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Ahead of PDAC 2013, Paul Moore reviews mineral exploration trends and technology, from drilling to geophysics

Emmerson Resources drilling in Australia's Tennant Creek Mineral Field

The main indicator of the situation in levels of exploration activity is the amount of drilling metres that have been completed, and those that have been budgeted for in the subsequent year. Currently, the outlook is mixed. A lot of concern and reining in of costs in mid to late-2012 on the back of a negative mood in Australia and uncertainty with regard to government action in other countries such as Mongolia and Argentina, along with struggling commodity prices, has in early 2013 been replaced by a somewhat more optimistic outlook, a metals and ores price recovery and a feeling that this may just have been a dip in otherwise continued growth.

In a November 2012 interview with *IM*, Francis McGuire, President and CEO at **Major Drilling**, one of the leading global mineral exploration drilling contractors said that the 2012 downturn was nothing like 2008 in depth and effect: "Many companies in 2011 drilled extra metres beyond what they had budgeted for but in 2012 they stuck to their original drilling plans. Much of this work is still from the mid-cap to the largest mining groups, with juniors still finding it very difficult with regard to raising finance; though this does not reflect any lack of need for new deposits. If anything this trend is worrying as it will have a lag in terms of new development not catching up with projected commodity demand."

A lot of the focus of the major groups is replacing resources that are depleting at the mature mines. While in the 1980s, a lot of near surface deposits were located using aerial

surveys, more and more the focus is on delineating deeper deposits. The average holes 7 to 8 years ago were in the 500-600 m range – now companies want holes drilled from 1,200 to 2,000 m and beyond. High altitude drilling is also on the increase, with the associated logistical headaches and narrow operational windows.

A mixed 2012

The uncertainty in 2012 was reflected by comments made on the industry by leading drilling groups Major Drilling, Energold, Boart Drilling Services and Layne Christensen. In its statement and review for the quarter ending October 31 2012, Major Drilling stated: "As expected during the quarter, two general factors contributed to a decline in revenue. Many mining companies did not extend their activities beyond their original budgets. Last year, most senior companies continued their drilling efforts well into November and December. While revenue from senior and intermediate companies actually increased year-over-year by some \$20 million, we saw a decline in our activities with junior mining companies. In fact, 78% of our revenue during the quarter came from senior and intermediate customers. Many of these projects are slated to continue and are expected to create a solid base for our operations in calendar 2013.....during the quarter, four branches faced specific challenges. Australia had many projects cancelled due to high costs, the high Australian dollar and new mining taxes. Mongolia and Argentina were

affected by political uncertainty, although both started to recover somewhat late in the quarter. Finally, Mexico had many projects delayed or cancelled as this region has a larger proportion of junior customers."

However, the group added: "Looking forward, if customers go ahead with their stated plans, we see consistent levels of activity coming in calendar 2013 from both the senior and intermediate mining houses as well as junior companies with projects in development. The bidding activity in most regions has been very similar to last year with the exceptions of Australia and Argentina...based on current customer plans, we expect demand for specialised drilling to continue in the year ahead. Specialised drilling continues to form the cornerstone of our corporate strategy. Although there has been a recent increase in junior financing activity, we have not yet seen any significant increase in their activity levels."

For the same period, **Energold** reported that: "Metres drilled during the third quarter decreased over the comparable quarter in 2011 as a result of the challenging capital markets, particularly in the junior mining sector." Its Mineral Division drilled 92,300 m in the quarter, a 46% decrease from the comparable quarter in 2011, while average revenue per metre was \$192 in the first nine months of 2012 compared to \$174 in 2011: "Management anticipates this to trend lower as excess rig capacity in the markets may lead to lower competitive bids. Gross margin percentage is historically tied to the business mix of frontier-style drilling and

established brownfield drill programs, with the latter moving the average revenue per metre lower. With a higher percentage of programs dedicated to majors' brownfields projects during the third quarter, gross margin was 28%, compared to 31% in the comparable period 2011." As of September 30, 2012, Energold had a total of 130 mineral exploration rigs, with Mexico, the Caribbean, and Central America accounting for over 52% of the metres drilled for the third quarter of 2012 with 45 rigs in the region, followed in importance by South America and Africa.

Layne's Christensen's Mineral Exploration Division revenues decreased 15% in the quarter, with the company stating this was: "primarily in Australia and Africa, reflecting reduced mine exploration activities by our clients...global economic and credit uncertainty produced a decline in mineral exploration activity in Australia and Africa, the result of which was lower quarterly revenues at our Mineral Exploration business."

Broad trends

The trends in types of activity are clear. Globally, drilling customers want to go much deeper and with declining grades, much higher tonnages need to be defined with drilling programmes.



Boart Longyear's new LX11 mineral exploration rig

Associated with this trend is a major step change in required equipment, skills and

associated training, especially above the 800-900 m level. At the same time, the largest equipment OEMs in some cases don't want to make highly specialised deep hole drills because the market remains smaller and they don't represent the same return on investment, as it is the drilling contractor that will see the greatest benefit in deeper drilling as opposed to the equipment manufacturer. But the contractors traditionally would rather buy-in drilling technology than have to invest in development themselves as this is clearly not their core business. As an example, Major Drilling used to own the manufacturer UDR, but sold it to Sandvik as it was not a core business – and the associated added plant and sales workforce as well as plant operational cost were hard to justify during downturns in drilling activity.

All of the drilling contractor majors would like a 2,000 m plus 'standard' drill as this doesn't currently exist in the market, and are working with key manufacturers on making this a reality. But there are also smaller drill rig players, for whom a \$10 million order is significant, who are more willing to make the necessary investments in more specialised rigs, though they do not have access to the same software/design and engineering resources.. And while it may be a smaller

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business for the largest OEMs for now, it is the main drilling services companies that have the main purchasing power going forward so their preferences will ultimately drive technology development.

As stated, the challenge is that contractors and their customers want the specialised deep hole rigs but they also want them to be portable/flyable to reach high altitude and very remote sites. But the rigs capable of deeper drilling are also heavier. There is no possible compromise – either deep hole drills have to get lighter or many of the planned drilling programmes will be very expensive as they will involve multiple helicopter trips of separate drill components.

Major Drilling points out that is the first drilling group to widely adopt lighter drill rods in the form of Boart V-Wall Coring Rods; and is considering standardising by adopting this type of technology across the board, as using a mix of rods makes logistics/inventory more complicated. At the same time, these new rod designs are 30% more expensive, so a move like this would have to be justified in its customer charges. John Nielson, global products manager, Boart Longyear told *IM*: “V-Wall rods offer up to 30% weight savings in each rod. They allow an existing drill to go deeper due to the lighter weight of the drill string. For example, a drill rated for 2,500 m would be able to manage a

3,250 m drill string using V-Wall. Also, in operations without rod handling equipment, the weight savings of V-Wall rods keep drillers and helpers lifting less weight, thus reducing fatigue. If the bore hole requires wedging, V-Wall is recommended because it is more flexible and is best suited to these deviated hole applications.”

On the drilling bit side, even though technology in materials and designs has increased, there is still significant price pressure due to the levels of competition and the fact that the market is still dominated by customer preference. In the past, the bit costs used to account for about 10% of a total drilling programme cost; now it is closer to 4%.

New drilling technology

Addressing the issue of more portable, deeper hole rigs, **Boart Longyear** has its LF130F model, which “is the only rig in its class that offers large diameter PQ drilling capabilities” and is one of the largest heliportable (breaks down into nine modules) rigs currently available, with features such as balanced lifting points and quick-connect hydraulic couplings to ensure quick and reliable setup and breakdown. It is rated to 2,640 m in a fluid filled hole with BRQ/BQTK core and to 1,510 m with NQ core. Justin Warren, Senior Global Products Manager, Boart Longyear told *IM*: “The LF130F can reliably

and consistently deliver these depths while using V-Wall rods, all with the flexibility that a flyable package provides. We also have two other models which are rated to exceed 2,000 m, the LX16 multipurpose drill and the LF230 surface coring drill. We also plan on enhancing our deep hole drill offering in the future.”

The latest news from the group, and new for PDAC 2013, is the introduction of the LX11, “an economical multipurpose drilling rig for the mineral exploration market.” The new LX11 multipurpose drilling rig features “improved safety mechanisms, track mounting, a smaller footprint, and an overall lower cost of ownership.” The medium-size LX11 is an addition to the existing line of Boart Longyear multipurpose drilling rigs, the LX6 and the LX16. With capabilities to perform reverse circulation (RC) and diamond core drilling, the LX11 allows exploration drillers to use one drill rig when encountering various ground conditions. This lowers initial capital investment and limits the costly downtime required to switch rigs to match drilling conditions. “The multipurpose LX11 drilling rig is the culmination of many years of hands-on experience, advanced engineering and field testing,” said Warren. “The versatility of the LX11 allows drilling contractors the ability to supplement the roles of multiple rigs with the simplicity of one, saving on equipment costs.”

The LX11 can reach depths of 1,450 m using

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NQ rods via diamond drilling and depths of 325 m with 114 mm rods via RC drilling. A 7.2 m mast and a top drive head allow 6m rods to be pulled under the head for increased productivity. A top drive single rotary drill head features 1,200 rpm and a maximum torque of 7.8 kNm at 100 rpm.

Several safety features are incorporated into the LX11, beginning with a strategically placed control panel for ideal visibility, a remote control for driving the rig at a safe distance and an interlocked safety cage to protect drillers from the rotating drill string. Lastly, the LX11 can be equipped with a rod handler for safe and efficient handling of both RC and diamond coring rods.

The small footprint of the LX11 allows for easier site access and manoeuvrability. It is also designed to fit into a 12 m high cubic container, making it more economical to ship to remote locations. Track mounting increases the mobility of the LX11 with the ability to handle steeper grades and lowers environmental impact.

Finally, in bits, the company recently launched the GTUMX diamond coring bit as the latest addition to the Ultramatrix (UMX) line. The GTUMX is designed for shallow holes and conventional drilling for both exploration and geo-technical applications. The ability to drill faster with high penetration rates and to outperform existing bit technology in a wide range of ground formations makes the GTUMX “ideal for customers seeking an affordable alternative” to their current bit selection.

“Boart Longyear is excited to introduce the GTUMX diamond core bits into the marketplace, especially South Africa,” said Matthew Baird, Global Product Manager for Boart Longyear. “The GTUMX bits are ideal for shallow holes and conventional drilling. This allows our customers to be very competitive with a bit of true value at a reasonable price.” Boart Longyear will launch



The control panel for Sandvik's new DE130x

an AXT size GTUMX bit first in the South Africa region. This will be followed by additional bit size releases and expansion into the Asia Pacific, Europe and Latin America regions. GTUMX diamond coring bits feature the Boart Longyear UMX formula. UMX bits use an advanced metallurgical formula that is impregnated with large synthetic diamonds. The formula optimises high penetration capabilities with longer bit life and allows the GTUMX to turn easily from one ground formation to another.

The GTUMX also features the unique Razorcut

design on the face of the bit. This speeds up exposure of the diamonds and enables the bit to begin cutting right out of the box. The wide tapered waterways dramatically improve surface flushing and cutting while reducing wear on the inner-diameter of the bit, particularly in broken, abrasive conditions.

Sandvik's DE100 series of compact core drills for surface and underground exploration applications now includes a fully ATEX certified rig, the DE130x. The design is based on Sandvik's proven DE130 core drill. Its modular design together with a depth capacity of 815 m at N-size, a feed force of 4.7 t, a pull force of 6.3 t, makes the DE130x “a truly capable exploration drill rig” states the company. The DE130x features a completely redesigned power unit which monitors; hydraulic oil temperature, electric motor temperature and incoming power. Intrinsic safety circuits are also included. The power unit is prepared for 400-1,140v of incoming power and the whole drill unit is certified and designed for maximum surface temperature of +150°C (class T4). In accordance with ATEX standards in Europe, some of the parts featured on the standard DE130 have been replaced by steel parts. Additional features from the standard DE130 include an extra gauge for rod holder surveillance on the control panel, and a wire emergency stop on the feed boom for increased safety. George Tophinke, Sandvik Mining's Global Exploration Equipment Manager, comments: “Historically the DE100 series rigs have been very successful for Sandvik and are in operation all around the globe, now with the expanding coal markets we saw the need to expand our offering to include a certified version of these drills, also in line with the important ongoing efforts Sandvik is doing with integrating EHS issue into their products.” ATEX consists of two EU directives (one for the manufacturer and one for the user of the



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equipment) describing what equipment and work environment are allowed in an environment with an explosive atmosphere. The DE130x is a fully certified exploration drill rig for underground coal applications according to these latest ATEX standards in Europe.

Schramm has announced the introduction of its new T685EX model to its exploration drill rig product line. The Schramm

T685EX is a heavy duty drill rig specifically designed for mineral exploration applications. A high capacity top head, sampling equipment, power breakout and automated pipe handling systems make it suited to a range of RC drilling programmes. The T685EX is offered in both track and truck mounting to offer the contractor optimum mobility to suit particular application needs. Schramm states: "We understand that exploration programs have varying depth requirements, so the T685EX is available in hoist packages ranging from 18,180 kg to 40,909 kg." The T685EX features increased engine horsepower and compressor capacity and is equipped with a V-Pack cooling system for increased efficiency. The MTU 12V-2000, 905 hp engine provides power required for all hydraulic systems and a high capacity Sullair compressor produces 38 m³/min at 34.5 bar. A mechanical clutch is provided to disengage the air compressor to facilitate a cold engine start and to conserve power and fuel when the compressor is not required. The compressor package also includes Schramm's patented air-CONTROL System which monitors



cooling system temperature and compressor volume requirements, matching fan speed and the compressor inlet valve providing maximum power efficiency. For added safety, galvanised steel hose whip socks are fitted to all 50.8 mm and larger hoses containing air, including the cuttings discharge hose. The top head drive is designed to

The new T685X from Schramm

provide drilling speed and torque characteristics required for tri-cone rotary bits or down-the-hole hammers. Low speed, high torque hydraulic motors provide a wide torque and speed range at high overall mechanical efficiency levels while spindle thrust forces are handled by large tapered roller bearings mounted in heavy fabricated steel housing.

The tracked carrier system includes a tramming station located at the front left-hand corner of the machine for operator convenience. The tramming station includes an adjustable height seat, a radio remote tramming control and a back-up manual hydraulic tramming system. The radio system allows for remote tramming when loading and unloading from transport trailers.

A variety of automated pipe handling systems are available to insure the safest possible operation. These systems provide hands-free operation for loading and unloading of drill rods directly to the top head. They mount on the

right-hand side of the mast, opposite the operator and lift rods from the side rack, remote racks or a support truck. To further enhance pipe handling automation, a hands-free, full breakout and make-up system eliminates the need for conventional wrenches or tongs. A hydraulic sliding holding wrench is supplied to support the drill rods in the table. A light weight hinge mounted guard is also supplied to prevent contact with the rotating drill string while an exploration jib boom, auxiliary and sandline winches round out the T685EX pipe handling package.

The T685EX is factory-equipped with side-inlet and discharge swivels, abrasion resistant discharge hose and plumbing, swing-arm mounted cyclone and wet splitter systems to meet all RC requirements. Assorted water and foam injection packages are available and can be combined with on-board water tanks and mist type dust suppression systems.

Coreboss has announced the delivery of its first F14T track-mounted surface coring drill. GDA Servicios Mineros of Chihuahua Mexico has a large drilling contract that was expected to commence by the end of January 2013. The hydraulic Coreboss drill is powered by a Cummins diesel power pack and is transported by a remote control module. Both the locomotion and drilling functions are handled off the same power unit. The unit can be set up ready to drill in as little as 30 min, with a fully integrated drilling platform on board. The drill is capable of drilling to 1,200 m at NQ sizes. A second drill for Mexico is being built with a third unit expected to close in the near future.

Dando Drilling International, the long established UK drilling rig manufacturer (now part of Energold), has launched a new lightweight, compact, multipurpose rig for surface mineral exploration. Drilling techniques performed by the machine include RC, wireline

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coring and Rotary Air Blast (RAB). The Dando Multitec 9000 has a pullback of 9,000 kgf, and can also be used for water well, geotechnical and ground source heat pump (GSHP) drilling applications. As well as its versatility, one of the main features of the Multitec 9000 is its ability to drill to great depths in restricted spaces due to the rig's small footprint and powerful performance. Other features of the rig include a mast dump to 45°; arm mounted drilling control; on board flush pump; hydraulic winch; high torque, high speed rotary head with hydraulic side shift and tilt; hydraulic rod clamps/ breaker. The Multitec 9000 is a new addition to Dando's ever-growing range of exploration rigs which includes the Mintec 6, 12.8 and 18, and the small, towable Dando Terrier drilling rig.

Drill hole analysis and alignment

A pioneering mineral exploration technology, which delivers real time information on rock formations while drilling a hole, has been developed by the South Australia-based **Deep Exploration Technologies Cooperative Research Centre** (DET CRC). Known as the "autonomous shuttle", a small sensor and data logger are pumped to the bottom of a drill hole where they protrude beyond the diamond drill bit. The shuttle then measures the properties of the rocks surrounding the hole as the drill rods and



The new Multitec 9000 from Dando

bit are gradually retrieved.

The autonomous shuttle was designed, built and tested by researchers at Curtin University and Globaltech (a Perth-based company supplying and developing tools and technologies for efficient exploration drilling) and has successfully recorded natural gamma

radiation in a test hole, indicating that it could differentiate between rock types.

"This means we can cost effectively retrieve real-time data on the rock formations deep inside the earth," DET CRC Chief Executive Professor Richard Hillis said. "The natural gamma sensor used in the successful trial is the first of several sensors that will be deployed on the autonomous shuttle. With a suite of sensors, the shuttle could replace much drill core, saving time and analytical costs and permitting drilling techniques that are only half the cost of conventional diamond drilling, at a time when Australian mining is feeling the pinch of high costs and declining commodity prices."

Hillis said the technology had been successfully tested at the DET CRC's Brukunga Drilling Research and Training Facility, in the Adelaide Hills, where new technologies can be tested against a fully cored and logged reference hole. The facility only recently opened but has already been the site of several successful field trials of new technologies. Gordon Stewart of Globaltech, one of the key researchers on the project, said the conventional process of analysing core from drill holes was time-consuming and expensive. "Mineral exploration holes are drilled to obtain information about the rocks at depth in the subsurface. Current methods require analysis of

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The "autonomous shuttle" sensor from DET CRC

core or rock cuttings from the hole or they require the time and expense of mobilising a separate wireline crew to run sensors in the hole. Since it can be deployed by the drilling crew to obtain real-time information from a hole without the risk of the hole collapsing before it is analysed, the autonomous shuttle is a major international advance and offers significant cost savings."

Hillis said the shuttle's full sensing capability would dramatically increase productivity by avoiding delays of weeks or sometimes months, when core is sent to laboratories for analysis. "It will also enable cheaper existing drilling methods to replace diamond drilling and open

underground environment. Traditionally; pegs, paint lines or flagging tape have been used to set out an azimuth to which the driller must align his rig. This is both time consuming and inaccurate resulting in errors in drill collar

The DHS Azimuth Aligner installed on a Swick drill rig

the door for next generation drilling technologies such as downhole motors and coiled tubing drilling."

A new Azimuth Aligner from Australia's **Downhole Surveys** (DHS) addresses the age old problem of how to align a drill rig quickly, in an

azimuth alignment. The Azimuth Aligner utilises the latest military grade North Seeking Gyro technology to rapidly and accurately determine true north. After just 25 minutes the Azimuth Aligner will provide an azimuth relative to true north. By placing the device onto a drill rod at collaring, the driller is now able to accurately and quickly align the drill rig to a given azimuth and dip. DHS states: "For the first time in the industry the Azimuth Aligner solves the problem of rig alignment underground and to a precision of 0.2 degrees." A 6.5 in full-colour touch screen provides the user with live high quality numerical and pictorial representation of the



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Photo: Nitro Lamego Mine

azimuth, pitch (dip) and roll angles as the drill rig is manoeuvring.

Two Azimuth Aligners are currently onsite at Newmont's Jundee underground gold mine site in Western Australia aligning five Swick MCR drill rigs, conducting 40 setups per month. A significant reduction in setup time has been reported. Traditional setup time had been between 1.5 to 2 hours and required several checks after setup. Setup time has been reduced to just 5 minutes and according to DHS, productivity has increased and additional metres are being drilled per month.

On the surface, with diamond and RC drill rigs often difficult to manoeuvre and align to a collar setup, the Azimuth Aligner can be mounted to the drill mast and the display mounted in the cab, displaying azimuth and assisting in the drill rig when reversing and manoeuvring to the collar position. As the hydraulic legs are activated to level and raise the drill rig, it continually outputs the azimuth and dip allowing the driller to position accurately. In addition the Azimuth Aligner continually displays the dip reading.

Company developments

Adrok, the Scottish "virtual drilling" technology development company has announced expansion plans which will see the company invest almost £1.8million in new staff and equipment over the next two years. Edinburgh-based Adrok has been awarded a Scottish Enterprise Regional Selective Assistance (RSA) grant of £180,000 to support the company's investment plans. By 2015, Adrok is aiming to hire 15 new staff in Edinburgh, increase the number of crews and equipment, and further improve technology to boost its international offering.

Adrok are creators of the Atomic Dielectric Resonance (ADR) scanner, which uses

radiowaves and microwaves to locate, identify and map subsurface natural resources to help exploration and production companies decide where to drill for resource deposits. The company states: "Unlike traditional seismic technologies, the portability of the ADR scanner makes exploring extreme environments such as glaciers or mountains possible. It is set to transform industries also looking for greener and cheaper ways to mine and explore for minerals, hydrocarbons and commodities."

In addition to the Edinburgh expansion plans, Adrok has been building its international presence having set up a base in Perth, Australia this year. A base in Houston, Texas will open early 2013. Gordon Stove, Managing Director of Adrok said: "We have had significant growth due to business wins, as well as our investment in Australia and North America and we are now in a great position to invest further in the future of our company. This grant provides the assistance we need to build the business and ensure we can continue to service our growing client base. As a business, we want to change the way oil & gas companies and mining companies think about and experience exploration and these investment plans are the next step in what we see as a new wave for the industry."

Donald Campbell, Adrok's Scottish Enterprise Account Manager said, "Adrok is an excellent example of a Scottish company with fantastic international growth potential and we are pleased that this grant can help them toward achieving their ambitions. Regional Selective Assistance is one of the ways in which we help companies to continue to invest in the current climate. It helps us create the right environment for companies who want to grow their businesses in Scotland, and in doing so to create much-needed jobs and positive economic growth."

Geoplano and **Cabo Drilling** have signed a

cooperation agreement to support each other's efforts in offering expanded geological services to mineral exploration and mining companies active in the Iberian Peninsula and select countries of North Africa. "Aligning Cabo Drilling's experience with core and reverse circulation drilling with Geoplano's geotechnical expertise is a natural fit as our sub-surface exploration, engineering and sampling services are complimentary," stated Terry Aimone, Cabo Drilling's General Manager in Europe. "Together we can provide a full set of services to the exploration and mining industry. I look forward to offering this expanded level of service in this market area and beyond." In 2001, after a change in the ownership structure, Geoplano's name was modified to Geoplano Aherne - Geotechnical Consultants, marking the beginning of what it calls "a renovation cycle." This has been marked by the strengthening of technical facilities, internationalisation to Eastern Europe and Africa, and an investment in areas such as groundwater works and environmental assessment. Cabo Drilling is a drilling services company that provides mining specialty drilling services throughout North America and has strategic subsidiaries in South America, the Balkan States and the global Cabo Drilling (International).

DMT, the Natural Resources Division of the TÜV NORD Group, is implementing a uniform branding policy for its subsidiaries around the world. As part of a series of measures to strengthen the DMT brand, Petrologic Geophysical Services has been renamed DMT Petrologic with effect from 2013. Petrologic is well established in the international market for seismic special processing while DMT has been active in the field of natural resources exploration ever since Ludger Mintrop developed the seismic exploration method over 100 years ago.

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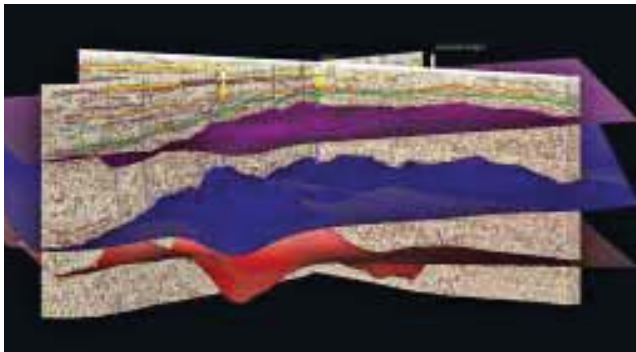
EXPLORATION

Mining software solutions group, **MICROMINE**, recently announced that it is expanding its portfolio of world-class exploration and mining consulting services. MICROMINE's international consulting arm, Micromine Consulting Services (MCS) helps mineral resource companies to drive operational efficiencies and develop resource reserve potential through "high-quality geological and mining consulting services." A special launch event for MCS's Exploration Services was held in December 2012. Leading MICROMINE's team at Mines and Money London is James Hogg, CEO of Europe, the Middle East and Africa who oversees the organisation's business development and strategic growth across EMEA markets: "Our growing team of international consulting geologists, engineers and support staff deliver unrivalled customised early stage exploration solutions that are supported by MICROMINE's award-winning in-house technology. We have continued to expand our global consulting services across all stages of the exploration process ranging from desk studies, grass-roots exploration and resource development, to production, data analysis, optimisation and tailings regeneration, across all commodities and deposit types." Offerings include a new version of its flagship geological exploration and mine design software, Micromine, its geological data management solution, Geobank, as well as its new geological field logging solution, Geobank Mobile.

Diamond drilling solutions major **Fordia** recently received the Grand Prix québécois de la qualité for its management and overall performance at an Awards Ceremony organised by the Quebec Society for Quality (QSQ). According to the QSQ, Fordia's teamwork and good business practices are what set it apart and make it one of the best businesses in Quebec. Its brand and the quality of its products are increasingly recognised throughout the world. In 2012, the company opened new offices in Colombia and South Africa, as well as distribution outlets in China and Mongolia.

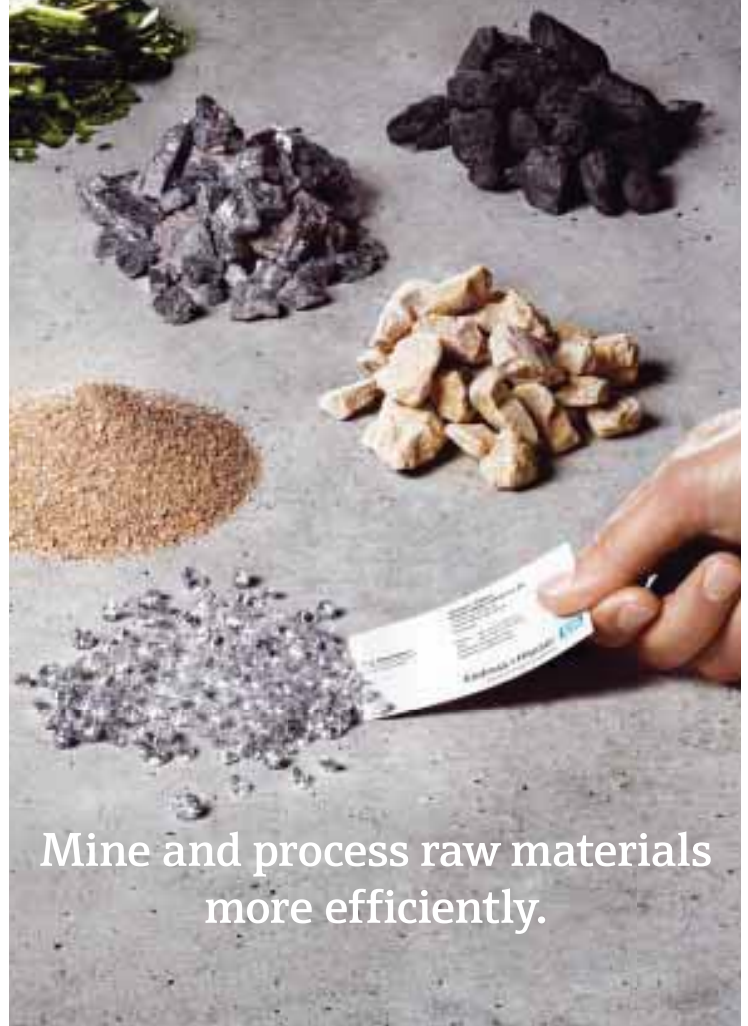
Exploration software

Maptek Eureka is the latest in a line of original solutions from mining technology developer **Maptek**, and is aimed at "giving miners an intelligent window into their data." Maptek CEO Barry Henderson states that Maptek had developed Eureka to help explorers satisfy the massive global demand for minerals: "In the next 30-50 years, the world will consume as much copper as has been mined historically. The same applies to iron ore and other metals." Allowing information to be analysed and exploited at a very large scale, Maptek believes that Eureka represents a paradigm shift in the way exploration data is used.



Screenshot from Maptek Eureka system

"A few years ago, an exploration company asked us for help in viewing seismic sections. Our software was 3D, the sections were in 2D and they really needed to see where those sections were in 3D space. Once we'd solved that problem, we realised that we could bring in other types of data and this was the catalyst for developing Eureka," Henderson explained.



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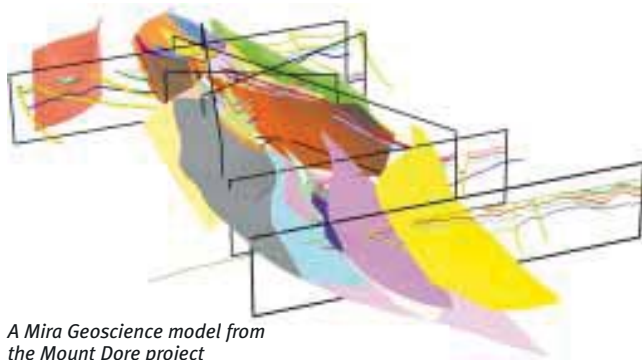
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A Mira Geoscience model from the Mount Dore project

Eureka allows large datasets with millions of points such as airborne magnetic and radiometric surveys, space shuttle topography data and imagery to be viewed in a single 3D environment. Interacting with the spatially located data in context allows geologist to analyse the relationships, and confirm their intuition.

The group states that Eureka offers much more than a viewing platform, as intelligent tools convert seismic time data to depth without ignoring the important drillhole information. Powerful, modern graphics allow geologists to “see the big picture over vast regions”, and also explore local targets in detail.

The Eureka Field tablet offers tabular data entry via drop-down list, hand-writing recognition or virtual keyboard. Logged data can be synchronised between the tablet and Eureka desktop application in real time using Wi-Fi or 3G connections. The company concludes: “Maptek Eureka will ensure explorationists make full use of data from expensive drilling and geophysical programs and allow serious explorers to achieve their goals.”

At the recent Explo Abitibi event in Rouyn-Noranda, Quebec, **Photonic Knowledge** launched a new software package called PK-LOGGER, which it believes could revolutionise the industry. President Eric Roberge stated that mining and exploration companies will be able to significantly increase their productivity by obtaining faster results, while at the same time

helping their geologists in objective data logging and management. The software makes it simpler and easier to record and analyse core samples and can digitally display what is physically present on a core logging table. One of the advantages of using PK-LOGGER is that there is no need for geologists to use a

measuring tape because the exact measurements and other data are displayed under the cursor in real time. “Even if a geologist is only working with a few boxes of core samples at a time, they will always be able to see the greater geological context represented by current samples thanks to an image of the entire drill core.” Once the work is completed, geologists can export the data in CSV format to make the information easily transferable to other drill core logging software applications. The company says it allows for a more objective creation and maintenance of drill core logs and with the click of a mouse, managers and geologists can see the greater geological context, through a high resolution image of the core sample without having to physically move the core sample boxes.

In seismic survey software, **Acceleware** recently announced that **DownUnder GeoSolutions**, a leading geosciences company, had selected its Reverse Time Migration library, AxRTM, to provide customers with “leading-edge seismic depth imaging services.” DownUnder GeoSolutions will integrate AxRTM into its DUG Insight geophysical software platform. The resulting state-of-the-art depth imaging solution is “purpose-built for the accurate mapping of complex geological subsurface structures.” In addition to providing customers with reverse time migration depth imaging services, DownUnder GeoSolutions will be offering the integrated DUG Insight RTM to

its software customers worldwide, under a sublicense agreement with Acceleware.

“AxRTM leads the industry in computing performance and image quality. The enhanced TTI stability mode, high quality imaging condition, advanced noise removal and new amplitude correction produce images of exceptional clarity and accuracy in areas with complex geology,” said Matthew Lamont, Managing Director of DownUnder GeoSolutions. “The unique API provides us with the flexibility to integrate the library into our existing depth imaging platform to provide our customers with the high quality images they have come to expect from us.”

Launched in 2008, AxRTM is an advanced pre-stack two-way wave equation migration library with VTI and TTI anisotropy capabilities. Supporting both GPU and multi-core CPU clusters, AxRTM is described as “a high-level library offering an optimised computational grid, flexible and optimised I/O solutions and efficient scaling for large volumes.

Mira Geoscience provides specialised software and consulting services in 3D geological modelling, geophysical inversion and interpretation, interpretive drillhole targeting, and geotechnical hazard evaluation. It also offers data management technology and services as a foundation for client modelling needs. The group told *IM*: “In the deep-search and under-cover modern exploration context, integration of 3D structural modelling, constrained geophysical inversion, and expert-system targeting is required to deliver optimum drillhole targets. In geotechnical hazard evaluation, integration of 3D geological and rock mass models with 4D mine geometry, stress, and microseismicity data yields the proven potential to forecast the evolution of groundfall hazard in mining.”

An example project was the assessment of the mineral prospectivity of the Mount Dore corridor. The Mount Dore project area is a 175km x 70km block located immediately south of Cloncurry, Queensland, Australia. It is dominated by copper, gold and iron oxide



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mineralisation across a strike length of 150km. The area hosts significant current, past and future copper-gold producers such as Osborne, Mount Elliott/Swan, Mount Dore, Selwyn, Kuridala/Hampden and Greenmount. A detailed 3D prospectivity analysis was completed as part of a larger Geological Survey of Queensland (NWQNEP) study. Mira's GOCAD Mining Suite was used to construct the geological model, geophysical inversion, rock property modelling and quantitative targeting. The methodology included: data compilation (geology, geophysics, rock properties), geological model construction, rock property analysis, constrained geophysical inversion, creation of a 3D pseudo-facies model, weights-of-evidence targeting, analysis and review.

GOCAD Mining Suite is a mining-customised version of GOCAD designed by Mira Geoscience for mineral exploration and geotechnical hazard assessment. It enables precise structural modelling, surface (wireframe) construction, stratigraphic and regular block modelling, and geostatistics. Add-on modules provide several 3D geological modelling environments, natural connections to geologically-constrained geophysical forward modelling and inversion, multi-disciplinary 3D exploration targeting, exploratory and geochemical data analysis, and geotechnical hazard estimation and monitoring. GOCAD was first developed for the petroleum industry by Paradigm, and leverages significant oil and gas R&D investment. Mira customised it for the mining industry with add-on modules.

Project case studies

Emmerson Resources is a junior explorer focusing on the Tennant Creek Mineral Field (TCMF) in Australia's Northern Territory. It is using innovative exploration techniques to target the next generation of deposits in historically one of the highest grade goldfields in the country. The company has made recent gold and copper discoveries at Monitor and Goanna. These are located east and west along strike of the historical Gecko copper mine within the Gecko Structural Corridor, and have both

reported bonanza gold (>10z Au) and copper (>8% Cu) drill intercepts. The new discoveries are hosted in copper-gold-quartz-pyrite veins within the sub-vertical Gecko shear zone, a new style of mineralisation for the TCMF which has been uncovered through the application of new generation electromagnetic system, HeliTEM, from **Fugro Airborne Surveys**.

HeliTEM was flown in 2011 over five areas within the TCMF to assist in the search for gold and copper deposits undercover that have been undetected by previous exploration. Fugro Airborne Surveys describes HeliTEM as a "new standard in helicopter-borne time-domain EM system. The high power of HeliTEM, coupled with the low noise at the receiver due to its placement above and not in the centre of the transmitting loop, ensures the greatest depth of exploration possible for any AEM system." HeliTEM combines the greater horizontal resolution and flexibility of helicopter-borne time-domain EM systems with proven GEOTEM/MEGATEM technology. Key attributes include: transmitter dipole moment of 2 million Am²; measurement of three components (X, Y, Z) of the secondary anomalous response; full sensitivity on-time measurement; measurement of both dB/dt and B Field; and access to a full suite of proven processing and interpretation packages.

Rob Bills, Emmerson's Managing Director & CEO, states: "HeliTEM allows us to screen large areas and reduce the search space to then allow ground based geophysical tools such as Induced Polarisation (IP). Add to this our geology and structure in 3D, then directional drilling to test the target."

Emmerson's says its exploration approach is multi-faceted and aims to integrate some new concepts (as applied to the TCMF deposits) with technology most appropriate to IOCG deposit types. At the highest level this includes establishing better prediction methodologies, such as vectors to the mineralisation through enhancing understanding of the structural and alteration syndromes of the known mineralisation. These prediction methodologies



The Brandywine craft with Sonic Drill installation on board, used for iron sands exploration in 2011

are then be coupled with the appropriate detection tools and applied in a systematic manner across the entire tenement package. A brownfield example includes reprocessing the existing geophysics utilising forward and inversion modelling to better define iron oxide bodies associated with the previously drilled prospects of Troy, Thrace and Marathon.

In 2011, a sonic drill from **Sonic Drill Corporation** was used for the first time on a former WWII US Army landing craft – the Brandywine – as an offshore drilling platform. It was extensively refurbished and is owned by Seaworks – a group of companies that provide offshore, subsea and marine vessels, ROVs, equipment and services. Working up to 15 miles off the coast of New Zealand, the sonic rig was tasked with coring through iron sands for a feasibility study. In the past, sonic rigs have done some offshore drilling near Brazil and in the Beaufort Sea but this was a very new application using the landing craft. To accommodate the drill, the Brandywine had a

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“moon pool” cut out of its centre which allowed the sonic drill to access the ocean beneath and helped to keep it stable. Initially, the sonic drill had an 86% core recovery rate from the saturated sands but, eventually, 100% core recovery was reached. With some holes being drilled to a depth of 76 m, the project used an SDC 550 sonic rig on tracks with a 50K head – the largest rig made by the SDC.

At the remote Kiyuk Lake area of southern Nunavut, Canada, **CSA Global** personnel have been working with Prosperity Goldfields Corp and a predecessor company, Smash Minerals Corp, since 2010 to complement their staff geologists and other consultants by providing technical expertise in mineral exploration, geochemistry, geophysics and glacial geology. Most recently, this partnership resulted in a highly successful 30 day exploration program at Kiyuk Lake during the summer of 2012.

Diamond drilling on the Kiyuk Lake property in 2011 and 2012 by Prosperity confirmed the presence of significant gold mineralisation in multiple areas along a 6 km-long trend. Gold is associated with pyrite and pyrrhotite in areas of intense sodic alteration and has some similarities to iron oxide copper-gold (IOCG) deposits. Continuing exploration on the property is hampered by the general absence of exposed bedrock and an extensive but thin veneer of glacial till. One objective of the 2012 summer

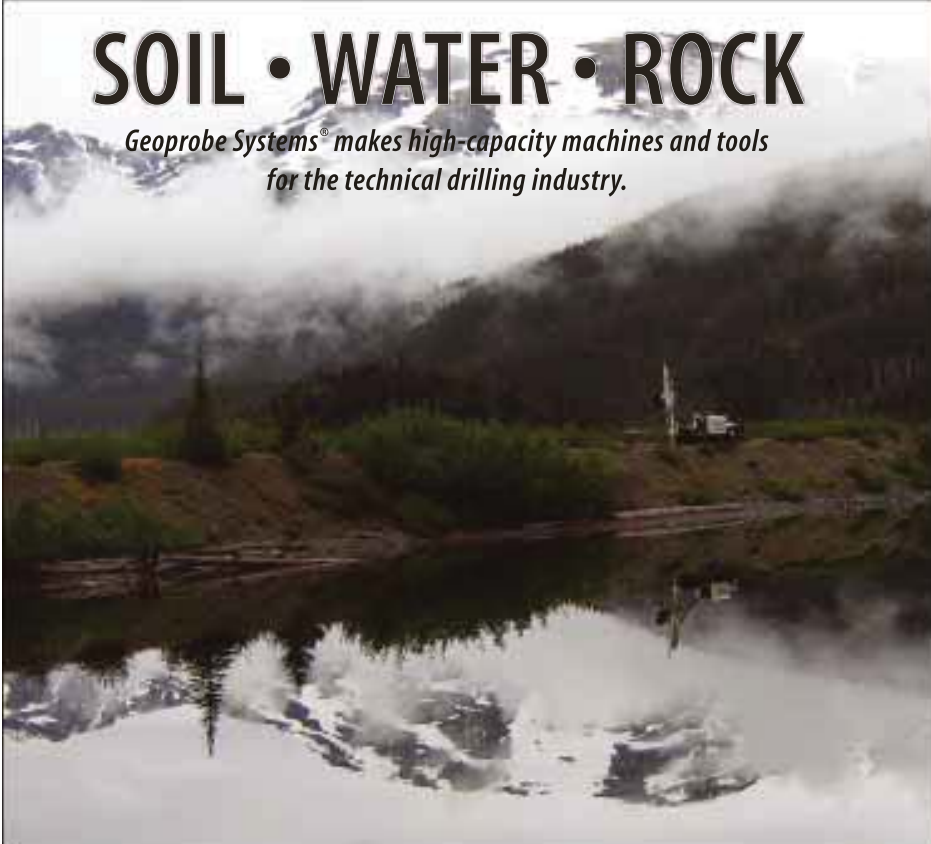
program was regional sampling of this till on a 1km² grid in order to test for glacial dispersal trails from previously unrecognised bedrock gold mineralisation.

All rock, till and soil samples collected on the Kiyuk Lake property were shipped to accredited geochemical laboratories for preparation and analysis. It can take weeks before the results are available, which was too long for a 30-day programme at Kiyuk, so field portable X-Ray Fluorescence (FPXRF) was used to analyse the till samples in the field before they were dispatched to the lab. The levels of gold in till and soil samples are generally too low to be detected by the method, but previous multi-element analytical work indicated that gold was associated with a suite of pathfinder elements such as As, Sb, Co, W and Mo at levels that could be detected using FPXRF. Till samples were dried in a heated shed and analysed directly in the sample bags using an **Innov-X Systems** Delta attached to a test stand before being dispatched to **AcmeLabs** for analysis. The gridded percentile images for arsenic by the two methods are virtually identical. Such consistency allows decisions to be made about follow-up work in the field within days of collecting the samples, which is critical in areas with short summer field seasons. Some of the targets generated during the 2012 summer field program are being tested by diamond drilling this winter.

Developed in Denmark by SkyTEM Surveys ApS, **SkyTEM** is a unique and powerful time-domain electromagnetic technology (TDEM) employed globally to explore for natural resources. The developers state that SkyTEM “is a notable advancement in airborne exploration technology and is recognised as a superior mapping tool for mineral deposits such as gold, nickel, uranium and coal and for energy resources such as geothermal and shale gas.”


SkyTEM is engineered to discriminate between weak geological contrasts and collects and delivers accurate finely detailed maps of the earth from the very near surface to depths of hundreds of metres. In order to achieve this SkyTEM is the only system capable of operating in dual transmitter modes: Low Moment (LM) mode with low current, high base frequency and fast turn off provides early-time data and high spatial sampling for shallow imaging; and High Moment (HM) mode with high current and low base frequency provides high quality late-time data for deep imaging. Depending on the exploration objective the system can operate with dual moments or a single moment based solely on HM to maximise the depth of penetration.

SkyTEM’s technology recently mapped conductors for Graphite One Resources that has led to the discovery of a world class high grade graphite deposit in Alaska. The data has a



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A SkyTEM survey, similar to this one in Colorado, was used by Graphite One Resources in Alaska

possible for Graphite One to increase the length of the known mineralised trend from 5 km to 18 km. A drill program was also carried out to determine the depth extent of the mineralization exposed at surface.

As a result of their 2012 exploration program Graphite One has verified that the 18 km long conductor detected by the SkyTEM304 system is directly related to wide scale, high grade, graphite mineralisation. It has been confirmed by drilling that width and depth of mineralisation are in excess of 250 m.

The data presented was collected by the SkyTEM304. SkyTEM also offers the SkyTEM508 – its most powerful system yet. The SkyTEM508 is focused on mineral mapping and has an

increased transmitter moment of approximately 500,000 NIA with eight turns on a 500 m² loop. System development is based on extensive experience with earlier SkyTEM systems and possesses the same features with regard to calibrated accuracy, repeatability, noise suppression and comprehensive, continuous monitoring of system parameters.

From exploration to mine development, from environmental monitoring to restoration and reclamation, **Geoprobe Systems** offers soil, water, and rock sampling equipment, based on high quality, hydraulically-powered, direct push machines that use both static force and percussion to advance sampling and logging tools into the subsurface. Geoprobe rigs such as

strong correlation with the bore holes and depth extent of the deposits. Graphite One Resources' Graphite Creek property comprises 129 claims totalling 6,799 ha on the Seward Peninsula. Mineralisation on the property is characterized by coarse crystalline (large-flake) graphite within graphite-bearing schist. The mineralisation is exposed at surface on the north flank of the Kigluak Mountains. It is continuous over 5 km of strike length with an approximate thickness of 100 m and is exposed over dip lengths of 100 to 200 m. During 2012, two SkyTEM304 dual moment time domain electromagnetic (TDEM) surveys were flown over the Graphite Creek property. The area was surveyed with a 155°/335° line direction in order to map possible extensions of the known mineralized trend. The planned line spacing was 50 m and the transmitter loop terrain clearance was 30 m in order to provide the maximum amount of detail.

The SkyTEM data is delivered as a resistivity model generated from a series of 1D inversions. The hot

colours in the 25 m resistivity depth slice indicate the spatial distribution of less resistive (more

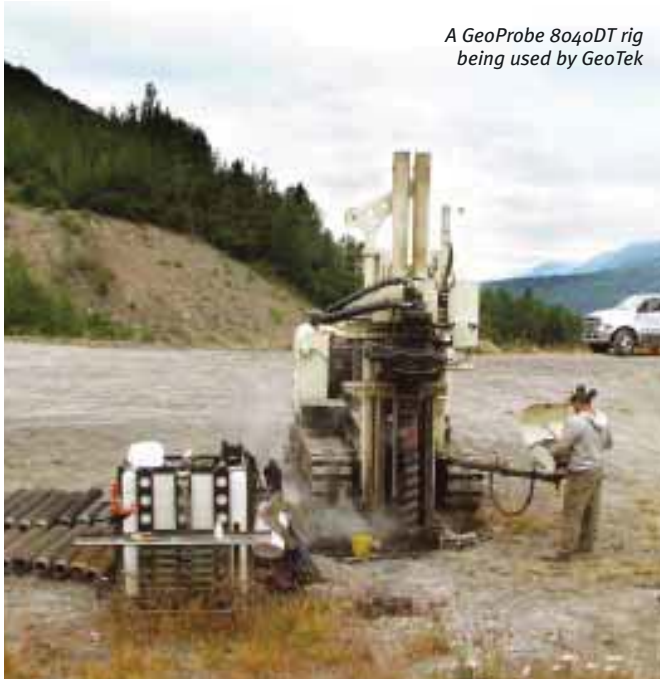
conductive) material within the survey area. The northern trend suggested a significant increase in the size of the previously known mineralised zone. Based on this information, Graphite One carried out a sampling and mapping programme to determine the size of the mineralised zone. The results of the sampling program confirmed the presence of graphite along the trend of conductors mapped by the SkyTEM304 survey. This has made it

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A GeoProbe 8040DT rig being used by GeoTek

the 8040DT have the power to compete with larger rigs, but their size and light weight allow for access to remote or confined sites. Geoprobe rigs are also fuel efficient and low maintenance.

Ernco Environmental Drilling and Coring in Sylvan Lake, Alberta, Canada, completed soil sampling and monitoring well installations at a site north of Waterton Lakes National Park in southwestern Alberta. Because of the direct push and rotary functions of the 8040DT combo rig, Ernco was able to advance to desired depths in rocky soil conditions, primarily large cobble and sand and gravel materials that would have presented major challenges for conventional rotary drilling equipment. Ernco drilled ten boreholes to approximately 24.4 m. Using the direct push feature of the 8040DT, they pushed the rods to 9 m, then advanced the remaining distance using air rotary drilling technology and 2.25 in drill rods. Monitoring wells were installed using 2 in and 1.5 in prepacked screens. Another Geoprobe 8040DT, owned by GeoTek Alaska in Anchorage, has been used at an old strip coal mine. During the mine operations over 40 years ago, the waste had been thrown over a ledge, creating giant spoil heaps. Since the tailings weren't compressed down when they were dumped, it created an oxygen-rich atmosphere that had a lot of heat. There are still fires burning within the spoil. GeoTek took in the 8040DT and turned carried out a 4.25 in Hollow Stem Auger (HSA) drilling programme, taking temperature and CO readings of the cuttings that came up. They drilled to over 45 m below ground surface, and determined that the fires were near the 31 m. mark. It was a challenge as the augers had to be handled with welding gloves as they reached over 200°.

In 2012, the US Department of Energy provided funding to install Geotech's fixed wing ZTEM system onto one of **Bell Geospace's** BT-67's, thereby allowing FTG and ZTEM to be acquired simultaneously. Although this combination will initially be applied for geothermal exploration, simultaneously acquiring ZTEM, FTG, and magnetic data should provide a powerful structural mapping tool. Bell

Geospace continues to develop data processing and interpretation methods that take advantage of the full gravity tensor. By using the horizontal tensor components as well as the vertical components to grid the data, geologic structure between survey lines higher resolution images of the density structure. Bell Geospace has also developed a special filter that uses the horizontal tensor components to emphasize the strike direction of geologic features.

In recent projects completed by oBell, an airborne full tensor gravity gradiometry survey was flown over the 600 m² Maquina Rocinha property located in Quadrilatelero Ferrifero (QF), Minas Gerais, Brazil to explore for iron oxide deposits. Iron oxide ore bodies occur as discontinuous lenses of varied sizes and shapes within the banded iron formation. Iron ores in QF can be classified into two main types, the high-grade hard haematite, and intermediate-grade ore itabiritic ore. Intermediate-grade itabiritic ore is thought to have been formed by residual concentration of the iron oxides after leaching of the surrounding minerals during the Cenozoic Era. The genesis of the hard high-grade is more complex and not well understood. This ore type generally preserves the original banding of the hosted itabirite formation and shows high-grade (haematite) re-crystallisation.

The measured gradient data has been processed and terrain corrected using a background density of 2.6 g/cc prior to evaluation and interpretation, while an enhancement technique combined tensor components into rotational invariants (R-1) and (R-2) that remain unchanged as the data are rotated about the Z-axis. The measured vertical gradient (Tzz) clearly outlined the Caue

Formation which forms part of the southern tip of the regional Gandarela fold and the first vertical derivative of the R-2 further enhanced shallow ore bodies providing good drill targets.

Bell comments: "The interpretation of high resolution airborne gravity gradient combined with geological data provides new insights into the knowledge of the lithologies and structure for the Maquina Rocinha property; the understanding of the property's regional and local geologic setting; possible new iron ore deposits; and the volume of new ore deposits, thereby giving an estimate of the overall value of the discoveries.

Underground mine RC exploration

Cubex has been active in RC drilling solutions for over 15 years, such as at Elko, Nevada, where Barrick uses 12 Cubex Aries and 5200 rigs purely employing this technology for definition drilling in narrow gold reef structures. The company drills 150 m in advance of the next main stope to get a better idea of the ore characteristics ahead of development. Cubex works with contractor, Connors Drilling, on providing this solution. There is global potential for expansion of the method. In the Australian gold industry, there is a tendency to use core instead of RC in similar situations, however, this only offers a third the speed of RC but is three times the cost. RC set-up is also quicker. Cubex argues that in a basic decision making application, RC offers a better alternative to coring in contact definition work, with current RC offering sample origin accuracy and interpretation that is on a par with coring. The advantage is that with the Cubex rig, it can be used for both mine production and this RC work, making it a highly cost effective and efficient option. The mine drills 4.5 in and 4.75 in bit holes and uses a Centre Return RC hammer, which has produced significant sample recovery improvement over an ITH hammer with cross-over sub. The current average drilled is about around 1,200 m per month. An RC drilling programme is always completed ahead of production and a riffle splitter set up on the rig is used for its simplicity.

Cubex states: "Based on the RC drilling application being a percussive drilling process and core drilling which is grinding of the rock process, the RC drilling application is much faster and cheaper than core drilling. The RC method of drilling will provide drill cuttings from the face of the bit to be blown through a centre tube in the drill pipe, reducing contamination, back up to the drill top drive, where the chips are collected and marked by their location, and can be sampled for rock type, ore grade, and other characteristics. We are currently drilling RC holes in Nevada and which are greater than 100 m in length."

The main benefits that can be gained by using RC drilling include increased definition of economic metals in the block allowing for increased mining selectivity and optimal blending; and increased definition of the deleterious elements in the block allowing for increased mining selectivity and optimal blending. It can also be used to explore near stopes and between blocks to increase definition of ore characteristics to better guide short range planning and scheduling.

The method also offers increased sample analysis frequency and more easily handled samples, with samples split at the drill site and sent to the lab after each shift. The RC method also has the ability to sample very blocky ground, and as stated, the RC drill and crews could also be used for production drilling during non sampling periods.

Cubex adds: "The RC drilling application is not there to take away core drills, but rather provide the underground geological engineering team with further information on grade control and ore contacts which will provide further drilling data quickly and more inexpensively when compared to conventional core drilling."

All terrain vehicles

L'Équipe Fabconcept, having begun mass production, is now in the marketing phase for its new amphibious all-terrain vehicle, the KASKOO-Xo4. The KASKOO-Xo4, completely designed in Saguenay, Quebec, has involved over 10 years of development, trials, prototypes and adjustments. The prototype and production model have been tested over a variety of difficult, if not impracticable, conditions and environments, in collaboration with IOS Service Geoscientifique Inc, one of the largest mineral exploration firms in Quebec and owner of the first production model. The President-General Manager of IOS Service, Rejean Girard, stated that the KASKOO-Xo4 can replace, in certain situations, the costly implication of helicopters used for the multitude of tasks related to their mineral exploration activities. Girard explains that this invention will be extremely practical during winter, when the access roads are closed: "There are also the vast marshy regions in Northern Abitibi and Baie-James, as well as forest roads where erosion over time has made them often inaccessible to standard vehicles. The machine is used for interventions covering a radius of over 20 km surrounding the mining and forestry camps."

The product's technology is integrated on all levels – it reaches up to 40 km/h, with high quality suspension and passenger compartment offering ease of driving and floatability. The machine is entirely manufactured and assembled in the Saguenay plant. Only the

tracks (Soucy International), the engine (Peugeot) and certain hydraulic elements come from external suppliers.

Geophysics instrumentation

Since 1923, **ABEM Instrument** has been pioneering the development of geophysical solutions. As a complement to its Resistivity, Seismic and Vibration instrumentation ranges, ABEM has introduced a new solution within the time domain EM technique: the ABEM WalkTEM. WalkTEM is a land-based Transient EM measuring system developed in partnership with Aarhus University and founded on SkyTEM technology. It is designed for near-surface geological surveys. The transient electromagnetic (TEM or time domain electromagnetic TDEM) method is described as very effective in determining electrical conductivity of the subsurface at depths from a few metres down to several hundred metres. Since electrical conductivity of soil correlates strongly with soil properties, TEM is a powerful tool for mapping of conductive layers and is commonly used for mapping sand and gravel aquifers, clay layers restricting groundwater flow, conductive leachate in groundwater, saltwater intrusion, and depth to bedrock.

The TEM method has been used for mining exploration for several decades but more recently has undergone a renaissance. Improved electronics and signal processing now allow for acquisition of high quality data for the interpretation and determination of a sedimentary geology.

ABEM, in partnership with Aarhus University, believes it has made a significant contribution to the advancement of the TEM technology resulting in solutions capable of accurately resolving subtle changes in geology in fine detail with excellent penetration of depth.

A combined resistivity-IP (induced polarisation) survey was carried out using an ABEM Terrameter LS for gold exploration. The field survey was done using an 800 m long ABEM Lund Imaging cable spread and measurements were carried out along three more or less parallel lines. The data were inverted using Res2Dinv, resulting in model sections with maximum depth of the models around 150 m. The good data quality resulted in mean residuals as low as 1-2% for both resistivity and IP models. The IP models revealed a number of high chargeability zones, with one of the zones at a shallow depth and thus an easy target for exploration drilling. Adding more investigation lines would make it possible to create 3D models of the expected geometry of the mineralisation which would be a very valuable asset when planning a core drilling program to delineate the 3D extension of the mineralisation.

The big picture

The number and quality of new large-scale mineral finds is declining, and particularly of those that occur at surface. New tools are required that will identify subsurface deposits in mineral belts and offer a predictive model for their discovery. The industry has advanced tools in the form of geophysics and deep drilling technology but the challenge is often where best to apply them.

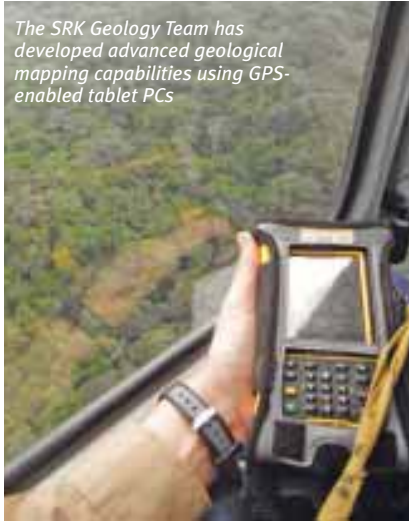
Neftex, a UK-based resource company has developed an integrated Earth Model that spans the Phanerozoic and late Precambrian, primarily in support of oil industry activity, but more recently applied to mineral exploration. The model provides the ability to delineate and track volcanic arc activity, subducting margins, major collisional events, large igneous intrusive events and the Phanerozoic redistribution of mineral-rich Archean terranes through time. To date over 3,500 deposits (porphyry copper/gold, epithermal and orogenic gold and volcanogenic massive sulphides) are incorporated within the Earth Model with data confirming geographic location, age of ore and host rock formation, incorporated commodities, ore hosting minerals and host rock type.

The validation of a model relies on its ability to identify known mineralisation and to predict new targets. The Neftex Earth Model is dynamic, that is, the geology at any one location will change over time with the movement of the Earth's tectonic plates. For example, if all Phanerozoic volcanic arcs are mapped to their present-day locations then some of them (from different geological time periods) will overlap in areas where subduction was prolonged, or where subduction settings affected the same area of continental crust repeatedly through geological time. Such areas are likely to have been prone to significant enrichment and fluid flow enhancing the potential for large-scale mineral deposits. The group states: "Using the Neftex Earth Model to map out volcanic arcs shows remarkable agreement with some 85% of the known Phanerozoic porphyry copper, epithermal gold and volcanogenic massive sulphide deposits worldwide, thereby providing a predictive framework and global road map for future exploration."

Back to basics

Bert De Waele, Principal Consultant (Geology) at **SRK** believes that geological and structural mapping continues to be a largely undervalued tool in the mineral exploration industry. He comments: "This lack of interest in mapping in part reflects the fact that market appetite is focused on vague declarations of 'mineralised corridors' and 'prospective structures.' And the fast pace at which exploration projects operate

The SRK Geology Team has developed advanced geological mapping capabilities using GPS-enabled tablet PCs



allows little time for mapping, which is perceived to be slow work. As a consequence, mapping skills are dying out, and many younger geologists lack the mapping skills needed to make sensible interpretations.”

SRK believes that geological and structural mapping should be conducted early in any project, to form a solid basis for a cost-effective exploration campaign. The cost of initial geological mapping fades into insignificance when compared with drilling or regional geochemical or geophysical surveys. What's more, the understanding gained by geological mapping allows a better definition of meaningful and cost-effective drill hole planning, defining target areas for geochemical or geophysical work and establishing a testable geological/structural model.

In recent years, the SRK Geology Team has developed advanced mapping capabilities using GPS-enabled tablet PCs and mapping protocols that allow the digital capture of mapping data in the field, producing maps more quickly than ever before. A geological map in digital form and all attached databases are usually finalised within a week of finishing field work. The mapping data is integrated into a 3D environment (LeapFrog) to assist in cross section generation and drill planning, and is presented to the client in GIS and LeapFrog format. SRK also works with a set of reputable laboratories to allow for quick sample returns for petrographic, chemical and even geochronological analyses, which may assist in geological interpretations.

Recent mapping work conducted by SRK Perth include iron, base metal and gold projects in Australia, West Africa, Southeast Asia and North America. The mapping has ranged from regional (1:50,000) to prospect scale (1:5,000) projects, sometimes incorporating 3D drilling data to aid interpretations.

SRK mapping has also assisted clients to identify target areas, by recognising outcropping

mineralisation, or structural interpretations, and where data are sufficient, has provided a testable geological model, in some cases, with exploration target sizes. Often, SRK is able to incorporate the surface mapping data into 3D geological models once drill data become available. This in turn leads to better constrained geological domains, and a more reliable resource estimate further down the line.

New GIS modelling capability

Geosoft saw strong demand last year for its cloud-powered VOXI Earth Modelling technology, which has reduced the time and effort required to generate 3D models using geophysical inversion techniques. The 2012 release of VOXI included the Geosoft Magnetisation Vector Inversion (MVI) modelling technique. MVI allows the magnetisation direction to vary within the model and thus take into account the combined effects of remanence, demagnetization, anisotropy and induced magnetisation. The result is a more realistic representation of rock magnetisation, which is the fundamental rock property measured with the magnetic method.

The next release of VOXI will support gravity gradiometry data, including full tensor systems and vertical gravity gradiometry. Geosoft will also introduce Iterative Reweighting Inversion (IRI), a powerful technique that can be used to sharpen smooth inversion results. IRI not only sharpens the inversion result but it also improves the geometry of the result and the amplitudes of the recovered physical properties.

In 2012, Geosoft also expanded its 3D gridding methods to include Inverse Distance Weighting (IDW) and direct gridding. These new methods better support the 3D gridding of a broad range of data types. Angled clipping of objects in 3D views provides the ability to clip parallel or perpendicular to dataset orientation or geological strike.

Finally, a new geological modelling workflow is being developed that will provide the ability to create 3D wireframe or geological models from 2D interpretations. Improved 2D digitisation tools and workflow will make it easier to manage interpretation files, share and collaborate on models. Geosoft is adding the wireframing tools to Oasis montaj, Target and Esri extensions. Fully integrated within the Geosoft and Esri platform, the 3D

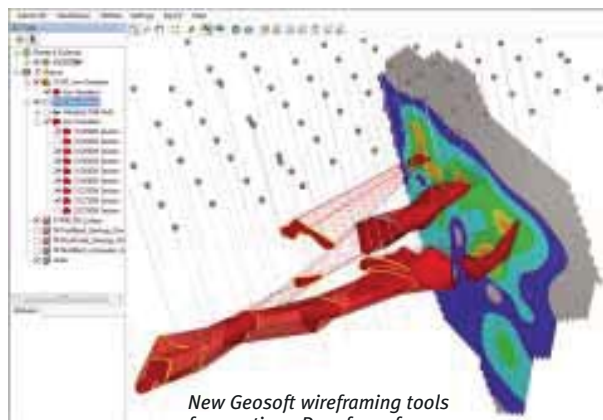
Geosurface files can be shared with other users and brought into VOXI to constrain inversions.

Remote site fuel

SEI Industries' Bulk Aviation Transportation Tank (BATT) has been adopted by numerous bulk fuel air carriers who supply Canada's remote mineral exploration and mining sites, with some making its use a requirement in their fuel delivery contracts. Users include Buffalo Airways, Nakina Air, Alkan Air, West Caribou Air, Thunderbird Air and Nolinor Aviation, with the BATT is being operated in a variety of aircraft from Caravan Shorts to Boeing 737 jets.

As covered before in *IM*, Initially developed as a tool for South American law enforcement drug interdiction operations, the BATT is the world's first collapsible fuel tank, specifically engineered to each aircraft's interior. Instead of rigid fuel drums that can leak and damage aircraft interiors, the BATT is soft-sided and customised to fill the fuselage area correctly. In addition to the hazards of using drums, fuel delivery is also more costly because the carrier has to return with no paying cargo, just empty drums. Once the fuel from the BATT is unloaded, the air carrier can easily roll the tank up, store it and re-use the same floor space on the return flight for other paying cargo such as drill core samples – essentially cutting the cost of bulk fuel delivery by 50%.

New for 2013, SEI Industries has also launched an extensive selection of off-the-shelf pumps for aviation/vehicle refuelling and fuel transfer. Built to withstand harsh conditions, these pumps are designed for diesel or jet fuel with pumping capacity ranging from 30 GPM to 150 GPM, depending on the pump selected. By stocking these critical pumps ahead of time, SEI can ensure a ready-to-ship inventory for mining companies. SEI also offers collapsible fuel storage tanks – the Arctic King, Desert King and Jungle King – made from proprietary fabrics that offer longer service life and operational features. *IM*



New Geosoft wireframing tools for creating 3D surfaces from 2D interpretations