Mineral potential modelling at the British Columbia Geological Survey: The next generation

BRITISH COLUMBIA
Ministry of Energy, Mines and Low Carbon Innovation

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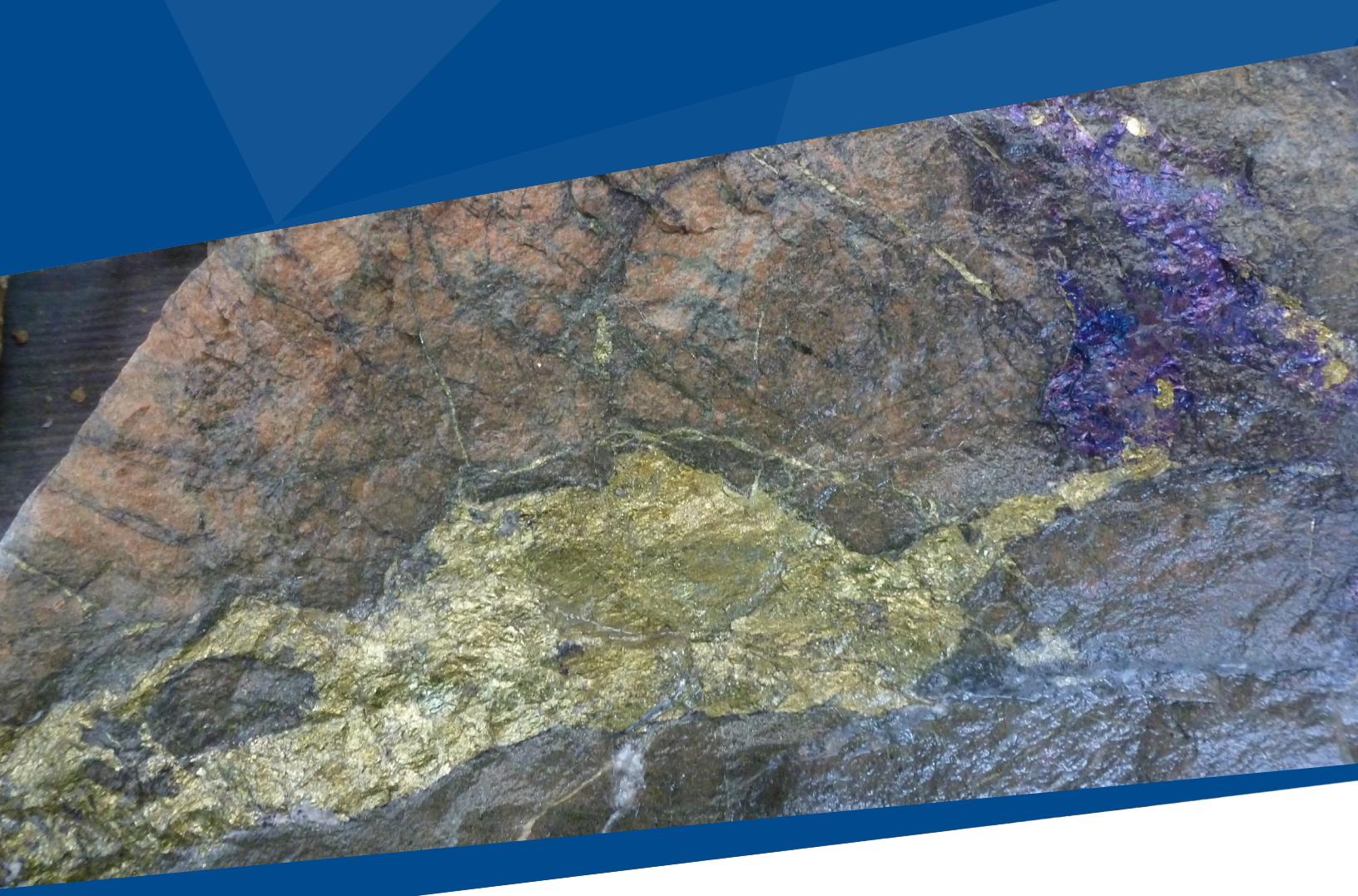


Modernized mineral potential modelling

Land-use decisions and co-management of natural resources need high-quality information. As one component of land-use planning, mineral potential modelling uses many different types of geologic data to identify areas favourable for mineral deposits.

More than 30 years ago, the British Columbia Geological Survey started a study to model the mineral potential of the entire province. Pioneering for its time, this work reviewed mineral occurrences and, combined what was then known about the geology of the province and what rocks are more likely to host minerals (prospectivity), developed a relative ranking of prospectivity and defined specific areas of low to high potential.

A lot has happened in 30 years. Exploration techniques have improved, many new mineral occurrences have been discovered, the geologic processes leading to mineralization have been intensively investigated, and bedrock mapping projects have increased our knowledge of the rocks underlying the province. Also, radical increases in computing power have led to significant advances in applying geographic information system platforms (GIS) and using computerized statistical methods to model mineral potential based on the factors needed to generate deposits.

Applying these advances, new modelling is identifying areas of high prospectivity for key mineral systems. A multi-year Survey project, this new modelling will assist land-use conversations between multiple parties having diverse interests.

Mineral systems approach

Although mineral occurrences are relatively common, mineral deposits of economic value are not. All the right geological conditions need to come together at exactly the right time and in exactly the right place.

The mineral systems approach used in modern mineral potential modelling emphasizes similarities between mineral deposits. The approach adopts a large-scale view of all the factors that control generating deposits. An economic deposit is unlikely if any one of the following three ingredients is lacking.

- **Source:** Is there a source of metals and is there thermal and mechanical energy to create melts and other fluids for transport?
- **Pathway:** Are there physical conduits along which fluids can be transported?
- **Trap:** Are there mechanisms, either physical or chemical, that would deposit and concentrate metals?

Some of the larger-scale mineral systems being considered by the Survey include volcanogenic massive sulphide, magmatic nickel, porphyry, and epithermal deposits.

Geospatial data sources

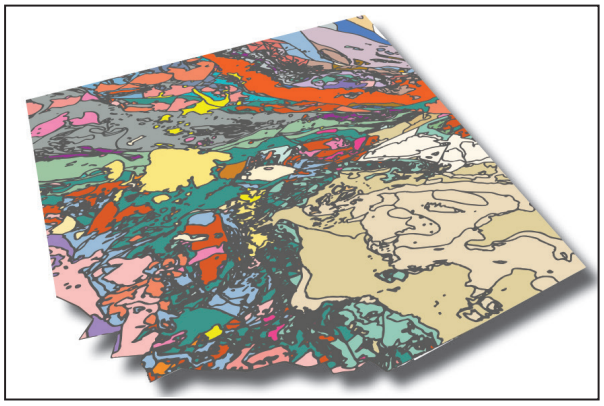
The current mineral potential modelling accesses data held in long-standing Survey databases.

- **MINFILE:** mineral occurrence location, host rock, country rocks, cross-cutting intrusions, structures (e.g., faults, veins), modification by pressure and/or temperature, alteration by fluids, age, presumed deposit type, grade and tonnage.
- **BC digital geology:** rock units (types, geometry, distribution, contacts, ages), structures (faults, folds; types, trends, geometry, ages).
- **Geochemistry:** multi-element analysis from samples of rock, till, soil, moss mat, water, stream sediment, and lake sediment.
- **Geophysics:** gravity, magnetic, and radiometric.

In tandem with mineral potential modelling, the Survey is modernizing its geospatial data infrastructure. This work is building an integrated operational environment to manage and update Survey databases. Compliant with open standards such as the Open Geospatial Consortium, the new infrastructure will enable sharing of geoscience data without the limits resulting from differing platforms, operating systems, browsers, or jurisdictions. The new infrastructure will also enhance Survey mineral potential modelling capabilities.

Geospatial data treatment

rock units



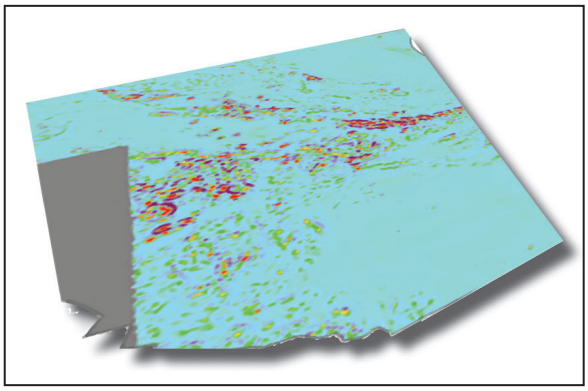
For any mineral system, hundreds of variables could be used to evaluate mineral potential. These variables include items like rock units favourable for the mineral system, distance with respect to faults, gravity data, and geochemical anomalies for key elements.

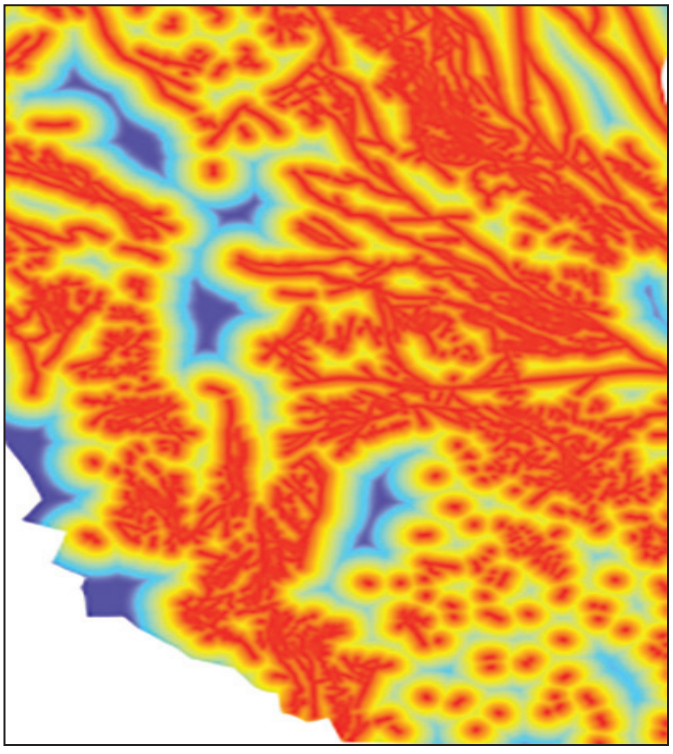
Specialized software interrogates the spatial databases and statistical techniques are applied to dozens of variables to decide which are most suitable for mathematically assembling a mineral potential model for a given mineral system in a specified area.

faults

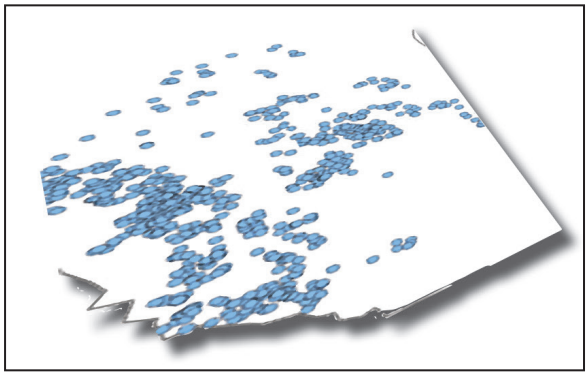
As an example, the distance to a fault of is one of the many variables that can be interrogated. Faults can serve as pathways to transport fluids and can create traps where minerals can be deposited. The fault database is queried to determine if a site is within a specified distance to a fault. The resulting distance-to-fault map depicts sites close to faults in red.

geophysics



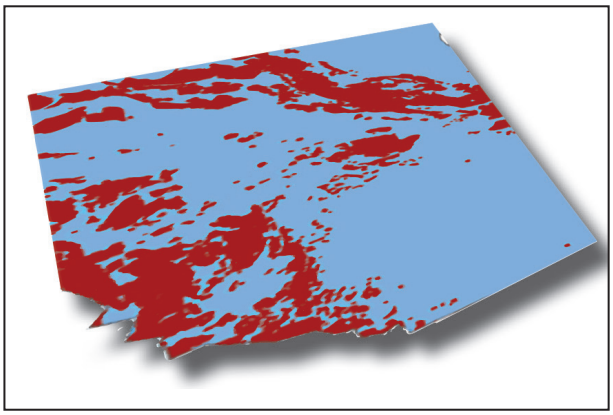


geochemistry

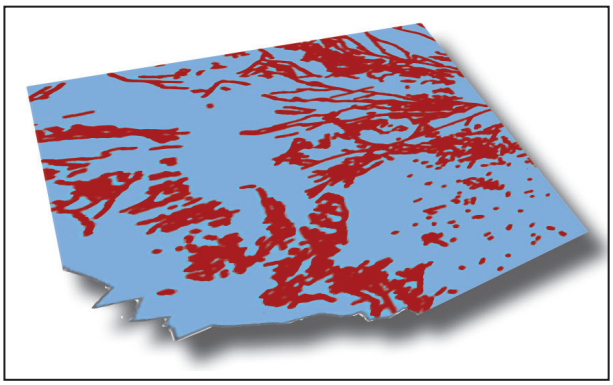


Predictive maps

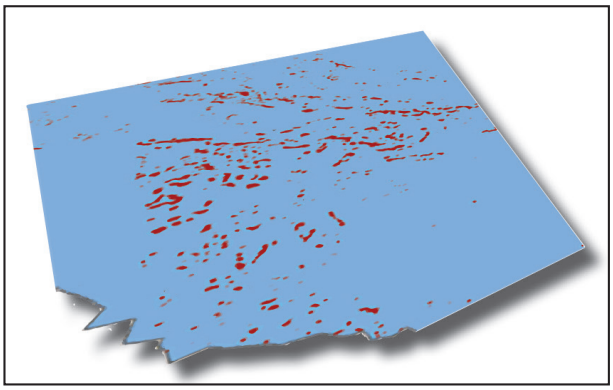
favourable rock units



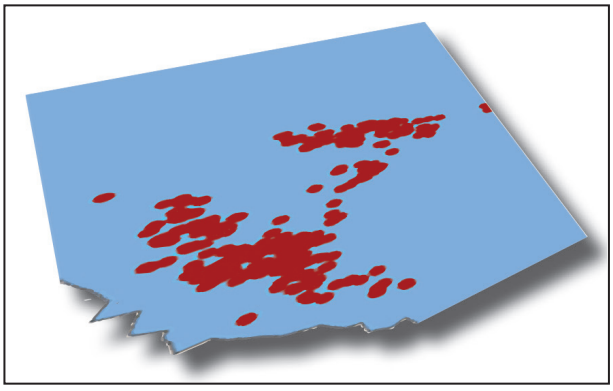
distance to faults



gravity highs



geochemical anomalies



A set of predictive maps are created for variables relevant to the mineral system using GIS software.

In weights of evidence modelling, the study area is gridded into many cells of equal area. Training points define the probability of randomly discovering a site of known mineralization. The weights of evidence technique creates these predictive maps by testing for a spatial correlation of the feature with the training data.

The predictive maps that capture the largest number training points in the smallest area will have the best correlation and highest weighting in the final model.

In these predictive maps, a map variable is tested statistically for being either favorable or unfavorable for capturing training data.

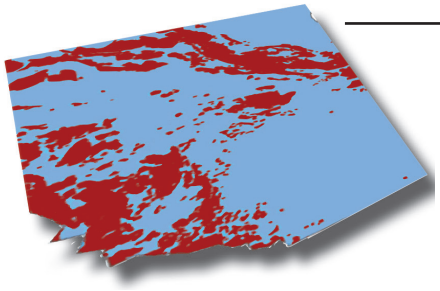
The maps are 'binary': areas in red are considered favorable for capturing training points; areas in blue are considered unfavourable.

Combining predictive maps into a mineral potential model

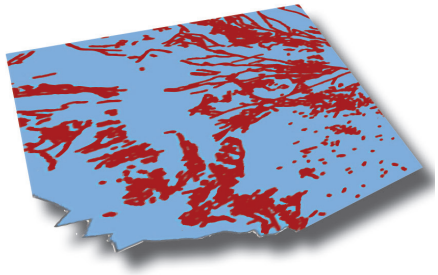
Dozens of predictive maps are generated and those that have the highest probability of predicting the occurrence of the training data, and therefore serve as the best proxies for mineralization, are selected for inclusion in the mineral potential model.

predictive maps

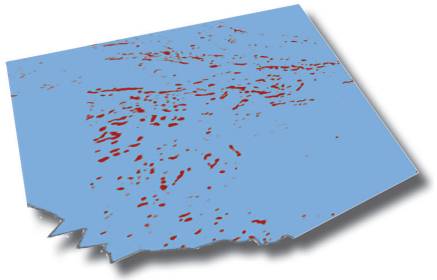
favourable rocks



distance to faults



gravity highs

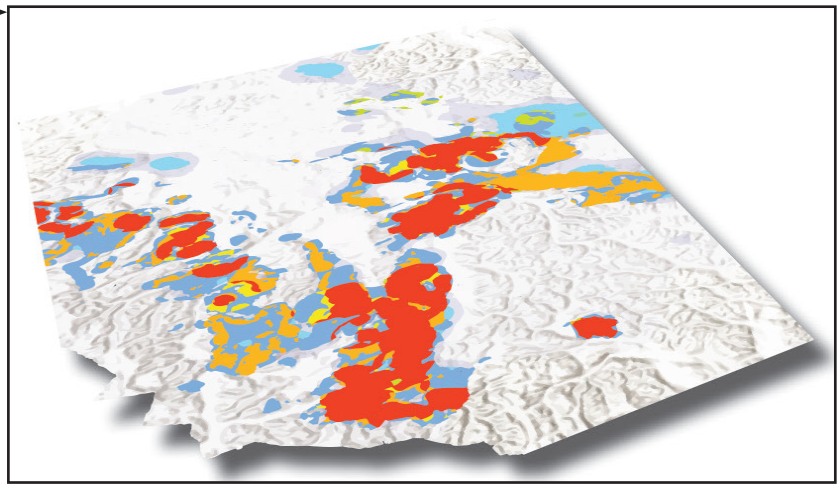


geochemical anomalies

Result

mineral potential map

The resulting mineral potential map displays the relative potential of finding mineralization in an area rather than an absolute measure. The map shows the full range of relative probabilities, with the greatest in red.



The mineral potential model must include predictive maps that represent each component of the mineral system, answering the question: does the area contain a source, a pathway, and a trap?

Mineral potential modelling and critical minerals

Mining has been an integral part of the history of British Columbia, starting with Indigenous peoples before contact with Europeans and continuing with the new mines of today. Significant potential for additional discoveries exists because much prospective ground remains underexplored.

Mineral potential modelling provides criteria upon which land-use decisions centred on exploration and mining can be negotiated.

Critical minerals are required to make electric vehicles, mobile phones, solar panels, wind turbines, electrical transmission lines, batteries, and medical devices, and to manufacture products needed for national defence.

Mineral potential modelling helps examine the endowment of critical minerals needed to support the low-carbon transition, grow the economy, and diversify global supply chains and for British Columbia to continue as a preferred supplier for partner nations.