

The machines that operate in the confined environments of narrow vein and low profile mines are built to be robust and compact, all while offering high development & production rates. Dan Gleeson speaks to specialists in the field to gauge where the market is heading

*Mine Master, which forms part of the GHH Group, also provides drills and bolters for the low profile and narrow vein market*

# A rich vein

**N**arrow vein and low profile mining are technically-complex fields constantly evolving as orebodies dip, steepen and plunge below ground.

The former sees small and thin machines follow narrow (and often vertical or steeply dipping) high grade veins of material in smaller drifts to minimise development cost and dilution.

Meanwhile, those establishing or expanding low profile mines, many of which are in Africa, are forced to tailor their fleets to fit into the tight mining environments they find themselves in.

Both applications are increasingly in need of tele-remote, or automated options, as the risk associated with ore extraction at these depths and within these confines increases.

Many innovations have evolved to help miners win these battles: Alimak mining for greater flexibility and manoeuvrability in narrow vein mining, narrow width and height LHDs for compact ore extraction applications, and low profile dozers, specialised mechanised drill rigs and tele-remote machines for improved safety and productivity, to name a few.

More innovations will be required to ensure mines with these profiles continue operating for years to come.

**Sandvik** has combined its narrow vein mining, low profile mining and tunnelling expertise to come up with a range of loading and drilling tools suited to compact extraction and development.

The latest addition to its range, the LH202 is, according to the company, narrower than

competing loaders, but comes with the best payload-to-own-weight ratio of its class.

Ideal for tunnel widths between 2 m and 2.5 m, Sandvik anticipates owners can save up to 36% per tonne of ore when using the machine compared with other loaders in the class. This is primarily down to the tight turning radius achieved thanks to the machine's reduced width and length.

The LHD was recently put to work on a tunnelling project at the Østerbø Power Plant, owned by Skanska, in western Norway.

The project included more than 7 km of tunnel works, drilling, blasting and concrete works, among other aspects, to build the required infrastructure for the underground

water power plant. For transporting the blasted rock material on one of the tunnel work sites, the LH202 narrow vein loader provided a compact, but high-performance solution, according to Sandvik.

The LH202 only weighs 8,800 kg. Furthermore, it can be disassembled into several smaller pieces to make transport easier to manage, according to Sandvik. This proved decisive on the Østerbø project: "The weight of the equipment sub-assemblies is a critical limiting factor at this site, as all required material must be transported to the work site by a helicopter with the capacity of 3,700 kg

"Moreover, the Sandvik LH202 dimensions are well suited for water tunnel preparation, as



*The ability to disassemble the LH202 into several smaller pieces proved decisive on the Østerbø project where all required material had to be transported to the work site by a helicopter with a maximum capacity of 3,700 kg*

the mountain tunnels are often small: the loader is only 2.1 m high, 1.5 m wide, and 6.2 m long.”

In June 2018, the Sandvik LH202 was first transported via road from Bergen to the Solnipa mountaintop. That is also where the loader disassembly took place. When the disassembly was completed, the loader components were transported by helicopter to the tunnel work site on Rustelvatne.

When the loader parts were received at their destination, re-assembly on top of the Rustelvatne took place, in mid-June. Putting the dismantled pieces back together took two men three working days, after which time the Sandvik LH202 was ready for operations.

“The actual operating time of the loader on the Strufoss Overføringa became relatively short compared to the time the equipment in mines are normally used, as the tunnel drilling, blasting and rock material carrying (carried out by the loader) only took approximately two months,” Sandvik said.

The employees working with the Sandvik LH202 appreciated the benefits that came with the EU Stage IV engine the loader was equipped with.

Asbjørn Fuglestad, Machine Operator for Skanska, said: “We have found out that the fuel consumption of the equipment is low, it can operate up to five hours on full power without a need to re-fuel, which is a clear benefit in these conditions.”

When asked about the future of the equipment, considering its relatively short period of use, Gunnar Lofthus, Skanska's Tunnel Drillmaster on the site, said: “We are confident that the loader will find its way to another construction site. It is typical that the equipment is disassembled several times as it is moved from one project to another. The loader is capable and doing a good job, and I don't think it will stand still.”

## Overprime options

**Overprime Manufacturing** has been making waves in the Latin America mining market since it started manufacturing loaders for narrow vein mining in 2016, with both diesel and electric versions of its 0.50 m<sup>3</sup>/0.75 yd<sup>3</sup> (XLH05) and 1.20 m<sup>3</sup>/1.50 yd<sup>3</sup> (XLH12) capacity loaders currently operating in Peru and Bolivia.

The company has also developed an XLD80 drill for narrow vein mining applications. The XLD80 allows drilling in three diameters: 60 mm, 75 mm, and 96 mm, with lengths exceeding 100 m.

All models can be controlled by a remote control system, as can its recently-released Scaler XSC517. Overprime said: “This is our latest and most successful contribution to safe mining.”



The company said: “Overprime's equipment design allows an easy maintenance process. Its robust structure and high-quality components in the mining industry allow equipment to maintain high productivity in even the most extreme work conditions.”

## GHH increases profile

A strategic marketing partner of Overprime, **GHH Fahrzeuge** has been supplying machines to the low profile platinum, chrome, potash and salt market for the last 20 years with over 850 machines currently operating in the field. In an effort to bring the product closer to the customer, for the past five years GHH Mining Machines, based in the East Rand of South Africa, has been designing and manufacturing low profile and narrow vein underground mining machines. GHH also specialises in rebuilding machines and repairing components and providing field support to all operating machines of GHH, **Mine Master (MM)**, **JH Fletcher** and **UVB**.

GHH Group is a total offering solution provider in this market segment, being able to supply not only the loaders from GHH, but also the drilling rigs and bolters from MM, in Poland (bolters in collaboration with JH Fletcher in the US), and the associated utility vehicles from UVB, in Botswana.

GHH's low profile and narrow vein mining diesel loader offering includes, but is not limited to, the LF3 narrow vein loader, as well as the key SLP5.1, SLP6.2, SLP8 and SLP14 low profile loaders. GHH also has more products in the design pipeline, including those in “alternative energies”, the company said. The UVB utility vehicle low profile offering includes people carriers, a scissor lift, tyre handler, bulk emulsion carrier and multipurpose cassette carrier for fuel and lubes, tools and spares as well as customer made options.

The LF3 is a 3.5 t machine, with an engine power of 67 kW, and an operational altitude of up to 4,500 m above sea level. The 5 t SLP5.1, meanwhile, has a well-established footprint and great track record of low running costs and excellent performance in the southern African market, the company said.

GHH also has the SLP 6.2, a 104 kW, 6 t machine that provides customers with an application specific, middle sized low profile option, in addition to the newest addition to the family, the SLP 8. The SLP 8 has the largest carrying capacity in its class, excellent ground clearance and unsurpassed visibility and ergonomic comfort in the operators' compartment, GHH said. “The modular designed 178 kW SLP8 loader will certainly be a trendsetter in the low profile market,” the company said. Also in the GHH low profile family is the SLP14, a 14 t, 1.88 m high, 265 kW low profile loader, with the best power to weight ratio in its class.

This GHH loader offering provides customers with the benefit of having an interface-ready Level 9 Collision Avoidance System retrofit option, as well as driver access control, product monitoring, partial- or full-speed brake interlock, anti-roll back, black box recorder, engine protection, operational monitoring and a communications router (connected machine).

“This visibility into the daily ‘health and performance’ of the machine gives end users the ability to better manage their underground mining operations, significantly improve safety and efficiently manage performance,” GHH said.

MM, which forms part of the GHH Group, also provides drills and bolters for the low profile and narrow vein market. MM's Face Master 1.4 is a mechanised drill rig for ultra-low seams designed for drilling blast holes of diameters between 41 mm and 76 mm and net length of 3.2 m, in underground workings of heights up to 6 m.



The Face Master 1.7 comes in different configurations depending on the market demand, with the recently launched Face Master 1.7K, for KGHM Polish Copper Mine, boasting a spacious, air conditioned, closed cab with excellent visibility and ergonomics, GHH said. This provides for high level operator comfort and associated performance. The FM 1.7K comes equipped with a more advanced feeder guiding system, where the on-board computer helps the operator execute desired drilling patterns, as well as generate 24-hour reports showing the quantity of drilled holes, time of drilling as well as comparison of planned work to actual results.

MM, together with Fletcher, provides roof bolters, with a rotary dry drilling system with dust collection for ultra-low and low seam mining. The Roof Master 1.4 mechanised roof bolter is designed for bolting hanging and side walls at a minimum height of 1.6 m with a maximum reach of 3 m and a bolt length of 1.6 m. The Roof Master 1.7 is also a mechanised roof bolter designed to operate within 1.9 m heights. It has a maximum reach of 4.5 m and is designed to install both mechanical and resin bolts at lengths of 1.6 m, 1.8 m and 2.6 m by a single operator. For narrow vein applications, MM has the highly productive, low tramming height Face Master 2.1 used for face drilling as well as long-hole drilling. This has a quick reset of the feeder position and an additional cylinder allowing for accurate drilling of the vein deposit.

"GHH machines enable the lowest cost per tonne production with highest performance capabilities," the company said. Its machines are robust, reliable, easy to maintain, simple to operate, and designed with safety in mind, GHH added.

"Our machines are created to work in narrow vein applications from the deep level gold mines



in Australia to the high altitude mines in Latin America, as well as in the low profile chrome and platinum group elements from the South African Bushveld Complex through to the Zimbabwean Great Dyke, in addition to the copper orebodies in Poland and the potash and salt mines across Germany," GHH said,

"We pride ourselves in the ability to constantly develop safe products that are moulded to the ever-changing customer needs, incorporating custom designed end user specific options, to make each of our underground mining products more fit-for-purpose than before, to suit specific mining operations," the company concluded.

"GHH Group is not only well known for its rock solid, robust low profile and narrow vein product offering, but its rigorous customer and product support throughout the life cycle of the equipment, which certainly sets us apart from the rest.

## More MUKIs

Resemin's MUKI family of mechanised narrow vein equipment has continued to expand in recent years, and CEO James Valenzuela told *IM* the company is preparing to add more products to the offering.

*Resemin, since launch last year, has sold three MUKI Bolters to local South America customers*

"In addition to our versions of MUKI Front Face, long hole and MUKI Bolter, it is very likely that we will develop a scaler for narrow veins," Valenzuela said.

The Resemin chief said the company, since launch last year, has sold three MUKI Bolters to local South America customers, but sees a much wider market ahead.

"The miners, each time, are asking for more safety in the bolting process," he said. This is a departure from the Australian roof bolting method using a MUKI Front Face, equipped with Telescopic Feed 6-10, miners were previously asking for, according to Valenzuela.

"This method (Australian roof bolting) is still the dominant one, but we have seen a growing demand for mechanised roof bolting processes in narrow vein mining," he said.

In addition to the recently launched MUKI Bolter, Resemin also released, last year, the narrowest ANFO/emulsion charger on the market, he said. The AC11 is just 1.3 m wide, with Valenzuela saying the use of emulsion can reduce nitrous gases produced by blasting and



Poland's KGHM Zanam showcased its new LKP-1701 underground LHD at Bauma 2019 in Munich which is the largest and most advanced machine to date in its range and it undoubtedly one of the largest available low profile LHD machines globally. The machine is 11,500 mm long, 3,335 mm wide and 2,370 mm high with a 47 t operating weight unloaded, front axle load of 21.5 t and rear axle load of 25.5 t and a standard bucket capacity of 9.5 m<sup>3</sup>. Trimming capacity is 172 kN and edge of bucket breakout force 220 kN. The machine can lift and dump in 8.5 seconds and do a full turn in 5.5 seconds with an internal turn radius of 3,450 mm and external 7,750 mm. Fourth gear speed is up to 27 km/h. It has a Deutz 12.0V6 Stage IV engine with 330 kW at 2,100 rpm. KGHM Zanam says its 1700 series LHDs are noted for high bucket capacity and lifting capacity along with their low profile

Anaconda Mining's goal of finding a technology to economically extract gold from the Romeo & Juliet deposit at its Point Rouse operation in the Baie Verte region of Newfoundland, Canada, has gained a global audience since it was named a finalist at the Goldcorp-backed #DisruptMining event earlier this year.

The company's technology-focused subsidiary thinks a combination of drilling and imaging techniques already proven in the oil & gas industry will provide the technical and economical means to mine the steeply dipping narrow vein mineralisation at the deposit.

The process, Sustainable Mining by Drilling (SMD), is divided into two campaigns: drilling the pilot holes and accurately mapping the vein, then enlarging the pilot holes to predetermined sizes to recover the ore. Using an inclined mast drilling rig, an inclined pilot hole is drilled along the centre line of the vein (equidistant between the hangingwall/footwall) with a directional drilling system.

Steering the pilot holes live with a survey tool will determine the current orientation and refine the 3D model of the vein used to plan the pilot hole enlargement, Anaconda said, adding that once the pilot has been drilled, a large hole-opener can be used to enlarge the hole's trajectory up to 2 m in a single pass.

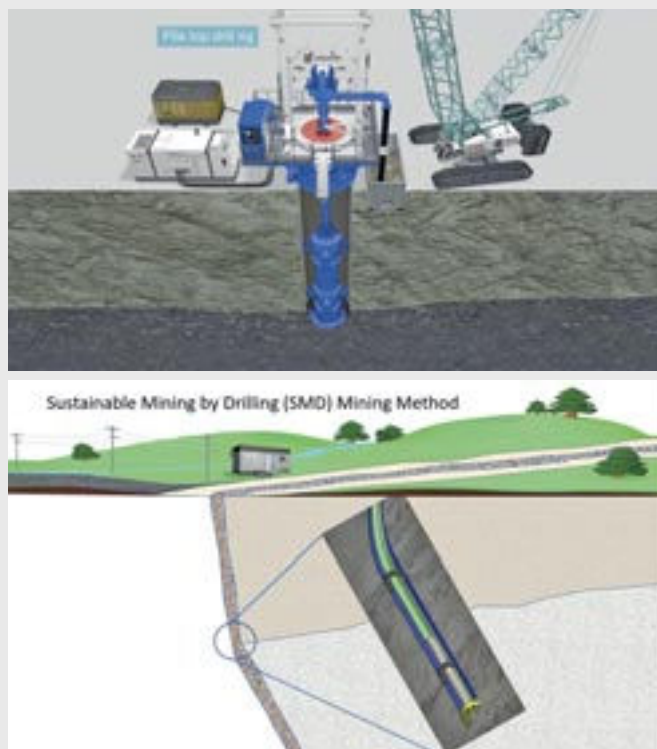
While Anaconda is focused on using SMD to mine its own complex deposit, as with many innovations in the mining sector, the technology looks like having global applications.

IM spoke with Dustin Angelo, President and Director of Anaconda Mining, to find out, among other things, how SMD can: reduce the cost to extract ore by 50% over conventional underground narrow vein mining techniques; increase operator safety by locating personnel above ground; access areas not open to conventional mining; reduce the environmental footprint of an operation; and bypass the crushing and grinding circuits by moving the  $\pm 2$  mm drill cuttings in a slurry direct to the mill.

**IM: Anaconda says the technology that has gone into SMD is proven in other industries: what are these industries?**

**DA:** We're basically adapting technologies that have been used in the oil & gas industry for quite some time; directional drilling and sub-surface imaging. Even though we are dealing with new technology and a new process, what we're working with, fundamentally, has been used elsewhere in other industries. We're not reinventing the entire wheel; we're just adding to that wheel.

We have got patent-pending inventions within SMD related to two key areas – the drilling and imaging. From the drilling standpoint, one of the key considerations we need to address is being in ore right from surface. We have developed some inventions that are added to a pile top drill rig to be able to get the required torque and thrust immediately from



Anaconda's Dustin Angelo says the company has developed some inventions that are added to a pile top drill rig to be able to get the required torque and thrust immediately from surface to extract ore using SMD

surface. We have also created a component that enables a drill string to be more flexible than normal to allow for course change during the hole opening phase.

In terms of sub-surface imaging, we are looking at ground penetrating radar (GPR), which is right off the shelf, but we're adding some surveying tools to it in order to be able to improve visualisation and more clearly orient ourselves when steering.

**IM: How flexible is that drill string? Are there limitations in terms of angle and depth?**

**DA:** We're looking at a 1 degree change every three metres in the work we are planning to carry out at Romeo & Juliet. And, right now, the depth is down to about 300 m. What we're using is RC airlift assist to bring the cuttings back up, so the technologies that are out there allow us to go to that depth. Yet, one of the drill manufacturers we are talking to is experimenting with getting down to 400 m; this is all dependent on the

make the mine cleaner.

And the company recently developed the Small Bolter 99 MESHA, a roof bolter intended to mechanise and install MINAX mesh from Geobruigg. Valenzuela said: "This kind of mesh is high resistance and specially recommended for rock bursts and seismic events."

Resemin is also making advances when it comes to both automation and electrification.

Last year, the company sold two MUKI LHBP-2R long hole drilling machines to Australia, on top of three units this year to India, equipped with CAN BUS system for tethered tele-remote control.

And, as reported in the battery-electric equipment article in February, the company is looking to electrify its fleet. Resemin plans to launch, in October 2020, its first battery-powered single boom front face Troidon 55 machine, Valenzuela said.

"After the trial of this machine (a medium size rig), we will offer our entire fleet of drilling rigs with a battery-powered system," he said, clarifying the battery will be employed for tramming, with drilling operation via tethered connection to the mine, which, at the same time, recharges the battery.

### Hybrid miniDriller

Aramine has looked to complete its narrow vein equipment range with the introduction of a diesel-electric hybrid miniDriller DM901 HDE drill rig.

The machine uses the diesel engine for tramming and electric motor for drilling, while it can be operated tele-remotely, removing the operator from potential hazards, Aramine says.

The DM901 HDE has a low centre of gravity for optimal stability. Despite its narrow width, the two front stabilisers offer perfect drilling conditions, according to the company, thus allowing both face and vertical drilling.



angle of the hole. In our field test, we intend to initially go down to 50-100 m depending on how much drill string we want to acquire.

**IM: Speaking of your field test, what application are you looking to test SMD on?**

**DA:** The deposit we are looking at trialling this on – called Romeo and Juliet – is, so far, measuring around 3.5-4 g/t Au, which is roughly three times the grade we have been mining in the area at Point Rouse. This is significant for us in terms of grade.

What we're trying to do with the trial is test the imaging technology and the ability to steer; the ability to put the pilot hole down the hole, roughly half way between the hanging wall and footwall of the vein, and then bring the pile-top drill rig in to enlarge that pilot hole. It is a proof of concept from that point of view.

We're going to try and select areas of the deposit to test where the dip angle and width of the vein is representative of where we want to be mining. The drill rig we are proposing to use right now for the trial is smaller in diameter to what we propose you can ultimately use SMD for. It's a 1-1.3 m diameter drill rig, so we are looking for a portion of the vein at Romeo & Juliet with that thickness for the trial.

**IM: Aside from the Faculty of Engineering and Applied Science at Memorial University of Newfoundland, are there any other partners you are working with on SMD?**

**DA:** Because of the notoriety we got from being a finalist of #DisruptMining, it has accelerated development of this technology in the sense we have had a lot of interest from gold producers and drill manufacturers – we are talking to them about potential partnerships, strategic investments and field trials.

The common theme among all these conversations is that SMD makes a lot of sense and many companies could see it being applied at their sites.

While we haven't signed any specific agreements with drill manufacturers, if this is a concept that takes off and there is lots of demand for it, it would make sense for them to be involved. They want to sell drills and we're not going to manufacture drills, so it is an opportunity for them to have another product to sell. We want to licence our technology and the SMD process, while providing services to optimise the system by end users.

**IM: Have you been surprised by the industry response to SMD since it has been more widely publicised?**

**DA:** It's not surprising to us that there is global interest, as there are

narrow vein deposits all over the world – we've had interest from Russia, South America, South Korea, Ghana, the US, Australia, all over the place. We've been focused on gold deposits, but it is certainly applicable in other deposits where there is narrow vein mineralisation, too.

One of the interesting things to come out of this exercise, which we didn't necessarily foresee, is that the imaging technology could also be applicable in mineral exploration, especially with the imaging and GPR capabilities.

**IM: Because the technology is new and unproven within a mining context, how do you see companies modelling resources based on SMD to a 43-101-compliant status?**

**DA:** We're not sure, from a regulatory perspective, how this technology could impact that. I would imagine, at this point, we would need a longer track record to prove its ability to transform uneconomic mineral resources into economic reserves. Once you start to build a history, companies can use that as a legitimate way to delineate reserves that they previously had to leave behind.

That's the whole purpose of SMD; there are mineral resources in the ground, whether it is whole deposits or certain zones of existing mines that cannot be mined by conventional methods. You can use this methodology in certain cases to extract the ore. If you can do that economically, by definition, it should be a reserve.

Up to this point, most exploration has been about trying to find orebodies to match conventional mining methods; your risk factor here is finding the ore. With SMD, we're flipping it round; you know where the ore is because you've already outlined a mineral resource. It just so happens that it is not economic using conventional mining methods. So, you just need to find a technology that can mine it, which we think we have for narrow vein deposits and zones.

From an exploration standpoint, you can use that image and extrapolate out better than with a conventional drill hole, so, in theory, you can carry out less drilling. Depending on the bandwidth and the GPR, you can look out five metres from where you are currently drilling. This allows you to get a better representation of the orebody and model it more accurately with less drilling.

**IM: What is the timeline on SMD demonstrations? And, will the first trial take place at Romeo & Juliet?**

**DA:** It would be Romeo & Juliet first, and we're targeting late-August/September with the trial lasting around two months.



*Aramine's diesel-electric hybrid miniDriller DM901 HDE drill rig uses the diesel engine for tramping and electric motor for drilling*

Aramine says the DM901 HDE only requires a 400 V electric connection and a water supply to operate and is designed with modular elements

for easy assembly/disassembly in a mine. It "sneaks wherever our L130 and L150 miniLoaders go", Aramine said. This means the new machine is ideal for sections between 6 m<sup>2</sup> and 12 m<sup>2</sup>.

With an existing partnership between Aramine and Epiroc, the company can offer an exclusive option with Epiroc Feed and Drifter, it said. "As most of Aramine machines are, the DM901 HDE complements perfectly the Epiroc range," Arnaud Paul, Aramine Equipment Sales Director, said.

Aramine is preparing its fully-electric battery-powered version for 2020, with innovations due at all levels of the machine, the company concluded. 