

Fulfilling the need for innovation

Mineral-exploration equipment manufacturers and contractors discuss the latest industry innovations and trends, from new rig and tooling designs to solutions that speed up the drilling and decision-making processes

Mineral explorers are facing an increasingly long list of challenges, in addition to the continuing downturn: from deeply buried mineral deposits and hard-to-reach, challenging locations to a general decline in major discoveries.

In accordance, new technologies and solutions are being developed to ease the explorers' task by reducing costs and creating more efficient ways to identify mineral deposits. To assist exploration companies, drillers need to be able to make decisions quickly and based on accurate information.

"With the current fiscal pressures on the industry, together with a need to drive efficiencies in exploration projects and more rapid target testing, the companies are looking for better ways to support rapid decision-making. Technology will need to provide the means not only to collect as much information as possible about the drilling process and the rocks being drilled, but also to aggregate this data and turn it into information," James Cleverley, product manager for AWD (assay while drilling) at Reflex, comments.

Carolyn Evans, director of Meridian Drilling and Meridian Geochemistry, adds: "Customers are looking for clean, efficient technologies that provide fast, precise results in order to make an assessment on the next stage of operations."

Drillers are also expecting more capability from their equipment and want to carry out a wider range of mineral-exploration methods with a single rig.

"For example, they may use rotary air blast (RAB) for a quick look and, on finding a deposit of interest, decide to take core samples. Reverse circulation (RC) is now also becoming more popular, where in the past geologists demanded core samples," explains Dando Drilling International's sales director, Quentin Dulake.

"Traditionally, drilling equipment

was almost single-purpose: there would be a big RC rig or a chuck-drive coring rig dedicated to each particular operation. That has changed and users now want more versatility as well as smaller rigs on a small footprint that can be brought to site with minimum environmental damage."

OVERCOMING OBSTACLES

Among the solutions created to tackle challenging exploration sites are Ausdrill's custom-built drill rigs, nicknamed lake-walking machines. They are designed to overcome the problems inherent in drilling in locations with substantial mud coverage; this includes the salt lakes found throughout the gold fields of Western Australia – similar conditions are found elsewhere.

"Ausdrill has been developing equipment over the past 16 years to access the salt lakes in the Goldfields, in order to explore for gold deposits," explains Ausdrill's general manager Brian Mann.

"A range of different technologies have been employed in the past to allow drilling to be carried out in the lakes. This has included the use of hovercraft platforms ►

"Drillers need to be able to make decisions quickly and based on accurate information"

Foraco Australia says its "Drill of the Future" has already been embraced by Rio Tinto and scheduled into the company's drilling programme





Above: the Multitec 4000 was designed for Dando customers requiring a small, affordable rig that could take samples to 200m

Above right: RAB samples are bagged using the angle-drilling Dando Terrier rig in the Congolese jungle



and the construction of temporary causeways to move conventional drill rigs out onto the lake. The lake-walkers have evolved over the past 16 years as lake conditions varied."

The lake-walking machines are designed and manufactured by Ausdrill subsidiary Drill Rigs Australia (DRA) at a facility in Perth, Western Australia. Due to the growing demand from clients, Ausdrill now has 10 of the specialised rigs in operation.

The lake-walkers have been designed to 'walk' on the surface of a lake. A key to the technology is the use of 2.2m-wide tracks, which stop the rigs sinking into the mud. The rigs weigh up to 25t each; at such a weight traditional drill rigs would sink straight into the mud.

Riding on their super-wide tracks, the lake-walking rigs have a footprint of 53m² in order to minimise the pressure on the lake surface. This is approximately 90 times the footprint that an average car has on the road via its four tyres. The drill rigs are accompanied by a number of support vehicles that carry drill rods and other equipment, fuel, water and personnel.

"In terms of benefits, they have opened up the potential to carry out exploration drilling in areas that were previously considered inaccessible," says Mann. "They have also removed the requirement to build causeways out over the lake. The problem with causeways is that if you build one,

you have to remove it later. These new machines eliminate the need for the whole process of building and removing a causeway, and they save the mining companies a lot of money as a result."

Mineral-exploration machines based on flexible and modular designs allow drillers to work in varied environments and choose components to suit their needs. This is also what Dando Drilling wanted to address when creating the latest rigs in its mineral-exploration line.

Dando's angle-drilling Terrier, for example, is a small rotary rig for prospecting where access is difficult and environmental disturbance needs to be kept to a minimum. It is capable of open-hole mud-rotary drilling and RAB drilling, as well as coring. The Terrier rig was modified for a customer prospecting for gold in the Congo, where both terrain and formations are sloping. It features a hydraulic mast dump that allows the rig to drill at angles of up to 45°. Measuring only 0.9m wide, the crawler unit can easily navigate between trees, which prevents the need for clearing and reduces environmental impact. The rig is capable of retrieving samples at depths of 40-50m.

The dual-mast Terrier provides the same advantages as the basic Terrier models in terms of size, but has the additional advantage of a percussive mast that allows continuous casing and sampling in geologies less suited to rotary coring. Switching between rotary

and percussive masts is quick and easy using a hydraulically deployed sliding carriage and allows a combination of drilling methods in a single hole.

The Multitec 4000, in turn, is a fully featured top-drive rotary exploration rig capable of RAB, RC, wireline coring and mud-rotary drilling on a small crawler unit measuring only 1.4m wide. While able to navigate through limited-access areas, the crawler-mounted rig has 4t of pullback and a versatile rotary head, which together provide the capability to core to 200m.

Rotary rigs often struggle to provide quality core recovery in unconsolidated geologies and that is where the Dando 4000 shell-and-auger rig excels, the company claims. It is a suitable solution for alluvial bulk sampling, and the simple, strong design provides longevity in harsh environments, as well as ease of maintaining and servicing. The D4000 is a towable unit and can be pulled by a 4x4 or a light truck.

SAFETY AND PERFORMANCE

Another Australian player, Foraco Australia, claims it recently delivered the "Drill of the Future" (DOTF) and "the most advanced RC exploration drill on the market today". According to Foraco, the drill's inherent safety features and advanced data acquisition have already been embraced by Rio Tinto and scheduled into the company's drilling programme.

The DOTF was developed by the collaboration of Foraco's mechanical, field, operations, HSEC and engineering personnel.

The development team initially aimed to reduce the risk of driller injury from falling objects and high energy sources – for example, high-pressure air and hydraulics, heat, vibration and noise. However, the Foraco DOTF also delivers a range of other benefits. These include additional data from the drill hole, real values for drillers to make informed decisions and greater mobility for the driller to run the rig from the

"Mineral-exploration machines based on flexible and modular designs allow drillers to work in varied environments"

optimum location. The DOTF is also designed to eliminate the need for spotters when setting up, and supports the training of less experienced drillers.

Peter Jacobs, the senior vice-president of Foraco in the Asia Pacific region, says: "I am really proud our local team has conceptualised, engineered, tested and delivered such an advanced rig – and one that offers substantial safety and operational advantages to the drilling industry."

The platform for the Foraco DOTF was a Boart Longyear KWL 700 high-capacity RC drill with 45t pullback, 1,350cfm (38.2m³/min)/500psi (34.5bar) on-board air, mechanised rod handling and breakouts. The developers added three radio-remote transmitters for drill set-up and to operate all drilling and rod-tripping functions – these remote transmitters are in addition to the existing controller for rod handling.

All of the primary drilling controls are grouped on one controller, while the rod-tripping and breakout functions are on another. The team used smaller controllers to allow the driller to move around freely, while operating the rig from the safest position and best vantage point. The controllers can also be mounted on the lightweight control panel, which incorporates two large LCD colour displays.

One display is for the output of four military-spec cameras on the rig, which allows the driller to see table spanners and breakouts, together with the top spindle joint when tripping rods.

The second display is a measurement-while-drilling (MWD) computer, which wirelessly streams 14 drilling parameters from the rig, including holdback, pulldown, weight on bit, drill-head RPM, drill-head torque, drill-head vibration, water flow, water pressure, air flow, air pressure, rate of penetration, hole depth, mast angle and the GPS location.

"By monitoring these key parameters, we are able to provide clients with valuable data

from the drill hole – in addition to the physical sample. It also provides drillers with real values to make informed decisions as opposed to interpreting a flickering needle on a hydraulic gauge," comments Jacobs.

Data from the MWD can be transferred via Bluetooth to the rig geologist or streamed anywhere in the world with a GPRS signal. Alternatively, the data can be ▶



The control panel of the Drill of the Future from Foraco Australia

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“Azure cuts fast through granite and cuts through rhyolite like butter”

► downloaded to a USB drive to be viewed or shared later. Another key advantage is the ability to dial into the MWD system from any location to see the same data the driller is seeing. Supervisors can assist other crew members remotely if they are encountering difficult drilling conditions, or the data can be used to train new or less experienced drillers.

Another company with safety and performance front-of-mind, Boart Longyear, says it is launching its new LF160 surface coring rig and rod handler in 2016. According to Boart, early industry reviews of the rig and its optional hands-free rod handler suggest that they have met customers’ needs.

Zachary Strauss, global product manager for Boart Longyear, describes the benefits: “When operating the rod handler, no intervention from the driller’s assistant is required to trip the rods, align the rods or connect the hoist plugs; all operations happen behind the control panel at the touch of a finger.”



Boart Longyear’s LF160 surface coring rig with optional rod handler



The LF160 rod handler is currently in site-validation testing, but early results have shown that the handler can cycle 6m rods in 60 seconds or less – the time it typically takes to manually trip rods. This means enhanced safety is achieved without compromising productivity, Strauss says.

In addition, the main hoist is not required to pull the rods based on the new capacity offered by the top-drive rotation unit that travels rapidly along the entire length of the mast. The rig and handler feature optimised hydraulics for improved fuel efficiency, low heat generation and ease of maintenance, as well as a Tier 4 engine to meet European and California emissions regulations; a Tier 3 engine option is also available. The LF 160 is also CE certified: all proper interlocks and guarding required to meet the CE European safety standard are featured on the rig and handler.

Boart Longyear explains that it had the driller in mind when designing the LF160 rig and rod handler: the drill rods are stored horizontally on the ground, reducing the risk of falling rods and enhancing driller ergonomics; and the handler reduces the risk of fatigue on the drill crew and enables them to spend time on other value-added tasks.

Next in line in product launches is the LF350 surface coring rig and rod handler, which Boart Longyear says will be one of the deepest drills on the market (3,500m-NQ). Engineered for productivity, it will also feature an integrated rod and core-barrel management system.

The LF90D rod presenter, in turn, is Boart Longyear’s next dedicated rod-presenting solution. Paired with the LF90D coring drill rig, the company claims the rod presenter provides the industry’s best solution for safe and partially automated handling of coring drill rods on both short and long holes.

TIME IS OF THE ESSENCE

This spring Atlas Copco will release the Azure higher-crown core bit for use in deeper holes,



which is part of its new core bit family. The manufacturer is also releasing a new core-barrel head assembly and overshot.

“Our focus is core retrieval for the mineral-exploration industry, and our main development mandate for core bits is longevity and drilling speed. For core-retrieval tooling we aim to provide the driller with a reliable system that is easy to use from assembly/disassembly to drilling in harsh conditions,” says Mike Duffy, global research and development manager for Atlas Copco Exploration Products.

“Our latest coring bit, the Azure, is the result of over 12 months’ development and is helping drillers set company records. To quote one driller, ‘Azure cuts fast through granite and cuts through rhyolite like butter’. This bit is very versatile and can be used in a wide range of ground conditions. Additionally, our new core-retrieval tooling has been field- and lab-tested with positive results.”

Late last year, the Deep Exploration Technologies Cooperative Research Centre (DET CRC) signed an agreement for its top-of-hole analysis technology, Lab-at-Rig, with Reflex. The technology provides a means of measuring drill-hole geochemistry and mineralogy at the drill site within minutes of the drilling process.



Cleverley explains: "Lab-at-Rig was developed as a collaborative research opportunity through the DET CRC. The project came about through providing a collaborative research framework that allowed geoscientists, engineers and drillers to look at ways to improve the process of mineral-exploration drilling.

"The research project was a collaboration between CSIRO, Imdex, Olympus and DET CRC, and brought together everything from sampling theory, hardware engineering and control to sensor technology. The technology was commercialised by Imdex in September 2015 and will be developed as part of the Reflex assay-while-drilling product suite."

Lab-at-Rig utilises the diamond-cuttings return stream and novel sample-preparation technology to provide near-real time analysis for geochemical and mineralogical information. The data provided will help on-site geologists make decisions, in near real-time, on where to drill and whether to make alterations to the planned drilling, to progress as planned, or to stop drilling altogether, and as such, reduce the risk of unnecessarily eroding a very limited exploration budget.

"The Lab-at-Rig system is designed to support rapid decision-making by providing first-pass geochemical and mineralogical data, and informa-

tion, as you drill. Efficiencies are gained throughout the whole exploration process from supporting core logging, allowing better decisions about which samples to send for lab assay, to remote decision support from the data. A remote geologist can tap into the benefit of expertise and data back in head office to help with making a decision about the current drill hole, and the next hole or target. This means better decisions can be made, faster," says Cleverley.

Furthermore, the company's newly released Reflex EZ-GAMMA, a driller-operable gamma-logging solution, promises significant time and cost savings. "Where the cost of traditional gamma logging has been prohibitive for many geologists, there is now a real opportunity to gain valuable insights as to the characterisation of rock, in the routine course of drilling, with access to accurate information from the cost-effective Reflex EZ-GAMMA," Cleverley adds.

When working to a strict budget – both financially and time-constrained – it is essential to make the most of one's resources. Some of those resources include time spent on site, potential of sample localities, efficiency of sampling and effective plans and implementation.

UK-based Meridian Geochemistry, in partnership with Tactical Environmental Response, says it

helps to make the most of some of those resources to benefit the client, local community and consumer through its new fast-track geochemical services. Tactical Environmental Response believes that on-site analytical geochemistry can and should be at the forefront of resource exploration.

"Together with Tactical Environmental Response we provide a range of desktop, laboratory and on-site facilities specifically catered for the resource target, local geology and customer requirements," says Evans.

These services include a full range of geographic information systems (GIS) services such as geochemical models, lithological and structural interpretations, geomorphology, remote-sensing techniques, historical information, 3-D visualisations and animations.

In addition, they provide in-house wet/dry laboratories, an engineering workshop and a CAD/CAM facility including 3-D printing and prototyping. The facility offers the latest Niton XL3t 980 and Niton FXL 959 Helium purge table-top and portable XRF analysers and GPS/satellite communications. It contains a petrological microscope, atomic absorption spectroscopy (AAS) and heating-furnace facilities.

"Testing is conducted on a customer-by-customer basis. This usually begins with desktop reconnaissance studies including GIS mapping applications, remote sensing, concise literature and reporting reviews and site planning.

"This is followed by on-site geochemical measurements, sampling of rock chip, soil, stream sediment and heavy metal concentrates, trenching, mapping, geophysical surveying and target acquisition for drilling and mining activities.

"Further laboratory-based geochemical follow-up work is undertaken in order to keep a tight control on the precision and accuracy of measurements, and provide data that cannot be ►

Main photo: Ausdrill's lake-walking technology in action on Lake Lefroy in Western Australia

Left inset: the Atlas Copco Azure coring bit line was designed to work in a broad range of ground conditions; drillers have reported favourable results

Right inset: Atlas Copco has just released a new core-barrel head assembly and overshot whose design focuses on productivity and safety



Reflex Lab-at-Rig ► ascertained simply by being on-site. All the work is documented and a report is produced for the client," says Evans.
on site in South Australia

The testing maximises the knowledge available in order to determine the best locations for drilling and sampling. These are based on geochemical anomalies and preferential concentration patterns, geological controls, mineralisation targets and historical mining activities.

"Each step aims to make full use of all the information at our disposal to save money and time in the future. It also provides a wealth of knowledge of a field area before putting people on the ground. Similarly, the programme gathers field targets for direct planning, undertakes on-site geochemistry to achieve instant results and interpretations, and organises exploration data and analytical strategies for methods of quantification.

"Such a procedure helps to avoid 'blind testing' and hours spent trying to locate suitable sample or drilling spots, wasted manpower, unnecessary sampling and unusable data," Evans adds.

IN THE FIELD

Ausdrill's lake-walking machines are currently in use on salt lakes in the Goldfields of Western

Australia, with the exploration company conducting drill campaigns for major mining clients such as Gold Fields and Anglo-Gold Ashanti. To date, exploration has taken place at Lake Carey, Lake Lefroy and Lake Cowan, and Ausdrill says the machines have performed well, with its clients happy with the results.

"We are experiencing increasing interest from our clients for exploration drilling in lakes and sandy areas. Our expertise in this field, combined with the specialised equipment we have developed, has put Ausdrill in a very strong position to deliver drilling programmes in what would otherwise be fairly inaccessible locations," says Mann.

Meanwhile, a prototype of the new Lab-at-Rig system has been trialled in the field in a number of DET CRC-supported drilling programmes, the latest being the current South Australian Mineral System Drilling Program (MSDP). The MSDP is a collaboration between the DET CRC, the South Australian government and two junior exploration companies, in order to test new targets in the southern margin of the Gawler Ranges. Making use of SatCom, the data from the remote drill site has been available to the group via the REFLEXHUB-IQ web portal a few hours after drilling.

Dando's managing director Martin Fitch-Roy, in turn, believes that one of the company's customers exploring for gold in the Congo is a good illustration of how the prospecting market has changed. Whereas in the past this tended to be a contractor's market, the initial investment required to contract drilling services for a full-fledged drill operation has become prohibitive. Prospectors are starting to invest in Dando's small rotary rigs such as the Terrier to obtain early evidence of mineral resources.

"This particular customer wanted a small track-mounted rig that could perform RAB angle-drilling at locations on rugged, rainforest-covered slopes. The

target vertical depth was 10-20m to get below transported colluvial formations or slope debris and tropical weathering profiles, and test the saprock. These shallow bores would be enough to garner data on the mineral deposits and justify starting a larger coring programme at a later date," says Fitch-Roy.

Low environmental impact was a requisite as the customer wanted to keep disturbance of the jungle to a minimum during the early stages of the project, and the rig had to be capable of angle drilling between 90° and 45° to suit variations in the angle of the formation.

"The Terrier rig has already proved cost-effective, and despite the small size of the rig and difficult topographical and geological conditions, the angle-drilling Terrier is achieving up to 65m per 9h shift," Fitch-Roy adds. The customer and Dando are now planning a Mark 2 version with additional modifications to continue the drilling programme in the most difficult-to-access and steeply sloped parts of the jungle.

FUTURE OF EXPLORATION

Drilling automation is an industry innovation that provides benefits to mining operations, drilling contractors and drillers alike. Boart Longyear also believes that automation in surface and underground drilling is the future and has started rolling out a range of advanced and patented rod presenters and handlers to partially or fully automate rod tripping, making and breaking rods.

Automated rod-presenting and -handling solutions in particular can enhance safety by removing the driller from the hazards of handling drill rods, and through the transfer of rods from the drill head to the rod handler in a horizontal position, thus minimising the risk of falling rods. Drilling productivity, in turn, is increased when drilling tasks are automated to the equivalent or a quicker speed than a driller can perform.

"The testing maximises the knowledge available to determine the best locations for drilling and sampling"

Automation also enables drillers to perform other value-added tasks while the machinery completes the otherwise manual tasks.

Dando's Dulake agrees that automatic handling of tooling is one area in which we will surely see advances. "At Dando we've responded to this with a specially designed front clamp-mounted single rod loader that removes manual handling from the equation. This unit can be fitted to many of our rigs or supplied for owners of existing rigs."

"Automation and condition monitoring will become the focus," confirms Duffy.

"In the future we will see a mix of low-cost commoditised tooling and consumables, along with more high-end options for smart technologies, to make the driller's job easier and safer.

"There will be a greater need for drilling to greater depths in harsher environments to get at new deposits, such as deep-



sea and remote exploration."

Mineral-exploration rigs will also need to offer more flexibility – and at a better price – so that exploration drillers can retrieve an accurate sample for less cost.

"Environmental concerns will also continue to influence design. We are paying particular attention to designs that allow customers to walk their rigs into environments without disturbing them. To achieve this, low ground pressures are required, and this means less weight, so materials will begin to be more important, especially

using lightweight materials in a way that doesn't compromise strength, drilling power or versatility," says Dulake.

Solutions that provide immediate access to information to support fast and confident decision-making, together with reliable communications and data-acquisition devices, will reduce the delays and consequently the costs for most exploration projects.

"Costly delays have been inherent in exploration due to the often remote locations, explains Cleverley. "However, the benefits of instant access to on-site information have the potential to significantly reduce these delays."

Evans continues: "The importance of on-site decision-making and remote-sensing applications cannot be stressed enough, and the solutions currently available have the potential to greatly improve and transform the mineral-exploration industry." ♥

Meridian Geochemistry offers lab-standard XRF and NIR testing on site

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