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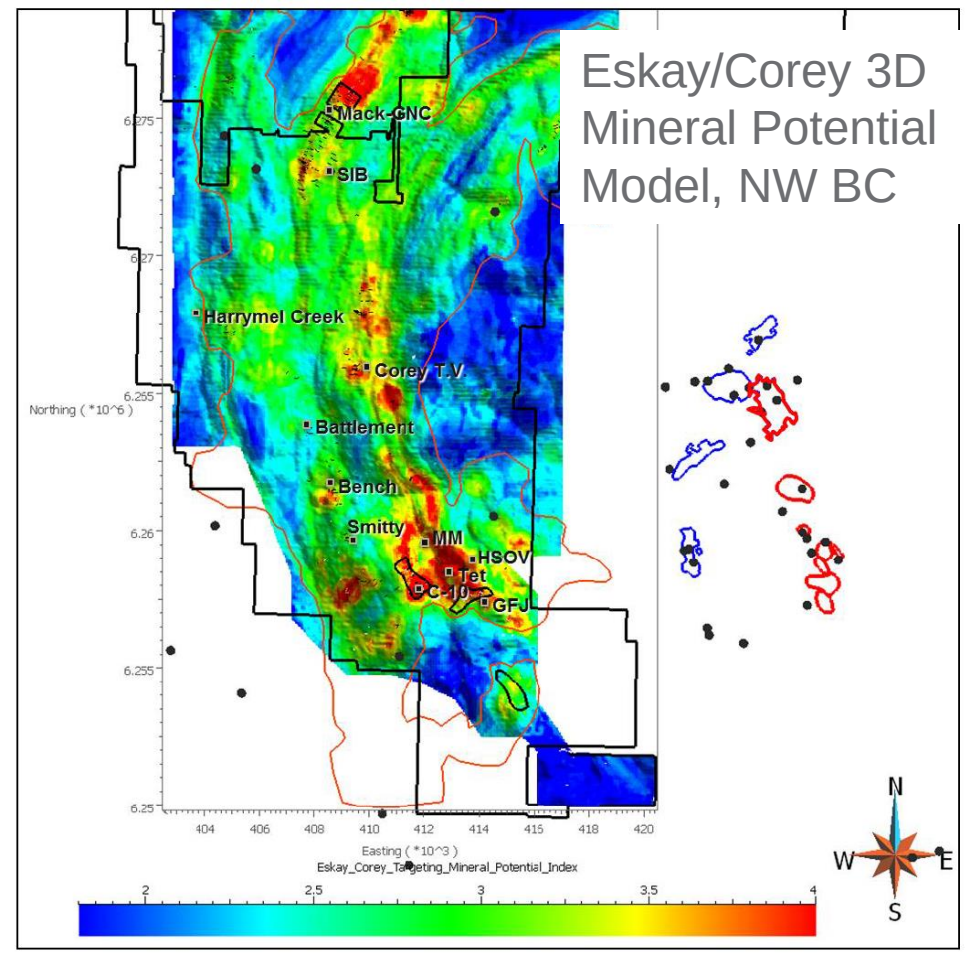
INTEGRATED INTERPRETATION EXPLORATION 2017 WORKSHOP 4



Targeting in 3D Workflow and Case Studies

Dianne Mitchinson, Mira Geoscience

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Acknowledgements

- Eskay/Corey Study
  - Mac Balkam
  - Jim Rogers

- Lalor Study
  - Hudbay Minerals
  - Kelly Gilmore
  - Bruce McMonnies

- Mira Geoscience team

Outline

- Targeting Workflow
- Ore Deposit Models to Targets
- Targeting Case Studies
  - Knowledge-Driven Targeting – Eskay/Corey properties, BC, porphyry/epithermal targets
  - Data-Driven Targeting – Lalor Deposit, MN, VMS targets
- Summary

Targeting Workflow

- **Phase I: Ore deposit model and exploration criteria**
  - Define objective
  - Define deposit model, or target
  - Brainstorm exploration criteria
  - Match criteria to data required
  - Plan construction of model
- **Phase II: Constructing models corresponding to criteria**
  - Compile and review required data, confirm and explore data relationships
  - Build evidence layers for targeting
- **Phase III: Model combination and target generation**
  - Run targeting
- **Phase IV: Drilling and data acquisition**
  - Groundtruth results, plan new surveys, or plan drill targets

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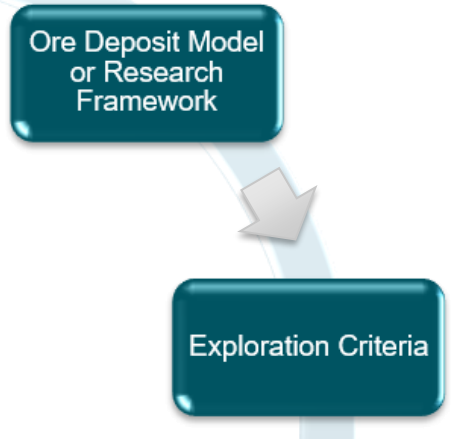
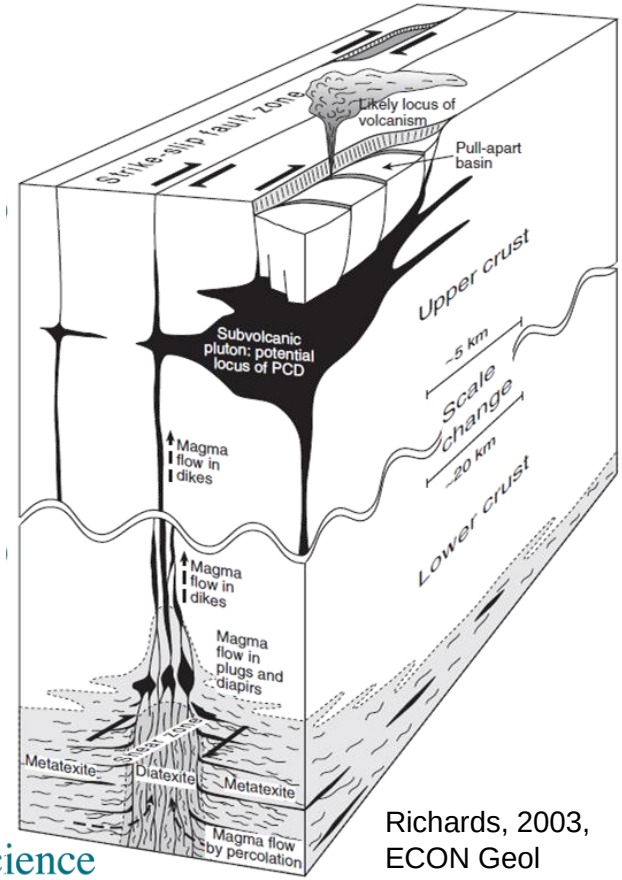
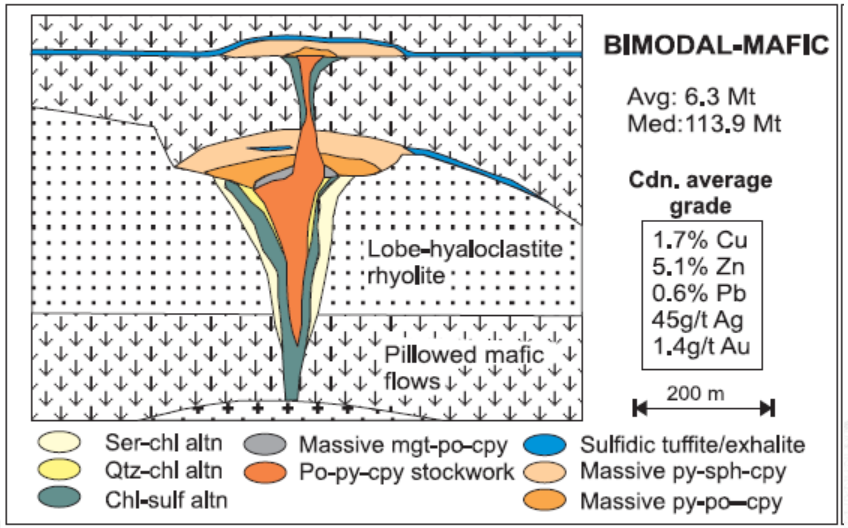
Ore Deposit Models – Importance of Scale

- The presented case studies represent two scales – regional and local scale – this has an important impact on the exploration criteria and data required





Richards, 2003, ECON Geol



Galley et al. 2007

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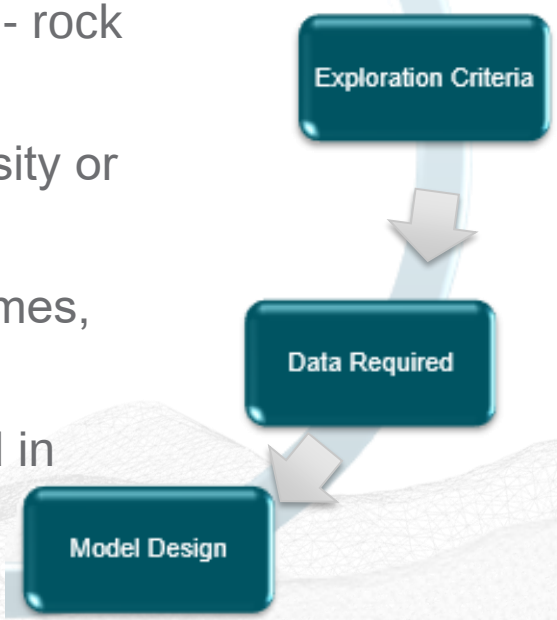
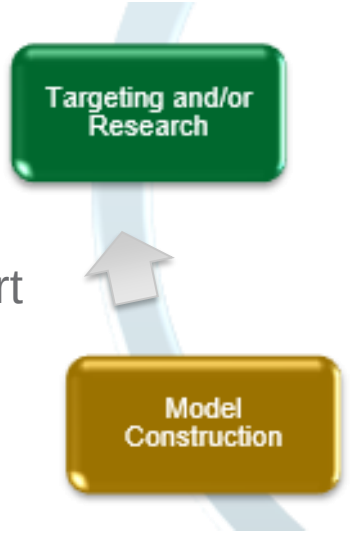
From Criteria to Model

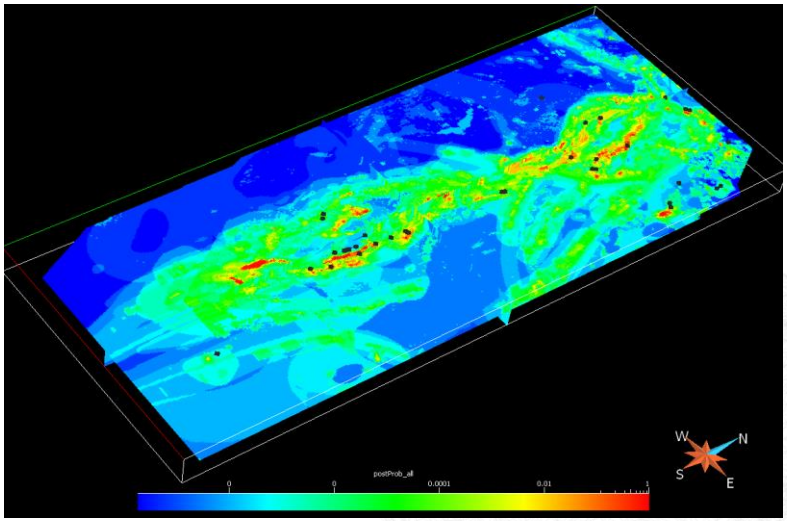
- Exploration criteria is often qualitative, but the targeting input data must be quantitative
- 3D modelling software and tools provide the means to highlight favorable features, and quantify criteria:
  - Geology or horizons (3D model – developed using geological, geochemical, geophysical information - rock code ID, ‘distance-to’ contacts)
  - Structure (3D model, ‘distance-to’ properties, density or frequency of structures)
  - Geometry of surfaces (3D model, ‘distance-to’ domes, basins)
  - Alteration (manifested in geophysical models, and in geochemical models)



From Multidisciplinary Model to Targets



- Thorough analysis of exploration data leads to development of meaningful evidential layers, each individually describing in part the mineral environment
- A targeting methodology is chosen – simple to complex – knowledge or data-driven
- With carefully chosen and modeled criteria, there should be confidence that a resulting mineral potential model is picking targets where all the right elements add up, and ruling out ground where few criteria occur



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Case Studies

Eskay/Corey Property, BC, CAN
Knowledge-driven
District scale
Epithermal/porphyry copper deposits

Lalor Deposit, MN, CAN
Data-driven
Property scale
VMS deposits

(geology.ca)

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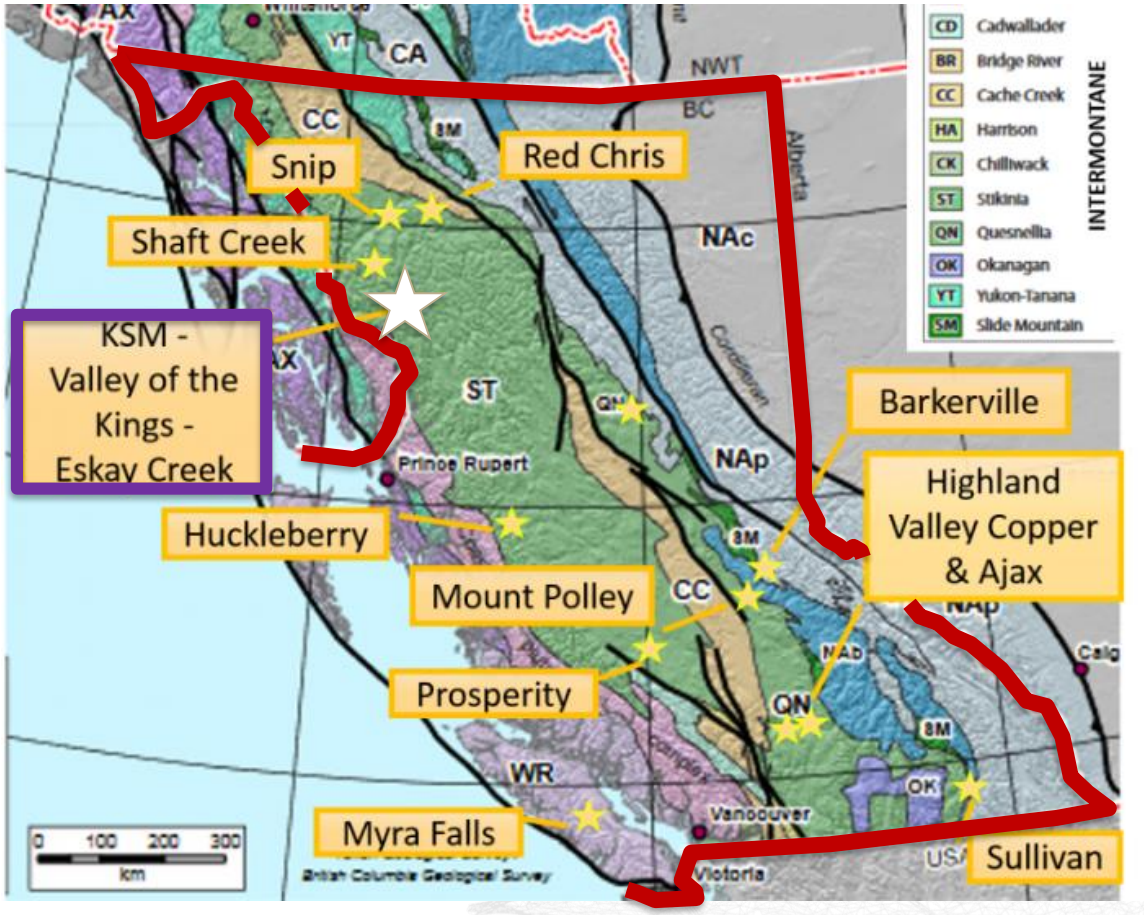
Knowledge-driven 3D Targeting – Eskay/Corey

Eskay/Corey property in northwest BC, Canada



(northernminer.com)

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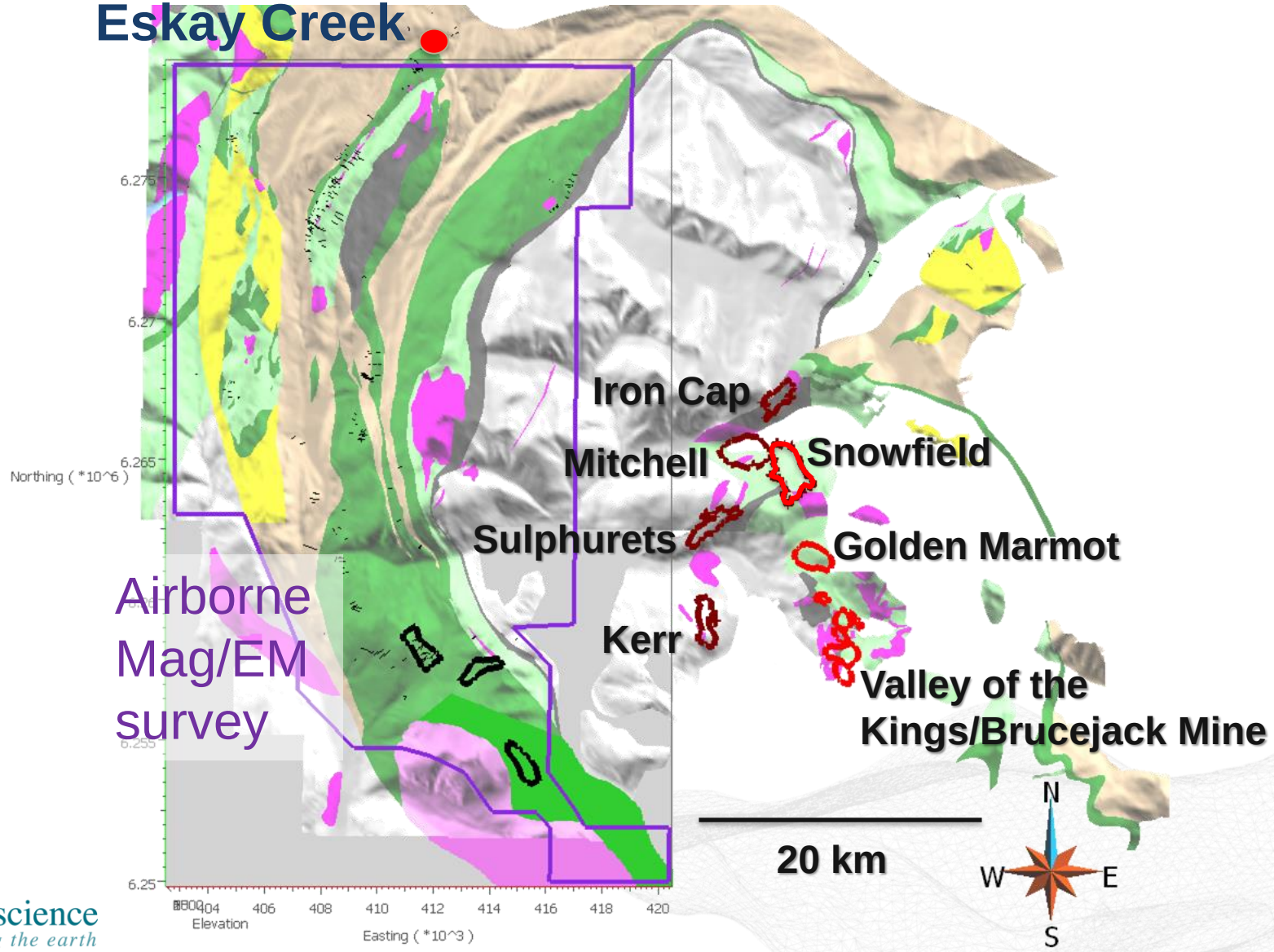
Knowledge-driven 3D Targeting – Eskay/Corey



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Knowledge-driven 3D Targeting – Eskay/Corey

Objective

- Use multidisciplinary district scale exploration data to identify geological settings that are conducive to hosting porphyry or epithermal mineralization

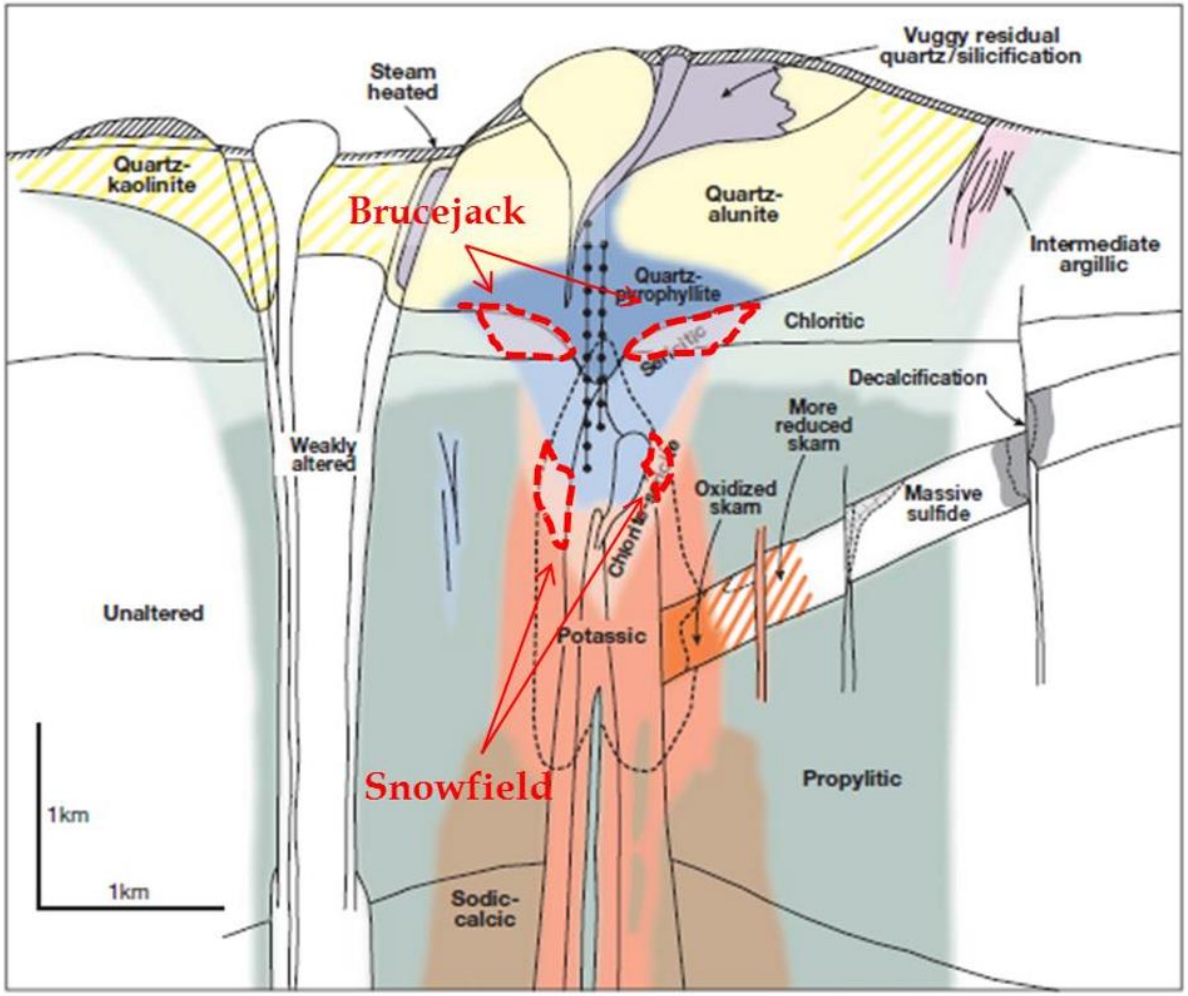
Knowledge-driven 3D Targeting – Eskay/Corey

Deposit model

Projected location of nearby Snowfield porphyry and Brucejack epithermal deposits within porphyry/epithermal model

Criteria

- Triassic to Jurassic host rocks
- Deep intrusions (Jurassic?),
- Deposits forming at margins and cupolas
- Deep structures to focus intrusions and move fluids
- Large magmatic-hydrothermal system with deep potassic cores, and shallow sericitic, quartz-pyrophyllite alteration
- Cluster of deposits



(Pretivm.com)

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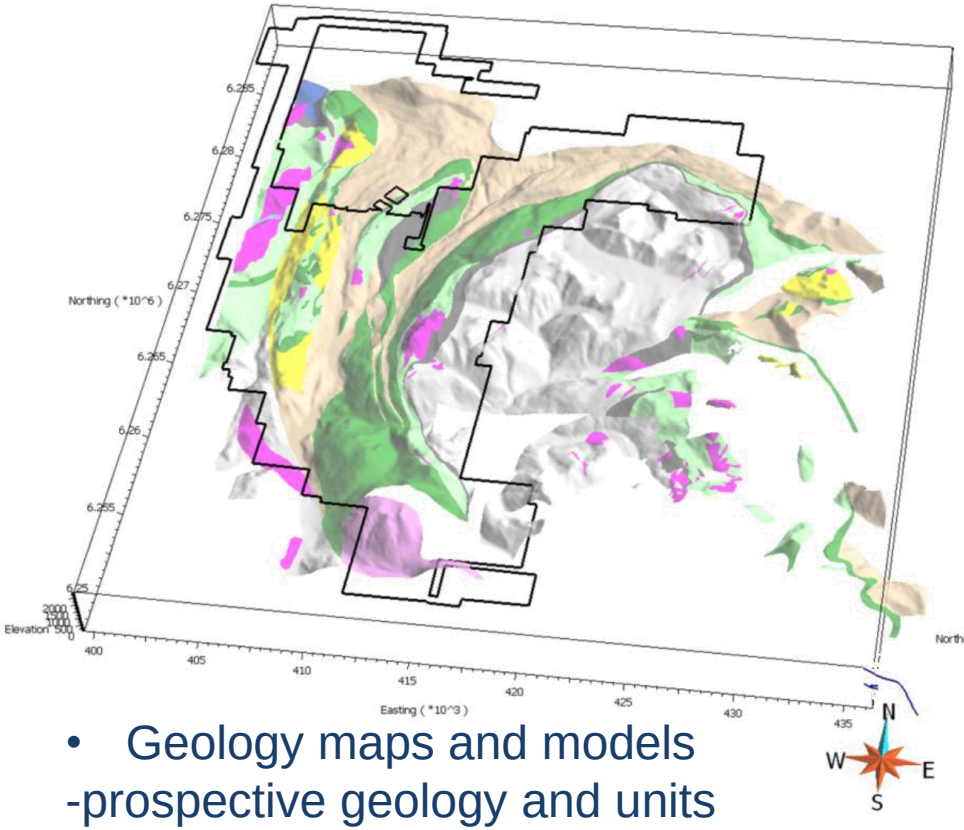
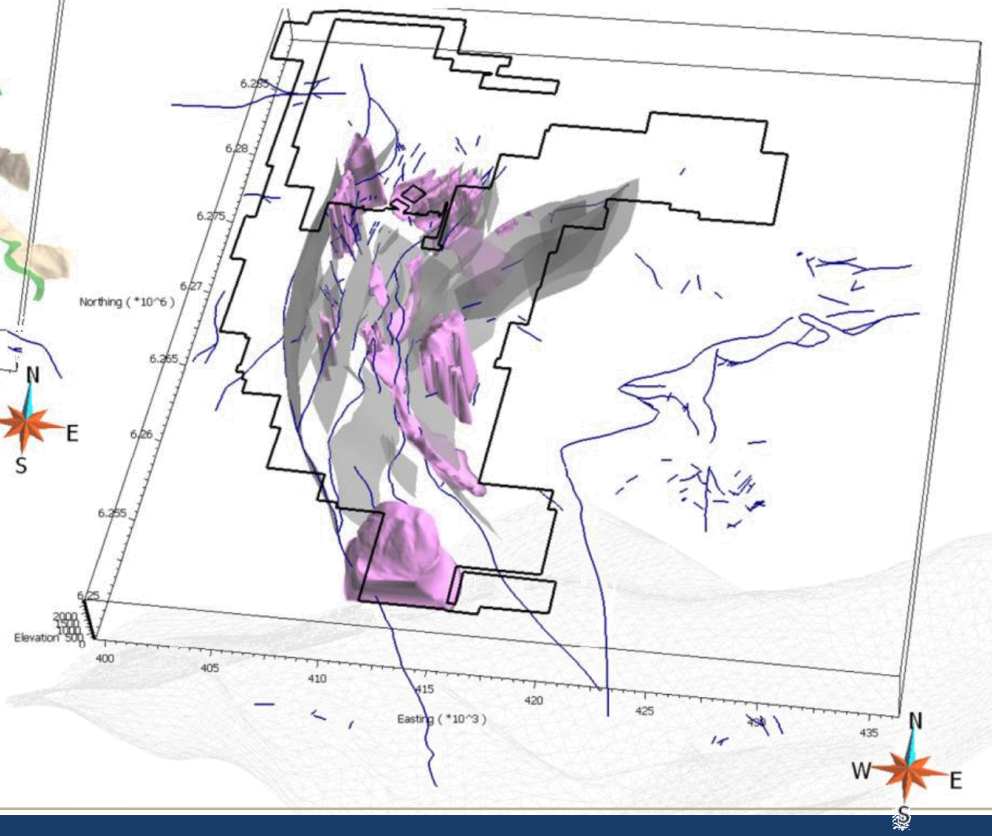
Eskay/Corey - Data and models



- Geology maps and models -prospective geology and units can be identified

- 3D intrusions and district faults – heat sources and plumbing system



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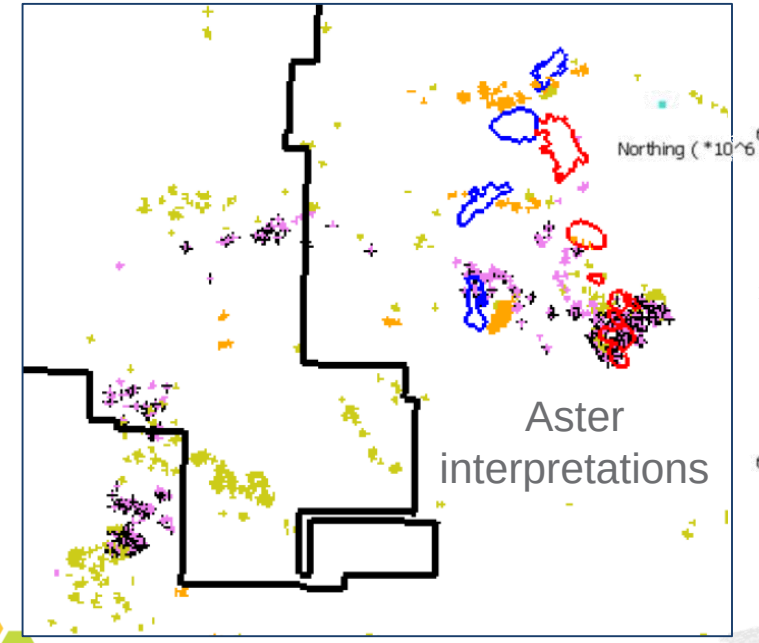
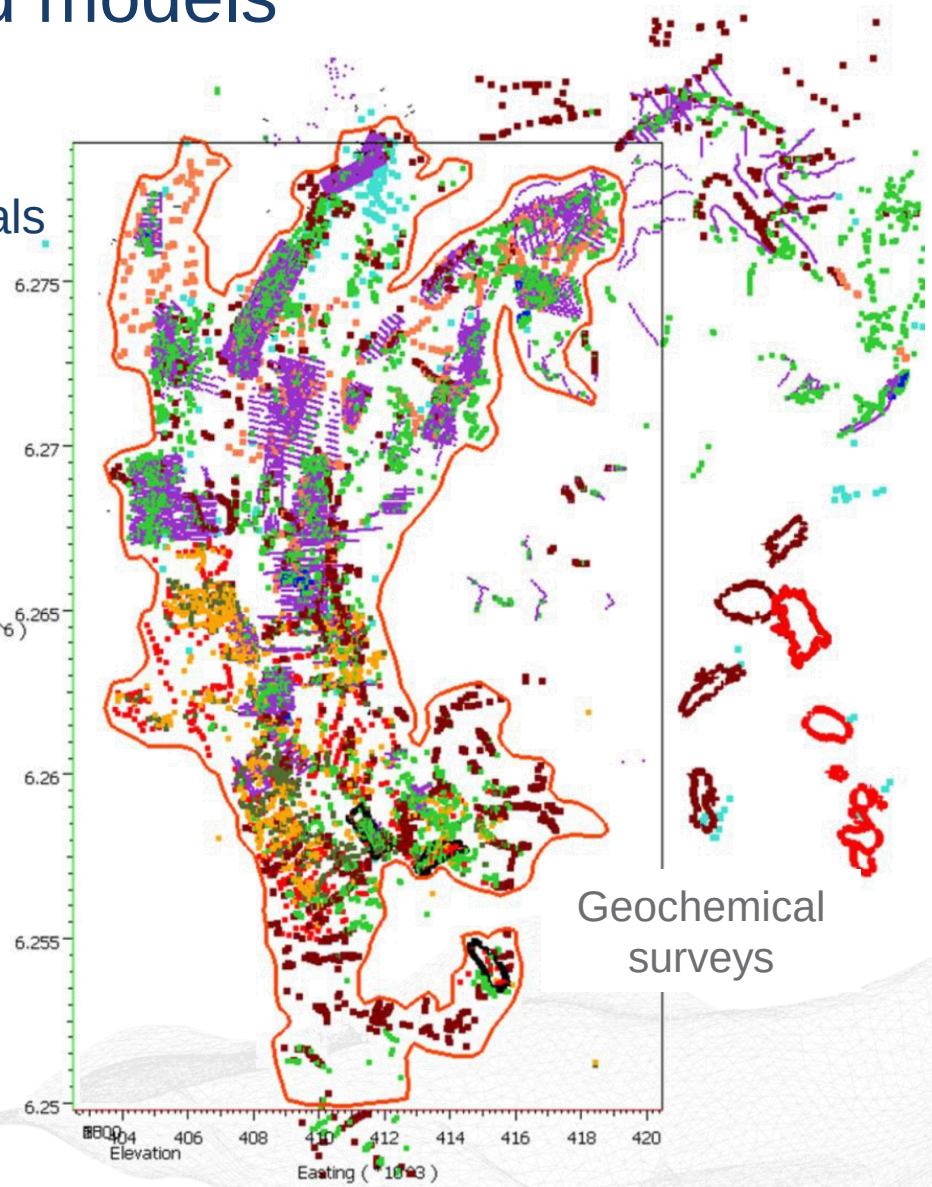
Eskay/Corey - Data and models

- Huge amount of geochemical data
- Limited Aster data from which minerals and alteration mineralogy was calculated
- -surface expression of alteration and metals



Aster interpretations



Geochemical surveys

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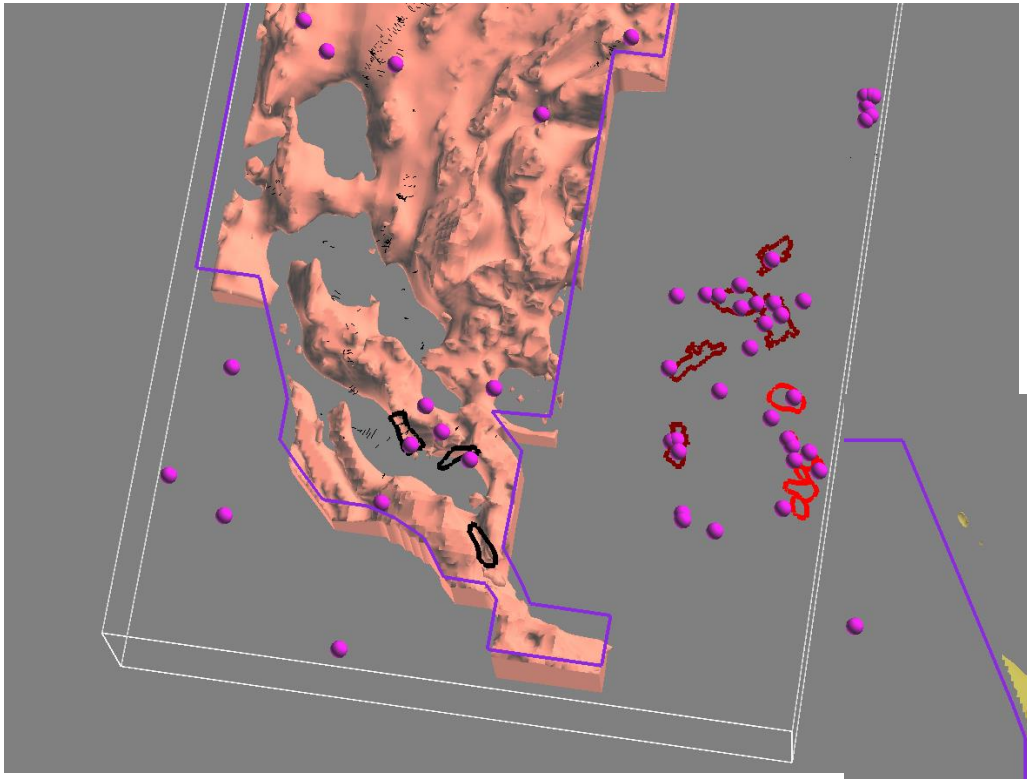
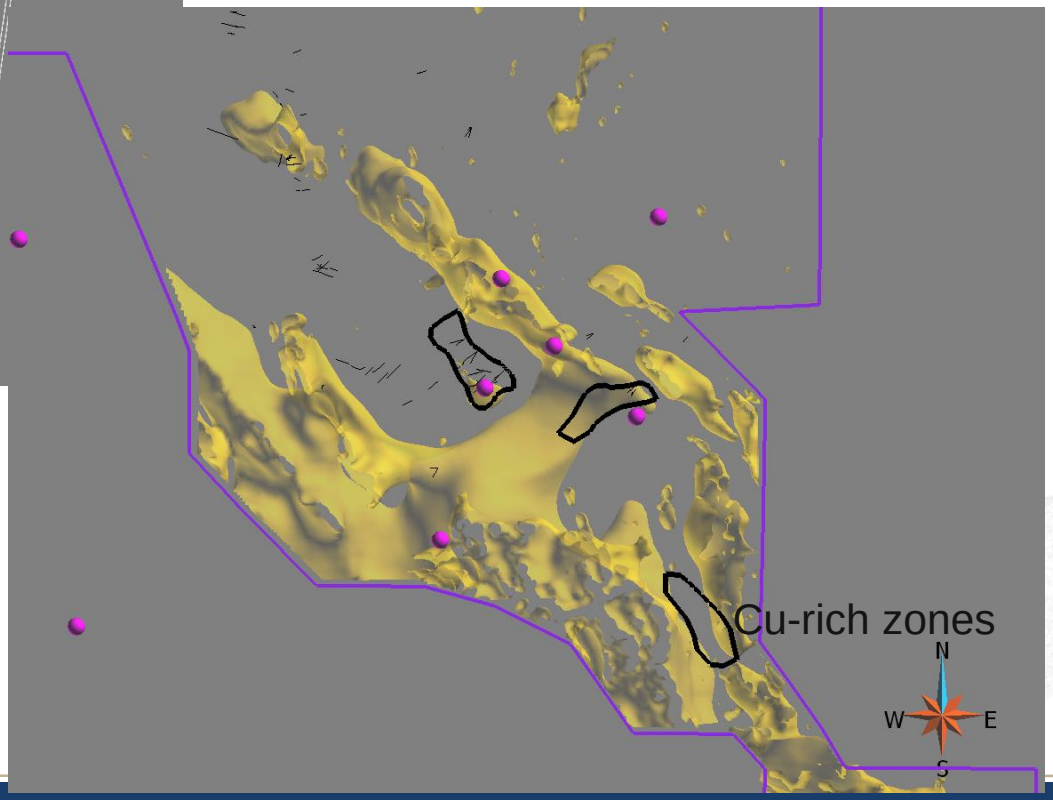
Eskay/Corey - Data and models



High susceptibility regions from regional and property scale magnetic inversion, interpreted to model magnetite bearing intrusions on the southern property – spatial relationship to known occurrences



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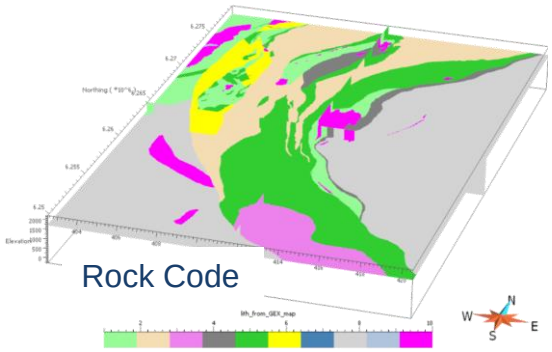
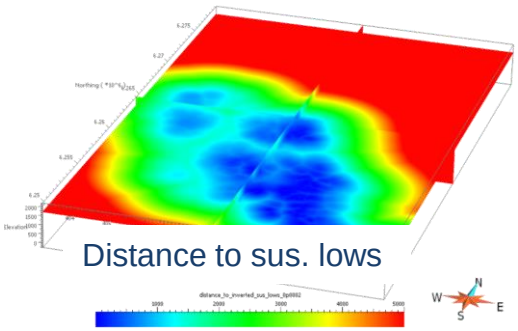
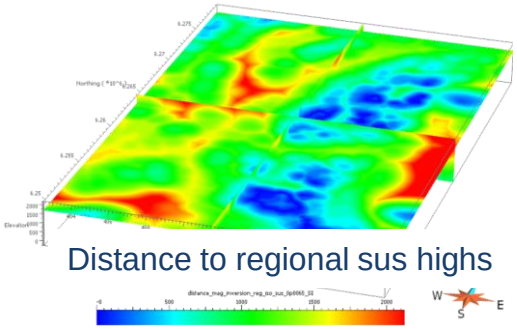
Eskay – Evidential Layers



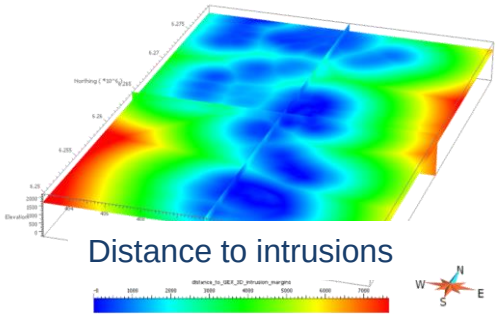
Rock Code



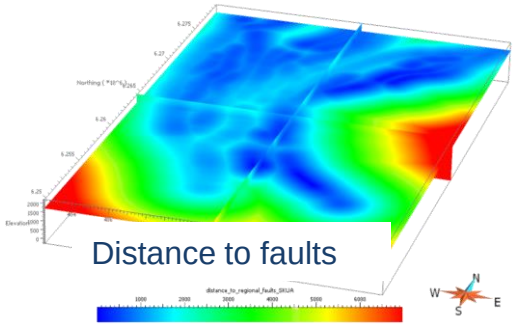
Distance to sus. lows



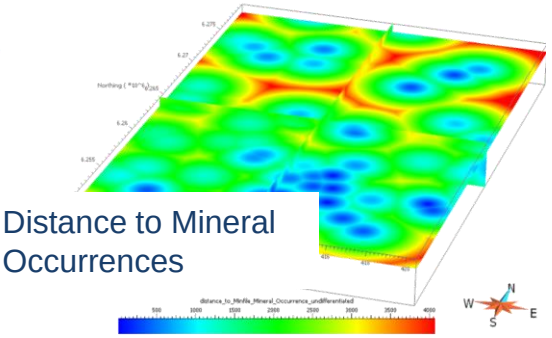
Distance to regional sus highs



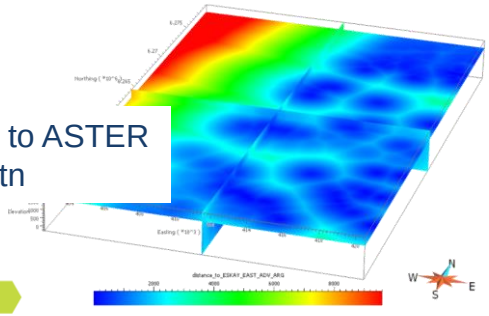
Distance to intrusions



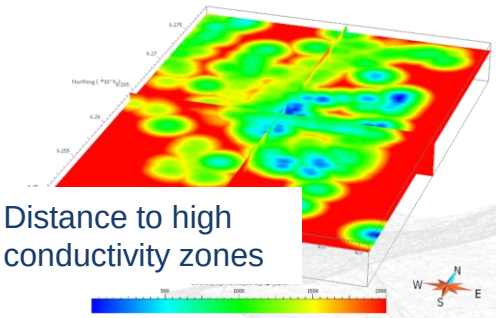
Distance to faults



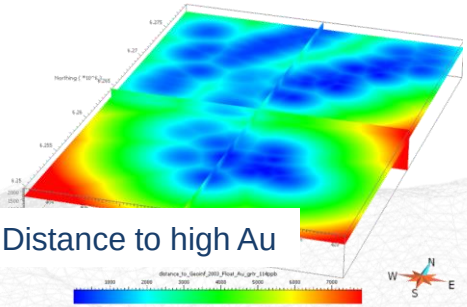
Distance to Mineral Occurrences



Distance to ASTER argillic altn



Distance to high conductivity zones



Distance to high Au

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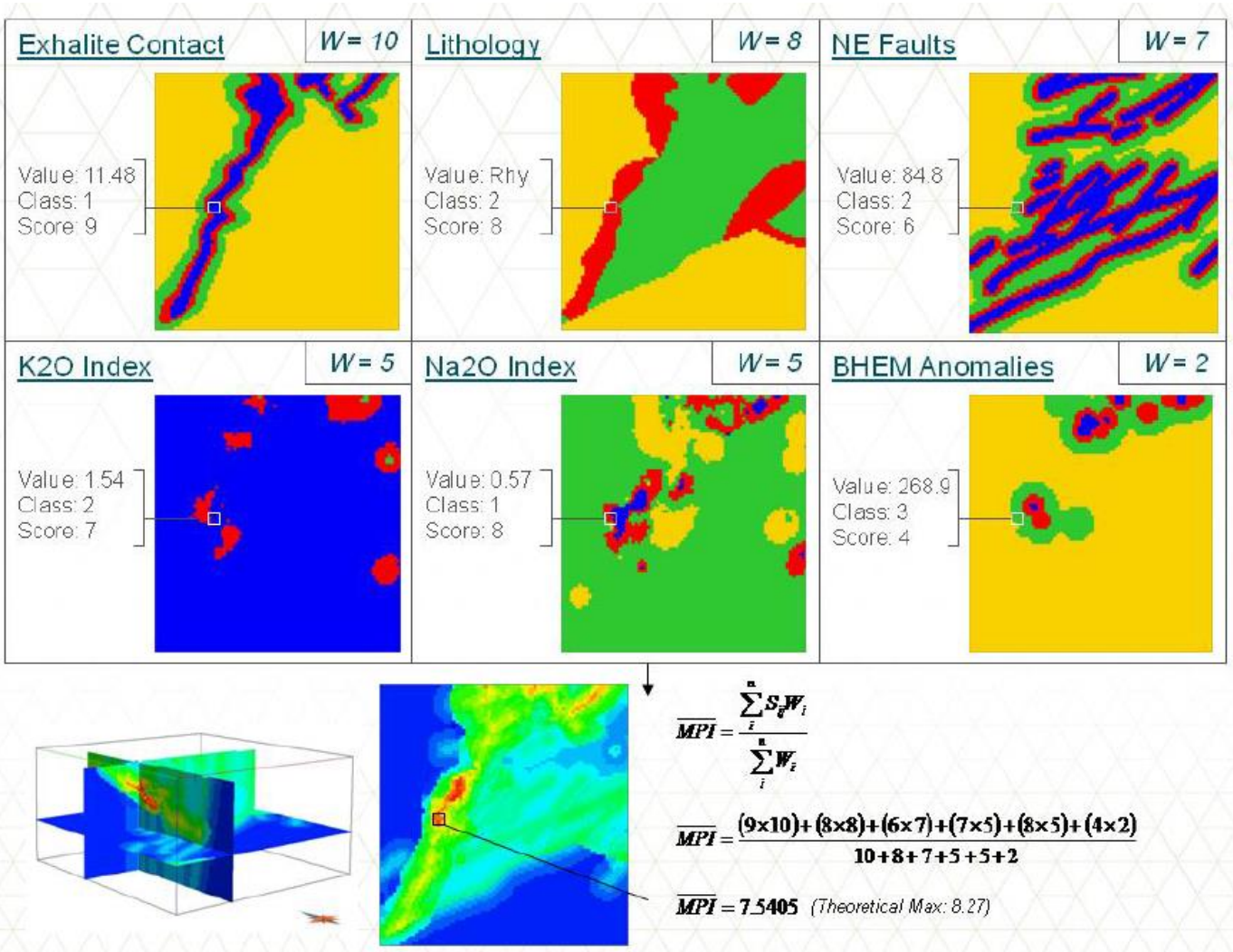
Eskay/Corey – Method – Knowledge-Driven



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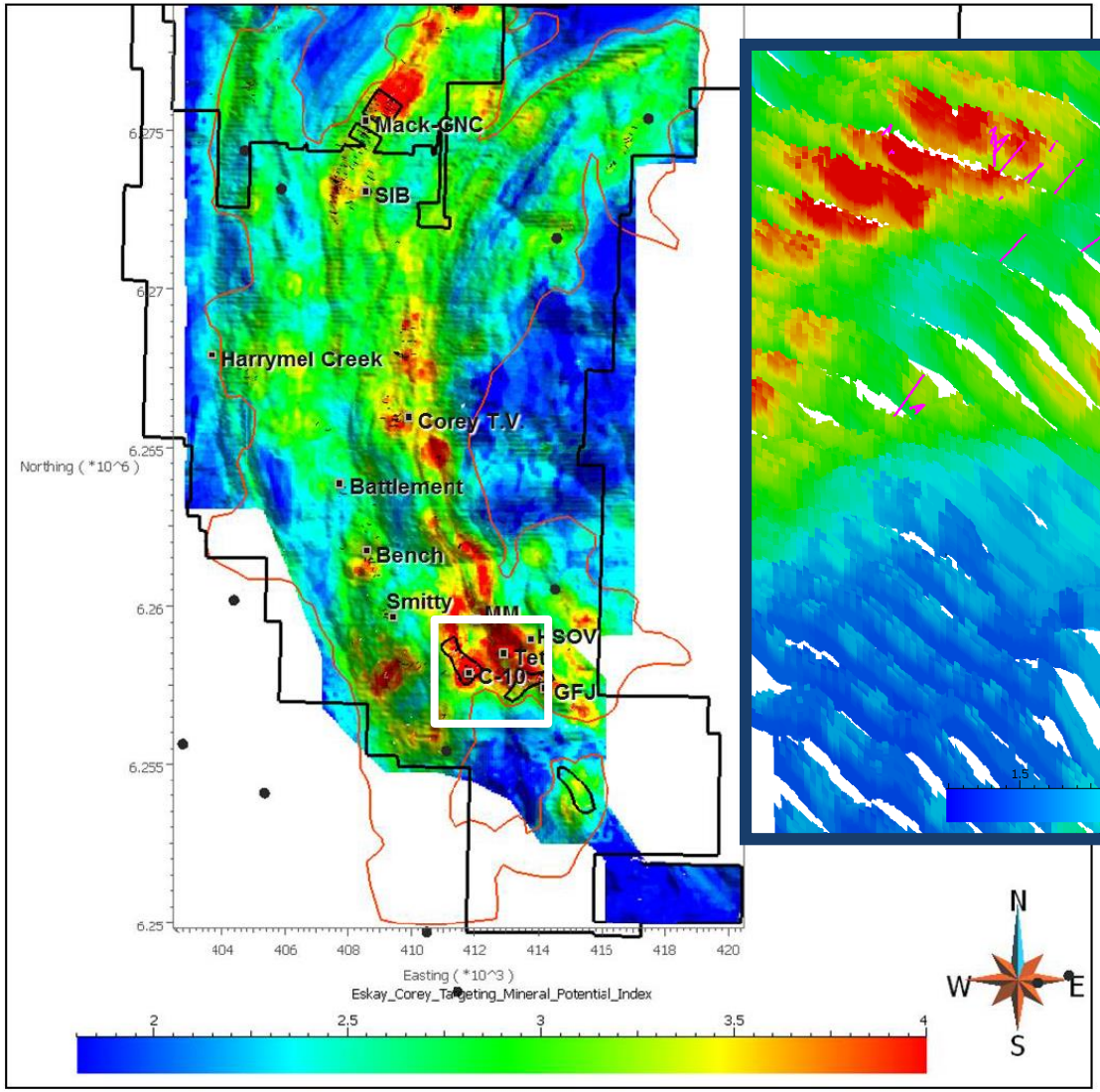
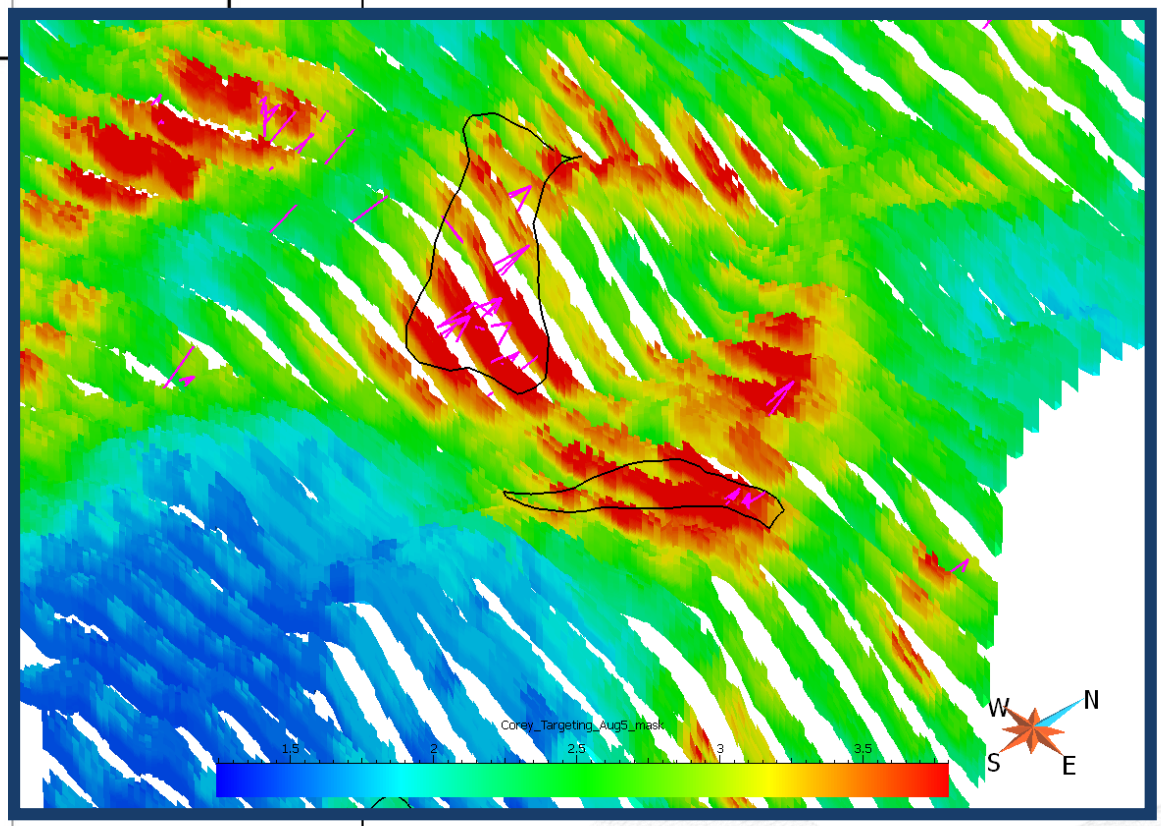
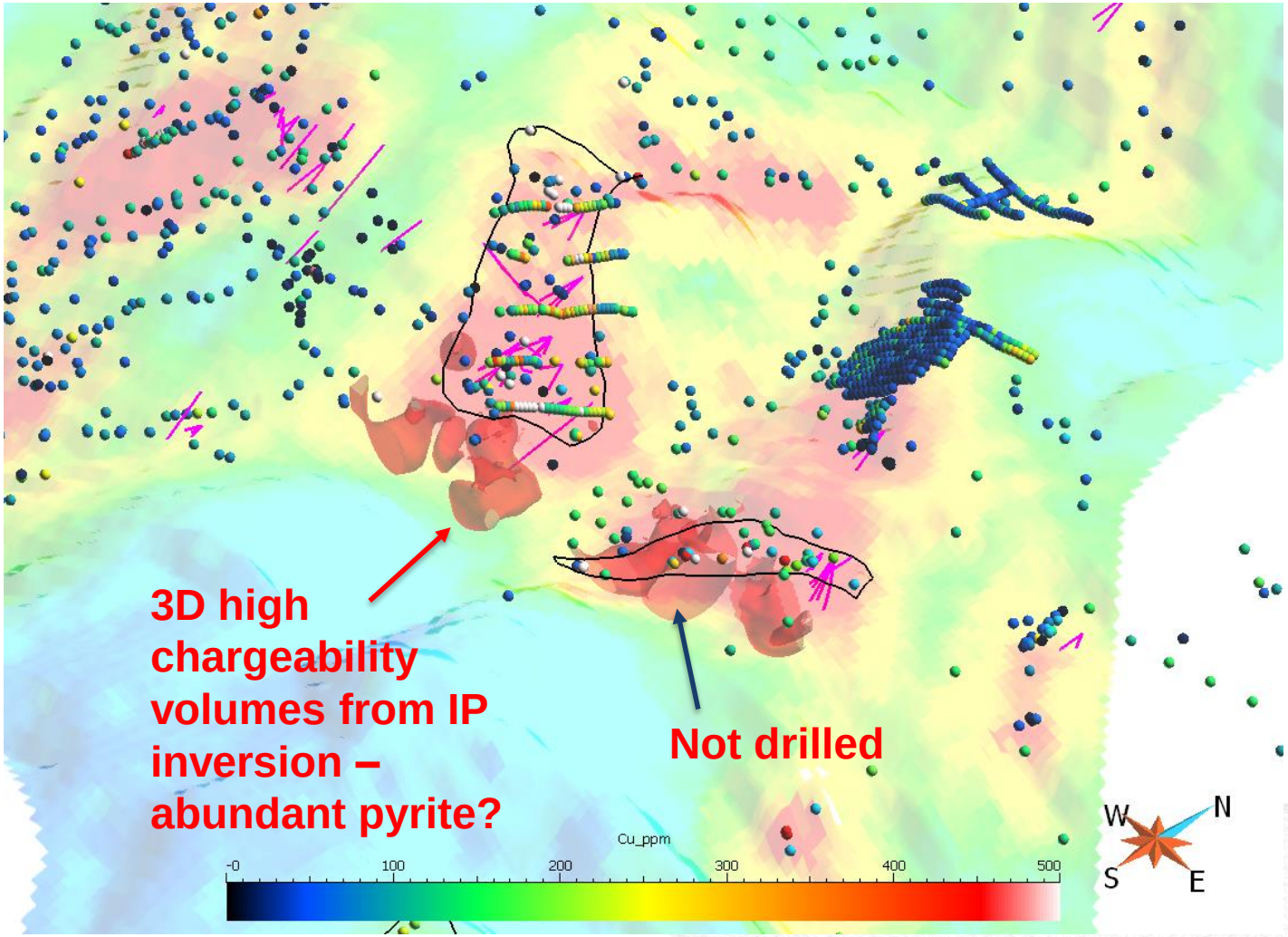
Eskay/Corey – 3D Mineral Potential Model





Eskay/Corey – Testing Targets with Independent Data



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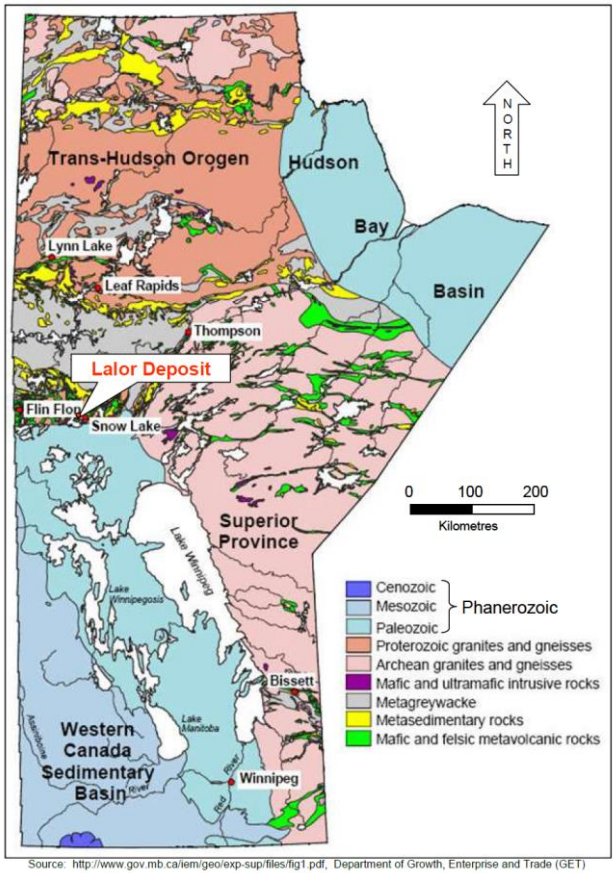
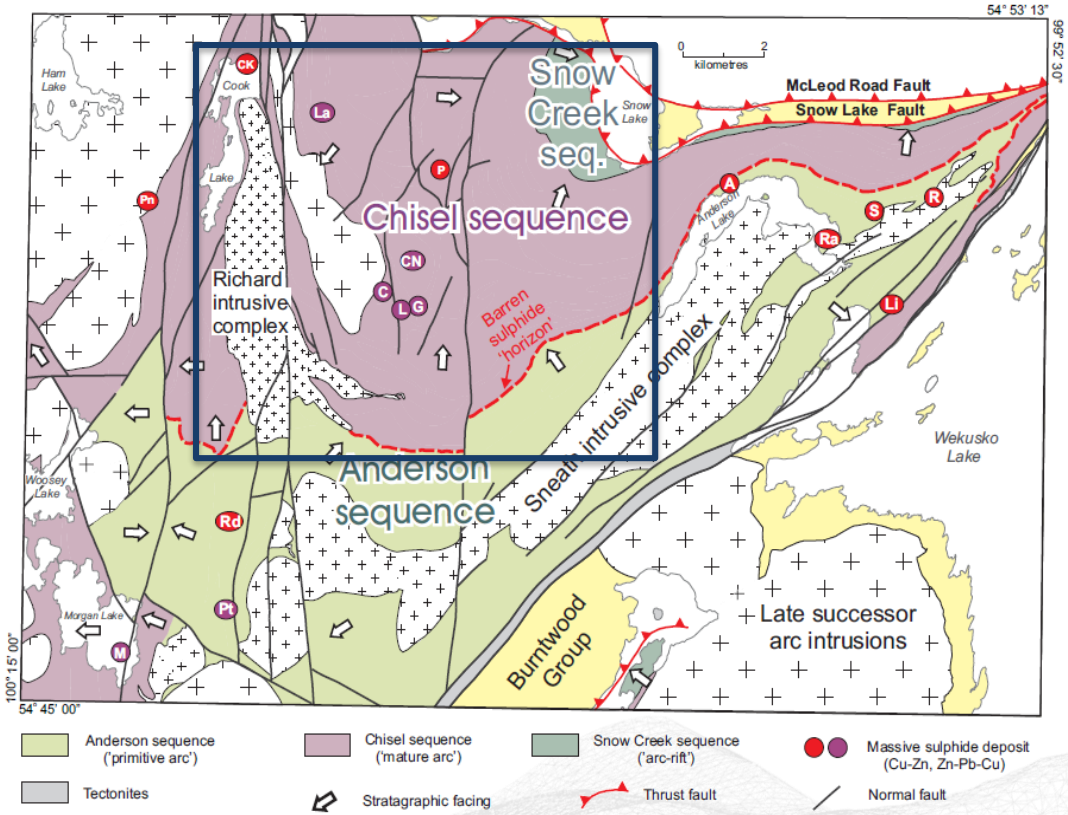
Data-driven 3D Targeting – Lalor

Lalor deposit in Snow Lake VMS district, central MN, Canada



Source: http://www.gov.mb.ca/iem/geo/exp-sup/files/fig1.pdf, Department of Growth, Enterprise and Trade (GET)

(Hudbay Technical Report)



A.H. Bailes and A.G. Galley 2007

Snow Lake Arc Assemblage

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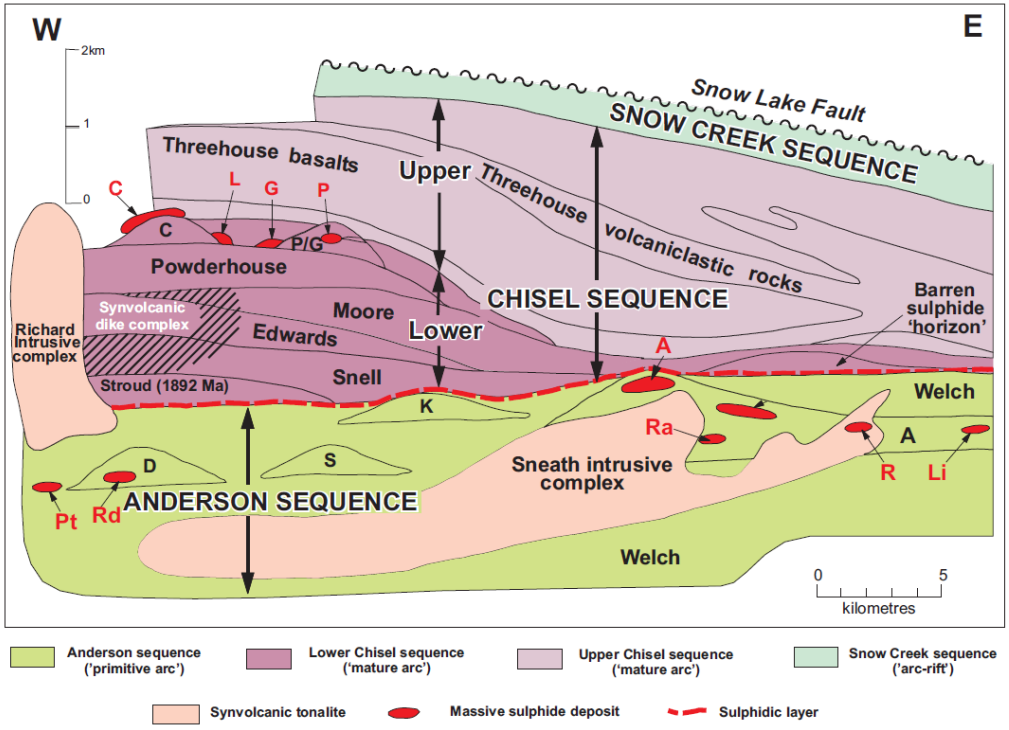
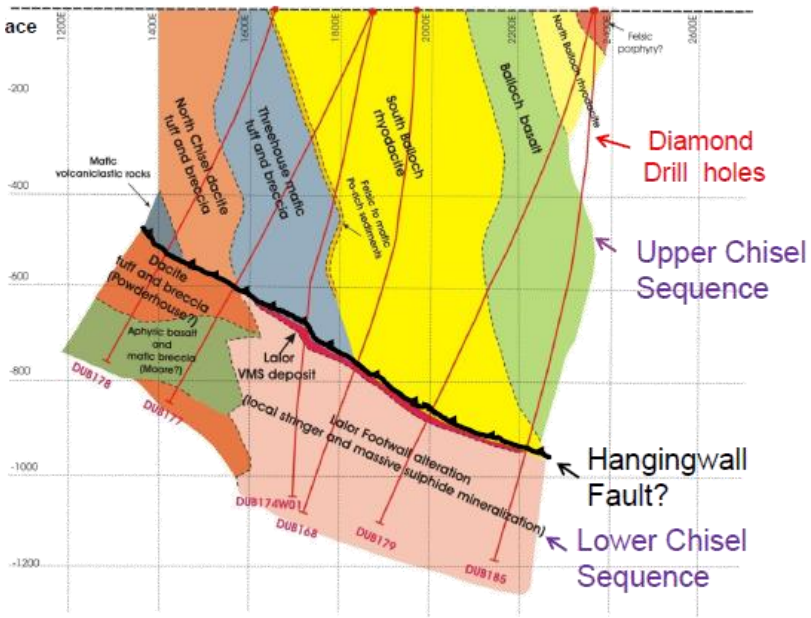
Data-driven 3D Targeting - Lalor



A.H. Bailes and A.G. Galley 2007



Geological Survey of Canada
Kelly Gilmore Hudbay – PDAC 2009

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Data-driven 3D Targeting – Lalor

Objective

- Identify new drill targets within the Snow Lake VMS camp that have similar geological, geochemical, and geophysical characteristics as the Lalor Deposit

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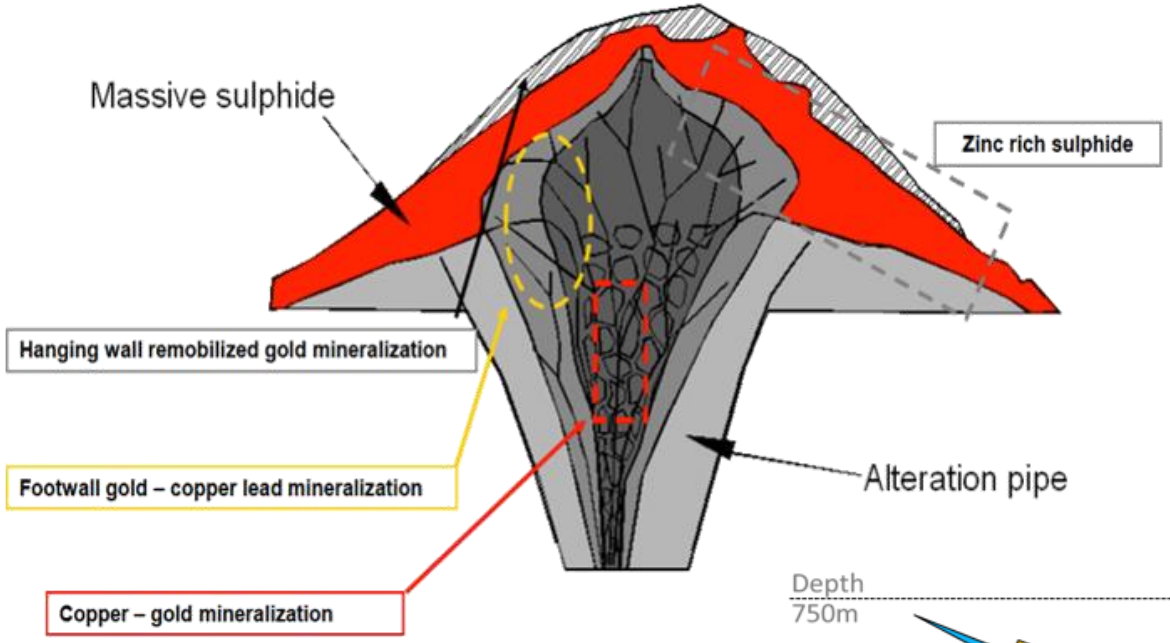
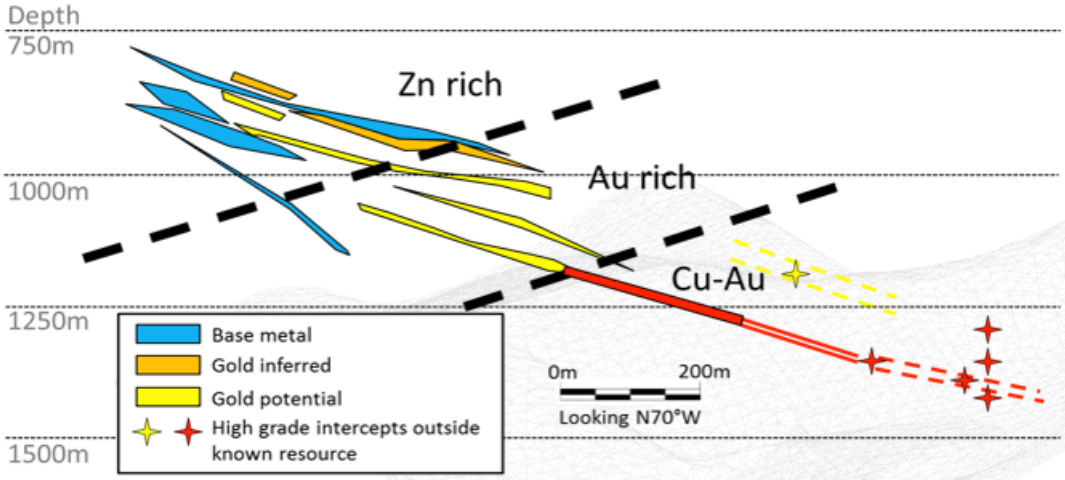
Data-driven 3D Targeting – Lalor

Deposit model



Criteria

- Dacitic host rocks/stratigraphy
- Synvolcanic faults as plumbing system
- Subvolcanic intrusives as heat source
- Later structures affecting the deposit location
- Hydrothermal alteration manifested as chlorite and sericite alteration zones
- Massive sulfide bodies



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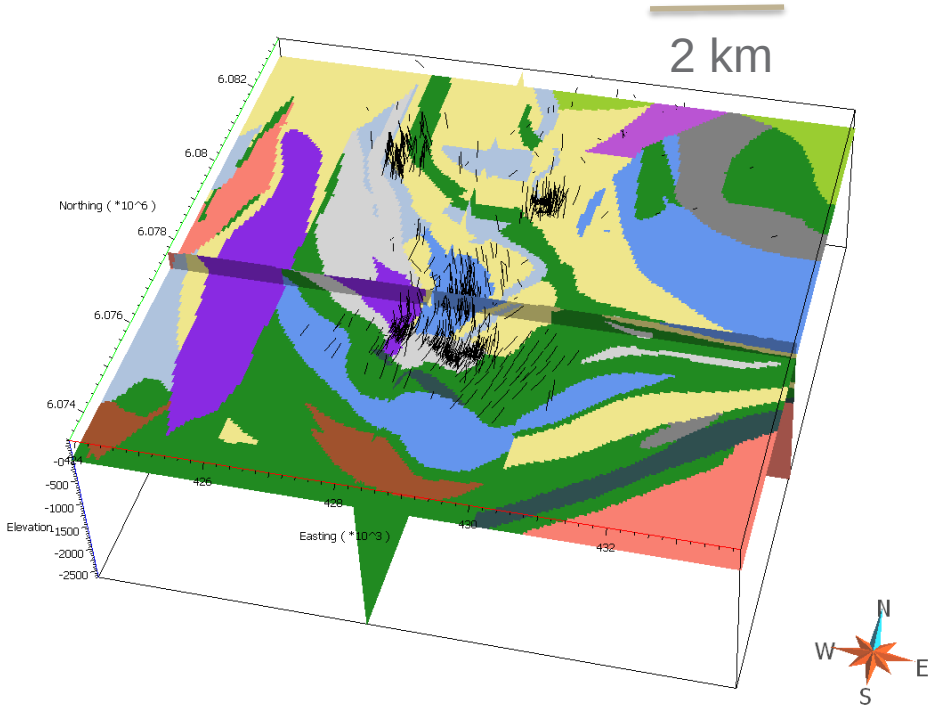
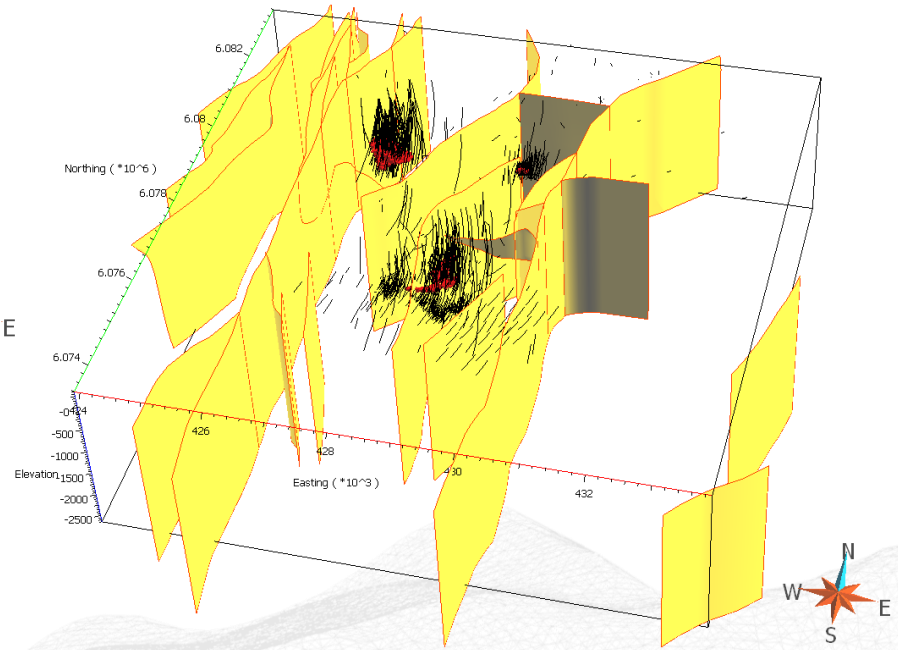
Hudbay Minerals

Lalor - Data and models



- 3D geological model with volcanic stratigraphy and intrusions - prospective geology and units can be identified

- 3D fault model containing the Chisel thrust – heat and fluid pathway and structural controls



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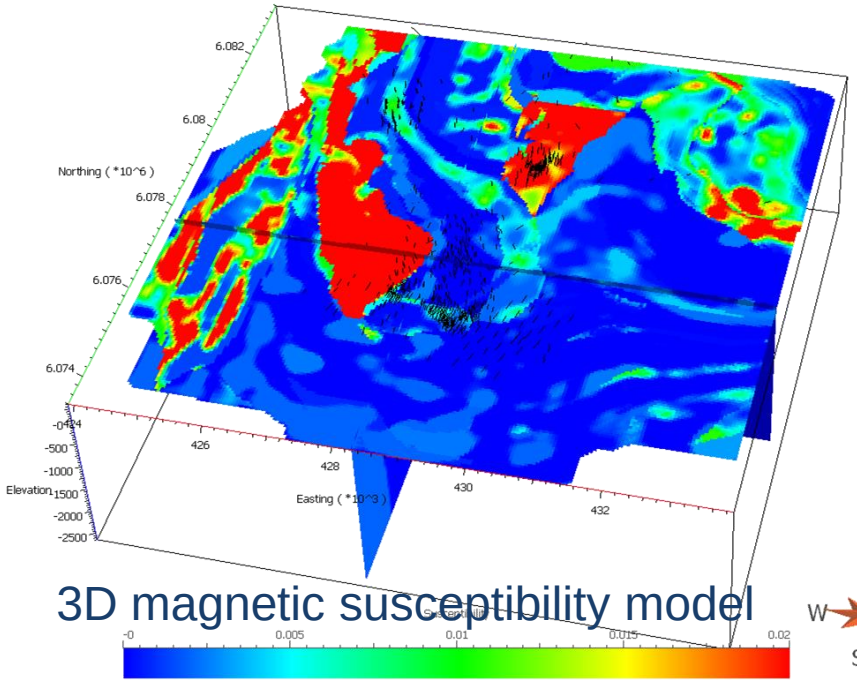
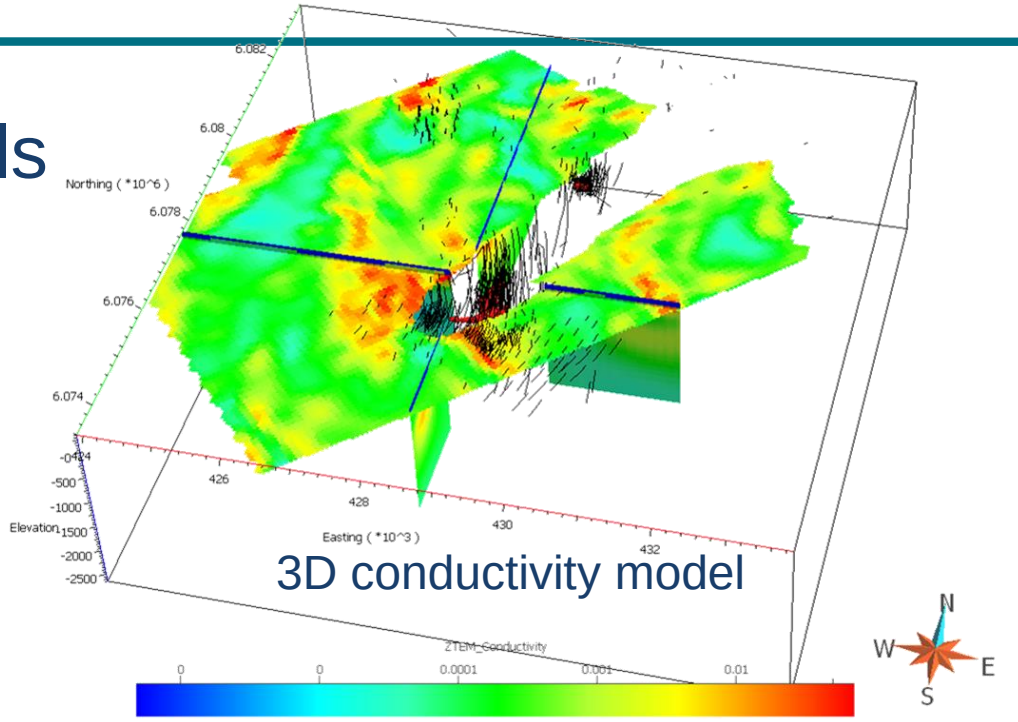
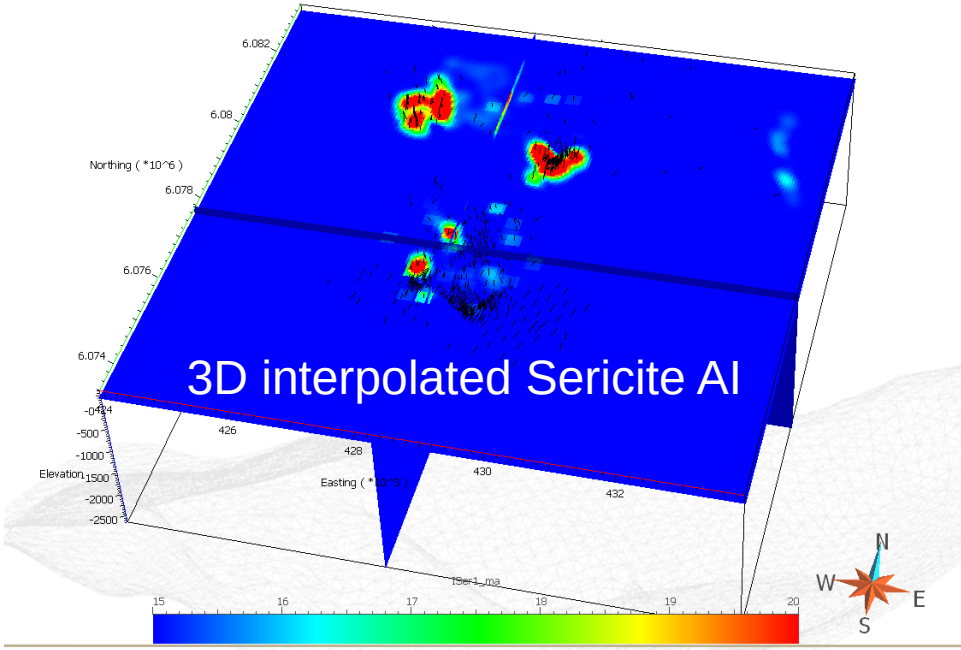
Lalor - Data and models



3D magnetic susceptibility model



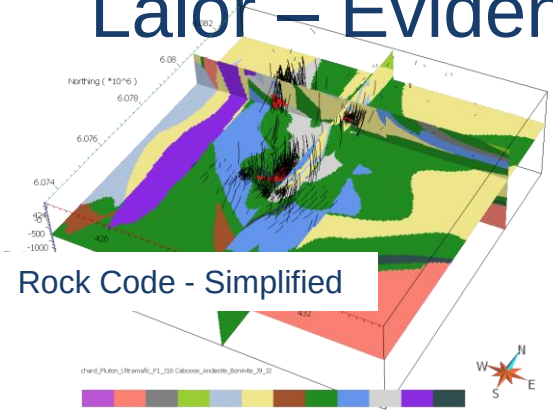
3D conductivity model



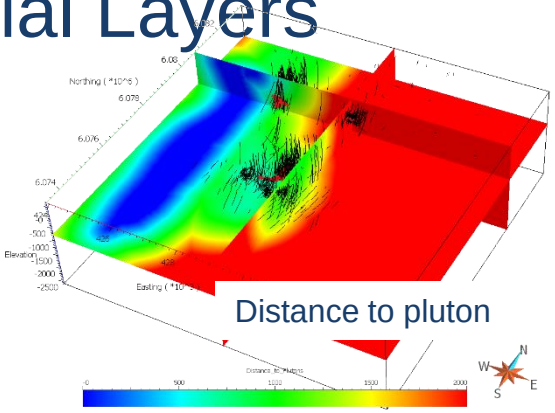
3D interpolated Sericite AI

- Magnetic susceptibility model identifies magnetite-destructive alteration
- 3D conductivity model for either direct detection of mineralization or alteration
- Interpolation alteration indices directly detects alteration

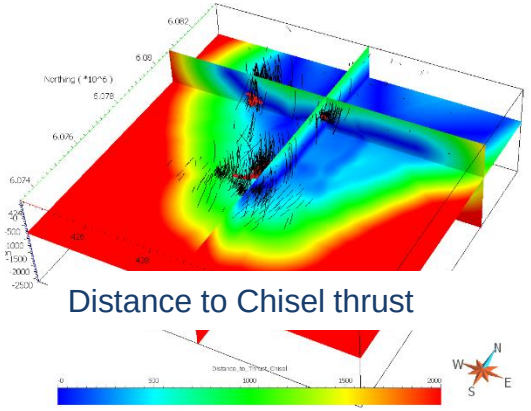
Lalor – Evidential Layers



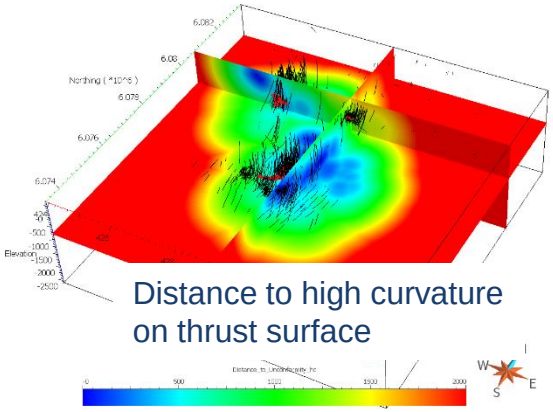
Rock Code - Simplified



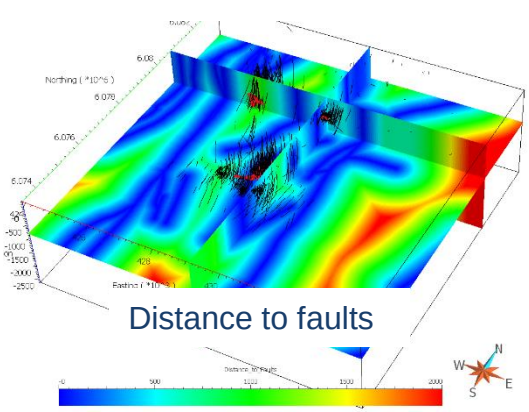
Distance to pluton



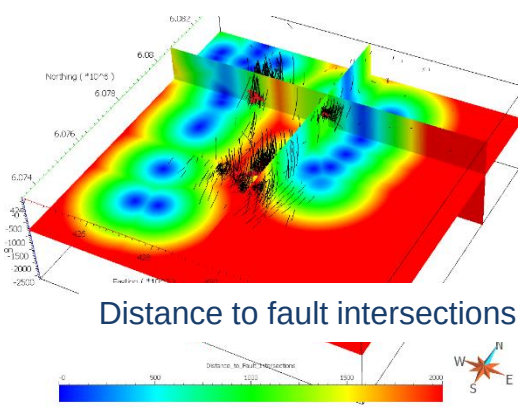
Distance to Chisel thrust



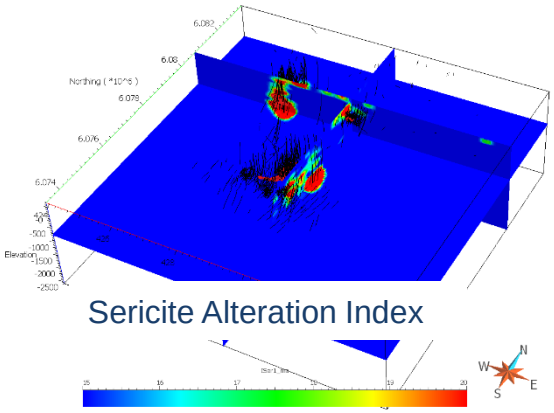
Distance to high curvature on thrust surface



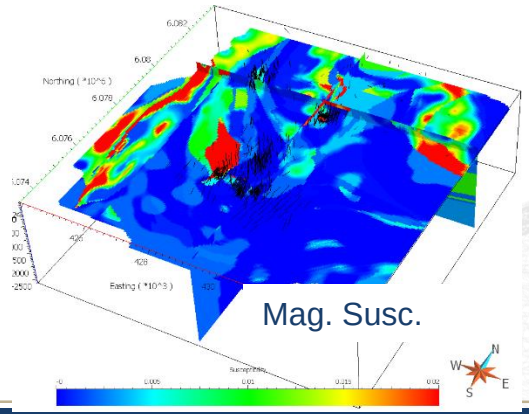
Distance to faults



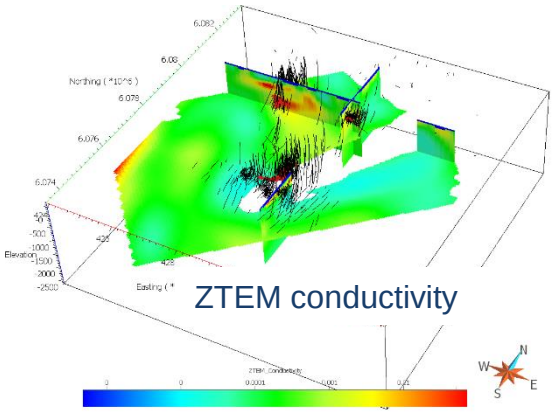
Distance to fault intersections



Sericite Alteration Index

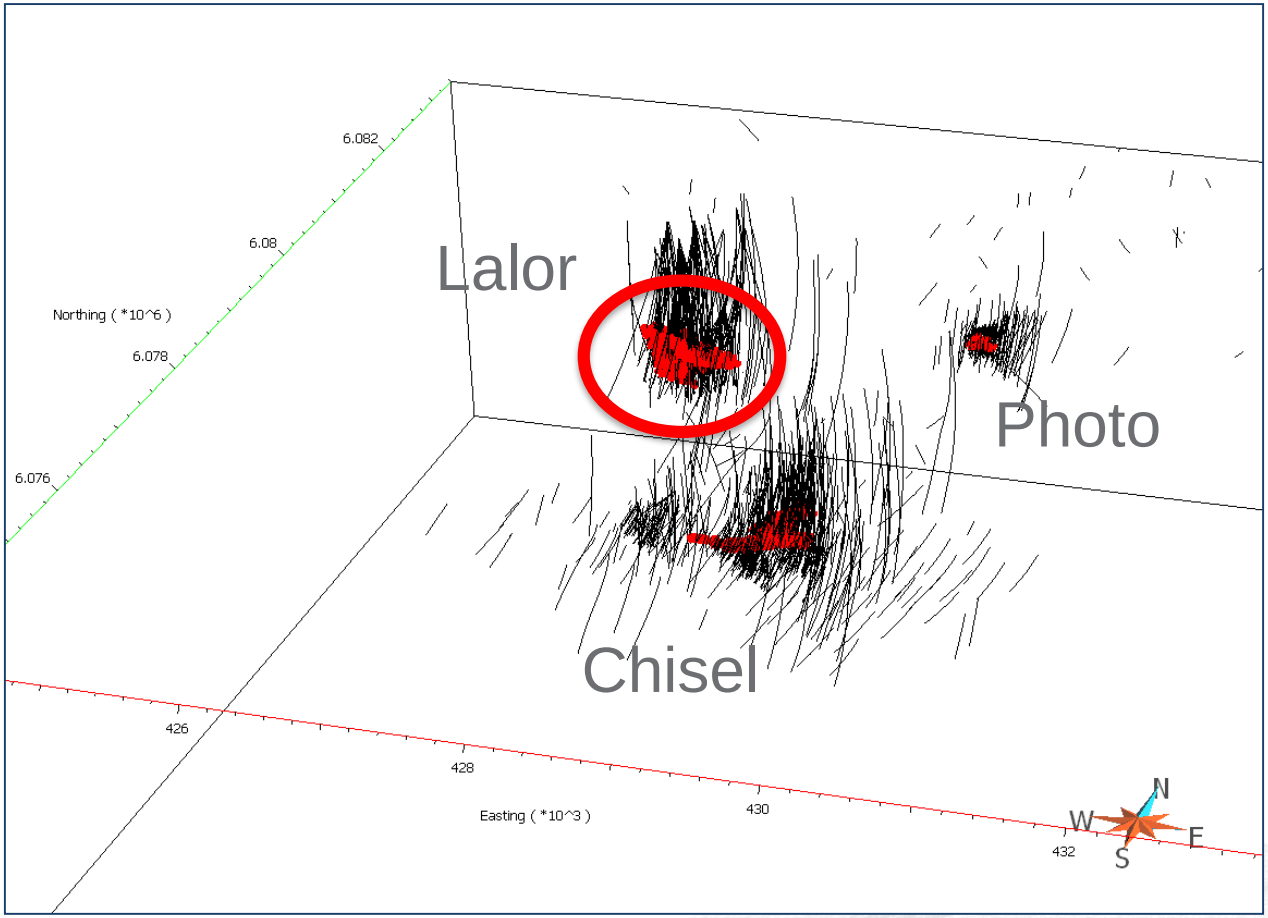


Mag. Susc.



ZTEM conductivity

Lalor – Training Data



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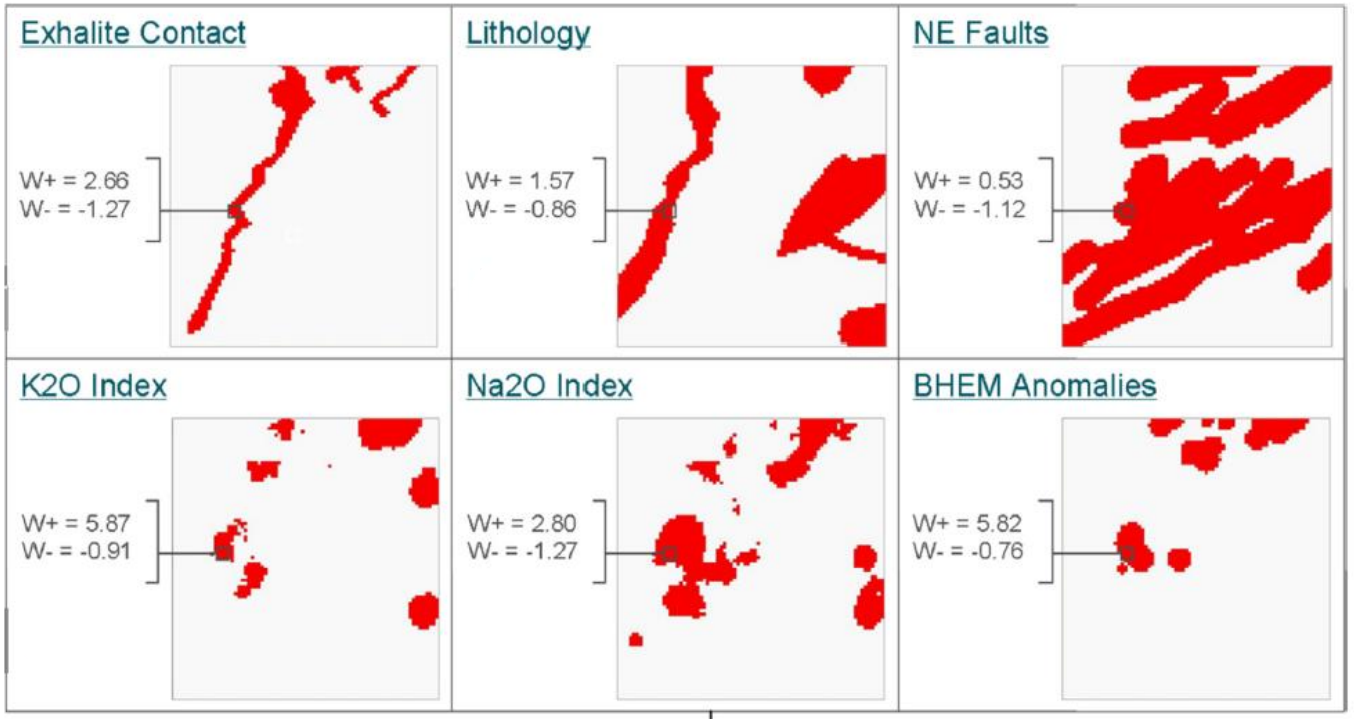
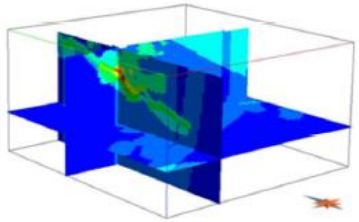
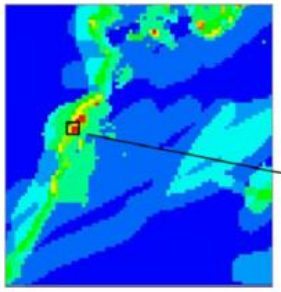
Lalor – Method – Weights of Evidence







$$\text{Prior Probability} = \frac{\#\text{ of training cells}}{\#\text{ of cells in model}} = \frac{343}{546\,504} = 0.063\%$$

$$\text{Posterior Probability} = \text{Prior Probability} + \sum W+/-$$

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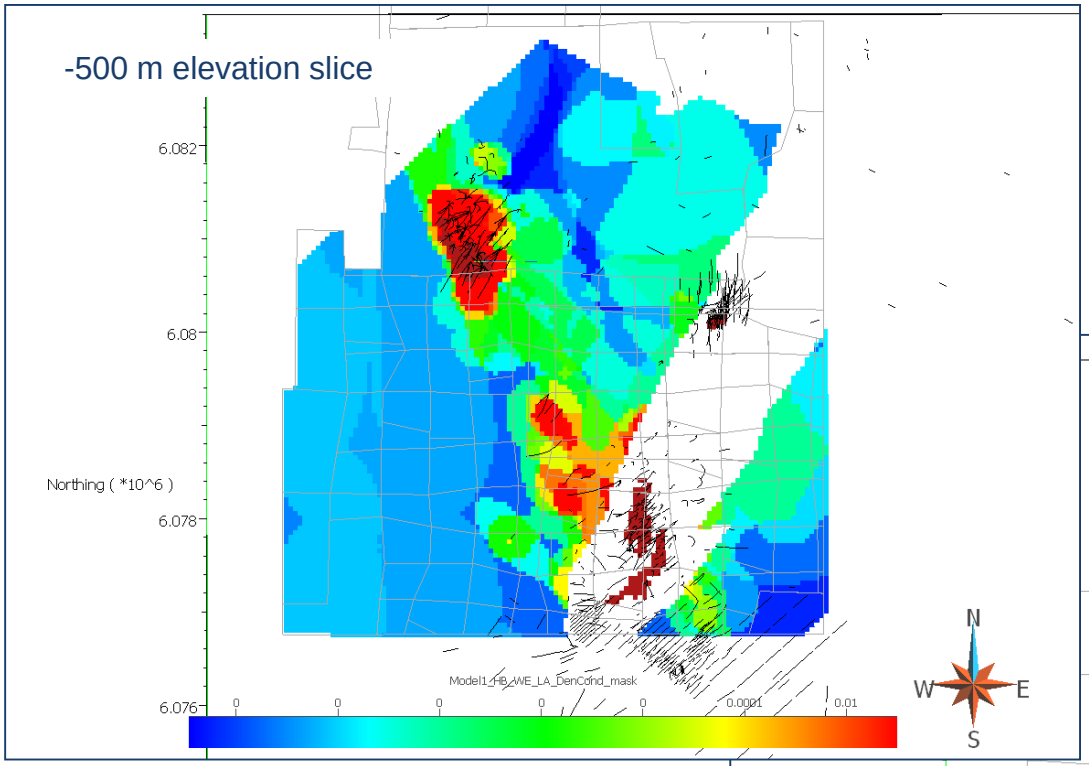
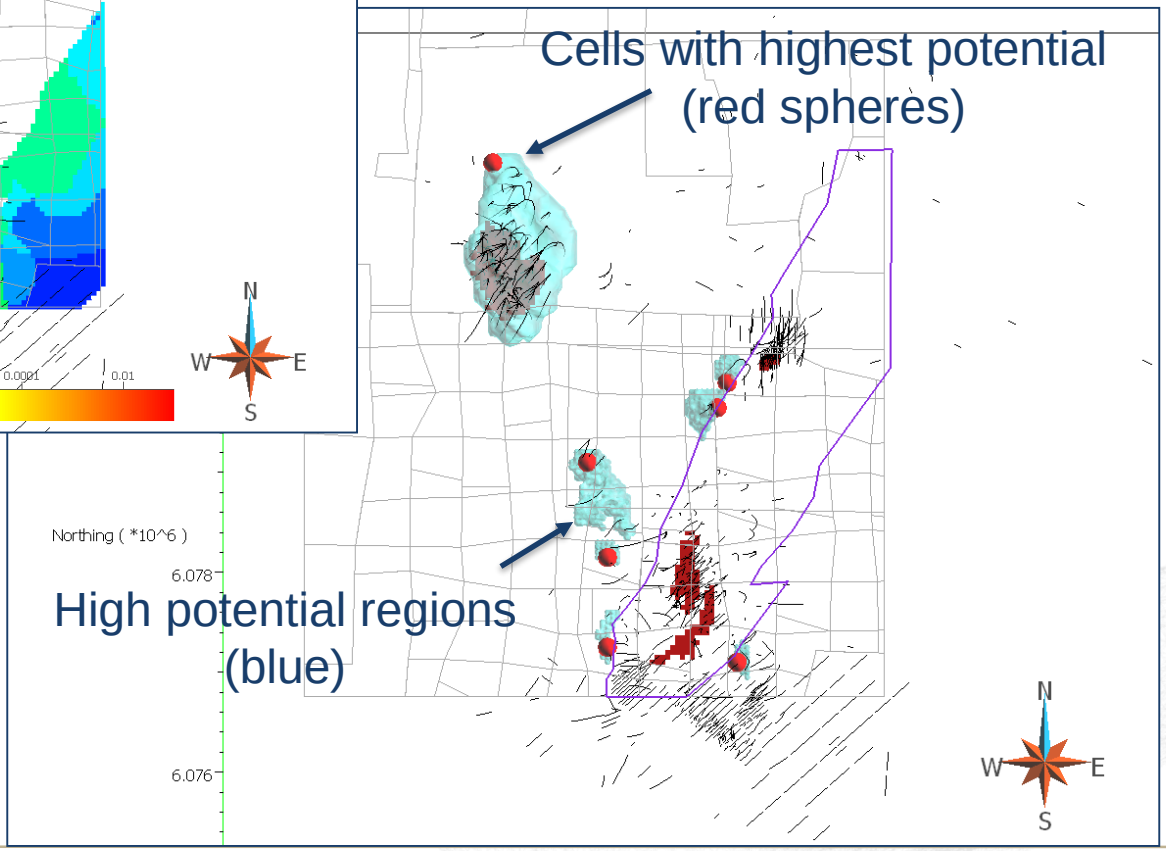
Lalor - 3D Mineral Potential Model





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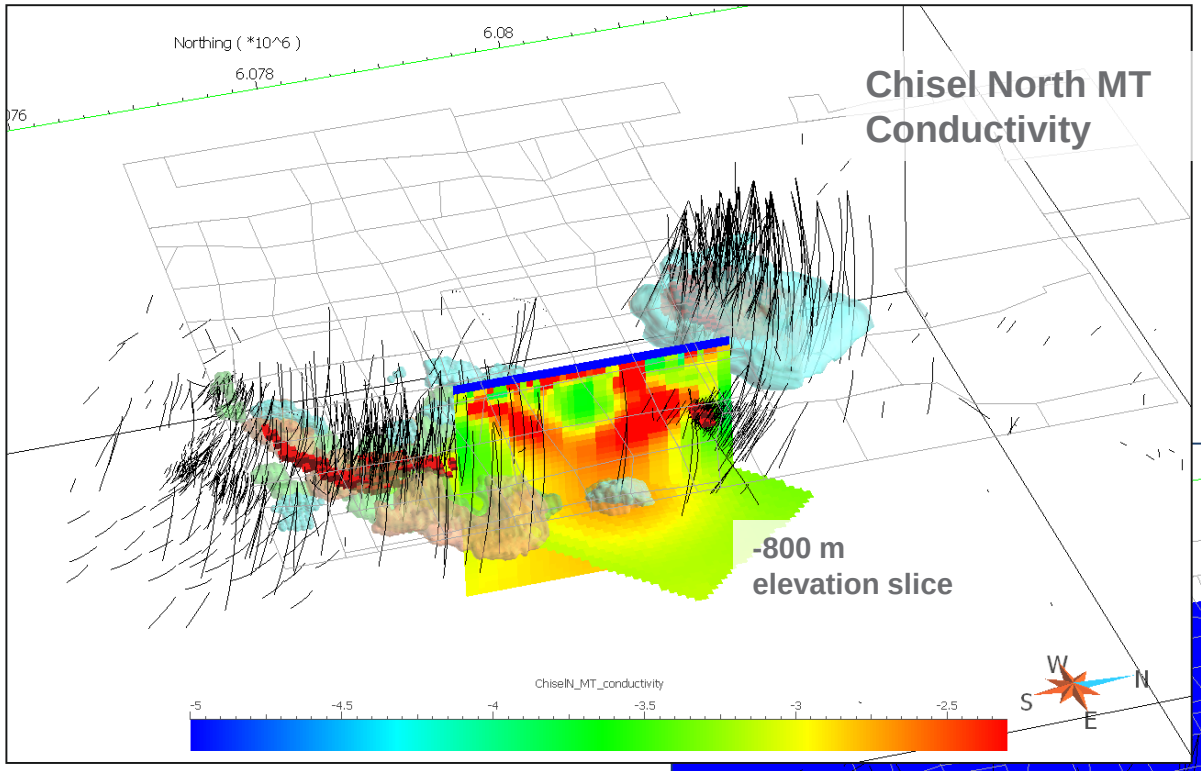
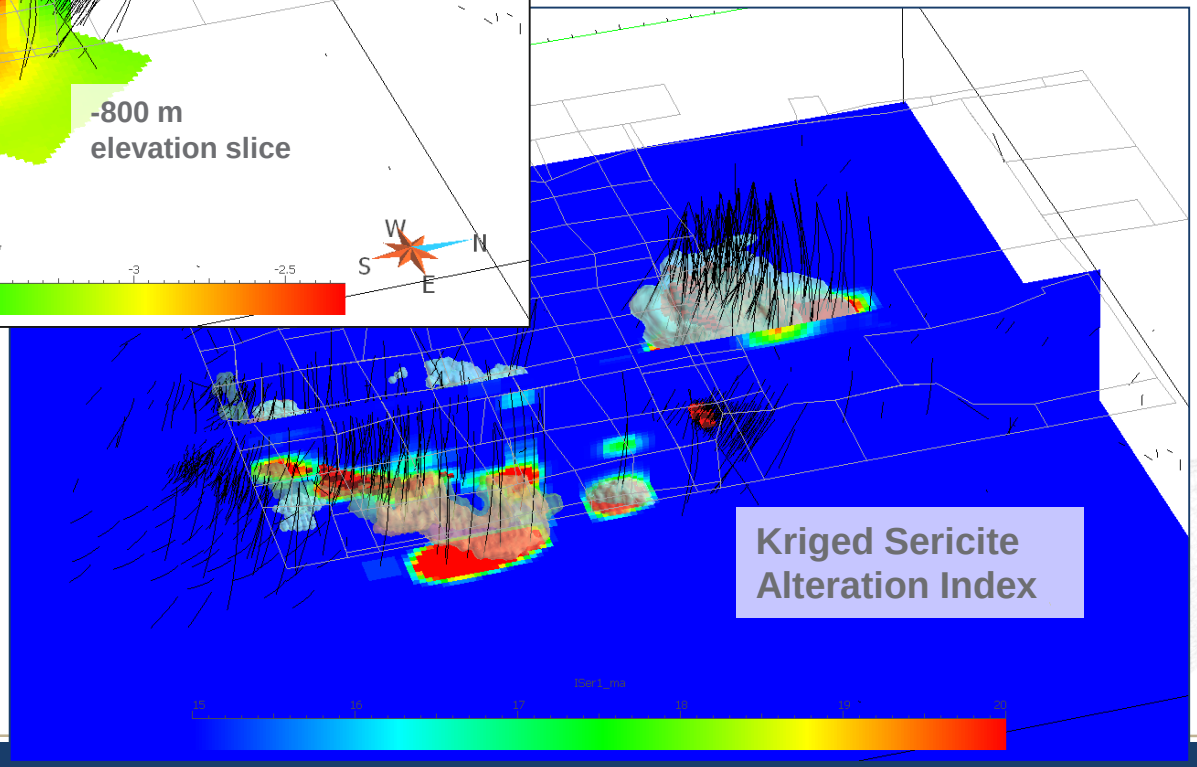
Lalor – Testing Targets with Independent Data





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Summary - Ingredients for 3D Targeting

- 3D data and models, ideally interpreted in an integrated way..
- Computer with 3D software to analyze and model data, and view results of targeting
- List of exploration criteria, with consideration of scale of project, scale of data, deposit model, local geological setting
- Ability to reclassify data and models to be representative of exploration criteria being applied or tested – extracting the critical components of a data set (e.g. distance to edges of high magnetic susceptibility bodies)
- Software or algorithm to query, or analyze data relationships, and someone who understands this software and it's output
- Multidisciplinary geoscientific team working together to build the best models and derive the most accurate interpretation of targets