surface drilling and crushing equipment in action around the world.

In the technical section, subjects range from the principles of rock drilling and blasting to safety and the latest techniques for low cost sustainable operations in construction, quarrying and dimension stone applications.

In addition, the case stories take readers to a wide range of interesting work sites including the Panama Canal, Turkey, Ghana and Korea.

Surface Drilling and Mobile Crushing is available from Atlas Copco Customer Centers and can be ordered online at [miningandconstruction.com](http://miningandconstruction.com)



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