Enhancing exploration

GeoDrilling International talks to industry experts about the latest innovations and solutions for mineral-exploration applications

Above: an early model of the Dando Multitec 4000 wireline-coring for diamonds in Sierra Leone

Overall market pressures and the fact that a vast majority of the economically viable mineral deposits have already been discovered have pushed technological innovation to the forefront of mineral-exploration activities.

There is a growing need for better technologies that can help reduce the costs of drilling operations and decrease the time it takes to find, sample, validate and mine mineral-resource deposits.

Up until 2012 the mineral-exploration equipment market was more straightforward, but when mineral prices, especially coal, took a dive, many major miners and contractors sought to freeze capital expenditure.

Dando Drilling International sales director Quentin Dulake explains that sales of Dando's larger rigs began to slow. Exploration continued to be necessary but the focus changed to obtaining good results, while reducing initial outlay and running costs. This was also when, Dulake reports, the company's small footprint, track-mounted Multitec 4000 caught the attention of the market.

"The Multitec 4000 is the most significant new rig in our mineral-exploration range at the moment," he says. "Up until 2012 the majority of our sales to this sector were for our powerful and versatile larger rigs like the Mintec 12.8. With a top-spec rotary head and a 900cfm/350psi compressor on board, these rigs are capable of wireline coring, reverse-circulation, rotary air-flush and open-hole mud-rotary operations from a single large crawler-mounted platform.

"Our customers saw the Multitec 4000 as an opportunity to continue drilling while maintaining profit margins that had suffered due to mineral market conditions," he states. Capable of the full range of mineral-exploration drilling techniques with penetration rates for wireline coring and open-hole boring that matched much larger, more expensive equipment, the rig was a cost-effective solution to demanding mineral-exploration programmes, but at a much lower price point, Dando claims.

CHEAP DRILLS

According to the Australian Deep Exploration Technologies Cooperative Research Centre (DET CRC), improving the productivity of mining and ensuring its long-term future, in the low sovereign risk countries of the developed mining world, requires that new Tier 1 discoveries be made beneath barren cover with greater success and at lower cost than has been achieved to-date.

Drilling is the only method by which discoveries can be made beneath cover, but is expensive, often permitting only single-hole tests of geophysical targets. Cheaper, safer and more environmentally friendly drilling techniques are the key to improving exploration success beneath barren cover.

Cheaper drilling and associated real-time sensing technologies can enable explorers to drill multiple holes that progressively vector towards deposits in a single campaign using their geophysical and/or geochemical haloes, i.e. 'prospecting drilling'.

Vectors include the mineralogical haloes around iron oxide copper-gold deposits (IOCGs) and the elemental haloes around gold deposits described by DET CRC or the elemental vectors for porphyries in greenrocks described by the Australian Research Council Centre of Excellence in Ore Deposits (CODES). ►

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The RoXplorer CT drilling rig

DET CRC says that coiled-tubing (CT) drilling can provide the step reduction in drilling costs required to increase the success of mineral exploration beneath barren cover.

CT drilling rigs employ a continuous coil of drill string, which is wound from a spool while drilling and wound back onto the spool as the drill string is recovered from the hole, as opposed to drill rods that must be connected and disconnected multiple times during the drilling process. This can lead to improvements in:

- cost efficiency (no rod changes, therefore bit drilling at bottom more of the time and rapid tripping in and out of hole for bit changes);
- safety (manual handling of drill rods is responsible for >50% of injuries in mineral exploration);
- environmental impact (smaller drill pad, fewer vehicles, rapid mobilisation and potentially fully enclosed fluid systems); and
- hole stability (no pressure variations during rod changes).

"With enthusiastic reports from existing and new customers, and plenty of feedback, our design team had a very strong picture of an ideal version"

Extensive testing of the new RoXplorer rig has been undertaken at DET CRC's Brukunga Drilling Research Facility in Adelaide, South Australia. Extensive field trials will commence at the Mineral Systems Drilling Program (MSDP) site in early February.

There will be approximately six months of testing ahead before the rig is offered for commercialisation to DET CRC partners. The centre's representative says that it is difficult to say how long it will take a commercial partner to further develop it to the point of being a product, but a reasonable estimate would be 3-4 years from now.

EXPLORATION VERSION

Dando explains that after its launch in 2015, interest and sales for the Multitec 4000 took off in the mineral-exploration sector with international sales across Africa and South America for a range of mineral targets.

So while it is a multipurpose machine, the Multitec 4000 was filling a niche in the market for mineral exploration. A number of sales to customers drilling in equatorial jungle regions with difficult terrain and limited access along narrow tracks and between trees spurred the design team to focus on producing a fully-fledged exploration version of the rig.

"The level of adoption from the mineral sector was probably greater than we had anticipated," explains Dulake. "With enthusiastic reports from existing and new customers, and plenty of feedback, our design team had a very strong picture of an ideal version."

Rupert Coler, design engineer at Dando, illustrates the criteria for the new model: "The Multitec 4000 was frequently being used in uneven, sometimes steep, forested terrain with muddy, sticky or slippery surface conditions. Our first target was to ensure the rig could navigate this kind of terrain quickly and with maximum safety to the operator." As a result, the Dando engineers focused on designing the chassis and component layout of the Mulitec 4000 Mk3 to achieve a low and central centre of gravity.

Wider 400mm tracks were selected than the standard 300mm versions, with options including steel single-bar grousers to provide good clearance of mud in wet environments, or rubber tracks for gentler surfaces.

The track-base was also widened slightly to 1.55m, which increased the tilt angle of the rig markedly with a view to increasing safety while traversing slopes or other uneven terrain. A high-power hydraulic climbing winch was designed-in as an option to provide additional security when navigating steep and slippery terrain.

In standard form, the rig is supplied with a 74hp Tier 4 Final engine to meet regulations in European and North American markets, and a 111hp Tier 3 has been chosen for the rest of the world, although other options are available. With the majority of customers exploring to depths in the 50-250m range and in core sizes between N and P, the compact RH6 rotary head usually used on the larger Multitec 9000 rig was selected as a high-performance option. To ensure sufficient oil was supplied to the 6,000Nm/750rpm head and uprated crawler motors, a high-efficiency hydraulic system was designed by UK-based Hydraulic Alliance around Bosch-Rexroth pumps and motors.

Two mast options are available for 2.6m and 3.6m working strokes and both have deployable mast extensions to allow two rods to be pulled at a time. The folding mast extension ensures that when tracking the mass is kept firmly at the middle of the rig, providing a stable base. Double-acting hydraulic breakout clamps at the foot of the mast make and break joints while an integrated soft coupling ensures the longevity of wireline rods and sub adapter threads.

A new console has been designed on a swing arm so that the driller can choose a position that affords them the clearest and safest view of the borehole. The rig conforms to all new UK and

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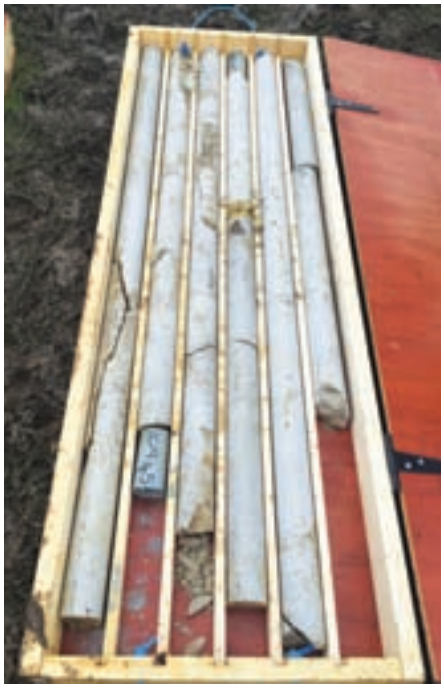
EU regulations and standards such as EN16228. Opening the guards leads to an immediate decrease in rotation speed, while the power units meet emissions standards and have noise-attenuated canopies. A robust radio remote-control option supplied by Scanreco enables this machine to crawl up steep inclines in muddy and slippery conditions.

Sales account manager Callum Mee says: "The mineral market is beginning to show signs of revival and we are receiving a stream of enquiries for the rig. We currently have three in build, two for coring and one for reverse-circulation drilling with an accompanying track-mounted compressor, and our sales figures show it is our best-selling rig over the last six months, with a number of sales already confirmed for the coming year."



Centre column: N-wireline core samples. The RH6 rotary head on the new Multitec 4000 allows the small rig to take H size cores to over 250m as well as N and P size cores where required

Above: SODERN's FastGrade geochemical logging tool

ACCURATE LOGGING

Back in May 2009, SODERN, BHP Billiton and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) decided to jointly develop a new neutron logging tool, especially designed to meet current operating procedures, field conditions and borehole characteristics common to ore extraction sites. The technology is based on a neutron analytical technique called Pulsed Fast & Thermal Neutron Activation (PFTNA).

PFTNA exploits several nuclear interactions of neutrons with matter in order to identify and quantify a large number of elements. Neutron energies are generally classified according to their kinetic energy into three categories: fast (E>1MeV), intermediate (1keV<E<1MeV) and slow (E<1keV). This latter category is itself subdivided into epithermal (0.1eV<E<1keV) and thermal (E<0.1eV).

When neutrons penetrate the matter, they progressively lose their energy, mostly as results of successive elastic collisions. Each collision causes the transfer of a percentage of neutron kinetic energy from the incident to the target nucleus. This process is called slowing down or thermalisation, which continues until the neutrons reach thermal equilibrium. Note that neutron particles have a mass nearly the same as hydrogen, making that element the most effective at slowing down neutrons following collision.

Particles (gamma photons in particular) resulting from these interactions are characteristic of the target nuclei; and thus can be used for their identification. Neutron capture and inelastic scattering are the most common interactions exploited in neutron-based borehole logging.

A large variety of elements found as constituents of common minerals can be measured using gamma rays resulting from neutron thermal capture reactions. Yet a few major elements display virtually no response to slow neutrons. Their direct measurement requires inelastic scattering interactions, which can only be initiated if the source can produce neutrons with sufficient energy to activate such reactions.

The use of energetic neutrons as produced by deuterium-tritium generators, for example, enables the excitation of surrounding material with a wide range of energies from thermal to fast, which opens up the opportunity to exploit the different types of reactions.

The FastGrade geochemical logging tool, which is manufactured by SODERN, has been designed primarily for exploration and resources evaluation programmes conducted routinely at mine sites. The FastGrade 100 tool was created to help improve and streamline exploration programmes and resource management.

Due to a great deal of accurate data provided for 3-D resource modelling, the FastGrade tool can significantly reduce the number of core boreholes and amount of reverse-circulation drilling needed (according to the nature of the deposit and the frequency of assay required).

The FastGrade tool can be used in blastholes as well. The log obtained by the tool, in real time, makes the optimisation of explosive charging holes possible.

FastGrade can lower the cost of mineral-exploration drilling through:

- fast and accurate elemental logging, which creates cost- and time-saving opportunities

Boart Longyear has signed a licensing agreement with DET CRC for the Wireless Sub

in mineral exploration and mining;
- reducing the overall amount of samples to be collected and analysed;
- eliminating a fraction of expensive diamond drilling; and
- optimising mine power consumption and reducing energy spent needlessly for low-grade material beneficiation.

Since 2012, three FastGrade tools have been used by BHP Billiton in Western Australia. Since its introduction, more than 200km of successful logging has been achieved by the first FG 100 tool put in service. Typically, on any given day, 1-6 boreholes are logged, and each tool used routinely logs about 60km per year. By measuring the elemental analysis (grade) directly and in real time, the FastGrade can significantly reduce the need of sampling and lab assays.

A new FastGrade 170 tool will be tested in blastholes at a Chilean copper mine in the June quarter of 2017.

MONITORING DRILLING

DET CRC and its participants and affiliates; CSIRO, Globaltech Corporation, Epslog and Boart Longyear; have also developed the Wireless Sub, which can monitor drilling parameters.

Generally productive drillers tend to be experienced and they rely on the 'feel and sound' of the drill rig in addition to information from its gauges for monitoring.

Some of the issues with these existing practices include:
- limited records of drilling parameters (such records permit, for example, systematic drilling optimisation and analysis of drilling failures);
- traditional gauges are not a reliable source for estimating drilling parameters accurately, e.g. the accuracy of weight-on-bit estimation is compromised by variable frictional losses in the rig; and
- not all the parameters required to optimise drilling are reported by traditional gauges, e.g. vibration of the rod string, which is a key parameter in optimising rotation speed.

The Wireless Sub, in turn, couples the drill rig to the rod string so that all output is transmitted through it, and thus provides measurements independent of the drill rig. The top-drive model provides precise and objective measurement of feed force, torque, water pressure, rotation speed, axial acceleration and tangential acceleration, DET CRC explains.

These parameters have been selected due to significant underlying fundamental research into the response of diamond-impregnated drill bits, research that will also underpin using Wireless Sub measurements to optimise diamond drilling.

The Wireless Sub provides a cost-effective option for the exploration/drilling manager to monitor what is actually happening at remote drilling sites. Simply using the data-logging feature of the Wireless Sub will enable drillers to replicate the highest performing parameters in any given drilling programme. Real-time data from remote drilling sites can be reviewed worldwide by exploration teams.

FUNDING FOR THE FUTURE

Boart Longyear was recently awarded C$1.37 million (US$1 million) from the government of Ontario, Canada, to support the development of mineral-exploration drilling site technology.

The funding comes from the Northern Ontario Heritage Fund Corporation (NOHFC), a development agency of the Ontario government that invests in projects with the potential to improve safety, increase efficiency, reduce costs and create jobs in Northern Ontario.

With the support of the NOHFC funding and a matching corporate capital investment, Boart Longyear has begun operating a surface-drilling technology development site at the Northern Centre for Advanced Technology (NORCAT) in Sudbury, Ontario. At the site, Boart Longyear is developing and testing new technologies to meet the future needs of its customers globally.

"We chose this location for several reasons: the cold-weather environment is ideal for testing our technologies in extreme environments; the local government and community are very supportive of the mining and drilling industry; and Boart Longyear has a long, successful history of operations in Ontario," says Mike Ravella, director of geological data services for Boart Longyear.

"Our work has already begun and includes testing and developing several proprietary technologies, including driller-deployable geochemical technologies and other new technologies that will increase productivity, improve safety, increase efficiency and reduce drilling costs.

"Some of the testing will include next-generation roller-latch and drilling-rod technologies, as well as cold-weather testing of our TruCore core-orientation system and TruShot magnetic survey tool. We already have a crew in place at Boart Longyear's Northern Ontario Technology Development Site, and we have begun drilling our first test hole at the site."