# Extending the limits of earth data visualization and exploration

**Increasingly powerful tools for geoscientific mapping, 3D visualization, and analysis respond to geoscientists' rising need for greater power, precision and productivity in accessing, integrating, and understanding large volumes of diverse data. Louis Racic, industry product manager, Geosoft, describes some of the practical implications for the minerals and other industries.**

Twenty years ago, earth exploration and computers were often thought of as mutually exclusive. Today, they are inseparable, and software is a critical enabler of timely and informed geoscience decision-making. Industry's need to efficiently access, integrate, and visualize larger volumes and diversity of available data have given rise to more powerful productivity tools for geoscientific data access, analytics, mapping, and 3D visualization. Desktop applications are routinely used to collect and view sample data for quick site assessment in the field, while robust mapping systems in the office provide sophisticated visualizations and construction of complex 3D earth models to guide subsurface exploration.

In this article, we look at some of the factors driving demand for more power, precision, and productivity and provide industry examples that illustrate the effectiveness of enabling technology in solving current data and workflow efficiency challenges in the geosciences.

## Industry data needs

Earth science projects are growing in complexity and scope. As the generation and availability of digital, geoscientific data grows, geoscientists are increasingly pressed to deliver and account for results. They must meet the challenge of accessing, integrating, and strategically using this rising volume of data within compressed project timeframes in order to support business decision-making within all industries and across all disciplines. Easy access, frequent updating, and continual manipulation of data, in real time, are in demand throughout the lifecycle of a geoscience project – from data analysis in the field, to collaborative interpretation in team meetings, to the presentation of results in the corporate boardroom.

Within mineral exploration, the need for more integrated, advanced and subtle methods is partially driven by the fact that companies are trying to find ore bodies in complex environments.. In many cases, geoscientists are working with larger volumes of geological, geophysical, and geochemical data. Exploration project data can include 500 or more drill holes, some of which are 1000 m deep or more - in combination with satellite imagery, GIS data, and surface and subsurface geology data.

Geoscientists in a variety of fields now require software tools capable of efficiently processing, analyzing for statistical variation, relationships and other factors, interpreting and clearly presenting large volumes of data from multiple data sources and in diverse data formats. They must do so within a single or transparently-linked interactive environment that allows for frequent data update, modification, and enhancement.

## Productivity crunch and transparency

With organizations driving the need for better, faster, and more cost effective earth exploration, geoscientists are challenged to meet higher employer and customer expectations. Organizations now require more accountability than ever before from their geoscientist employees and consultants. More stringent government regulations compel geoscientists to make their processes transparent en route to their conclusions. And satisfying regulatory requirements has heightened the need to address data integrity issues in the face of mounting compliance issues such as Sarbanes Oxley, Bill 198 and NI 43-101. In the private sector, there is also the onus of corporate governance which extends well beyond financial integrity to include social responsibility and timely returns on investments.

In this new culture of immediacy and shared visual data, geoscientists are expected to produce site assessments, projections, and results in real time, as well as checks and balances on a project's viability. Decision making via laptop has replaced the traditional report.

Larger and more sophisticated investigations that rely on greater collaboration across industry partners and across disciplines has created an increased need for efficient data integration, software interoperability, and data exchange. Integrated geoscience projects typically involve geophysicists, geochemists, and geologists working together as part of multidisciplinary teams - sharing data, maps, and interpretations with colleagues in their organizations and with stakeholders in their community. Exploration programmes often involve two or more companies working together within joint ventures, option agreements, and other partnership arrangements.

While connectivity requirements vary across industry and discipline, demand for improved connectivity and easy data

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sharing is a key theme in the geosciences. Each discipline has its own set of data types and formats, such as point data, grids and images, map objects, GIS vector layer, well logs, and others. Add to this the numerous software providers each with their own proprietary data formats, and one begins to have a sense of the magnitude of the data integration challenge.

## Technology-driven productivity solutions

The software industry has responded to these data challenges and productivity needs with improvements in software interoperability, interface, workflow automation, speed, and performance. Industry software vendors have progressively added new format support to meet increased demands for collaborative data exchange and seamless software interoperability. Many software developers provide a SoftwareDeveloper Kit (SDK) to allow other developers to read and write their formats. In addition, standard exchange formats, such as GXF for grids, can be used by all. While

data exchange challenges continue to exist, geoscientists are better able to share data, maps, and interpretation results across departments and industries, and with colleagues across the globe. New generation geoscience technology solutions are delivering more powerful productivity tools for dealing with large, geoscientific datasets, and maximizing their value in business decision-making. To improve productivity and workflow efficiency, geoscientists and organizations are deploying powerful mapping systems that incorporate awide range of analytic tools, production mapping capabilities, and advanced visualization within a single, 3D environment. This democratization of data and its increased interchangeability among all stakeholders has helped minimize the frustration and downtime associated with format and software incompatibility.

Powerful, advanced mapping systems have become a staple of geoscientists needing to satisfy the real time expectations of results-driven employers and customers. Modern geoscience mapping systems combine advanced scientific
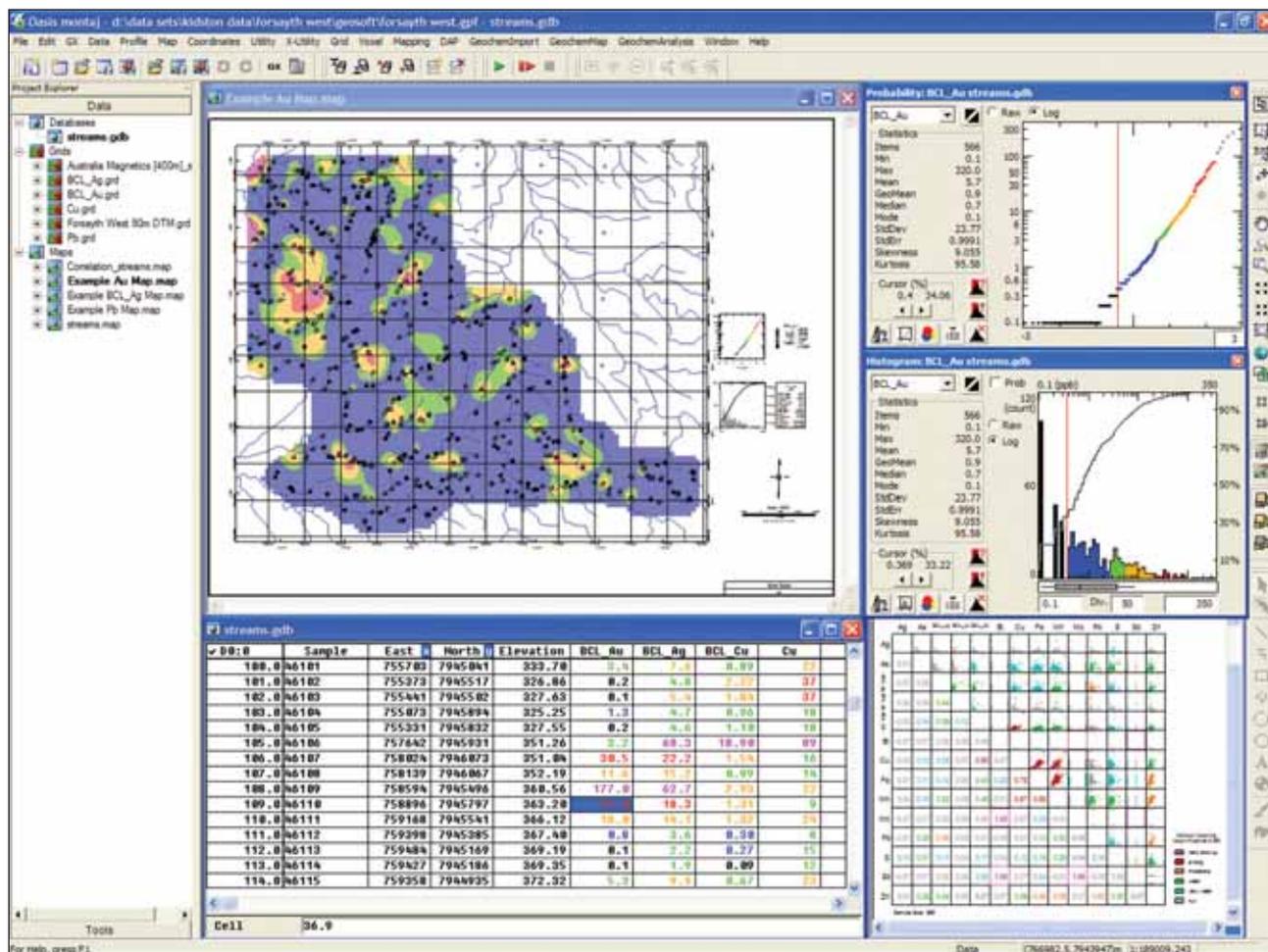


*A single screen, a multitude of data: advanced geochemical analysis tools enable users to graphically analyze and determine the correct statistical variation within datasets to identify and highlight anomalous areas for further investigation – within a fully integrated mapping environment.*

methodology and powerful processing, mapping, and analysis tools to create 'power-mapping' capabilities that are removing the efficiency limitations of the past. Earth data exploration is a rigorous and iterative process. This latest generation of power-mapping software automates many aspects of this process, allowing geoscientists to continually and rapidly edit their maps and interpretations as fresh project data becomes available.

The rich range of functionality within one power-mapping environment allows geoscientists to integrate, analyze, and visualize large, multi-disciplinary datasets, and also manage their data project from beginning to end within a single environment. Using one application rather than four streamlines workflow and improves efficiency. It also contributes to greater data integrity, project continuity, and higher quality interpretations.

Power-mapping software typically includes useful production tools such as scripting, GX development, batch printing, and core functions that aid the user throughout the process.

Easy-to-use interactive map templates provide a framework to quickly and easily determine where to place map elements, and set the paper size and data views to define the look and feel of the map. They can also add logos and other map elements into fixed positions every time, thereby eliminating guess work and providing greater precision and control.

More dynamic and interactive visualization capabilities enable geoscientists to apply multiple layers of data within one integrated environment, add vector and geochemical data onto a geophysical background layer, or use geological data as a cross-reference in the interpretation of geophysical data.

Users can incorporate data elements such as proportional symbols, contours, and shaded colour grids from several database sources, including magnetic, gravity, electromagnetic, and geochemical information. They can combine geochemistry, geology, and geophysics data in dynamically-linked maps, in 2D or 3D, and also include qualitative and quantitative assessment in context with other data sets for confirmation of the validity and quality of data. They can include insets, 2D or 3D views, and surfaces along with JPG images of digital photos pointing to areas on the map. They can overlay scanned topographic or satellite images. They can be labelled in just about any language, then custom coloured and patterned for maximum effect. Sophisticated interpretations and advanced forward modelling and inversions that aid in deeper understanding of the sub-surface are also becoming commonplace.

All of these elements can be hidden, masked, or made transparent to allow users to visualize and interpret all the data they have at their disposal, or create many data-rich views and maps on one screen.

Efficiency is key to the result-oriented geoscientist. Technology is addressing this challenge through improvements in software interface and automated workflow. To
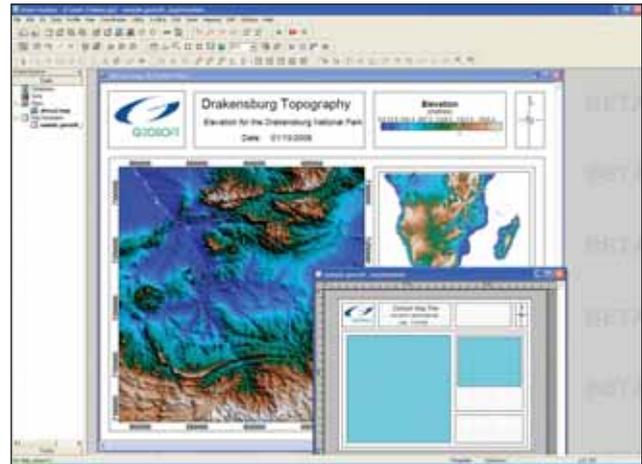


*Workflow automation: map-making is simplified with the use of interactive, standard, or custom templates*
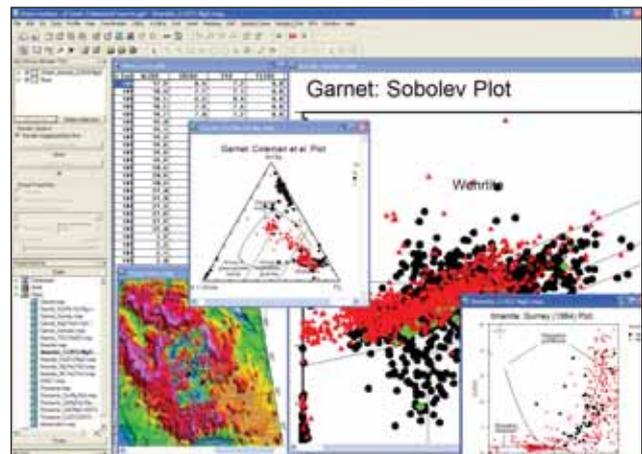


*SEMPlot geochemistry workflow allows geoscientists to efficiently work with large volumes of geochemical data and visualize findings related to diamond exploration.*

accommodate the difference in workflows across disciplines, many software packages have arisen with built-in standard best practice menus for handling and displaying data of specific disciplines. These menus can be customized to meet a wide range of geological, geochemical, and geophysical requirements for processing, displaying and analyzing data. To provide additional flexibility for help with workflow customization, software programs have also incorporated scripting or macro writing abilities. Where standard software configurations or generic scripting or macro writing abilities do not meet a specific organization's workflow needs, custom development can often provide a unique solution. The up-front costs for custom solutions can be high, but their time savings and cost efficiencies can pay off. We know of a custom solution for one organization that reduced a week-long manual process to less than 30 minutes. Every efficiency improvement is not that significant, of course. But

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even small, incremental productivity improvements bring cumulative benefit and operational efficiency.

## Multi-disciplinary workflows

The advancement of unique multi-disciplinary workflows, for geochemistry, geology, and geophysics embedded within software has also contributed to greater efficiency. Within exploration, the way we use geochemistry has evolved from using the data to create single element anomaly maps, to analyzing multi-element data, recognizing geochemical associations and creating better defined exploration targets.

Geochemical investigations, including surface and subsurface investigations, are an integral part in assessing mineral exploration projects, not only in gold, base metal, and diamond exploration, but also in oil and gas, coal and iron ore projects. As an example, the use of Kimberlite Indicator Minerals for discrimination is standard practice in diamond exploration,
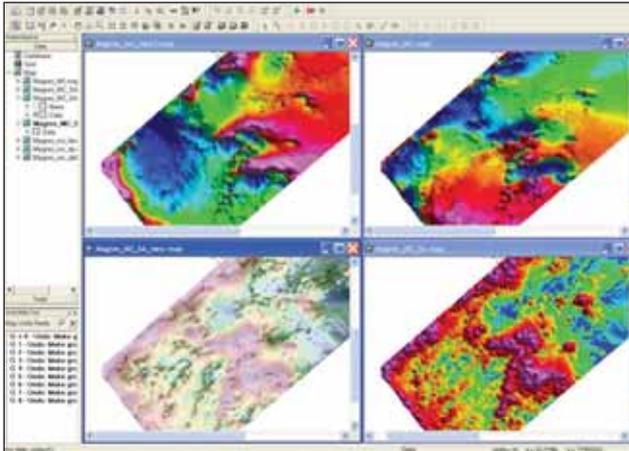


*Optimization of algorithms has sped up gridding processes by as much as 50% when working with large datasets.*
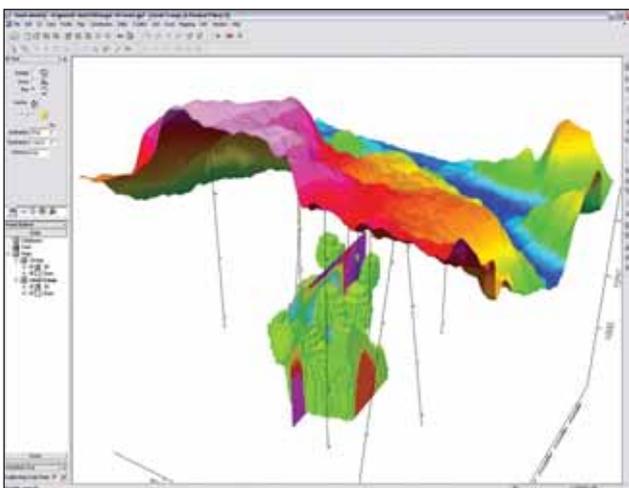


*Subsurface 3D viewing software is now available for the ArcGIS environment, filling the need to display drill holes, sections, grids, and voxels within ESRI's ArcView.*

and the development of a unique geochemistry workflow has been proven to benefit diamond target selection.

Rio Tinto Exploration, a world leader in finding, mining and processing the earth's mineral resources, developed SEMplot (Scanning Electron Microscopy) geochemistry workflow to analyze Kimberlite indicator minerals. Andy Lloyd, Rio Tinto Exploration project geologist in South Africa, attributes the power of SEMPlot to its ability to take very large volumes of microprobe data; use known, scientific analysis tools such as histogram plots and scatter tools to analyze it; and then quickly produce spatial maps, graphical maps and plots. 'SEMPlot allows the data to be displayed in a graphical format, so it can be effectively interpreted,' says Lloyd. 'Its ability to manage data in excess of a million data points, with ease and simplicity, makes it a very powerful tool.'

SEMPlot has been recently added to Geosoft's software environment and provides a simple-to-use workflow for the analysis of indicator mineral grain geochemistry. The workflow includes the import of the data, the mineral identification of the grain based on its chemistry, display of the selected grains on the discriminating graphs, and interactive re-classification.

SEMPlot users see strong benefit in the workflow's dynamic linking which ensure maintenance of the spatial context between the grain graphs, database, and maps, and make anomaly location and target selection quicker and more efficient.

## Speed and processing power

Speed is an obvious advantage when geoscientists need to quickly and clearly view the quality of data at every phase of investigation, from initial data processing and quality control through to visualization, integration, and the final interpretations. Improved memory handling using dual processors, and optimizing processes and algorithms to correct bottlenecks have gone a long way toward speeding up visualization. Enhancements to increase the speed of memory-intensive processes, such as the minimum curvature gridding process, has cut the time of the memory-intensive gridding process in half, even with today's larger datasets.

The emergence of 3D visualization as the standard for integration and analysis of inter-disciplinary data has presented a significant performance challenge in the sheer volume of data that must be manipulated. Each 3D voxel has 1000 cells on each side, giving it a total content of one billion cells. Users can easily rotate one billion points of data as they spin their 3D data. Three dimensional visualization technology has made dramatic advances in responding to the growing requirements to represent and visualize surface and subsurface 3D data. Working within a fully integrated, 3D software environment, users can quickly and easily combine surfaces, drill holes, and geophysical models in 3D and view them from numerous perspectives. Users can highlight only the data or horizon of interest on the screen.

They can also use a vertically-exaggerated perspective to more readily understand what is happening in shallow drill holes over a large area. Among standard capabilities these days, users can interactively zoom, pan, and rotate objects in 3D.

During the initial reconnaissance of an area, users might choose to drape satellite images or geology layers over a digital elevation model. With a few clicks, they could add surface data and potential drill collars, and/or display drill traces intersecting targets from inverted models, or display selected mineral horizons or sedimentary units.

**Summary**

Faced with growing data volumes and larger projects to manage, geoscientists are demanding - and using - more advanced capabilities for integration and visualization of large, multidisciplinary geological, geophysical, and geo-chemical datasets. They are deploying powerful mapping systems that incorporate a wide range of analytic tools, production mapping capabilities, and advanced visualization within 3D and subsurface environments. The end result is a more complete picture, and stronger corroborating evidence to support interpretations and guide decision-making.

# Production mapping streamlines environmental site assessments

Production mapping software is significantly improving efficiencies in the survey products group of US-based W.L. Gore & Associates. The company's customized application of robust mapping software has eliminated repetitive tasks in the production of maps and, at the same time, improved the visualization of data for more effective client presentations.

Gore conducts environmental site assessments with clients and regulators, to locate, identify, and delineate subsurface contaminants. It then focuses subsequent sampling, remediation, and monitoring programmes in a cost-effective and timely manner. The company uses a high-performance storage database, as well as software tools for analyzing, visualizing, and managing large volumes of multi-disciplinary data sets. The end result aids the environmental consultant in developing a robust conceptual site model, which leads to accurate selections of subsequent soil or groundwater sampling locations, and optimization of remediation programs.

Dr Jay Hodny, a product specialist at Gore, says that the cost of groundwater clean-up and long-term monitoring programmes can be in the millions of dollars and it's not uncommon for a groundwater monitoring programme to require regular sampling for over 20 years. 'If we can accurately locate the contaminant plume early in the investigation, and ultimately drill fewer monitoring wells, we deliver real value. Greater accuracy is the difference between installing and sampling five monitoring wells, versus 50, for 20 or 30 years.'

Hodny combines CAD-based sitemaps illustrating the sample locations with the analytical data in an integrated software environment, and also utilizes robust contouring algorithms and map editing and visualization tools to generate accurate assessment maps of volatile and semi-volatile organic compounds in the subsurface soil gas.

Data retrieved from the GORE Module, the company's patented, waterproof, vapour-permeable sampler, can create a voluminous data matrix for larger projects, such as large military bases that utilize hundreds or thousands of the samplers. Having production mapping tools saves time and
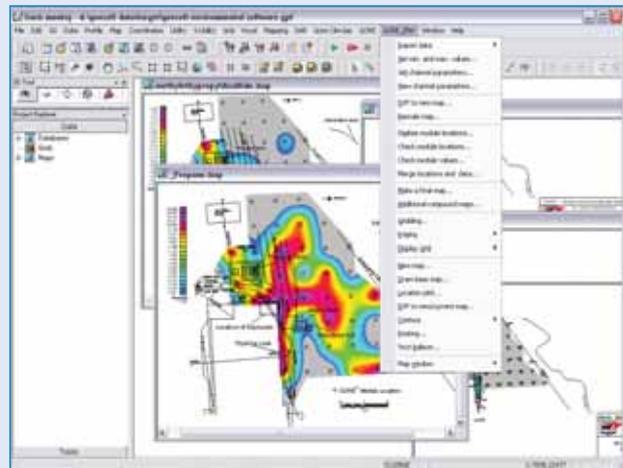


*Gore's customized application of production mapping software has eliminated repetitive tasks in the production of maps and improves the visualization of data for more effective client presentations*

improves efficiencies by quickly producing contour maps of relevant compounds across the survey area. From a full suite of 90 different compounds, informative maps can be rapidly produced for any of the compounds of interest. If this had to be done one map at a time, the processed would be tortuously lengthy.

Gore's mapping solution automates several repetitive mapping tasks, such as creating title blocks, plotting north arrows, and using archived digital data. The solution was developed based on an understanding of Hodny's map-making routine, with built in automated functions that shrunk his tasks from 50 steps down to 10. As a result of the production mapping software, Hodny estimates he has automated 90% per cent of his map-making. Key to the software's success is its flexibility, providing the ability to stop at any time, do something unique to the maps, and then continue, while still having access to the full functionality of the software for other tasks.