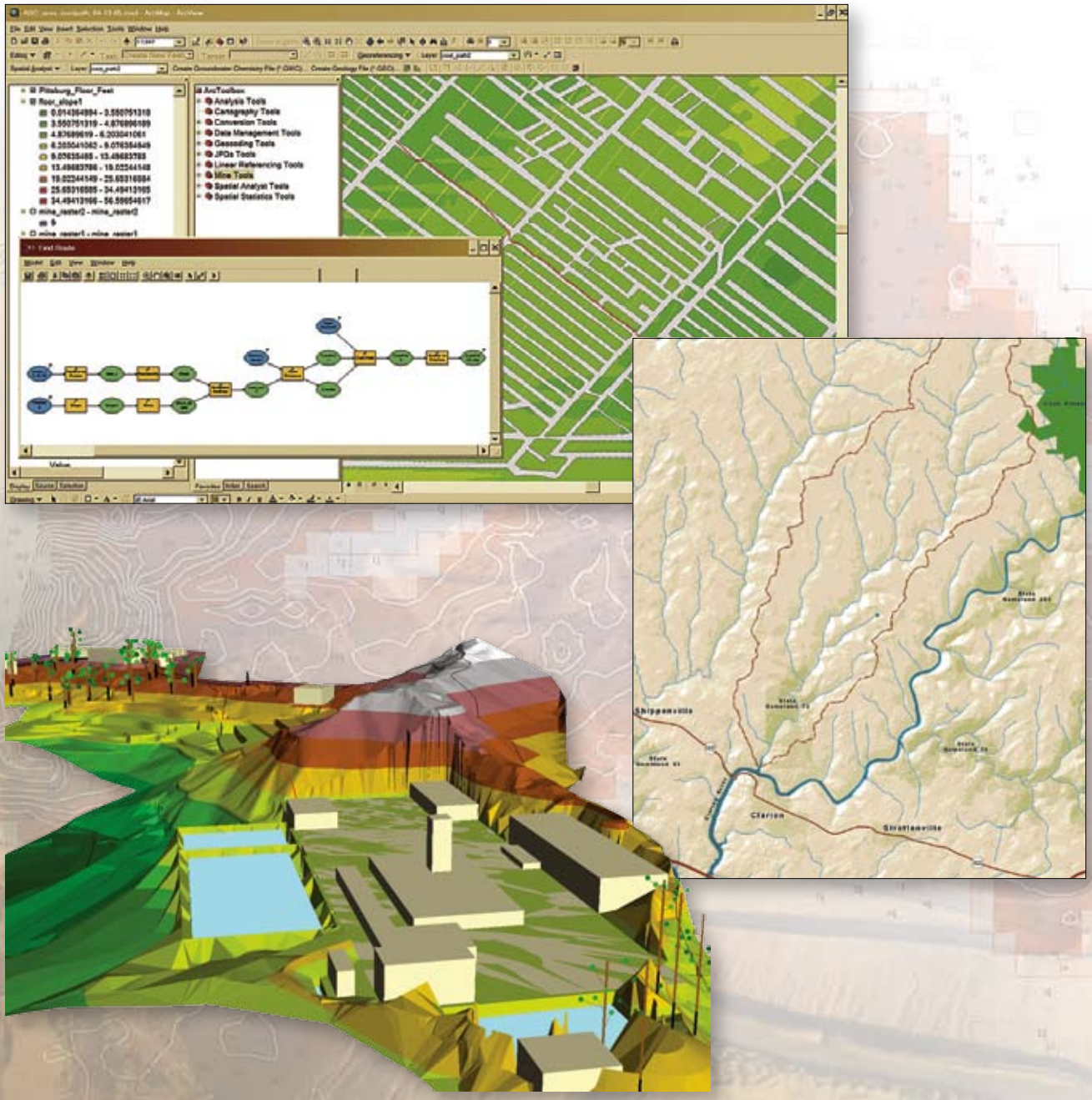
The Geographic Advantage™

GIS Solutions for Mining



ESRI®

The Geographic Advantage

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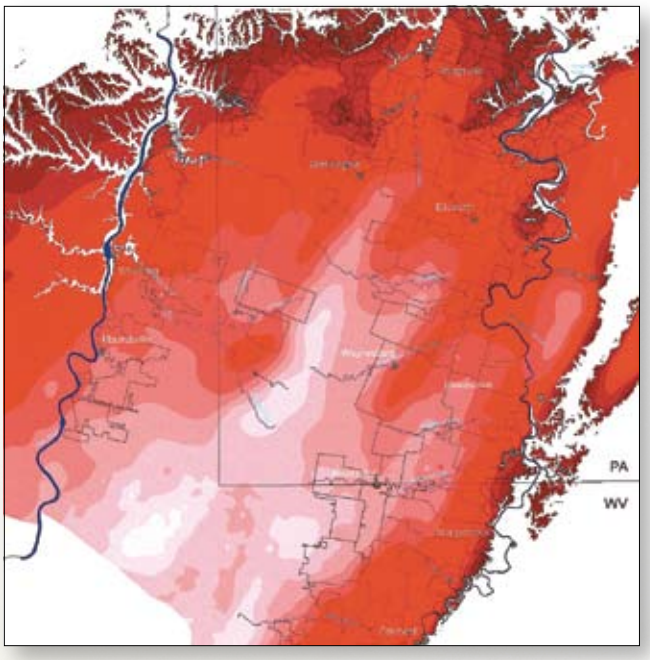
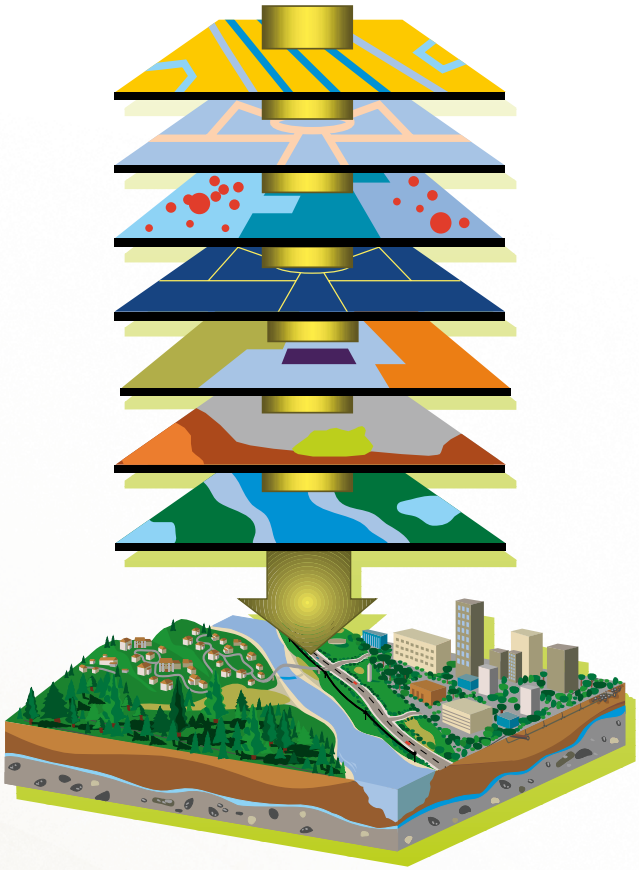


Structure contours of the base of the Pittsburgh Monongabela Basin



The business of mineral exploration and extraction is inherently spatial. Since most mines cover large expanses of land, managers require access to volumes of location-based information to guide the operation. For this reason, the tasks of mine management are perfectly suited for ESRI® geographic information system (GIS) technology. GIS is a versatile tool for gathering, storing, and accessing geographic information quickly and easily.

ESRI GIS software is ideally suited to assist mining professionals in meeting the complex challenges of running the mine operation, with tools to compile, process, display, analyze, and archive massive volumes of data. From discovery to production to mine closure and reclamation, ESRI software solutions are increasingly being applied to the business of mining.

Mining professionals use ESRI software to increase productivity and save costs. Engineers and operations staff use GIS for facility planning applications, helping miners keep track of existing infrastructure and integrating up-to-date information with the mine plan. Facility managers also use GIS to incorporate recent survey data with block models or design data from other software packages. Simply put, there is no component of the mine that cannot be better managed with ESRI GIS technology.

Mining companies use GIS to

- Target mineral exploration.
- Evaluate mining conditions.
- Model mine construction.
- Display geochemical and hydrology data.
- Improve facility management and policing.
- Apply for mining permits.
- Assess environmental impact.
- Manage land titles.
- Process closures.
- Plan reclamation activities.
- Improve community education.

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Access Map Databases

ESRI's GIS Server Technology Puts Geography in Many Hands

GIS for the Enterprise

Most mining information, including financial and asset information, has some sort of spatial component that, when represented in map form, provides greater context. Recognizing this fact, management and mineral economists are now using GIS in their evaluation of corporate and competitor assets to consolidate information and make more accurate business decisions.

ESRI ArcGIS® software provides direct access to data in the most common corporate spreadsheets and relational databases. Reserve estimates, annual planned production, and cost-per-ton statistics can be linked to prospective sites or existing mine locations and used to control map symbols. Placing these sites in a geologic, political, and economic setting aids exploration. Detailed exploration prospects and active mine data are accessed through intuitive interfaces and easy-to-navigate visual displays.

Many companies are taking advantage of the vast amount of GIS data available on the Internet. ESRI ArcIMS® technology provides these companies with the ability to distribute map data throughout the enterprise or over the Web, allowing mining professionals to share information in real time with anyone who has need of it across the global corporation.

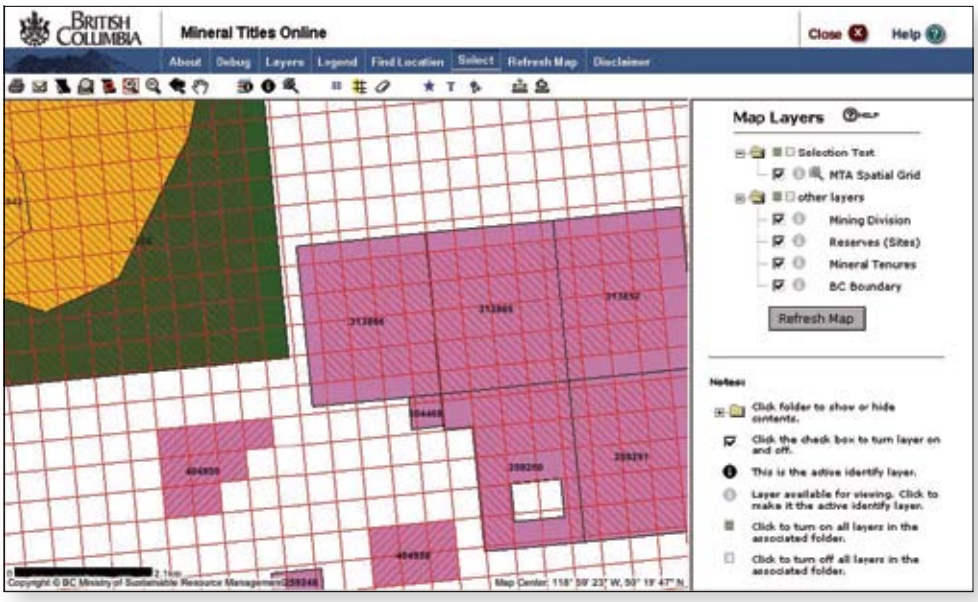
Case Study—Administration of Mineral Titles Online in British Columbia

The 2005 implementation of the Mineral Titles Online (MTO) system provided a foundation for significant growth of mineral exploration in British Columbia. By using MTO, the Ministry of Energy, Mines, and Petroleum Resources (EMPR) saw more than one million hectares of acquisition in the first week and five million hectares in the first year.

Using a secure login, the mineral exploration industry, authorized agents, and staff from private mining companies can acquire mining rights by selecting a claim on the electronic grid map rather than staking a claim on the ground. Establishing a secure title on accurate electronic basemaps integrated with other online resources has streamlined the entire claim acquisition process, reduced conflict, and supported a shared use of the land.

Powered by Pacific GeoTech Systems' *true*PERMIT™ framework software, MTO was developed and implemented using ArcIMS, ArcSDE®, ArcGIS, XML, Java™, Java 2 Enterprise Edition (Java 2EE), Apache Ant, Log4j, Oracle®, Apache Struts Framework Model-View-Controller-2 (MVC2), design patterns, and the government's MIRA Java Payment and Internet Mapping Framework (IMF). The entire MTO system is Web based and accessible through a standard Web browser and provides robust, secure, and powerful geospatial capabilities and complete online help.

Return on investment was realized in approximately two weeks, and government has increased its ability to administer and monitor activity, remaining current with the 400 percent increase in activity. Mineral permit expenditures in British Columbia increased from $39 million in 2002 to $315 million in 2006. MTO is the first stage of a complete permit system that enables Web-based workflows to support the selection, submission, review, and administration of electronic mineral acquisition throughout the approval process.



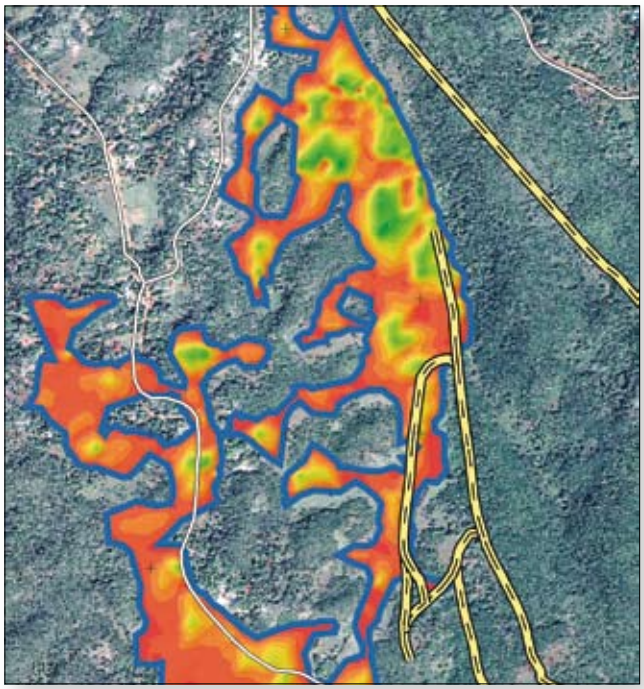
Mineral Titles Online is the first e-commerce, GIS Web-enabled system for mineral title acquisition in British Columbia. (Courtesy of Mineral Titles Online, British Columbia.)

Target Mineral Potential

GIS for Mineral Exploration

ESRI software gives mining companies the geographic advantage to target mineral potential. Mineral exploration geoscientists use diverse types of datasets to search for deposits. They need to view and analyze this information quickly and easily. ESRI brings this data together in easy-to-use software applications and tools, increasing the spatial context of the information available to mining planners and giving them a more thorough understanding of the geography of prospective sites.

Exploration targeting can be performed based on advanced analysis using either qualitative or quantitative methods. Multiple geophysical images can be displayed simultaneously using ArcMap™ and overlaid by other datasets to evaluate their qualitative spatial relationships. Using ESRI's ArcGIS Spatial Analyst extension, geologists can calculate the potential of mineral sites through raster-based map algebra using either data- or knowledge-driven methods. Using ESRI's state-of-the-art GIS applications increases information communication, maximizes processing efficiency, and improves decision making, thereby increasing the chances of finding profitable deposit regions.



The thickness of bauxite deposits in Jamaica is determined using ArcView.

Mine Planning with GIS

The siting of ore passes, draw points, ramps, and other components of the mining operation can also be successfully managed with GIS. For example, by overlaying various thematic layers and viewing them in combination, GIS software can be used to determine the best areas to dispose of waste rock and mine tailings. The same methodology can be used in planning road networks and determining the optimal route for vehicles in your fleet. GIS gives miners a much broader perspective of the work environment than before.

GIS is also helpful in gauging the impact of mining operations on nearby communities. With it, mine planners can calculate the slope angle and direction of surfaces to determine visibility between points on a map. This way, the extent of visual obstruction can be controlled without adversely affecting operations, alleviating concerns of nearby residents.

From data on population density, socioeconomic distribution, labor resources, housing, and recreational infrastructure, GIS gives mine planners all the data they need to prepare for the most thorough residential and environmental impact assessments.

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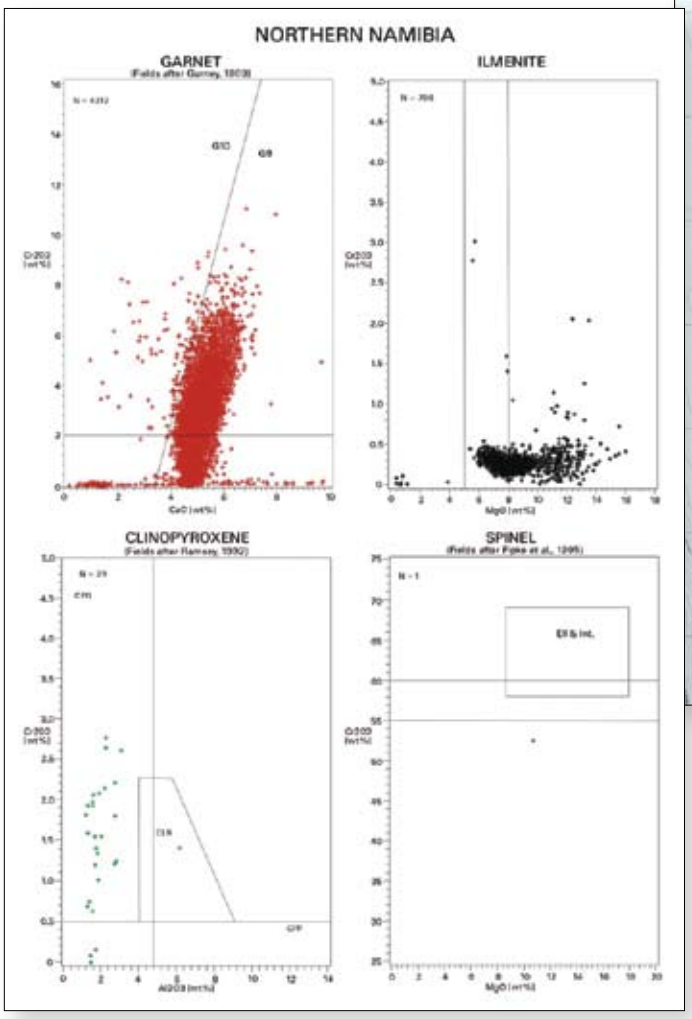
Assess Mineral Potential

Lithography Maps for Prospecting

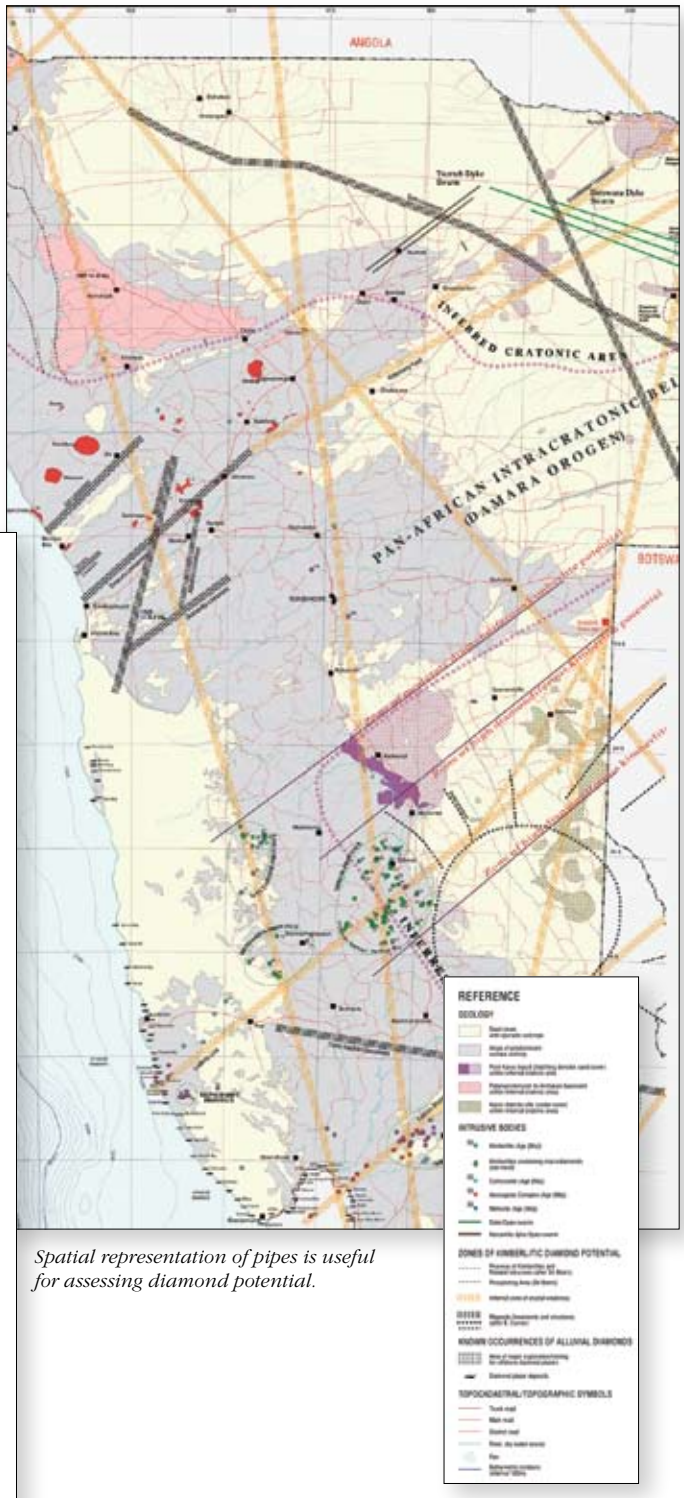
Case Study—Diamondiferous Kimberlite Potential of Namibia

The economy of Namibia is largely based on the exploitation of its extensive fluvial diamond placer deposits along the Orange River as well as alluvial and eluvial placers along the coastline. In addition, a potential for diamondiferous kimberlite pipes, having been discovered and currently being mined in neighboring Botswana and South Africa, has recently been recognized.

Various criteria have been used in diamond-bearing kimberlite exploration (e.g., identification of Archean cratonic areas, zones of crustal weakness as identified by the presence of intrusive bodies and/or geophysical data, geothermal gradients, and chemistry of indicator minerals). Using ArcInfo®, these features have been compiled in this map, which is being used as a prospecting tool to aid in the continuing search for diamonds in Namibia.



Mine prospectus map depicts geophysical and mineral indicators.



Spatial representation of pipes is useful for assessing diamond potential.

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Monitor Assets and Risk Potential

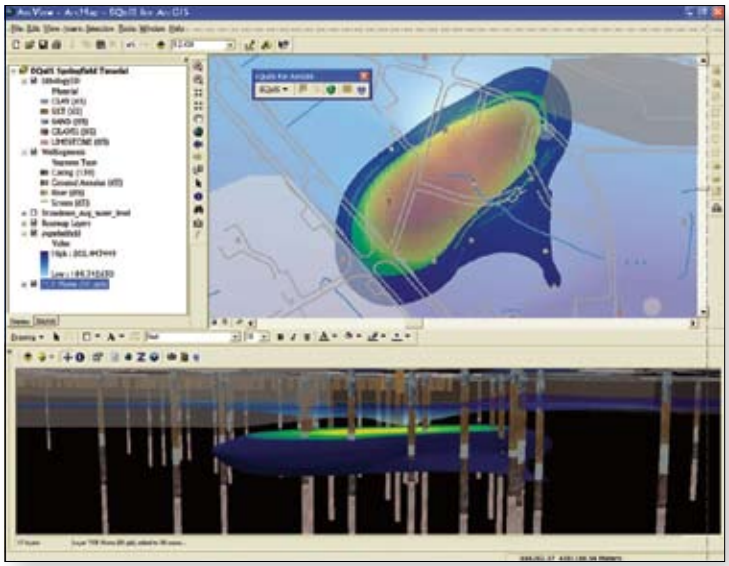
GIS for Facility Management

Asset Management

Moving mining equipment, including dozers, draglines, cranes, and shovels, can be guided and managed using GIS and advanced GPS technology. GIS combined with GPS enables managers to track, for example, the status and location of dump trucks, providing information about direction, velocity, and load size. Use GIS to monitor and dispatch haul trucks and drills and to assess grade control on shovels. Monitor all your mining assets in real time.

GIS in the Field

Miners must contend with a constantly evolving landscape. Using ArcPad® loaded onto a GPS-enabled PDA, mine operators are able to monitor these constant changes and give more informed instructions to heavy equipment operators. In addition, ArcPad and integrated survey analysis tools provide a fast and accurate solution for replacing and maintaining control points and calculating the volume of material moved.



A trichlorethylene (TCE) plume is viewed from different angles using the EQuIS for ArcGIS application.

Mine Safety

Oftentimes, mine crises are the result of mine operators' inability to view the overall picture and plan accordingly. ESRI's powerful 3D modeling and network analysis functionality solves this problem, reducing the amount of guesswork involved in visualizing the production environment. For example, the proximity analysis capabilities of GIS software make short work of siting refuge chambers within a safe distance from production stopes. The distribution of refuge chambers and exits can be planned using ArcGIS Network Analyst and the shortest route from production areas can be determined by creating a distance grid.

With its powerful network analysis capabilities, ESRI GIS software can assist in providing a safe production environment for mining staff by determining the most feasible sites for refuge chambers, greatly aiding in the evacuation of mine personnel in case of an emergency.

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Reduce Environmental Impact

GIS for Abandoned Mine and Reclamation Management

Mine Closure and Reclamation

Mining companies use GIS to actively monitor the environmental impacts that may be caused by their activities and conduct reclamation. GIS is used for monitoring and reclamation by analyzing and mapping soils, vegetation, surface hydrology, and groundwater. ESRI and its business partners actively promote sustainable development through building a suite of GIS applications that are specifically designed for environmental study.

Performing advanced analysis and visualization of environmental and geologic data can be done easily and quickly using the EQuIS ArcView® interface. This solution involves the integration of several industry-standard applications, such as ArcView, EQuIS, RockWorks™, and EVS, to produce a world-class, customizable solution for subsurface investigation and analysis.

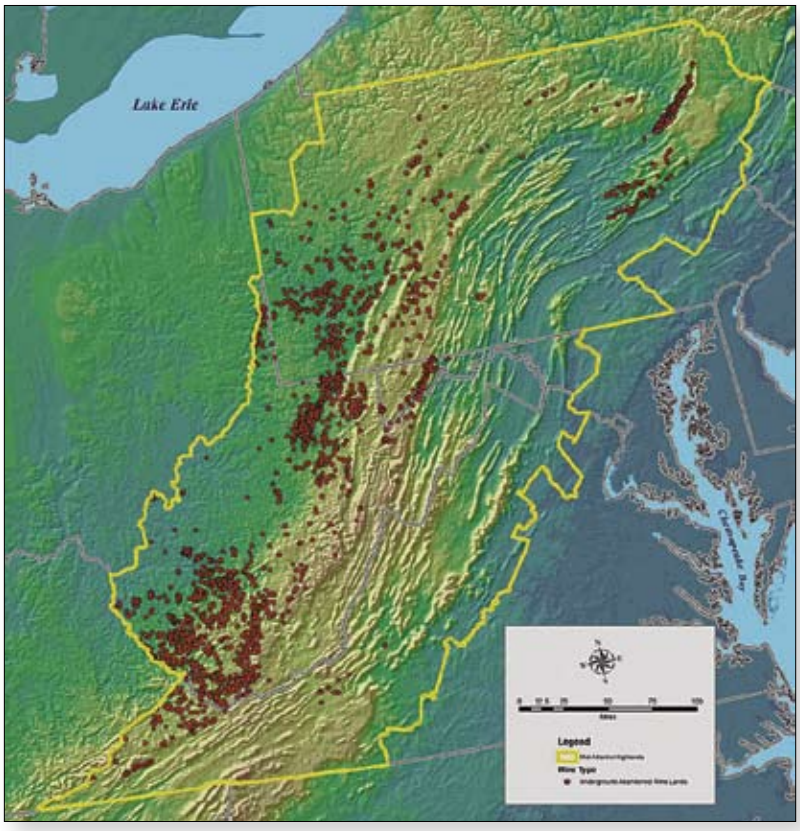
Case Study—Abandoned Mine Mapping in Western Maryland

The threat of land subsidence from mine tunnel collapse and acid mine discharge (AMD) from abandoned mines in western Maryland has adversely impacted development in and around increasingly sprawling communities. To stem this threat, pilot projects have been undertaken to demonstrate the effectiveness of coal combustion by-products (CCP) grouting in abandoned underground coal mines. The projects require georeferencing historic (circa early 1900s) mine maps typically available only in hard-copy form. To accomplish this, project engineers use ArcGIS Desktop (ArcEditor™) and ArcGIS Spatial Analyst in the mine map and raster development process.

ArcGIS Spatial Analyst is used for developing mine floor elevation surfaces and slopes. Once the mine map and geometry (i.e., mine floor slope) is finalized, ArcGIS Spatial Analyst and ModelBuilder™ are used to simulate the path of CCP grout through the tunnel network. This modeling is especially useful for planning field operations and optimizing grout injection points.

Once the mine maps are finalized, GIS can be used to create a grid of optimally spaced boreholes based on the mine floor slope and the flow (rheologic) distance characteristics of the CCP grout. The CCP grout can typically flow approximately 400 feet given a four- to seven-degree mine floor slope. Borehole locations determined in ArcGIS may be extracted and distributed to field crews for pinpointing drilling locations that will penetrate the mine tunnel network.

With an extensive arsenal of ArcGIS tools and expertise, the Geospatial Research Group of Frostburg State University, Maryland, develops the mine map layers and provides iterative spatial adjustment and digitizing of the associated mine map layers for all the western Maryland project areas. Using ArcGIS software, many states in the Mid-Atlantic Highlands are leveraging the power of spatial technology to develop coal mine mapping projects and repositories.



Abandoned underground mine lands in the Mid-Atlantic Highlands

To learn more about GIS and mining, visit

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ESRI
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For more than 35 years, ESRI has been helping people make better decisions through management and analysis of geographic information. A full-service GIS company, ESRI offers a framework for implementing GIS technology and business logic in any organization from personal GIS on the desktop to enterprise-wide GIS servers (including the Web) and mobile devices. ESRI GIS solutions are flexible and can be customized to meet the needs of our users.

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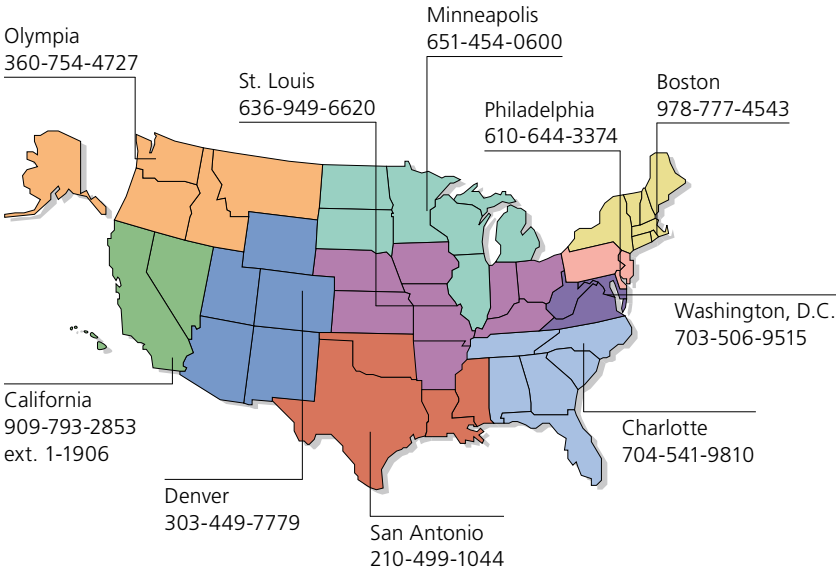

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