Exploring new options

Ailbhe Goodbody examines how innovations in mineral exploration are even more important during a downturn, and what's new in exploration drilling and software

The exploration and mining industry is currently experiencing what some are saying is the biggest downturn, percentage-wise, for 40 years. This has had a significant impact on the mineral-exploration industry in key mining regions globally.

As a result, there has been low activity and weak demand in the exploration business for quite some time. The availability of capital is limited, and what is available is usually spent on projects that can realise results in the short term.

The decline in commodity prices has made it more difficult for exploration companies to raise funds for drilling campaigns. When profits dropped for many miners and spare cash became scarce, exploration budgets were often the first to be cut. For example, the mines still required dependable, fast, strong exploration drilling rigs, but they started looking for lower-cost solutions.

The prospecting market has also changed. In the past, it tended to be a contractor's market – now, the initial investment required to contract drilling services for a fully fledged drilling operation has become prohibitive. As a result, prospectors are starting to invest in smaller rotary rigs to obtain early evidence of mineral resources.

Contractors have been forced to lower their costs to win business. Martin Fitch-Roy, CEO of Dando Drilling, explains: "As a result, they too are looking for cheaper equipment so that they can bid low on a project to get their foot in the door. Basically, everyone is looking for more bang for their buck."

In addition, mining projects are becoming more complex and more expensive to develop. Access to mineable resources has become a big challenge; deposits are deeper and in less accessible locations. The costs to prove these resources, let alone develop economically viable operations, have increased drastically.

Tough times force mining companies to home in on costs; mines must re-evaluate efficiency and productivity in all areas of a project. Software has an important role to play in such re-evaluation, as a tool for driving greater efficiencies in businesses.

Glenn Wylde, chief innovation officer – planning at Hexagon Mining, says: "It's this combination of factors that has

Dando Drilling's Terrier drill rig offers rotary drilling to 50m for a very low capital outlay

actually elevated the role of software in mineral exploration. It's now more important than ever to reap the benefits software can provide, while also understanding the science behind this technology so that results can be audited."

With a higher level of scrutiny by investors and less funding available, there is an increasing need for explorers to demonstrate that they have efficient data collection and management systems, along with good governance practices, transparency and auditability. This is where exploration software has a key role to play.

Workflows can help users to manage large amounts of data and decrease the effort in maintaining it. Peter Johnson, general manager, Australasia at Maptek, recommends: "Accurate data representing the geology, geochemistry, structure, shape, location and size of the resource makes a successful mine."

Integrating the systems that collect, model and report data contributes to improvements above and beyond the individual performance gains of each process. Integrated systems deliver more than the sum of their parts.

Tim Dobush, president and CEO of Geosoft, says: "Mineral explorers are looking for ways to take more risk out of discovery. With tighter budgets and risk-averse shareholders, they want to make full use of available resources and data to improve the potential of their projects. And they are merging proven science with technological innovation to do this."

If there is anything positive about the current exploration downturn, it is the opportunity for explorers to take a breath, comb through the data they've collected, purge what is redundant or corrupt, and organise what remains to make it more useable. Software technology and services exist to help automate this process, and make valued data and information more readily available to exploration teams.

While this effort will take time upfront, ultimately it will deliver increased exploration efficiency and provide more insight to improve target selection and hit rates.

Shaun Maloney, CEO of ARANZ Geo, adds that while the downturn has been painful, there is still an upside: "You can't fix anything unless it's broken, and adversity drives innovation. Now exploration and mining practices are shown to be badly broken, there are significant and game-changing fixes on the horizon." ▶

> "Accurate data representing the geology, geochemistry, structure, shape, location and size of the resource makes a successful mine"

Combining Hexagon's MineSight Implicit Modeler and MineSight Torque: drill holes through a coal-seam model
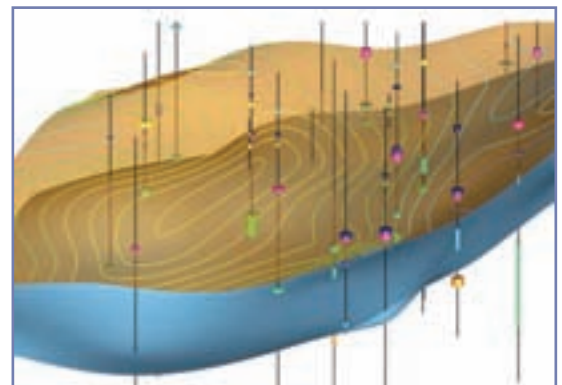
Exploration drilling

The Sandvik DE151 diamond core drill rig

Most recent innovations in exploration drilling have focused on engineering rigs down to a lower price – adding value into the rig so that exploration drillers can retrieve an accurate sample for less cost.

Another constant globally nowadays is that drilling must have a low environmental impact. Sonic drilling is an ideal solution in these circumstances. Dando Drilling has recently been focusing on sonic technology in collaboration with Sonic Drill Corp.

Quentin Dulake, sales manager at Dando Drilling, notes: "Sonic drilling is very fast up to depths of around 100m, it retrieves unparalleled samples, is exceptional in difficult geologies such as mixed sand, gravel and till, and requires little or no drilling mud, so it isn't messy and helps preserve the environment."

Dando has also been developing new rigs based on the changing mineral-exploration market. The company is focused on compact but fully featured rigs that are modular in design.

The first of these models was the Multitec 9000. Sitting on a small crawler unit that is only 142cm wide, this rig features 10,000kg of pullback and can take H wireline cores to more than 500m with pullback to spare if difficult drilling conditions are encountered.

Rupert Coler, rig designer at Dando Drilling, says: "The Multitec 9000 features a modular design that allows the customer unprecedented control over the specification.

"The customer can, for example, choose between Caterpillar, Kubota or John Deere engines, a number of mud and coring pumps, a hydraulically deployed mast extension that allows tripping of 6m sections of rod, an on-board rod rack and a rod loader. There is also the option for crawler,

> "Most recent innovations in exploration drilling have focused on engineering rigs down to a lower price"

Master Drilling's R&D has developed a driller application for a smartphone device to create a paperless system on the drill site

truck- or trailer-mounted versions."

The modular nature of the rig means that very quick changes can be made based on the customer's preferences. The result is a unit that can meet the needs of the drilling project on a very short lead-time and at a price that suits the budget.

Coler comments: "Probably our most exciting new rig, however, is the Multitec 4000. This is a smaller crawler-mounted rig that can take H wireline cores or drill open hole to 200m."

Like the larger Multitec 9000, it is modular by design and has a versatile rotary head capable of the full complement of drilling methods. At a fraction of the price of the bigger models, it is aimed at contractors with smaller operating budgets.

Coler says: "With 4t of pullback, and two mast sizes allowing the loading of 2m or 3m rods, an on-board rod rack, and a number of engine options including a Hatz silent-pack engine, this rig is already receiving a steady stream of orders."

Dando has one of the most powerful sonic rigs on the market using the biggest Sonicorp 50K head, and is developing a micro-sonic rig with a 50Hz sonic head on the Dando Multitec 4000 base. Dulake explains: "This is a rig on a crawler that is only 1.36m wide and a little over 2m long. It's a very exciting prospect for low-impact, low-cost sonic drilling."

Master Drilling, meanwhile, has been focusing on automation, improving safety, working conditions and productivity. All of its diamond drills are now fitted

with operator cabs, and drilling operations are monitored by cameras that can be accessed remotely. Development of automated rod handlers is well advanced and will be implemented during 2015.

Sandvik Mining also has on-going developments in its product and exploration-drilling technology. The company launched the Sandvik DE130i and DE140i at PDAC 2014, and new product launches in equipment and tooling are planned for the near future.

R&D

Dando is continuing to develop new rigs that are smaller, lighter and even more capable than traditional models but at a lower price. This includes lightweight, or modular, rigs that can be knocked down into easily transportable sections but still have the full complement of features and power provided by the Dando range.

The company is working towards rigs that are light enough to be heli-lifted into locations; many of its customers need to be as low-impact as possible, and cutting new roads to drill sites is often impossible.

In many areas this means looking at new technology in terms of materials and components. Coler states: "For example, we are working with alloys such as aircraft-grade aluminium to reduce component weight and incorporating components such as compact high-performance, turbo-charged aluminium engines to further reduce rig sizes."

Dando is also starting to incorporate flexible, expanding hydraulic tanks into its designs, which vastly reduce the weight and space usually occupied.

Master Drilling's R&D has developed a driller application for a smartphone device to create a paperless system on the drill site. This allows for immediate accurate access to drilling information, and a direct link to the quality and safety system. This aims to enhance the efficient management of safety and quality on a remote drill site.

Sandvik's main areas of research and development are currently in mechanisation and automation.

RECENT DELIVERIES

Despite the tough times, rig manufacturers are still racking up sales.

Sandvik has just delivered a DE880 drill rig to a customer in China – this is the company's biggest exploration drill rig, which is capable of drilling both reverse circulation and core mineral samples.

The company also recently delivered a DE840 to a customer in Australia, which will drill core samples.

One of Dando's customers is using the Dando Terrier drill rig for gold exploration in West Africa. Dulake says:

"Our latest Terrier model for the mineral-exploration sector has been fitted with a hydraulic mast dump to allow angle drilling up to 45°. The Terrier sits on a tiny crawler system that is only 800mm wide so no clearing of the jungle is required."

Dando also supplied a separate crawler-mounted compressor to accompany the rig, so no water is needed. With this setup, the customer is able to drill two 50m holes a day using rotary air blast. The customer can collect chip samples, which provides the information required to start the next stage of its wider exploration programme.

"The overall low initial outlay of the Terrier setup and low running costs compared to the high returns from a successful prospecting project are, I think, a good representation of the current exploration market," explains Dulake. "For us at Dando, business is looking very promising because we took the initiative early on and have exactly the equipment required by the current market: high-performing, reliable, low-cost rigs that provide a substantial return on investment."

Geosoft's data-services team has worked with Cameco on the design and deployment of strategic exploration information management solutions

Exploration software

One of the big issues facing the mineral-exploration industry right now is how to make sense of the 'big data' produced through the adoption of technology to drive meaningful decisions on operational efficiencies.

Almost US$75 billion was spent on exploration in just five years from 2009 to 2013, according to research by SNL Metals & Mining. However, the industry has only a handful of discoveries to show for it.

Part of the problem is that most of the 'easy' deposits have been found. Those remaining lie either deep under cover or in remote or dangerous areas that are difficult and expensive to access. Yet there is another, more controllable factor: although the amount of exploration data is growing exponentially, much of that data has not been dealt with in an efficient, integrated way.

From the moment the exploration process starts to the operation of a mine, a vast amount of multidisciplinary data is gathered to use, share and interpret. Dr John McGaughey, president of Mira Geoscience, says: "The notion of 'data integration' has

become broadly accepted as essential to effective interpretation. In recent years, it has become a common theme of exploration technical conferences. However, for practical reasons, coherently managing disparate and complex data streams remains a daunting challenge."

The big emerging technologies are cloud computing, software-as-a-service and big data analytics. Wylde notes: "One major innovation that has only really appeared in the last year or so is the ability to render massive point clouds on your standard desktop or laptop. Operations have been collecting these massive datasets for years, but have had to make compromises on how much data they can display/use."

Exploration companies are adopting collaborative and multidisciplinary, real-time approaches to improve exploration effectiveness. They are maximising the value of data and technology to deepen insight, prioritise opportunities and select the best drill targets.

As a result, organisations globally are looking for far greater interoperability

between different specialist software suites rather than placing their reliance solely on more generalist packages.

It is possible that in the future, explorers will be able to choose a location anywhere in the world, access all of the exploration data ever collected there, and immediately begin to build an integrated 3-D model to guide further exploration with the intent of improving the odds of discovery.

Innovations that are helping to make this possible include: the emergence of high-performance geocomputing in the cloud; more sophisticated and faster methods for integrating and modelling large multidisciplinary data; and web-based solutions for managing and delivering exploration information.

NEW PRODUCTS, CAPABILITIES

ARANZ Geo recently released several updates across its range of Leapfrog 3-D geological modelling software, starting with Leapfrog Geo 2.0 in July 2014. Its vein-system modelling tools utilise the dynamic implicit modelling of Leapfrog to rapidly model complex multi-vein systems. ▶

"The notion of 'data integration' has become broadly accepted as essential to effective interpretation
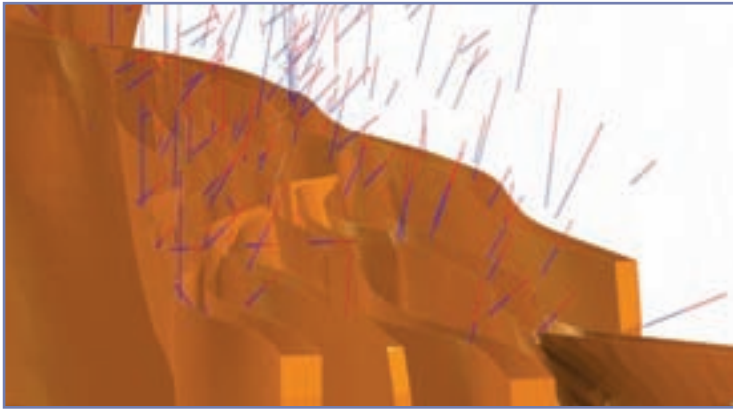
► Users can model curved or folded vein systems that branch or terminate within the intuitive 'vein systems' workflow. Narrow geological units such as dykes or shear zones can also be modelled within this new workflow.

Maloney says: "Another feature that a number of our users have been impressed with is multi-core processing, which better utilises the increasing power of users' computers. These improvements can more than halve the time taken to process models."

The company states that Leapfrog Geo 2.1, released in November 2014, heralded the start of the Leapfrog Partner Programme for advanced interoperability, with leading partners including the Snowden Supervisor geostats tool, the MapInfo Discover geographic mapping and analysis application from Pitney Bowes, and the Esri ArcGIS geographic information system.

Snowden Supervisor gives Leapfrog Geo 2.1 users the ability to combine the speed and power of Leapfrog's FastRBF engine for grade interpolation.

In the past year, Datamine has released a number of new applications. Fusion Core Shed Management is a comprehensive asset-management tool that tracks the physical locations of core boxes and sample bags.

Fusion LIMS API integrates the Fusion solution with on-site and commercial analytical labs to streamline the reporting of assay results. Approved results are validated and integrated in to the database, eliminating the need for manual file import of lab certificates.

Fusion Report Manager is a new flexible QA/QC reporting solution to gain an in-depth understanding of variance and uncertainty in a deposit, as well as the performance of analytical labs. Using Report Manager, users can monitor the precision, accuracy and contamination of all drill-hole and point-sampling data.

Fusion Hosted is a secure cloud-based solution that offloads the work of database administration and reduces the costs of on-premises IT infrastructure. David Kerr, solutions manager – exploration at Datamine, says: "This service enables users to focus fully on drilling and sampling programmes, rather than time-consuming and expensive IT-system administration."

Hexagon's MineSight has recently added a streamlined workflow for seam support to MineSight Torque, which now includes more data types available for import, whether it's a downhole sample or a point sample.

Torque manages drill hole, blasthole and other sample data in a Microsoft SQL Server database. The data is fully integrated with other MineSight products for coding, spearing, compositing, interpolation, statistics and display.

Version 4 of the product, released in January, includes support in MineSight 3D for viewing, MineSight Data Analyst for statistics, and MineSight Basis for model interpolation.

Point samples can be individual standalone points (such as soil or geochemical samples), grouped into point sets, or can be points located within a drill hole (such as a fault intercept).

"We've made numerous improvements to MineSight's coal-modelling capabilities," comments Wylde. "For block models, MineSight is the only software package that can model unlimited seams in one project. With greater spatial precision, Sub-Blocking enhances MineSight's underground solution and makes modelling even the narrowest coal seams both quick and simple."

True thickness logic has been added to MineSight Implicit Modeler, which can now model complex veins directly from drill-hole data in minutes.

In May 2014, MineSight Dynamic Unfolding was introduced to further tackle the challenges presented by complex geology. Wylde says: "This is unique technology – no one else offers ►

The big emerging technologies are cloud computing, software-as-a-service and big-data analytics

Project focus: Geosoft

Geosoft's software has been used at a number of recent mineral-exploration projects. For example, Colorado Resources' North ROK property in British Columbia, Canada, used the Geosoft platform to integrate data and build knowledge: from creating maps and simple survey grids in the early stages, to analysing geochemistry and building geophysical models as the project advanced, to finally preparing the resource wireframes.

More than 80% of the data analysis was done using Geosoft Oasis montaj and Target 3-D geology programs.

Coastal Gold's Hope Brook project is a former gold mine in Newfoundland, Canada. Several explorers have investigated the land around the mine, but exploiting the mineralisation that they have focused on would be uneconomic at current gold prices.

However, Coastal Gold has improved the project's potential by integrating geophysical, lithogeochemical and geological data in a 3-D model to provide a new perspective.

The data integration successfully highlighted a higher-grade area that could provide an acceptable rate of return. Coastal used Geosoft Target for ArcGIS to integrate and visualise the multidisciplinary data. The drill targets were identified by a 3-D inversion of resistivity and electromagnetic data imported into Geosoft Oasis montaj.

In addition, Cameco has just launched its Geospatial Envision Technology & Information Transfer (GET-IT) system, a web interface for exploration and land-management data, in Australia. The North American launch will take place in April.

As a key component of GET-IT, Geosoft's DAP server stores the company's geophysical data consisting of 650 surveys ranging from seismic to airborne EM.

Cameco also makes extensive use of Geosoft exploration applications for data interpretation, presentation and modelling, including Target for 3-D geology and VOXI Earth Modelling for geophysical inversion.

Mira Geoscience's GOCAD Mining Suite is for advanced integrated modelling

a product like this. As the industry explores and mines more complex deposits, MineSight software grows to accommodate that complexity."

The Relative Surface Interpolator, released last year, allows for the creation of dilution shells and intermediate surfaces. Wylde adds: "Combined with the MineSight Implicit Modeler, Dynamic Unfolding caps rapid solid and surface building with interpolation representative of grade trends in a fold. Geologists can move from raw drill-hole data to a fully interpolated model quicker than ever before."

Maptek's Vulcan 9.1, released in October 2014, connects geological modelling to mine design, planning and scheduling.

Vulcan Implicit Modeller handles complex geological settings, modelling faulted geometries and combinations of geological database elements. Modelling parameters can be fine-tuned in real time. Implicit modelling can be automated via scripts so that designs update when changes occur in drill-hole data. Johnson says: "'What if' scenarios can be previewed prior to building a robust resource model, which can be relied on during design and planning."

Exploring in 3-D has been a primary focus for Geosoft, with significant advances in geological modelling and continued development of its cloud-powered VOXI environment for geophysical 3-D inversion and forward modelling. Most recently, it has added geosurface handling utilities.

Since the release of VOXI Earth Modelling, Geosoft has continued to improve its Magnetization Vector Inversion (MVI) and Iterative Reweighting Inversion Focusing techniques for increasing geophysical model accuracy. The most recent addition is support of electromagnetic (EM) data.
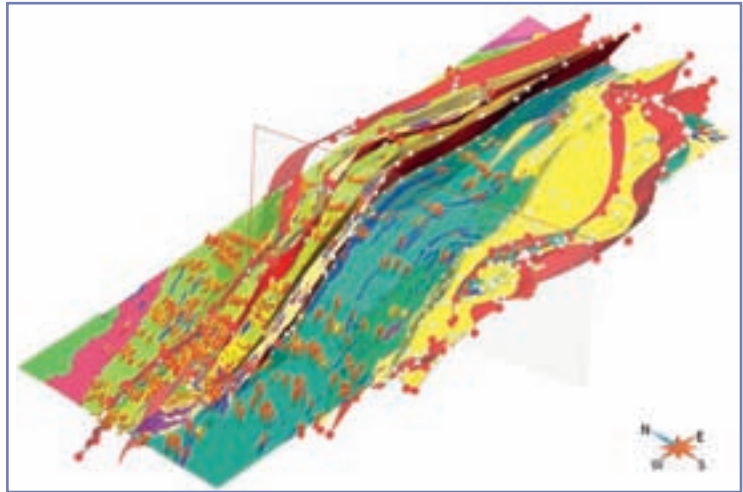
Geosoft currently provides data support across a range of products including acQuire, Micromine, MineSight, Surpac and programs from Datamine. Over the past year it has

supported Maxwell DataShed, and will be expanding its third-party support to include Vulcan formats.

With recent releases, Geosoft has enriched geology analysis capabilities in its Target for ArcGIS by including interactive drill-hole planning, drill-hole intersection of 3-D surfaces and improved wireframing.

Over the past few years, Geosoft's data-services team has worked with companies such as Cameco and Hudbay on the design and deployment of strategic exploration information-management solutions.

Geosoft has expanded its data services to assist with the analysis, organisation and digitisation of large historical data collections. It uses automated toolsets to scan large volumes of exploration data held within a company's network, and identify high-value data so that it can be placed into managed data repositories.

Geosoft has also strengthened its integration services with Esri, providing the ability to create ArcGIS Image Services to stream data to end users from its Geosoft DAP Server.
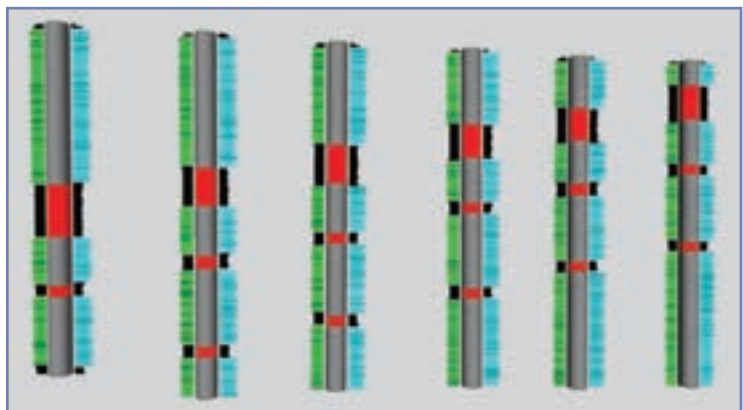
The latest version of Geovariances' geostatistical software solution Isatis

offers a new application called Simulation Reduction. The objective of this is to evaluate projects using a representative subset of simulations. From hundreds of simulated realisations, the application extracts a given set of them that best capture the different scenarios for further convenient post-processing.

It can be implemented to characterise the risk attached to a project due to the uncertainty on the resource for open-pit optimisation and mine scheduling, evaluation of projects when taking financial and technical uncertainties into account, and mine optimisation for a portfolio of deposits.

Simulation Reduction has been applied at SLN's Tiébaghi orebody in New Caledonia. Five sets of simulated recoverable grades have been picked up by the procedure, from which SLN has derived five pit designs.

Mira Geoscience's software development has focused on its Geoscience INTEGRATOR for data management, GOCAD Mining Suite for advanced integrated modelling, and Geoscience ANALYST for decision making and communication. Mira Geoscience also contributes to the development and

> **"Organisations are looking for far greater interoperability between different specialist software suites rather than placing their reliance solely on more generalist packages"**

Project focus: Geovariances

Isatis has been used in a number of recent projects, including the estimation of recoverable resources using local uniform conditioning at an Eramet project in South Africa, and the estimation of global manganese resources located on ore deposits characterised by problematic geometries for Comilog.

Measurement while drilling (MWD) data in Maptek Eureka

commercialisation of UBC-GIF and Fullagar Geophysics VP Suite. Additional research in predictive modelling and data integration is ongoing.

Mira Geoscience is utilising its experience in developing integrated geotechnical data management systems for underground mines (for example, Rio Tinto's 'CaveCad' system) to address the management of integrated exploration data. It is extending its proprietary Geoscience INTEGRATOR data-management system so that drill-hole data can be managed seamlessly alongside all types of geological, geophysical and geochemical exploration project data.

In June 2014, Paradigm renewed its long-term agreement with Mira Geoscience for the delivery of Paradigm SKUA-GOCAD modelling software to the global mining industry. Mira Geoscience is now working on the upcoming release of version 14.

In partnership with HyperCube Research, Mira Geoscience has researched and is now offering to the mining industry a predictive-analytics approach to the exploration targeting problem.

McGaughey explains: "The method provides a series of robust rules describing the relationship between input exploration data variables and mineral occurrences. The rules discovered are typically of much greater utility than statistical trend observations. These methods have the potential to improve discovery rates when applied as part of a carefully planned and systematic process of modelling, interpretation and target generation."

AMIRA Project P1022, 'Rapid Approximate Inversion of TEM Data', completed its work in 2014 with a breakthrough in 3-D TEM inversion. The research was conducted by Fullagar Geophysics and CODES (University of Tasmania), sponsored by AngloGold Ashanti, Gold Fields, Rio Tinto and Mira Geoscience. The new inversion algorithm, VPem3D, offers both speed and practicality. It is suitable for airborne, downhole and ground dB/dt or B-field data.

VPem3D was released commercially by Mira Geoscience in March.

UBC-GIF recently released a substantial upgrade of its GRAV3D, MAG3D, DCIP3D and DCIP2D forward modelling and inversion programs. Enhancements allow users to save time and run efficiently on large-scale problems with multi-processor capability. The new versions provide
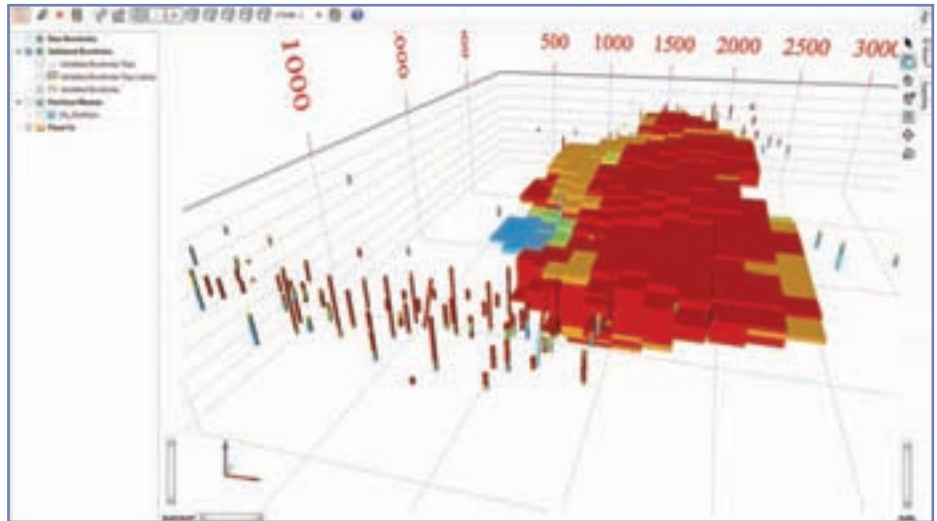
increased capability to incorporate geologic information via a multicomponent regularisation function, the reference model, petrophysical constraints, and use of active and inactive cells.

UPCOMING RELEASES

ARANZ Geo has two major software releases planned for 2015; one in April and the other later in the year. Maloney comments: "The forthcoming release contains a range of features that improve Leapfrog's compatibility with mine design and scheduling packages, as well as improvements around our core implicit interpolation tools."

The second release will focus on more control and flexibility for the Leapfrog geological modeller, especially in stratigraphic settings. ARANZ Geo will also expand its users' ability to take advantage of the wide range of data available in the modern resource industry.

Datamine is focusing its R&D efforts on the needs of technical-services professionals. Its solutions are delivered using the Fusion Database platform, Studio desktop application environment and Summit cloud technology.

Kerr says: "Fusion drill-hole

databases can be viewed directly in Studio, and the 2015 releases of Studio products will connect directly with Summit for storage, sharing and viewing of technical data."

In the exploration field, the company has four releases planned for 2015. These include Fusion 8, which is available from April.

In addition, StudioEM is a new entry-level resource modelling product that will be available in April. Its features include:
- Connectivity with drill-hole databases;
- Logs, plots and sections;
- Exploration statistics;
- Orebody block modelling; and
- Wireframe modelling.

Datamine's Summit Web Reporting tool, which is slated for release in mid-2015, is designed to enable organisations to transform their geological data into useful information, and deliver it in an actionable format to a distributed group of users.

Fusion Desktop Reporting features enhancements to the desktop reporting tools, providing users complete control over data querying, filtering, input parameters, report authoring and scheduling. It will be available in late ▶

Geovariances has just introduced Minestis to the worldwide mining-exploration market

Project focus: Hexagon

Several companies use Hexagon MineSight software for mineral exploration; most of them use MineSight Torque for their drill-hole databases, and associated MineSight tools to view the drill holes, create solids and obtain resources.

Some of the copper-exploration projects using MineSight software include Grupo Mexico's sites in

Mexico, Glencore in Australia and Compania de Exploraciones Orion in Peru. MineSight software is also being used at gold-exploration projects including Timmins Gold Corp's exploration at the San Francisco project in Mexico and Vista Gold's projects in the US and Mexico, along with OK Tedi's copper and gold exploration project in Australia.

Datamine's Fusion Report Manager is a new flexible QA/QC reporting solution to gain an in-depth understanding of variance and uncertainty in a deposit

▶ 2015, and integration with Summit will provide additional options for data delivery to key stakeholders.

Recent exploration projects that have used Datamine software include:

- Using Fusion and Studio to identify priorities for future exploration drilling;
- Improving governance by implementing corporate standards and centralised corporate databases that aggregate data from multiple sites – often spread around the world and in multiple languages; and
- Working with customers to develop new products that solve specific problems in their day-to-day operations. Kerr adds: "The Core Shed Management module of Fusion is the result of collaboration with a customer in South America."

Geosoft has two major releases planned for 2015, both of which will advance the company's exploration workflows for 3-D geology, geophysics and geochemistry, as well as its 3-D geology and geochemistry software for ArcGIS.

Geovariances has just introduced Minestis, a new software solution dedicated to resource estimation, to the worldwide mining-exploration market.

Minestis takes the user through every step of its resource-modelling project and ensures a coherent management of the estimation domains for reliable resource estimates. Minestis domain modelling will be publicly released in 2016. Geovariances says that for advanced functionalities, Minestis can be complemented with its Isatis geostatistics software.

Maptek undertakes continuous R&D with regular product releases. An example of this is a recent development

in Maptek Eureka using downhole geophysics and telemetry data to build accurate strata models. Coal, which is generally less radioactive than its host rocks and softer than overburden, is readily identifiable using gamma and density logs. Importing geophysical (LAS) data relating to drill holes and assigning downhole intervals based on the change in properties of differing material types automates what is otherwise a time-consuming process.

Johnson says: "Geological modelling tools in Eureka create roof and floor surfaces of each seam, which can be used to give an accurate reference for charge placement, with potential for improving drill-and-blast performance. However, the holes still need to be geophysically logged, which is resource-intensive, and usually only every fifth hole is logged."

Information is available for modelling even earlier by exploiting measurement while drilling (MWD) data. Drill-rig automation systems capture vast amounts of telemetry data such as pull-down pressure, air pressure, drill bit rate and torque. MWD logs record the changes in variables as the hole is drilled.

This information can be visualised in

Eureka, analysed and converted to strata models. Building a coal surface from every hole drilled in a blast pattern gives a clearer account of the resource.

For through-seam blasting the MWD method allows accurate charge placement and loading for every single hole, leading to less coal damage and greater recovery. Johnson explains: "Cost savings are significant. An operation with 800 holes could save up to US$24,000 per blast, as well as several days of logging from the drill-and-blast schedule."

Mira Geoscience played a key role in the largest-ever Canadian mineral-exploration research project, the industry- and NSERC-funded CMIC 'Footprints' project, by providing its software suite as the project's key 3-D integrated earth-modelling platform, and providing direct research leadership in the data-integration component of the program.

Mira Geoscience is releasing various software products in 2015, following the launch of VPem3D in March.

GOCAD Mining Suite version 14 is planned for release in the September 2015 quarter, with enhancements that include the automatic classification of data on import into geological categories. The new tab layout allows users to view, investigate data and store results; hence a more auditable process. It also has a powerful Javascript-based macro programming environment.

Geoscience ANALYST, which is slated for release in the December quarter, is a brand-new analysis and communication tool for integrated multi-disciplinary earth models. McGaughey says: "It provides powerful visualisation geared towards mineral-exploration decision makers rather than modellers. It can import data and objects, modify graphical attributes and allows you to save your work. We are bringing mineral-exploration communication in 3-D to the world so that everyone has a chance to adopt it. That is why we decided it will be free of charge."▼

"Cost savings are significant. An operation with 800 holes could save US$24,000 per blast, as well as several days of logging from the drill-and-blast schedule"

Project focus: Mira Geoscience

Hudbay Minerals has been successfully exploring the Snow Lake Greenstone belt for the past 50 years with numerous discoveries, including the gold-rich Lalor VMS deposit hosted within Snow Lake's Chisel Basin.

In 2014, the Geological Survey of Canada chose the Lalor deposit as a test site to conduct a 3D-3C seismic survey as it provided an intact, well-characterised, large, deep ore deposit with a rich catalogue of geological and geophysical data, as well as extensive drill-core, and downhole geophysical and geological logs.

Using GOCAD Mining Suite, consultants at Mira Geoscience, together with Hudbay geoscientists and consultants, created a Common Earth Model of the Chisel Basin.

The model successfully integrated geological, geophysical and geochemical data to create an internally consistent and unified model.

The model became the foundation for 3-D mineral potential modelling, driven by an exploration model and exploration criteria developed based on existing VMS deposits in the district.