Spatial modelling techniques and data integration using GIS for target scale gold exploration in Finland

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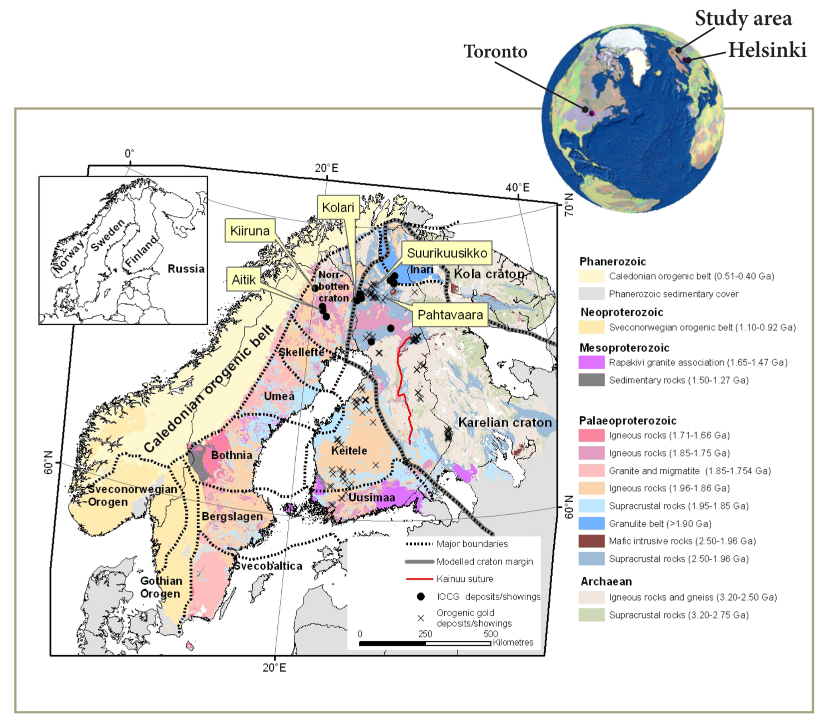


Simplified geological map of the Fennoscandian Shield. Filled circles represent deposits and showings with IOCG affinities and crosses represent orogenic gold deposits. Thick grey line represents the Archaean craton margin.

Spatial modelling techniques used in this study for a mineral prospectivity analysis

- weights of evidence
- logistic regression
- fuzzy logic

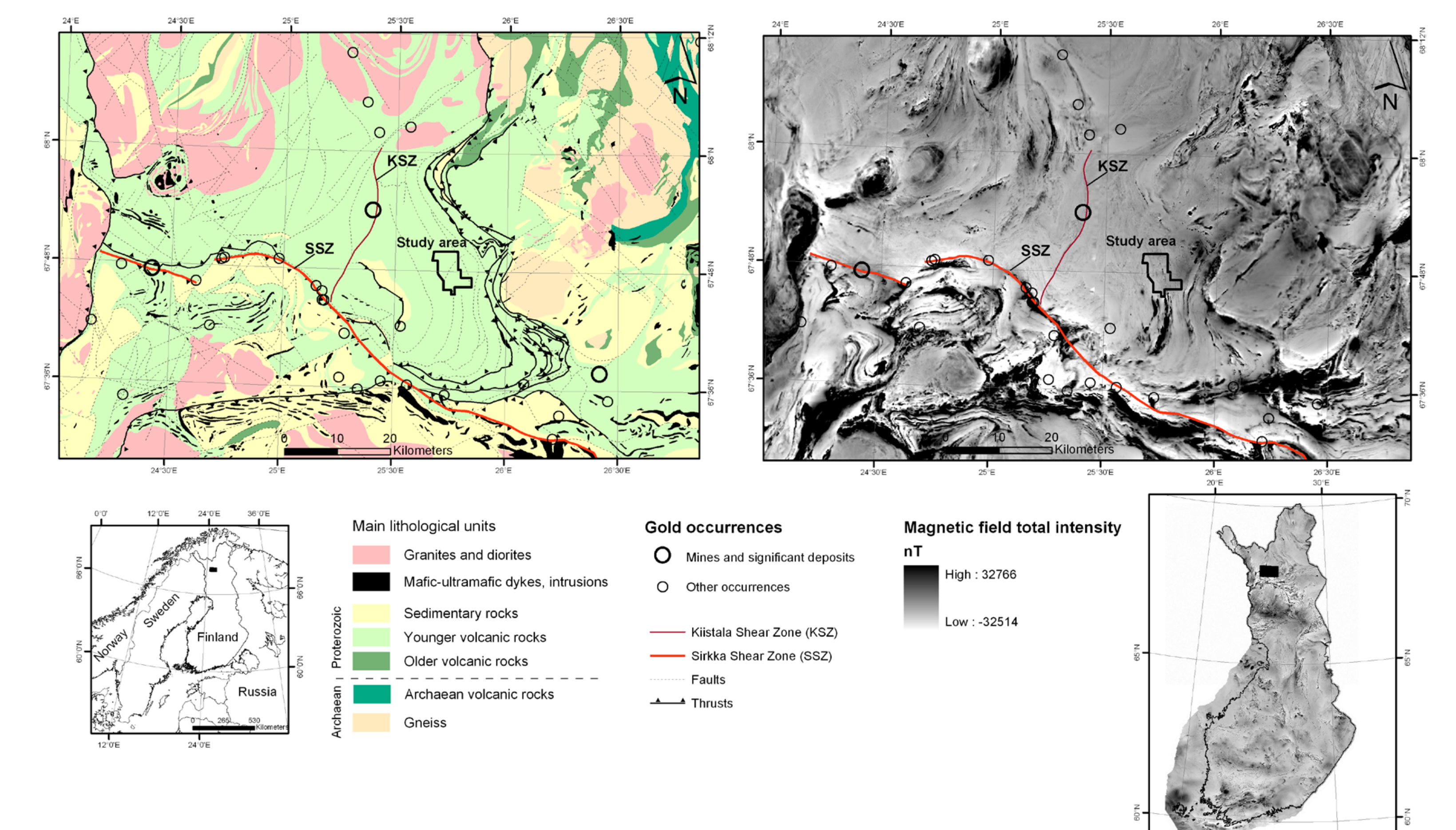
Aim is to test the utility of these methods in a target scale gold exploration project within the Palaeoproterozoic Central Lapland Greenstone Belt (CLGB) in Finland, Northern Fennoscandian Shield.

The datasets used in this study are:

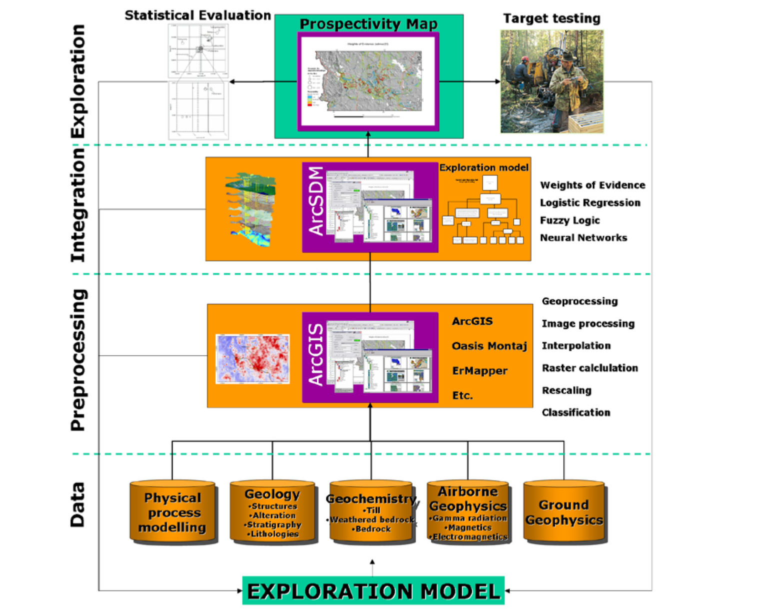
- very high resolution airborne geophysical survey (magnetic, elecetromagnetic and gamma radiation measurements)
- regional ground gravity survey and
- target scale till geochemical survey

Spatial analysis in Geographic Information Systems (GIS) is an efficient and accurate way to quantify relationships between existing targets (e.g. mineral deposits) and various geoscientific datasets and to produce a quantitative measure of the favourability of the desired feature, typically a specific mineral deposit type.

Drilling samples with over 0.5 g/ton gold were used as 'training points' for the spatial modelling.



Generalized geological map of CLGB on the left side and airborne magnetic map on the right side.



Flow chart describing a typical workflow in a prospectivity mapping project.

Till geochemistry

The target scale geochemical sampling was done using 250 m point spacing resulting in the collection of 559 samples within the 31 km^2 study area.

Assays were done using ICP-AES and GAAS (for Au) methods after partial leaching.

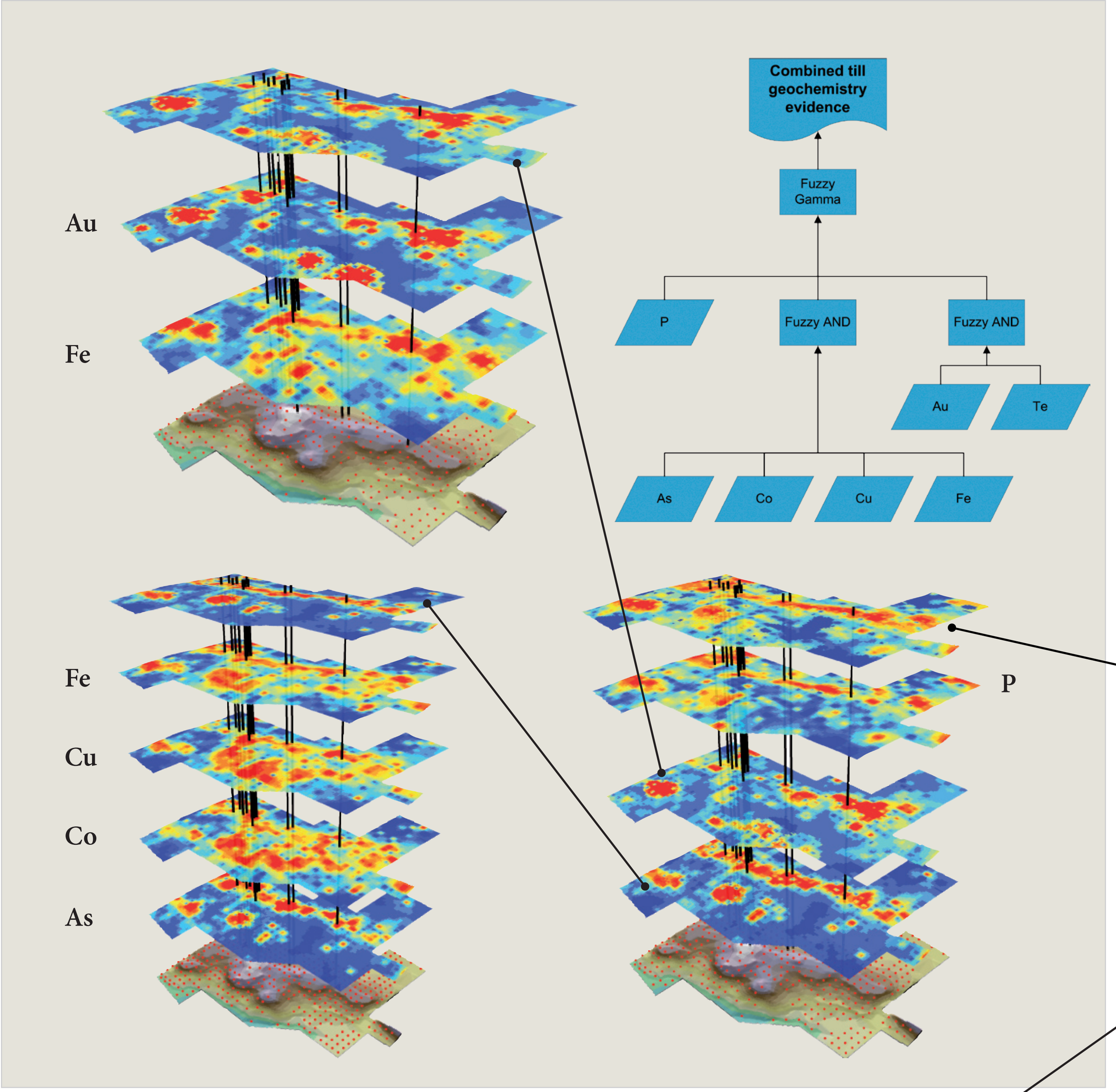
The original point data were interpolated using the inverse distance weighting (IDW) method and a 50-m grid interval to create the gridded color surface maps for the selected elements.

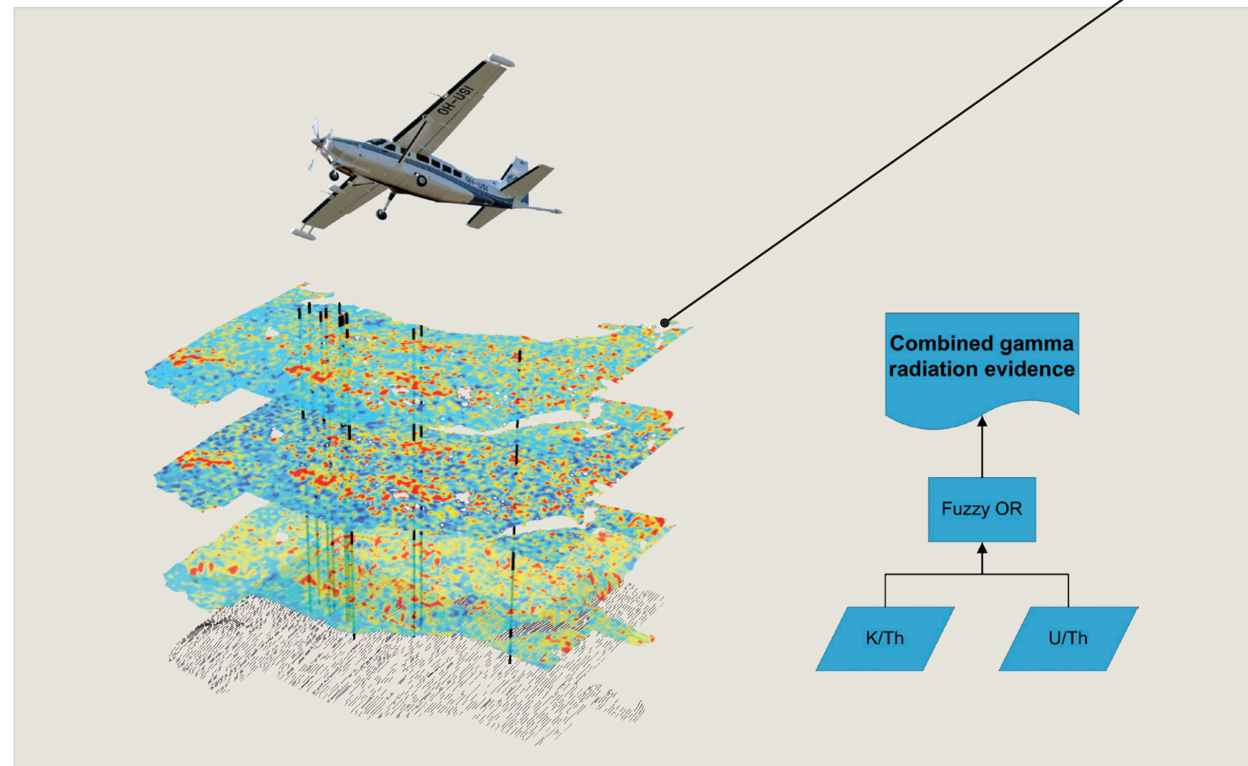
Values for each grid were then divided into 16 classes by quantiles for further processing prior to modelling.

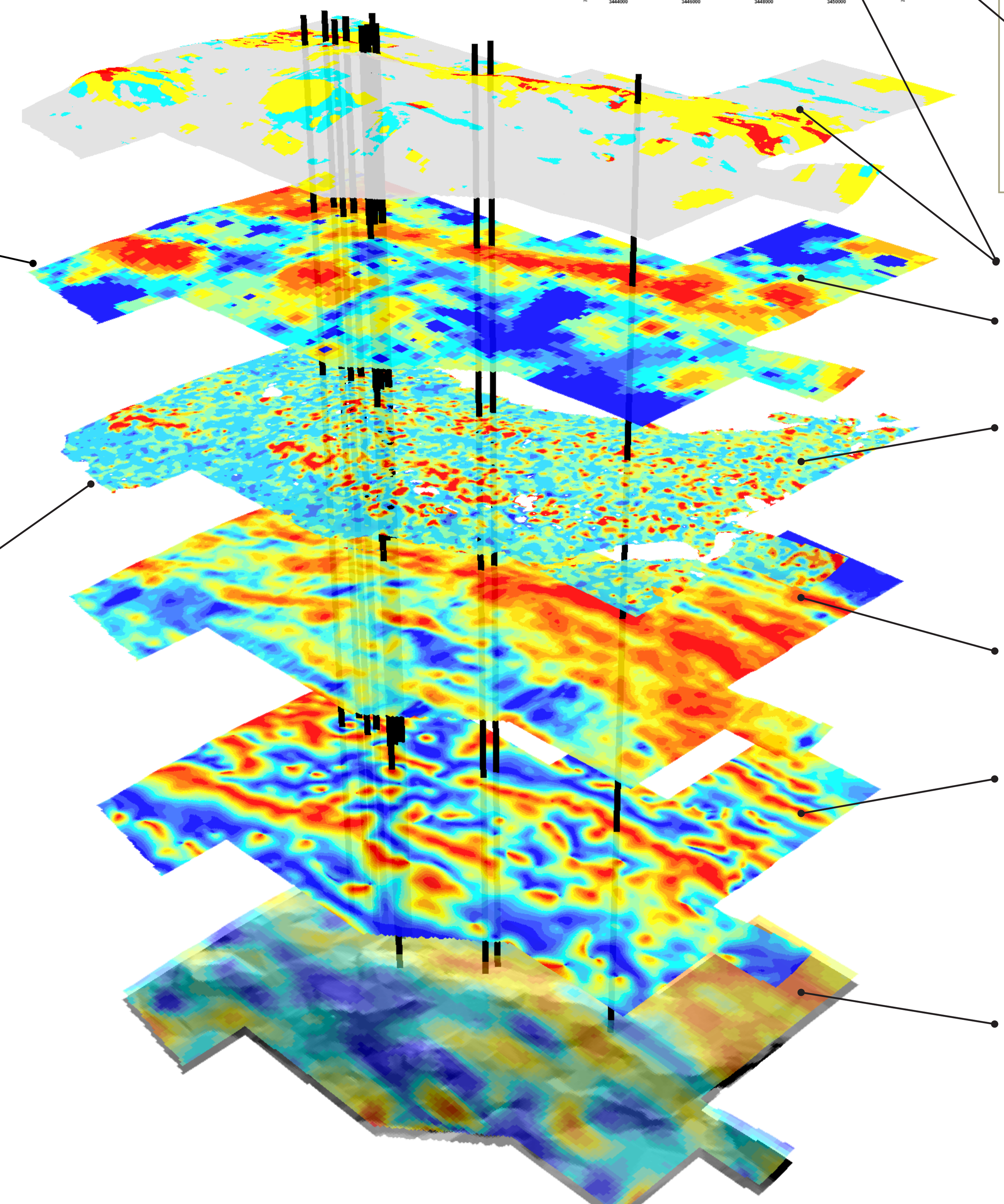
Suites of elements were considered together to determine favorability for certain sources. The suites used were Fe, Cu, Co and As (sulfidic source), P (alkaline alteration) and Au together with Te (mineralized source). These suites of elements were combined together using Fuzzy logic methodology and the resulting combination was used as an evidence layer.

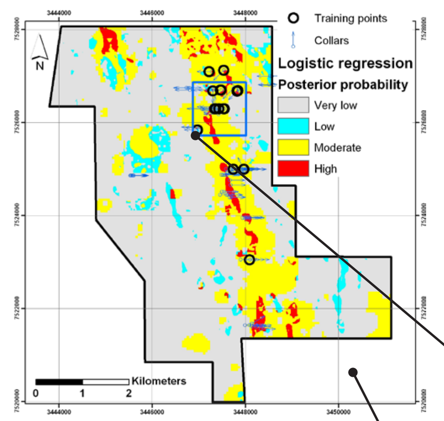
High resolution airborne survey:

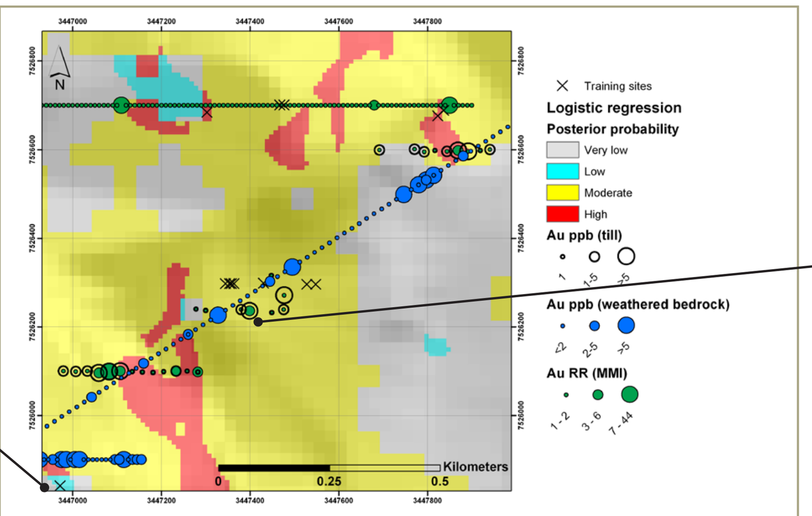
- 260 km^2
- Cessna Caravan aircraft
- Line spacing 50 meters
- Flight altitude about 30 meters
- Flight direction east-west, perpendicular to the dominant geological strike
- Positioning by using a differential GPS resulted spatially in extremely high precision data
- The measurements include three standard components:
  - Magnetic
  - Electromagnetic
  - Radiometric data
- Radiometric data was integrated by combining K/Th and U/Th grids into a single grid by using Fuzzy OR operator in GIS



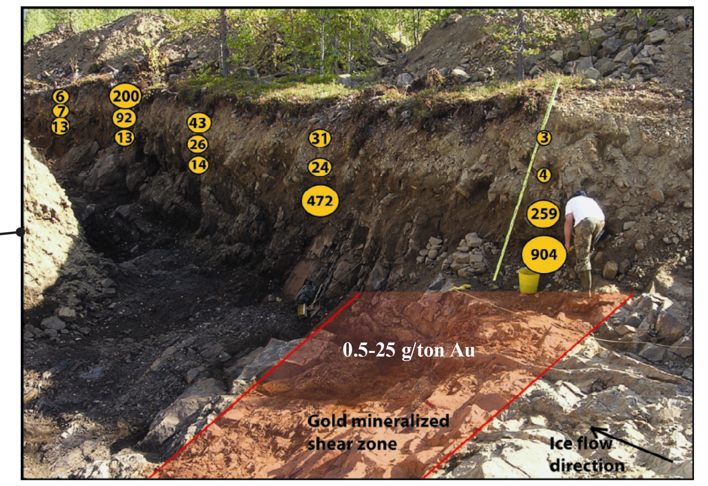








Results of geochemical surveys plotted on the top of the posterior probability map. Units for till and weathered bedrock surveys in ppb. Units for the MMI survey in 'response ratio' i.e. value divided by the background value. Background value is defined by averaging the values for the lowest quartile (25%) of data.



Test pit in one of the target areas. The yellow cirlces are defining gold values (ppb) in till. Gold value range in the shear zone in graphite chert is derived from 1 m sections of channel sampling.

Prospectivity map

Till geochemistry

- Fuzzy combination of Au, As, Fe, Co, Cu, P and Te

Radiometric

- Exploration GR-820/3 gamma-ray spectrometer with 8 downward and 2 upward looking crystals.
- Registered energy range is 0.001-3.0 MeV
- The number of channels is 256.
- Potassium (K) content in the ground directly estimated from measurement of the 1.45 MeV.
- Uranium (U) and thorium (Th) equivalent contents are calculated on the basis of their daughter isotopes of decay series after the required reductions.

Electromagnetic

- Dual frequency fixed wing EM equipment (3 kHz and 14 KHz).
- The in-phase component of frequency 3 kHz was selected for the prospectivity modeling describing these sulphide conductors.

Magnetic

- One cesium magnetometer at back boom of Cessna Caravan
- Secular and other kinds of magnetic field variation are corrected according to data from a base station registration done during the surveys
- The tilt derivative (TDR) was calculated for 100 m upward continued magnetic field total intensity data to describe and illustrate structures, which might be associated with the gold deposits

Gravity

- Gravimetric ground survey using a density of six points/km^2 and covering area of 169 km^2
- Horizontal gradient of Bouguer anomaly [mgal/km] describes structures originated from density variations of bedrock
- Horizontal gradient of Bouquer anomaly was selected to describe structural control associated with orogenic gold occurrences

Unaltered magnetite bearing graphite chert.

Sheared gold bearing pyrrhotite- and arsenopyrite rich graphite chert.

Conclusions

Geophysical and geochemical datasets were integrated together to create a prospectivity map to support decision making in an ongoing exploration project. Three independent geochemical surveys were used to test the validity of the modelling.

This study shows that integration of high resolution data in a GIS using quantitative spatial modelling techniques can be used to highlight potential new drilling targets at a prospect scale. However, since the spatial modelling techniques used are sensitive to training point selection and availability, the accuracy of the modelling can be randomly biased if the training set is not representative of the target mineralization. Therefore the exploration model has to be revised as more data is gathered and the model revised.

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