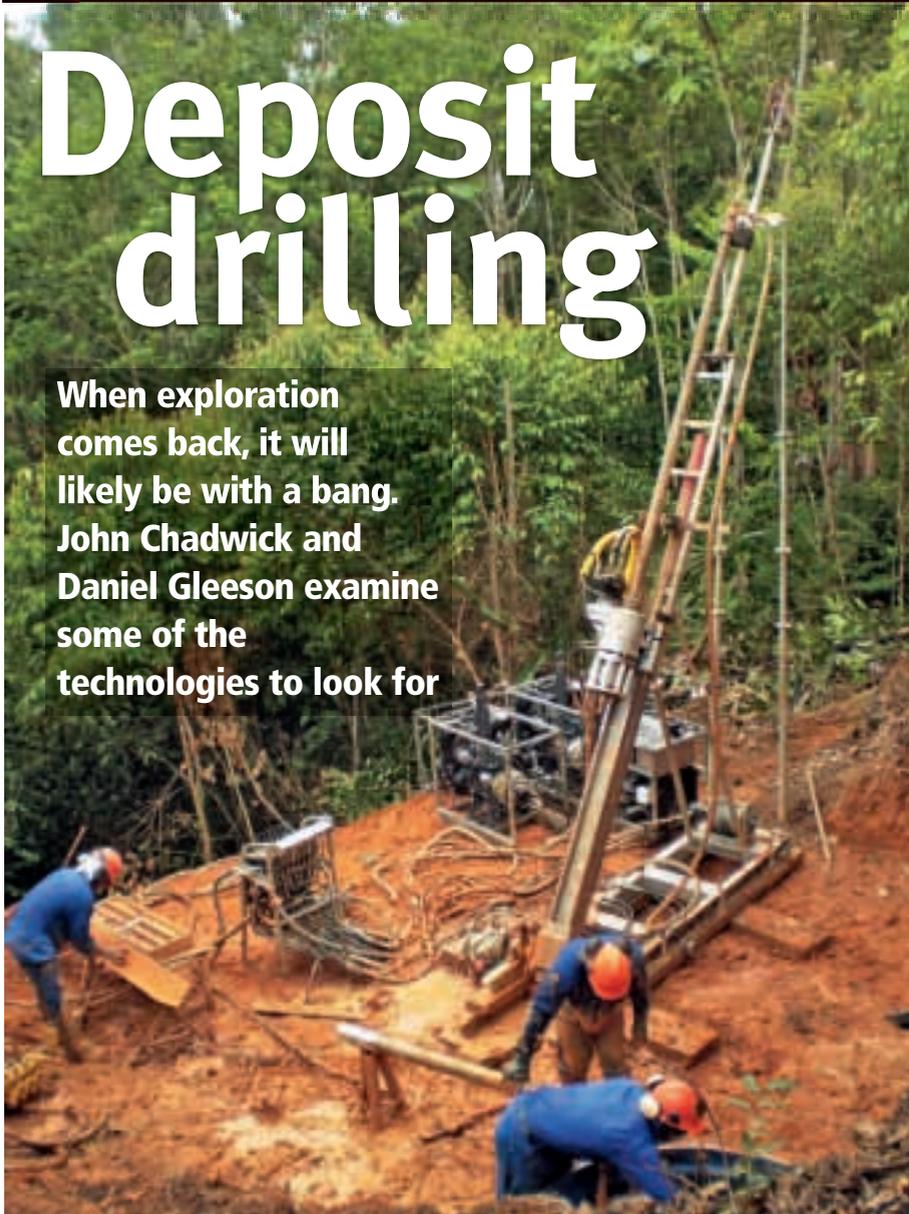


Deposit drilling

When exploration comes back, it will likely be with a bang. John Chadwick and Daniel Gleeson examine some of the technologies to look for



Exploration has suffered badly in the global recession. Many companies feel their funds are better used to look for strategic acquisitions and other opportunities rather than in spending these funds on exploration. In today's market it is cheaper to buy than to explore and drill for production and resources.

Sadly, this is storing up trouble for the future when the project pipeline will have worn thin and there is a sudden mad rush to satisfy the demand for more. At that time, many geologists will once again have been lost to the industry and the vicious cycle continues to turn! Advancing technology can be one of the saviours.

Before getting into specific new technologies, let us look to the future. Interviewed in the CSIRO publication *Earth Matters* (issue 18: Nov/Dec 2008) the CEO of Geoscience Australia, Dr Neil Williams, offered two predictions for 2030.

"By 2030 I think most exploration will be

focused on the discovery of deeply buried mineral deposits; 500 m or more below the surface. The dominant exploration tools that industry will be using by then will be geophysical tools. Magnetic and gravity-based methods are important today and will I think still be just as important in 2030. However the way we collect the magnetic and gravity data will be different and my first prediction is that airborne gravity data acquisition, a technology now in its infancy, will be standard and bringing benefits in 2030 in the same way that airborne magnetic data is doing today.

"My second prediction relates to the way we interpret geoscience data. Today exploration is very much focused on individual deposits whereas by 2030 I suspect the focus will be on entire mineral systems. The elucidation of mineral systems will involve the use of four dimensional (4D) geoscience maps and models (comprising the three dimensions of space and the fourth dimension of time) in the way that 2D maps were used in the 20th

The Explorer Plus MD4 is the newest version of Ingetrol's Explorer Plus surface drill series, expanding on the success of its MD3 rigs

century to help locate shallow mineral deposits.

"4D geoscience maps and models will be constructed using magnetic, gravity, electromagnetic, magneto-telluric and seismic reflection data. A critical step in the construction process will be integrated inversion modelling of these different types of geophysical data. Inversion modelling is another technology in its infancy today, and is one I also see flourishing in the 21st century."

Favourite redesigned

The popular, multipurpose Atlas Copco ROC L8RC drill rig has been redesigned to increase its performance and versatility – with greater flexibility and higher capacity than previous models.

The ROC L8 is now also available in reverse circulation (RC), in the L825 RC and L830 RC models. These are used for efficient in-pit grade control or shallow exploration holes using RC. Conversion to conventional DTH drilling from RC drilling can be carried out quickly, which guarantees maximum utilisation of the rig's investment. The ROC L8 with the RC system is light, flexible and transportable, for quick and successful site-to-site operation.

As a standard feature, the rig stores 36 m of RC drill pipe, including 30 m in its revolving magazine, which is usually enough for in-pit grade control through two or more benches. It stores 54 m of RC drill pipe, including 48 m in its revolving carousel. The feed capacity facilitates deeper RC drilling, up to 100 m by the insertion of additional RC pipes into the carousel while drilling.

The boom and feed system makes it possible to raise the exploration holes up to 45° forward and 30° left and right without moving the rig, to find the boundaries of the orebody in the minimum number of holes.

Mobile coring

Ingetrol offers great portability to the exploration world through its Explorer Plus MD4, which is intended for clients drilling in very difficult-to-access areas. The Explorer Plus MD4 features transportable modules that weigh under 150 kg, with the exception of the four 27 kW turbo diesel power packs, which weigh 175 kg each. Ingetrol also offers an option of four 41 kW turbo diesel power packs, which weigh 260 kg each. The modularity allows the rig to be assembled or disassembled for transport in one shift or less. It can be

transported by helicopter, truck or by hand.

According to Luis Silva, Ingetrol's President and CEO, the concept of the Explorer Plus MD4 is "portable powerful drilling, just like our slogan indicates. Ingetrol wants to offer its clients rigs that can be more easily transported anywhere without compromising on core size or depth."

The MD4 can reach depths of 200 m in HQ, 575 m in NQ, 580 m in NTW, 800 m in BQ and 950 m in BTW. The rig features a hydraulic N chuck and has a lifting capacity of 17,105 kg through two hydraulic cylinders on each side of the feed frame. Also included in the Explorer Plus MD4 is a load sensing system, so the motors work more efficiently, using less fuel and extending the life of the motors.

Atlas Copco has launched the Diamec MCR (Mobile Carrier Rig), a highly mobile underground core drilling rig. The Diamec has been long appreciated for its performance and easiness to operate, but has so far mainly been available on skids. The wheel-based Diamec MCR offers the full advantages of the traditional Diamec, with additional reach and higher flexibility. It was developed together with Australian drilling contractor Barmenco, to meet increased demands for higher flexibility in underground core drilling.

The Diamec MCR can be set up and moved around in less than a quarter of the time needed for a skid-based rig. As the new rig is self-propelled, the exploration driller no longer needs to use other machines in the mine for support when moving the Diamec. There are also great benefits from not having to disassemble the rig prior to a move, as this easily is a source of errors. The power and control units are fitted to the rig.

The flexibility and mobility make the Diamec MCR especially suited to drill medium-depth holes underground, typically ore definition drilling, where the need to move around is greater. With a 1.8 m feed frame, the Diamec MCR maintains the high productivity achieved by standard Diamec core drilling rigs.

Cobar-based GOS (Geological Ore Search) Drilling in Australia took delivery of a Sandvik DE130 diamond core drill for exploration drilling at Peak Gold's underground mining operation at Cobar. The DE130 delivered to GOS Drilling was the 30th of these rigs to be sold in Australia – with around 280 of these drills having been sold around the world, previously sold under the ONRAM name.

The unit was delivered to GOS Drilling in the last week of June 2008. Robert Everett, the company's Underground Drilling Manager agreed that the rig had performed to the high expectations the company had of it. "On the

first shift we drilled 51 m, which was fantastic. Then we did 27 m on the second shift and 30 m last night. It's going really well at this stage," he said. "It's got a double-chain driven feed frame, so you can change over the rods really quickly and achieve very high rates – and that's the key to fast drilling. In this game, it's all about speed, reliability and metres drilled – and most of all it's safety. That's what our clients want."

To reduce weight, the standard drill unit consists of a stiff torsion-resistant aluminium profile feed boom mounted on a frame with hydraulic tilt cylinder and mechanical supports.

The mounting frame has been specifically designed for easy set up when fan drilling, with a full range adjustment from vertical down to vertical up. "It is a very powerful unit in relation to its size and weight, with the ability to drill vertically down to 600 m with the 'N' size," said Håkan Ockborn, Product Line Manager. Feed force is 46.1 kN, with the drill head developing torque of up to 800 Nm in low gear. Higher torque versions are also available.

Hydraulically operated rod holders allow for fast rod-handling and quicker drilling rates, while ready access to all key components ensures easier maintenance. Ockborn noted that a larger version of the DE130, the DE140, made its Australasian debut at the Drill 2008 exhibition and conference in Auckland, New Zealand in August 2008.

Designed to meet demand market for deeper and larger holes, features of this new rig include:

- Direct feed, eliminating the use of chains
- 10 t push and pull capacity
- MaxTorque control for underground use, with power options including 55 kW or 90 kW power units.

"Sandvik's MaxTorque control system used on this drill allows an optimum balance of torque and rotation speed, for maximum productivity and reliability," he said.

Major news in the underground sector was the finalisation in December 2008 by HUD Mining Supplies in South Africa

of the purchase of the global Kempe and Metre Eater product lines from Boart Longyear. The latter gave notice that it was exiting the underground coring consumables market in July of 2008. Boart Longyear is also transferring its diamond coring bit plants in Adelaide, Australia and Roodepoort, South Africa to its Salt Lake City headquarters.

HUD Mining has not only taken over all the existing stock, but also all formal and legal rights to the drawings, designs, brand names and other intellectual property on both Kempe and Metre Eater. HUD immediately commenced significantly increasing its stock holding so as to provide "a comprehensive stock on hand, and faster service."

Managing Director David Huddy and General Manager Ian Omand explain "We have a fully equipped workshop for machine assembly and are expanding it to cater for all testing requirements. Our goal is to develop both the Kempe and Metre Eater product lines in the months and years ahead to, where necessary, enhance these products from safety, energy efficiency, cost effectiveness, productivity, durability and maintenance viewpoints."

HUD has also commenced the manufacture of all underground impregnated bits and ringset, ribbed and slugset reamer shells at its newly opened facility in Johannesburg. The first bits were produced in September 2008 and HUD is now in full production of AXT, EXT, BX and NX sized bits, and all grouting systems, in several different series. Huddy and Omand explain: "Previously we concentrated on surface exploration drilling consumables, mainly for wireline drilling, and with these two expansions we can now supply all surface and underground exploration drillers requirements."

Minerals Down Under, an initiative of Australia's CSIRO is working



The Diamec MCR is based on a Simba 1257 carrier, and a Diamec U6 boom, well proven, robust and safe components



Loglogic offers a range of track based mobile platforms designed for undertaking dynamic sampling and rotary drilling on extreme slopes. The working platform and drilling mast are automatically levelled in both planes to allow safe working on side slopes and steep inclines. The wide steel tracks, fitted with single grouser pads, achieve good ground penetration to give maximum grip on steep inclines up to 45°. A 7,500kg winch is fitted for added security on critical sites. One of the main features is the slope climbing ability under remote control. This provides a very quick set up time, without using scaffolding etc.

The Geotrack GT300 is fitted with a 1.6 m mast and sliding tool post to allow the fitting of a four-speed rotary head, hydraulic percussive hammer and SPT rig.

The Geotrack GT100 soil-sampling rig is designed for undertaking windowless sampling and SPTs on extreme slopes. Within reason, the Geotrack platform can be equipped with the customer's choice of mast and drill heads.

The Geotrak GT150 support vehicle is a mobile platform designed as a tender vehicle able to service the two drilling rigs, transporting equipment, consumables, samples, water, etc.

All the machines have radio control for travelling, winch operation and platform levelling override. Once in position the fold down walkways and drilling mast are deployed to give a secure level working area fitted with heavy-duty, GRP floor grating and guarded with removable handrails, kickboards and stanchions

with Boart Longyear to implement and test automated Sweetspot control on a diamond core drill rig as well as a rotary percussive rig. The goal is to use the automated system to increase production rates through an increased penetration rate and increased bit life.

CSIRO scientists developed and built a data logging/drill control module, which was commissioned on a diamond rig at Boart Longyear's Adelaide facility, and then fitted to

a diamond rig working underground at Olympic Dam mine. Following practical testing of the system, the control module was modified and recommissioned at Boart Longyear Adelaide.

The next phase of the program at Olympic Dam will test Sweetspot control on both feed and hold back pressure control configurations, and compare penetration rates between Sweetspot control and operator control.

Boart Longyear now offers an automated road handling system for RC drills. One of the reasons it has developed this, the company explains, is that "manual handling of rods is the most common driller/helper cause of injury." The company highlights a number of design successes:

- Reduced overall handling time
- Failsafe jaws never drop a rod
- Ultimate flexibility on a drill site
- Adaptable to a wide range of drills.

It is now standard on all Boart Longyear RC drills and can handle rods up to 8 m in length and manage a rod weight of up to 200 kg. It features driller and helper control for quick operation. Flexibility is provided by 3 m of height adjustment, 100° slew, 180° roll-over and 270° pickup area.

Boart Longyear says that if the handler allows drilling of 76 rods per shift at 300 shifts per year and that equates to the safe handling of 22,800 rods each year, weighing up to 4,240,800 kg.

The complete drill

Sandvik additionally has the DE710 diamond core drill, operating on exploration and mining projects all over the world. Configured to suit the customer and location, the drill can be truck mounted for manoeuvrability and relocation between sites. It can be fitted to crawler tracks, powered from the rig hydraulic system, making the drill a small self propelled unit for areas with difficult site access. It is also available in a shack mounted configuration for cold weather applications. Its rotation head stroke length of 3.45 m improves productivity by allowing longer continuous core runs without stopping drilling to re-grip the drill pipe.

The depth capacity of the drill is NG to 1,000 m. Designed using integrated 3D modelling and finite element analysis (FEA) design packages, the main winch and mast allow up to 7,711 kg single line pull. The mast dump feature of Sandvik multi-purpose drills has been incorporated into the DE710. The mast dump allows an ergonomic working height to be maintained at various drilling





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EXPLORATION DRILLING

angles. The mast dump stroke is 1,067 mm and ensures the mast is always able to make contact with the ground even at acute angles and/or when working on an uneven drill pad.

It is powered by a 6.7 litre engine producing 141 kW at 2,200 rpm to power the rig hydraulic system. The engine complies with the Tier 3 emissions standards that are being introduced in many countries. The main hydraulic pumps and motors are the highly efficient variable displacement design allowing for greater flexibility and precise control of critical drilling functions.

The DE710's rotation head stroke length of 3.45 m improves productivity by allowing longer continuous core runs without stopping drilling to regrip the drill pipe. The longer head stroke length also allows for greater flexibility in drilling operations with the ability to add three metre drill rods and casing under the head. The design of the head traverse system includes a hydraulic cylinder that is directly coupled to the rotation head carriage. This design significantly reduces the amount of moving components in the traverse system and of course reduces the overall maintenance costs for the drill.

The long feed stroke length combined with the optional PQ size rotation head and chuck

in conjunction with the ability to side rack the rotation head away from the mast centreline, provides the driller with more flexibility and a variety of options that cater for most drilling situations.

In keeping with Sandvik's philosophy of delivering a complete drill, the wireline winch and the water pump assembly are both built into the rig base and powered from the rig hydraulic system. All controls are located in the operator's control panel. Standard accessories supplied with the drill include the common sizes of jaws for both the rod clamps and chuck.

The drill mast can be fitted with an optional mast rod rack for standing the rods when tripping in and out of the hole. Adjustable mast stay rods are used to

The Sandvik DE710 diamond core drill is one of the world's most popular exploration drills. Its compact nature allows a small footprint on site. The depth capacity of the drill is NQ to 1,000 m. The Sandvik designed main winch allows for up to 7,800 kg single line pull



adequately support the load which is imposed onto the mast from the racked drill rods. Alternatively, the drill rods can be run in and out from behind the drill.

With the introduction last year of its mini-sized sonic rig, the Sonic Drill Corp has continued to refine its smallest and lightest rig on the market – producing its latest version, the Sonic Probe 200. With its small footprint, easy manoeuvrability and unique sonic drilling method, this offers four substantial benefits over direct-push rigs. It can drill quieter, faster, deeper and easily through cobble material while providing continuous core samples. The first Sonic Probe 200 has been sold to Superex S.A. in Chile. The company has indicated that its initial plan is to use the rig for sampling on mining projects.

This latest version is different from the original Sonic Probe thanks to an increase in power (for higher elevation work) and a longer tower to enable the use of 2 m drill rods and a three-level breakout table. Like its larger sonic rig brothers, the Sonic Probe 200 works by forcing oscillations down the drill string to allow it to easily drill through a variety of materials – with or without using any drilling fluid and without producing any cuttings. It also carries a significantly smaller price tag than a full-sized sonic rig, allowing more companies to incorporate sonic drilling technology into their business.



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Drill power

Drilling at depth is not possible without an efficient, powerful compressor. Atlas Copco's DrillAir™ compressor enables drillers to drill deeper and larger diameter holes at the "fastest penetration rates". Atlas is hoping to capture sales from not only the mining market, but also the geothermal market, an area which the company has recently

registered strong growth in. It provides both the highest air volume and air pressure available on the market, whilst being the most energy efficient with the lowest specific fuel consumption for the air delivered. The objectives of the product are to increase fuel savings and provide higher air volume, with the company believing this will become apparent to drillers.

Four models have been introduced to give free air deliveries of 606 – 630 litres/sec at 25 bar and 566 – 591 litres/sec at 30 bar. Both 30 bar versions can be optionally fitted to offer dual switching for operation at 25 bar to suit the application.

According to the company, the new screw element is a key feature of the compressor. This element ensures a 4% reduction in energy consumption compared with the previous

The patented Sonic Probe 200 is built using the same exacting engineering standards as larger versions and, conveniently, it also uses all standard direct-push tooling

design, a reduced risk of leakages and a 15% reduced lower thrust load. The new gear box configuration offers reduced forces on the bearing to provide increased working range of the element and energy savings. Improved lubrication also guarantees longer life and increased bearing efficiency.

Hole surveys

One of Canada's leaders in mineral exploration tools, Fordia, has developed a new driller-friendly survey tool series. The company says "VisionR is a serious competitor to other existing down hole survey systems, as it offers simplicity and accuracy at a very competitive rate."

"Fordia has always been at the forefront of its customers needs – we believe this survey tool series better addresses their needs; simplicity and accuracy," says the Product Manager,

Luca Arnaldi, part of the technical team dedicated to the project. "Drillers can operate these sturdy probes in no time and get results that meet every geologist's needs." That is, indeed, what drilling contractors are looking for.

The new system enables drillers themselves to keep track of their drill holes and to visualise their exact path. They can survey with any of the three probes available, SingleShot, MultiShot or AtWill. VisionR is fully equipped with Fordia's new SecuR-Connect® technology, a design that allows a secure and speedy connection between the top-sub and aluminium spacer bars, saving the survey tool from being dropped down the hole. As this system is also on all adaptors, the only threaded parts on the system are the connections between top and bottom sub to the pressure barrel, ensuring great safety and minimum loss of time.

Fordia is a leading manufacturer and supplier of high-performance drilling tools,

Atlas Copco's DrillAir compressor (pictured - the skid mounted unit) enables drillers to drill faster at depth, aided by the Caterpillar C18 Acert T3 diesel engine and the options of either a 975 litre or 1,550 litre fuel tank



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accessories and equipment for mineral exploration.

CSIRO says "it is now recognised that Logging While Drilling (LWD) has the potential to be more widely adopted by minerals exploration to boost efficiency and cut costs." Since geophysical logging traditionally occurs after a hole has been drilled, there is an inevitable delay between drilling and interpretation, and it requires the mobilisation of additional personnel and equipment. "It can also prompt production losses and delays and has the potential to cause the loss of information due to post drilling borehole collapse and blockages. All of these factors can result in additional costs that could be

Fordia's VisionR product (pictured here) is according to the company a "serious competitor to other existing down hole survey systems", being both simple to use and very accurate

reduced by replacing the two-stage process of drilling and geophysical logging by logging that is carried out while drilling, using high-speed and robust data acquisition sensors."

According to CSIRO Exploration & Mining's Principal Researcher Dr Binzhong Zhou and Research Leader Dr Paul Degnan: "LWD in the oil industry can now provide all the measurements that were traditionally acquired through wireline logging, including electrical, electromagnetic, acoustic, and nuclear logging parameters and images, which can be used for rock type identification and correlation, rock mass characterisation, litho-stratigraphic interpretation, orebody delineation and grade estimation.

"LWD (and the associated methods of 'measurement-while-drilling', or MWD, which use sensors and other tools to monitor the drilling process itself) are techniques that have the potential to be introduced into the hard rock mining industry. They can also be applied in coal mining where there is a requirement for geo-steering for drilling horizontal gas drainage holes within coal seams associated with gassy and outburst coal mines."

However, adapting LWD/MWD



systems for use in exploration and mining is still in the research stage with no commercial system developed so far. This is mainly because of the significant costs involved in adapting and making the technology more widely available, but now the oil industry has overcome many of the technical issues associated with slimhole LWD, it may motivate the mining industry to adopt the LWD and MWD techniques.

LWD's potential benefits include:

- Real-time evaluation of rock mass properties, lithology and grade – without the need for coring
- Improved blast design, fragmentation and recovery
- Ability to increase distances between sublevels
- Data guarantee even if the hole is lost
- Unobtrusive and cost effective integration of logging with drill operations
- Early indications of ore, geotechnically weak

zones and other zones of interest

- Improved sampling of coal and orebodies when combined with steerable drills.

Devico, a Norwegian directional core drilling and borehole surveying company, says it has strongly improved its position in the North-American borehole surveying market after signing contracts with two important sales companies. Equipment Jexplore in Canada and RockTech have decided to take Devico survey tools into their stock of quality products and both companies have already long experience of selling and maintaining survey tools. Together with Devico's license users in Canada, for instance Tech Directional Drilling, Devico now offer a complete package for everything from deviation surveying to steering of boreholes with core drilling in the North-American market.

Devico is also increasing activity in Latin-America. Ingetrol will be representing Devico in Peru, Chile and Mexico offering its tools and services. Devico President, Viktor Tokle, says he is happy with the new agents and stresses the importance of having skilled people close to the clients.

New areas and increased sales of survey tools has resulted in easier operations for the users. The field software has been translated into several new languages and can now be used in English, French, Spanish, Portuguese and Norwegian, as well as choosing between metric and imperial units.

Latest product developments include a faster and more reliable continuous core orientation system for NQ-size where the EMS tool stays onboard the inner tube during drilling and the results are downloaded directly from a communication port on the inner tube. Devico has also put effort into making user friendly devices for surveying vertical boreholes. The latest innovation here is an orientation tool for orienting the

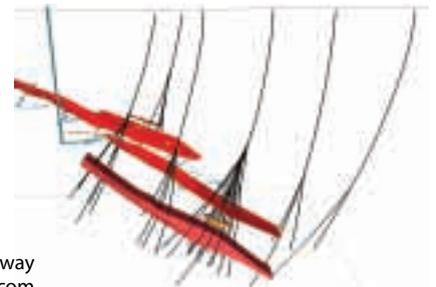


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DeviFlex, a non-magnetic survey tool that surveys inside the drill string.

The value of drilling?

Coeur d'Alene successfully used Geovariances' ISATIS to quantify the return on investment (ROI) of further drilling and the risk on resource estimation. Several hundred meters of drilling is of course a costly undertaking and companies such as Coeur d'Alene often hesitate to increase their drill sampling campaigns without knowing whether they will gain in the estimated recoverable resources. In order to base a decision on tangible figures, Coeur's objective was to find a new decision-making tool to carry out accurate resource estimation and risk analysis and to achieve sophisticated workflows as the one described hereafter

"To quantify the ROI of further drilling, I needed to run a sophisticated workflow on my dataset. To reach my goal in an efficient way, I was seeking a tool that would allow me to achieve the workflow in its entirety in one single software package. Indeed, I have no time to spend in going back and forth from one software package to another one," John Sims, Coeur Director of Mineral Resources explained. "I contacted Geovariances because they are known as the leader in advanced geostatistics and offer solutions that you do not find anywhere else."

Geovariances offered Coeur to purchase ISATIS together with a workshop training session. Coeur's expectations were:

- To gain advanced geostatistical skills
- To build an interactive and customised workflow guideline for classic geostatistical processing (variography, declustering, kriging) in ISATIS
- To set an advanced and genuine workflow for drilling optimisation and risk analysis
- To practice and validate the workflows on Coeur's main projects.

The numerous geostatistical capabilities of ISATIS (kriging and conditional simulations) provide the first expectation, whereas its modularity enhanced by the journal file system allows the creation of sophisticated and interactive workflows easily usable by beginners.

This kind of one-to-one mentoring provided was particularly valuable to Sims. Indeed, it allowed him not only to become familiar with ISATIS but it also allowed him to build and run the workflow he needed in three weeks – under the guidance of an expert geostatistician.

The workshop was carried out on data from

Coeur's Palmajero project in Mexico, within the Sierra Madre precious metals belt. The deposit consists of two very large vein systems, with auxiliary hanging wall and footwall veins. Each major vein is composed of different mineralised areas corresponding to different clavos (ore shoots).

"ISATIS, with its great flexibility and its unique ability to build tailored workflows through its journal file system, provided me with the solution I expected." Sims noted. "I found no other software package as powerful as ISATIS for in-depth data analysis and quality control."

Another possible promising development is to extend the technique to the multivariate

framework for Coeur's combined silver/gold projects. Indeed, by taking advantage of the existing correlation between silver and gold grades, Coeur will gain confidence in its resource estimations.

"This quantitative approach obtained from different drilling plans is valuable to our Palmajero project," John Sims concluded. "I can now base my decision on proofs. Today, given this example, I know that if we multiply the drilling density by about 3.5, the tonnage to be sent to the mill will be reduced by 6% for a mean grade higher by 11%. These results are most important for long-term mine planning and avoiding unnecessary mining costs." *IM*

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