CSA Global
Mining Industry Consultants

Geoscience BC

BRITISH COLUMBIA GEOLOGICAL SURVEY

Integrated Assessment of Regional Stream Sediment Geochemistry for Metallic Deposits in Northwest British Columbia

Dennis Arne, Rob Mackie, Eric Grunsky,
Chris Pennimpede, Matthew Bodnar & Yao Cui[1]
[1]BCGS

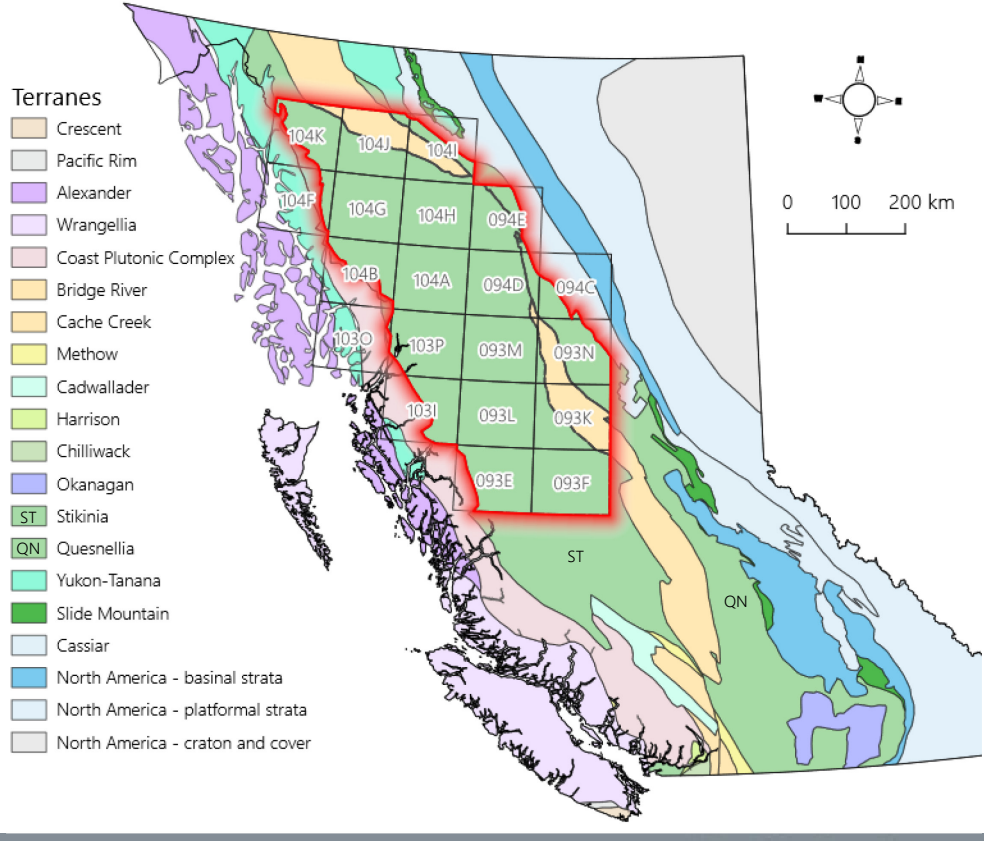
AUSTMINE 2017 AUSTMINE AWARD WINNER
CRAIG SENGER EXCELLENCE IN EXPORT AWARD

Outline

- Project Details
- The Problem
- Objectives
- Catchment Analysis Approach
- Geochemical Assessment Workflow
- Results and Implications

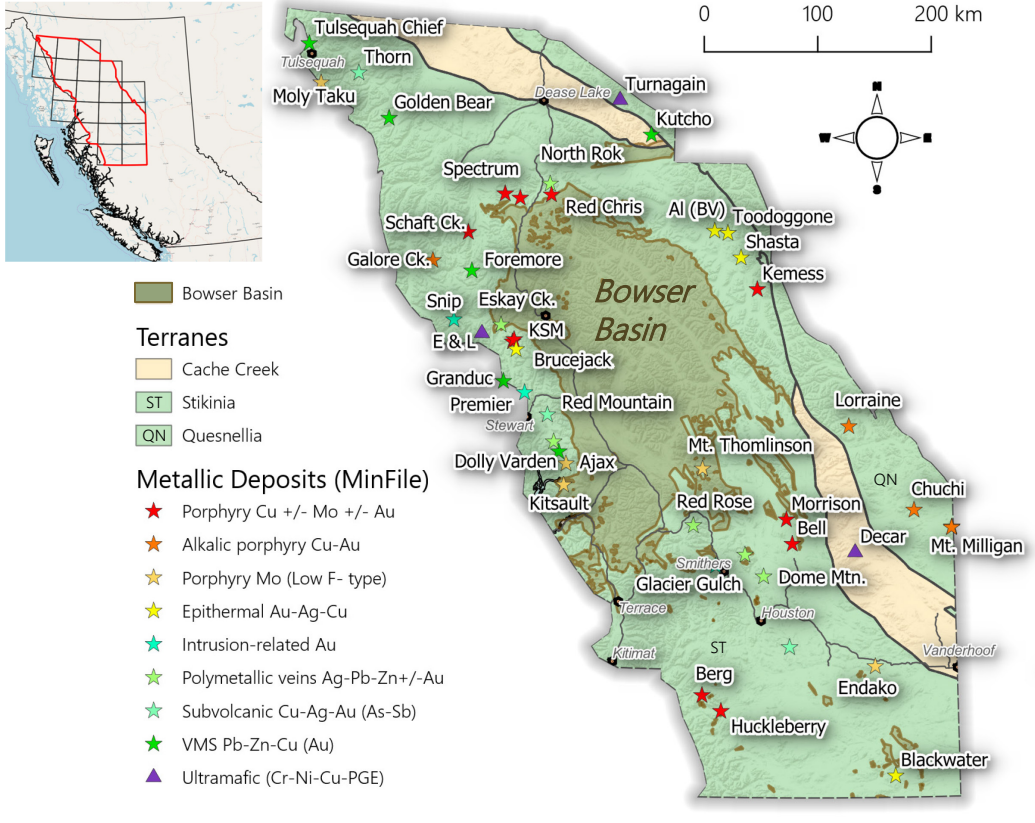
Project Area

- ~200,000 km^2 of NW BC
- Data from 14,863 stream sediment samples interpreted following reanalysis of archived material by Geoscience BC using ICP-MS/OES
- Area dominated by the Stikine terrane, but with Quesnel and Cache Creek also present
- Overlain by Jurassic sediments of the Bowser Basin



Metallic Deposits

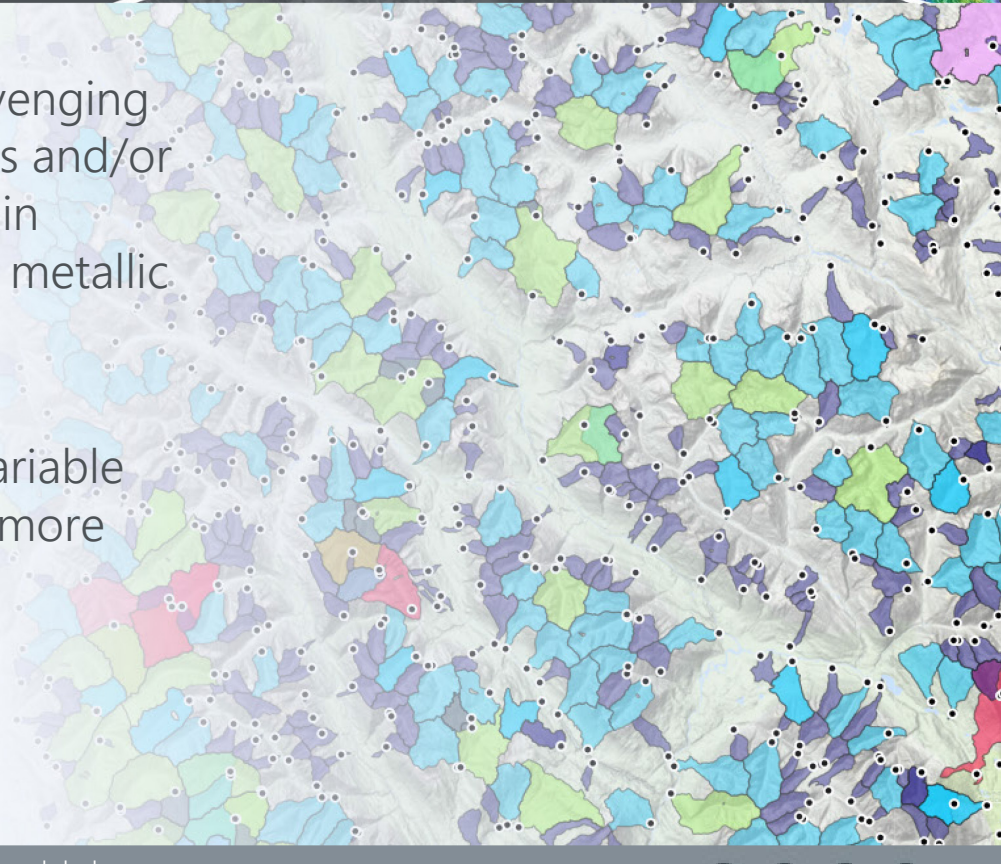
- Many mineralization types occur in the project area:
  - Porphyry Cu
  - Epithermal Au-Ag
  - Polymetallic vein-hosted
  - VMS / VHMS
  - Magmatic Ni-Cu-PGE
  - 'Golden Triangle'
- Bowser sediment cover a challenge to exploration (~45,000 km^2)



The Problem

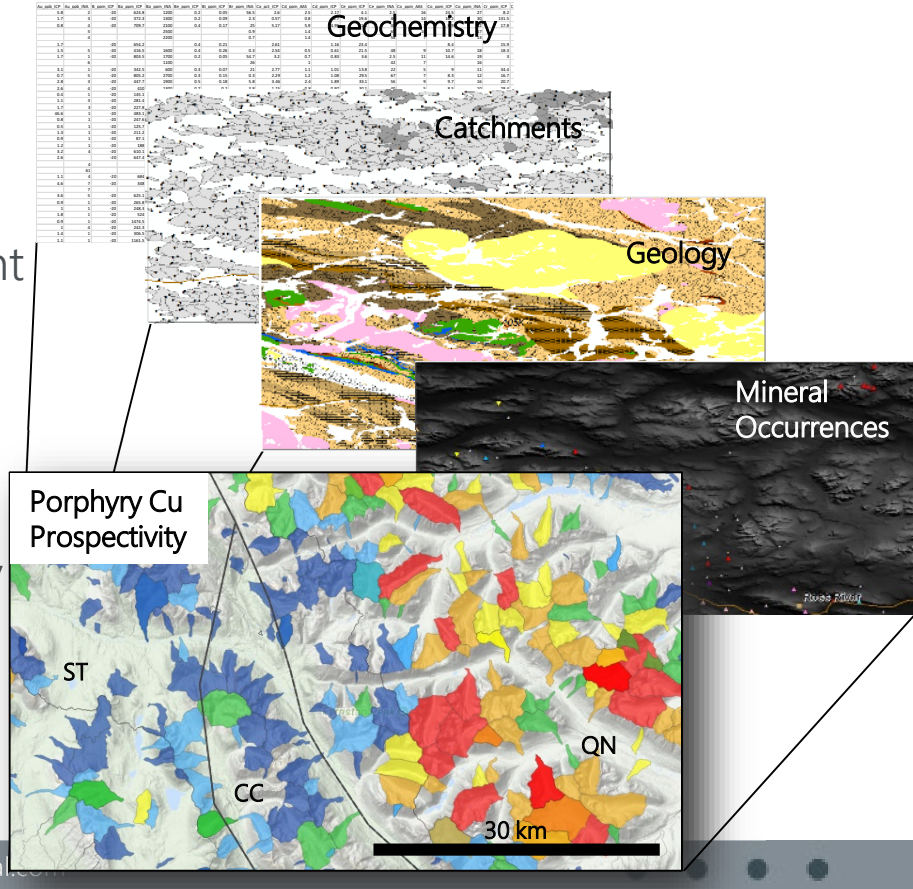
- Variable lithology and secondary scavenging effects of hydrous Fe/Mn-oxides, clays and/or organic material can mask responses in stream sediment chemistry related to metallic mineralization

- How can we filter out the effects of variable lithology or scavenging to develop a more robust prospectivity map for specific mineralization styles?



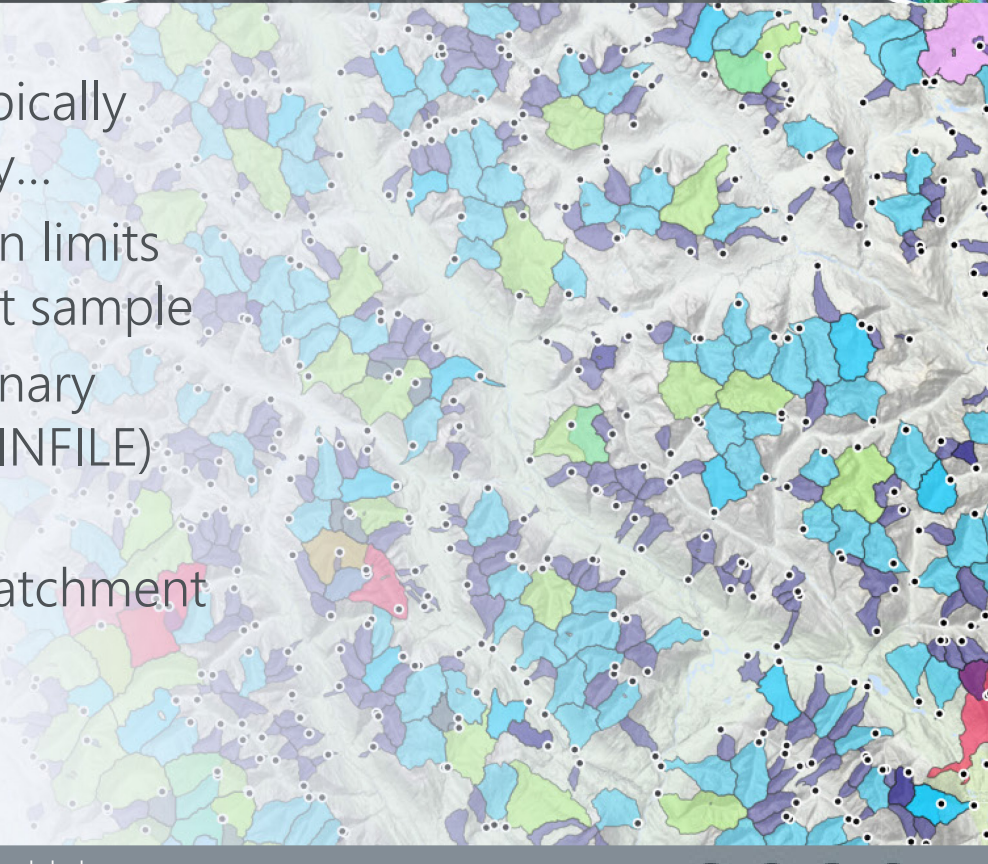
The Objectives

- Interpret compiled re-analysed stream sediment geochemical north-west British Columbia
- Integrate geochemistry with the catchment basins, bedrock/Quaternary geology and MINFILE mineral occurrences
- Evaluate a variety of data treatment and advanced data analysis methods so that the results from different approaches may be compared
- Generate catchment prospectivity for mineral deposit types



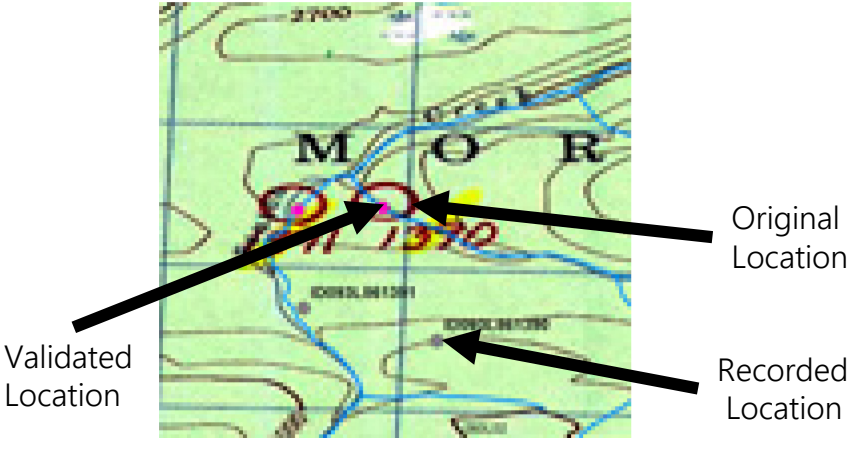
The Catchment Approach

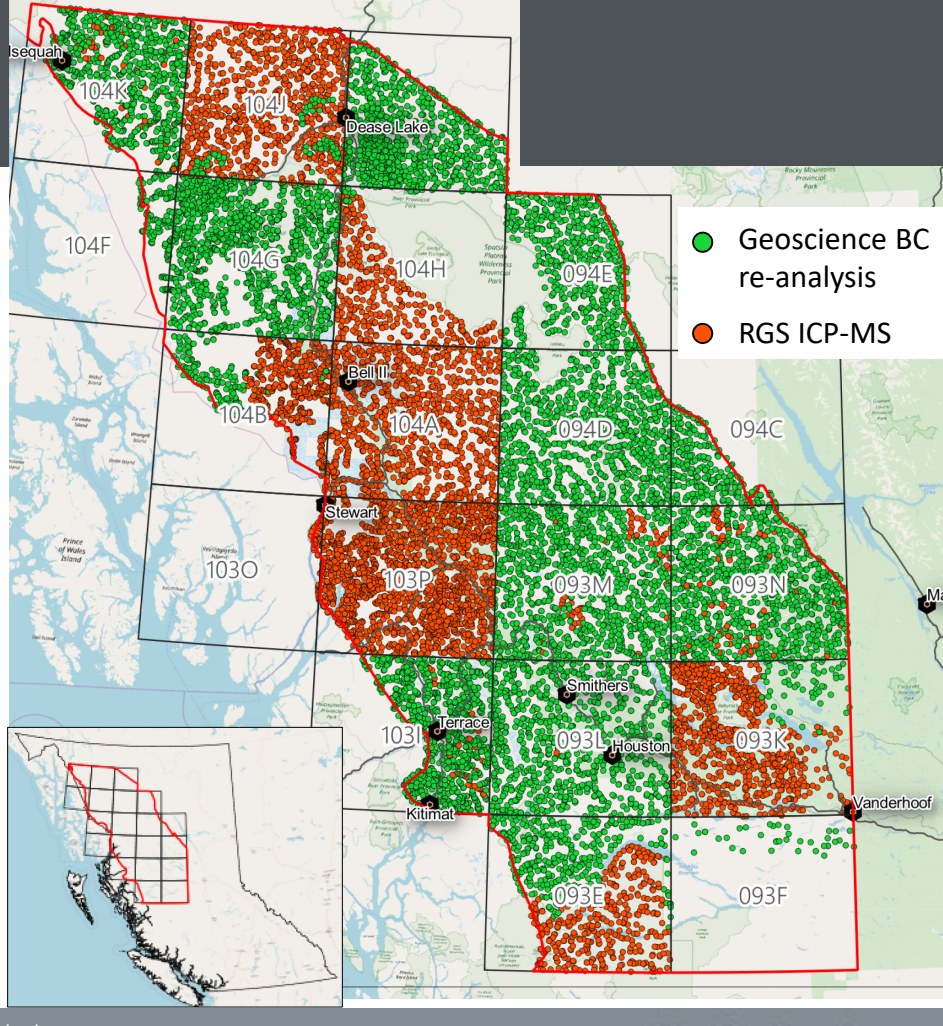
- Stream sediment geochemistry typically reflects upstream bedrock geology…
- Delineate effective catchment basin limits and area for each stream sediment sample
- Query bedrock geology or Quaternary cover and mineral occurrences (MINFILE) for each sample
- Correct for dilution effects using catchment basin polygon area (sqrt of area)



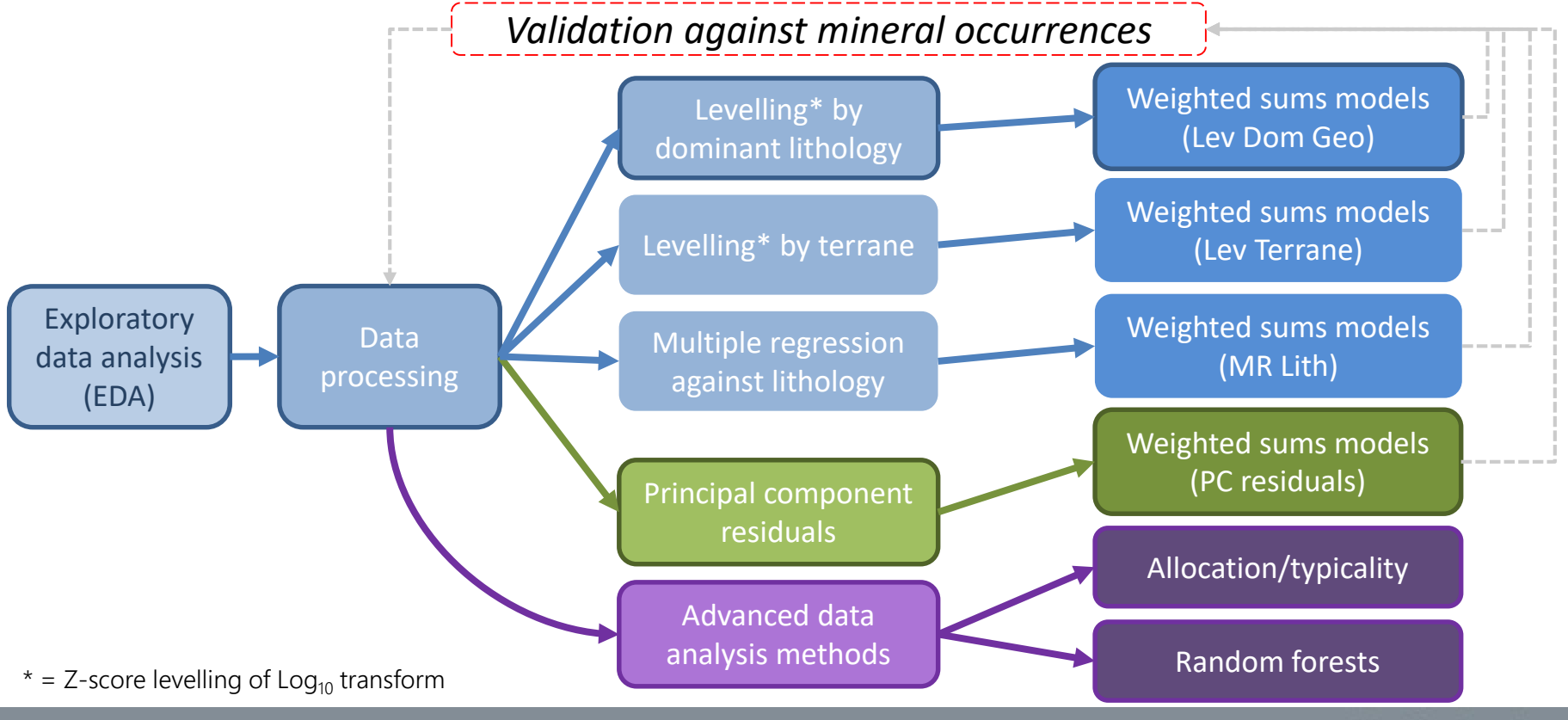
Location Validation

- Original locations recorded on hard copy maps and then transcribed manually
- Sample locations verified with archived maps and adjusted to TRIM hydrology in GIS





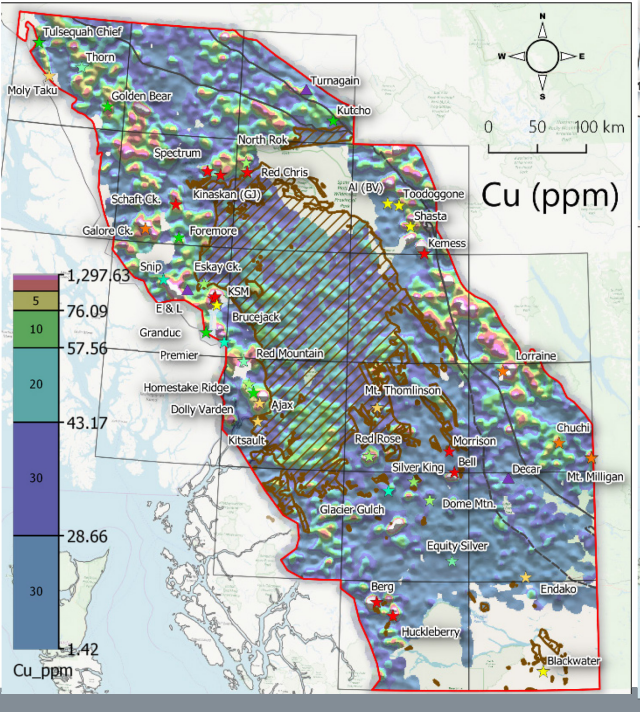
The Workflow

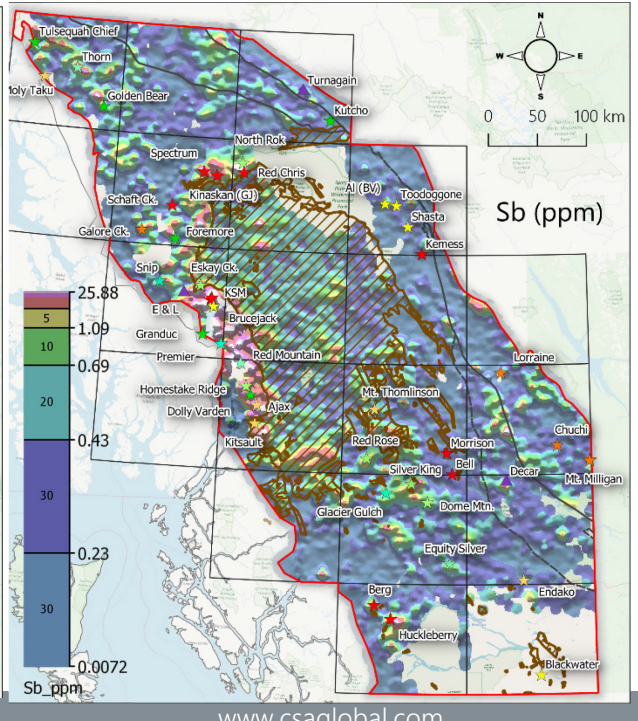


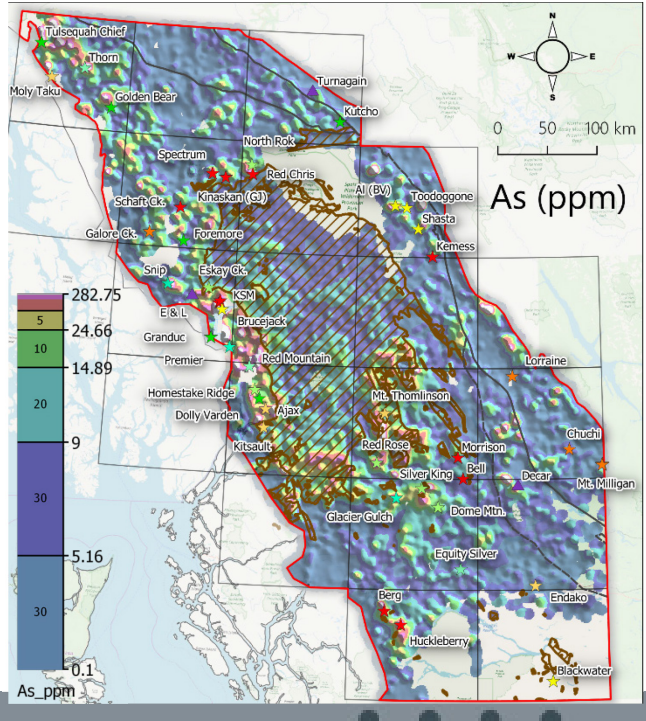
* = Z-score levelling of Log_{10} transform

Raw Element Patterns

- Commodity and pathfinder elements influenced by lithology (e.g. Bowser Basin)
- Raw element gridded images are informative, they reflect only obvious signatures.

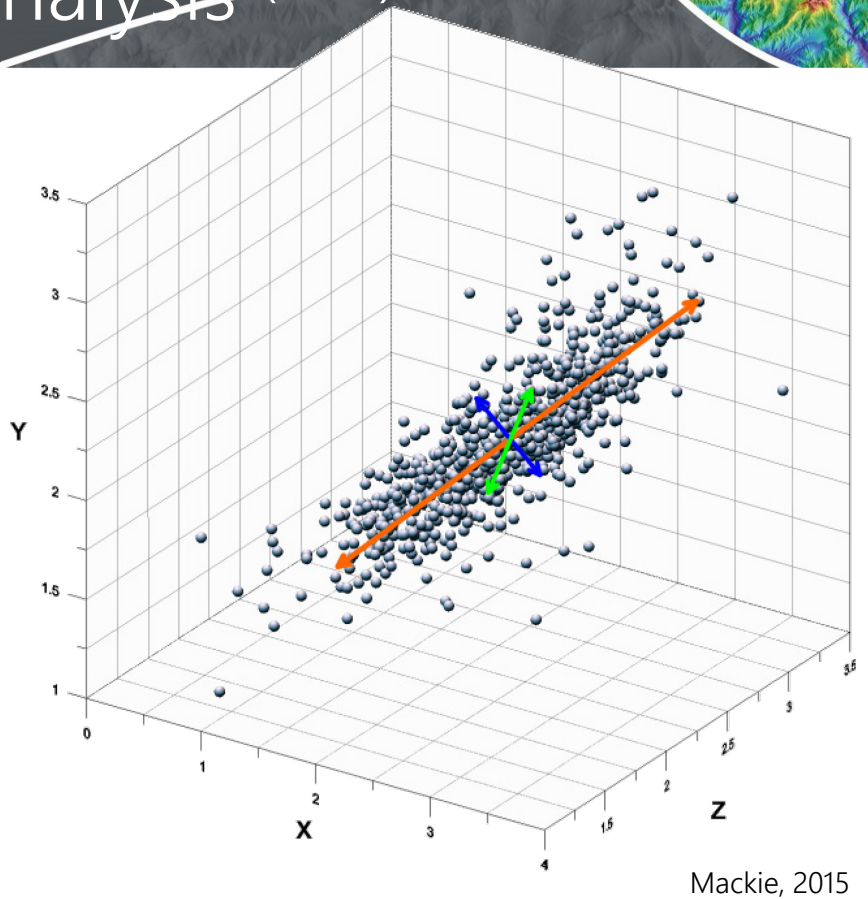






Principal Component Analysis (PCA)

- Mathematical routine that incorporates all available / suitable elements
- Identifies compositional trends that explain variability in multi-element dataset
- 'Principal' components are combinations of highly correlated elements
- Components are numbered according to the proportion of variation they explain
- Most important principal components *typically* reflect bedrock lithology
- Input used centred-log ratios to correct for the effects of geochemical closure



Mackie, 2015

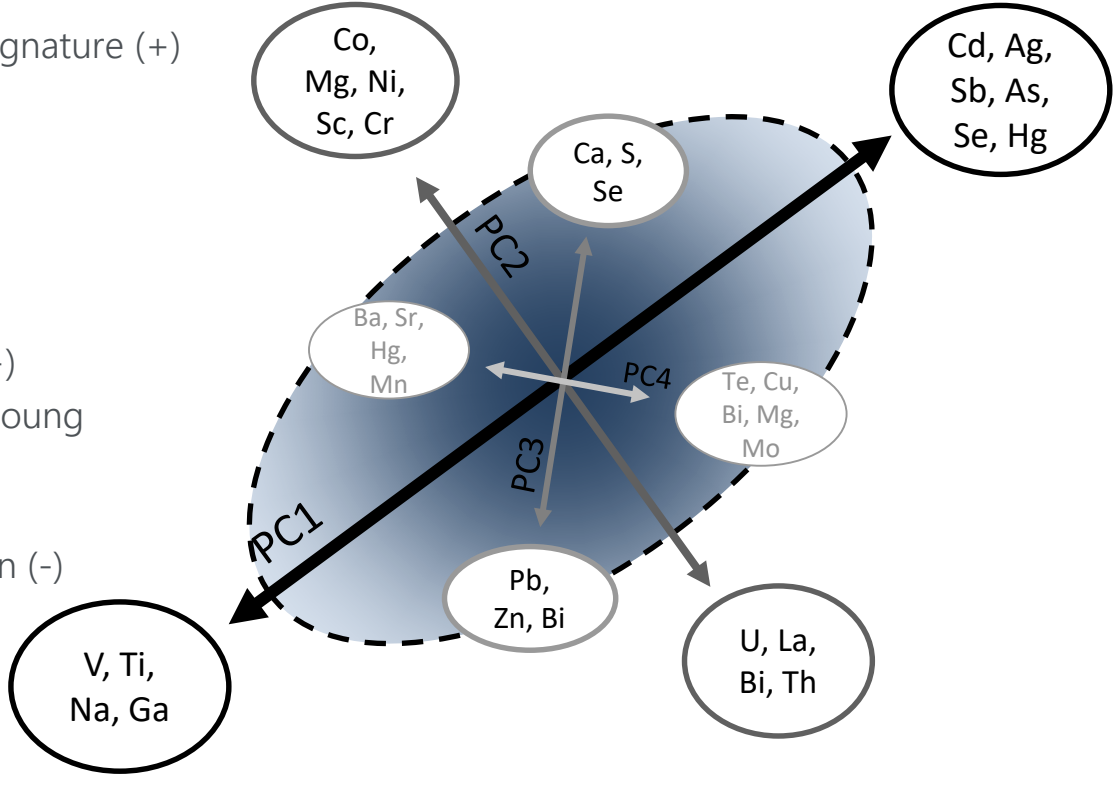
Principal Components

PC1:
- Metallic pathfinder element signature (+)
- Intrusive rocks (-)

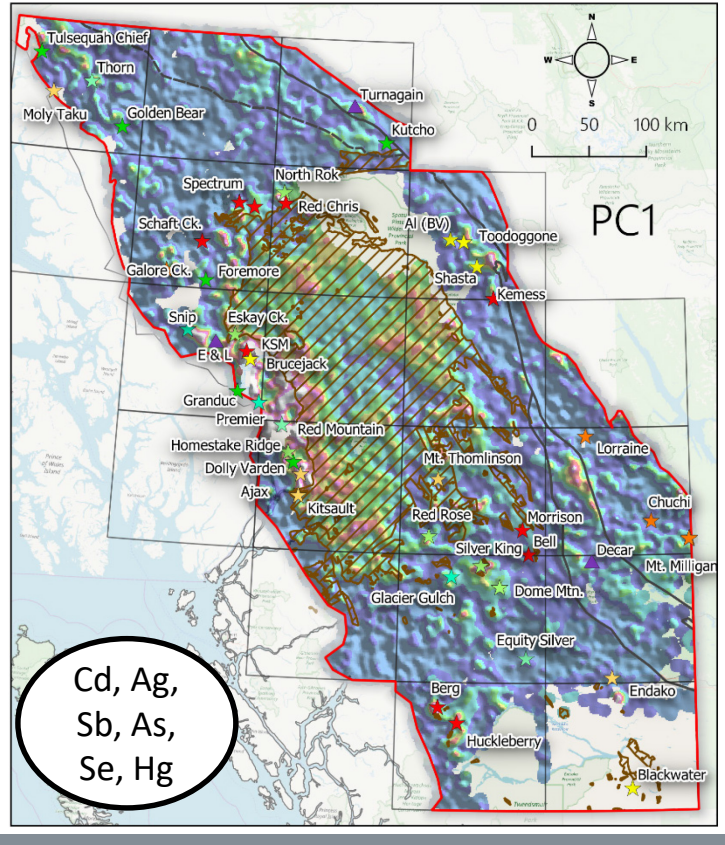
PC2:
- Mafic / ultramafic rocks (+)
- Felsic rocks (-)

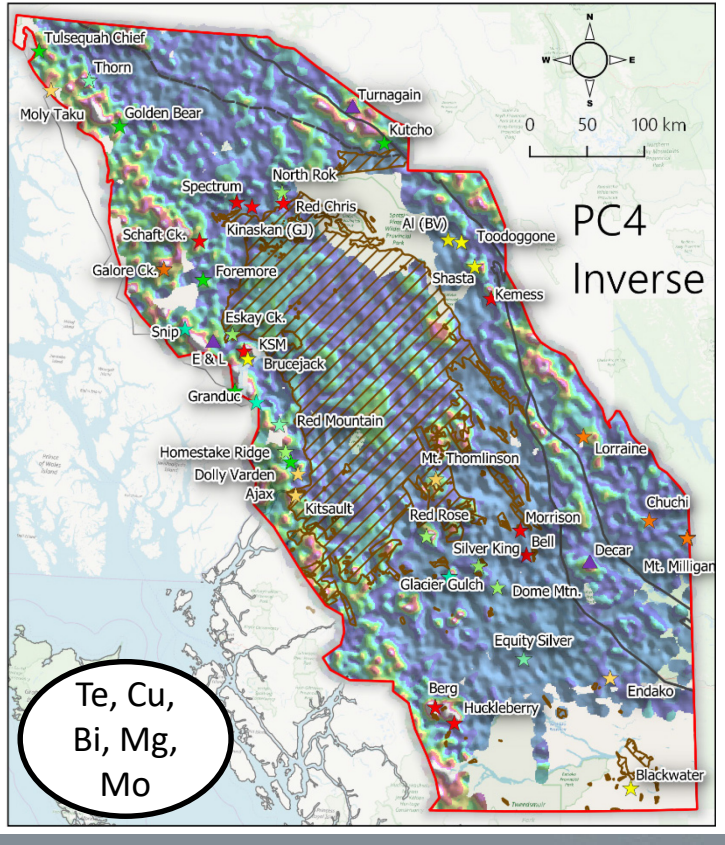
PC3:
- Possible scavenging effects (+)
- polymetallic vein deposits & young volcanics (e.g. Mt. Edziza) (-)

PC4:
- Scavenging by organics (+)
- Porphyry Cu-Au mineralization (-)



Principal Component Maps

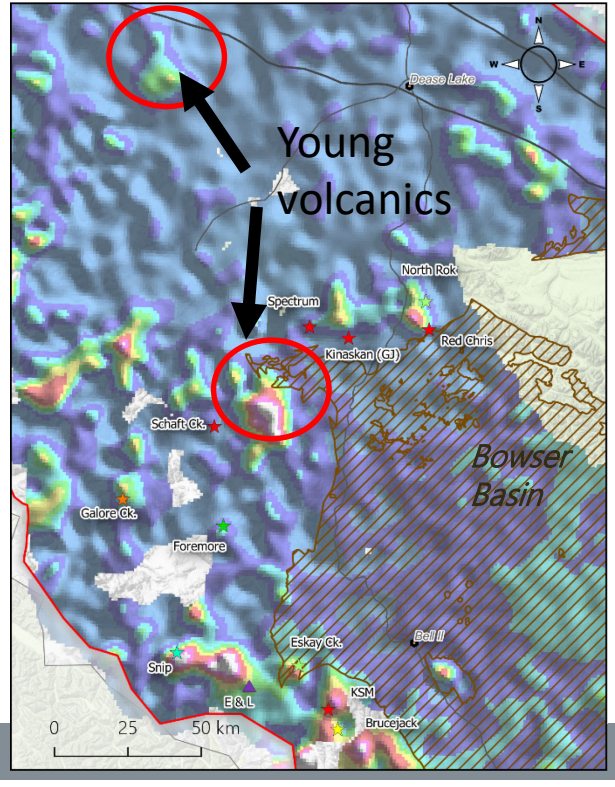




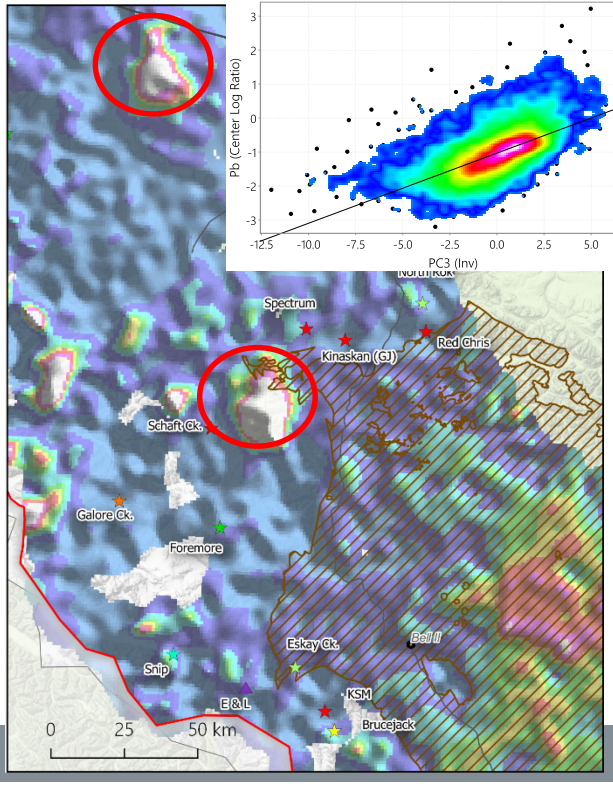
PC Residuals

- Regress raw element against PC to isolate geochemical signature, e.g. Pb

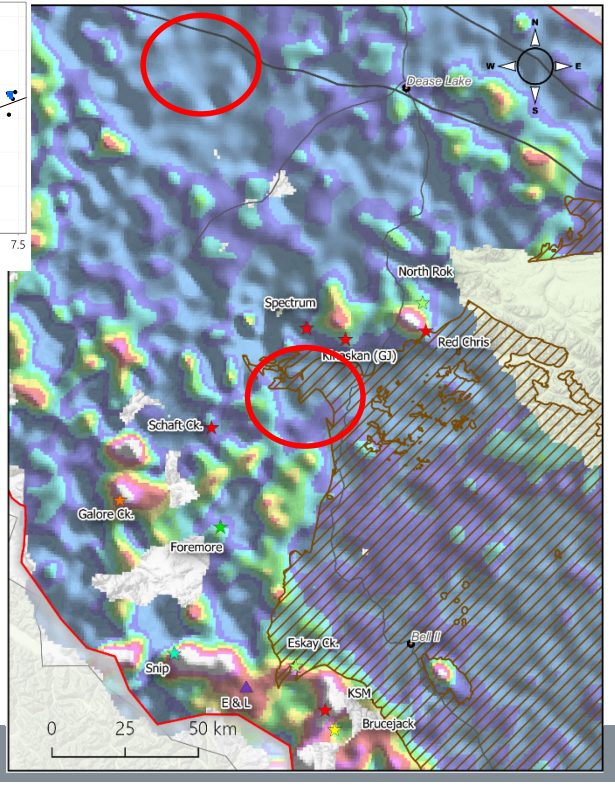
Pb (ppm) CLR



PC3 inverse



Pb residuals - PC3 inverse



Weighted Sums Modeling

- Assign importance rankings to selected variables based on a-priori knowledge of the mineralogy/chemistry of a target deposit type
- Positive rankings used for those elements that are expected to be high in the target deposit type
- Negative rankings used for elements expected to be low in the target deposit type

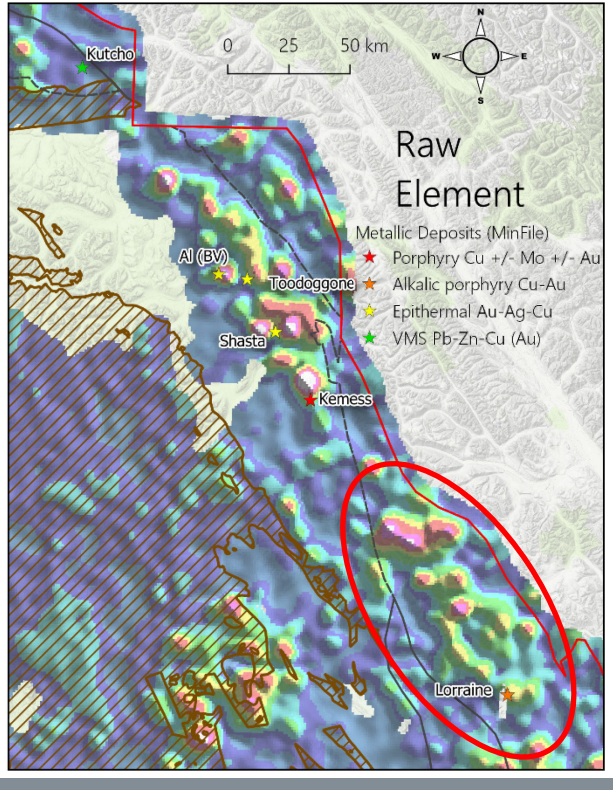
Example;

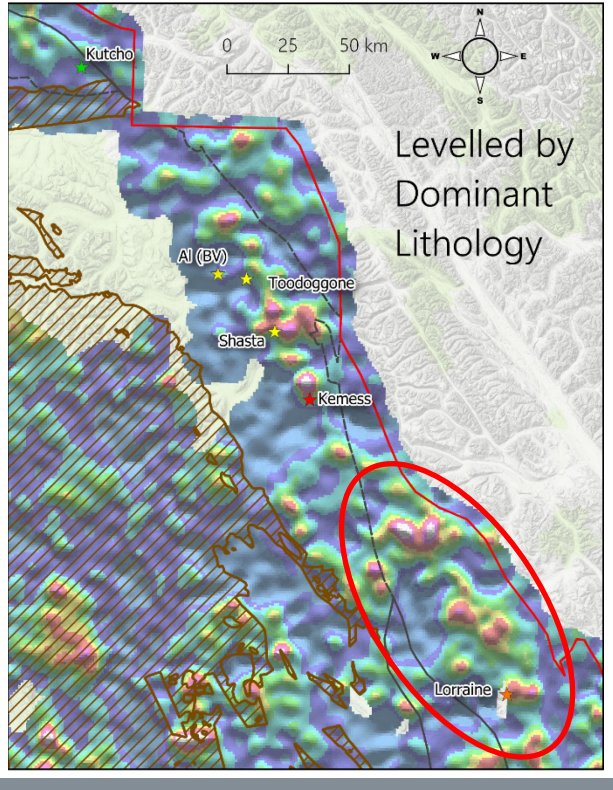
	Pb	Zn	Ag	As	Ba	Sb
SEDEX Pb-Zn	4	4	2	1	1	-2

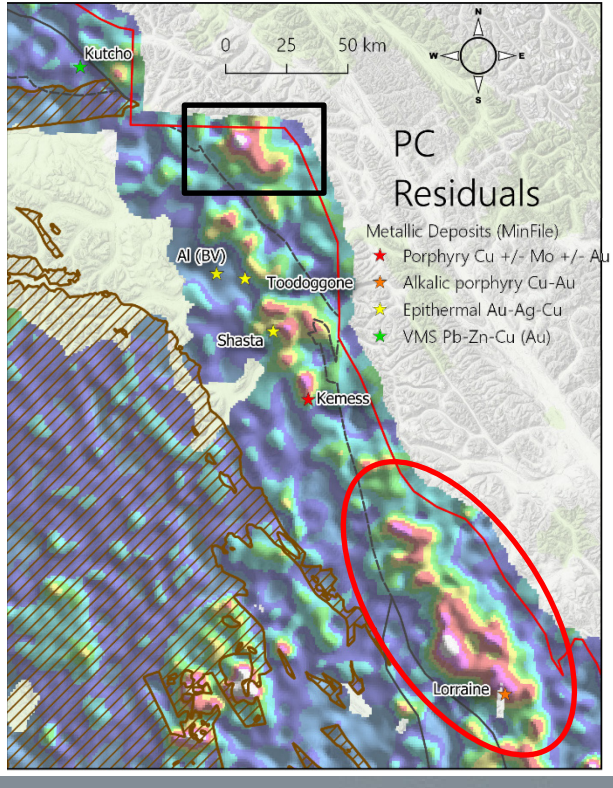
Garrett & Grunsky, 2001

Porphyry Cu - Lorraine

Weighted Sums Models (Cu, Au, Bi, Mo, Te, As)

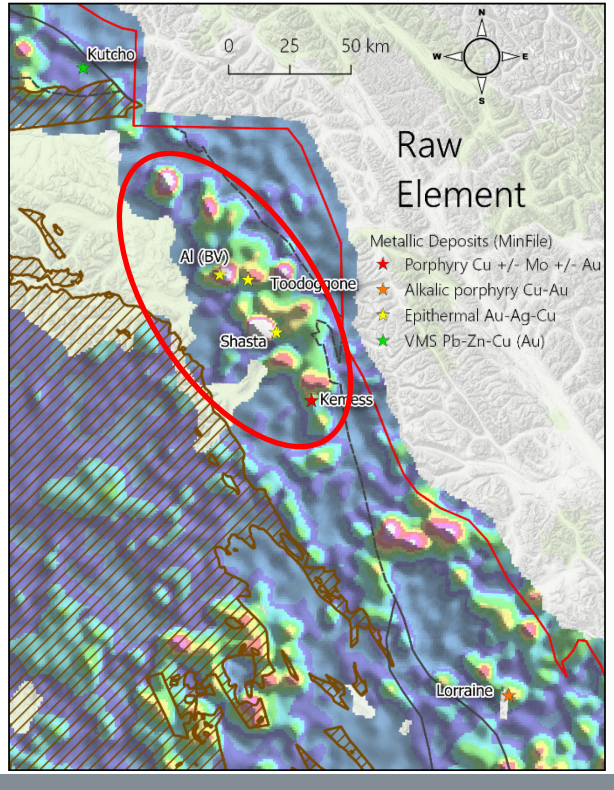


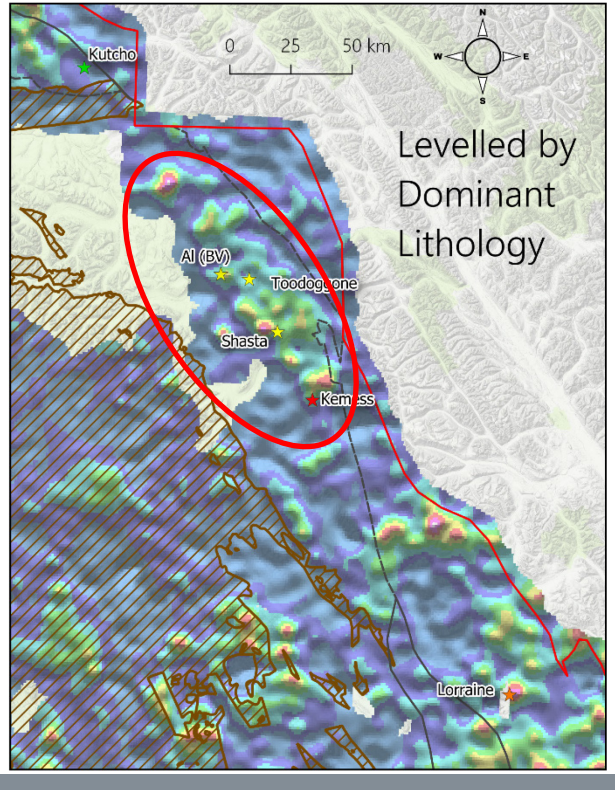


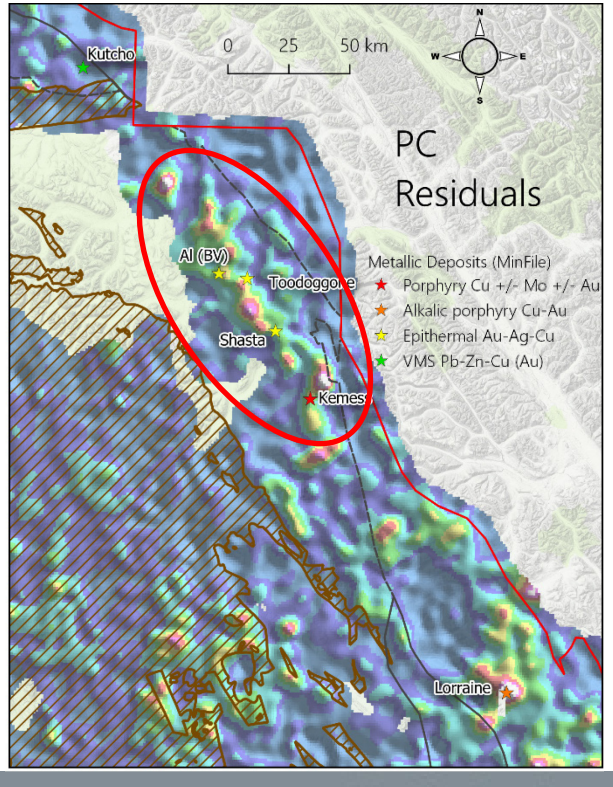


Epithermal Au-Ag - Toodogonne

Weighted Sums Models (Au, Ag, Sb, As)

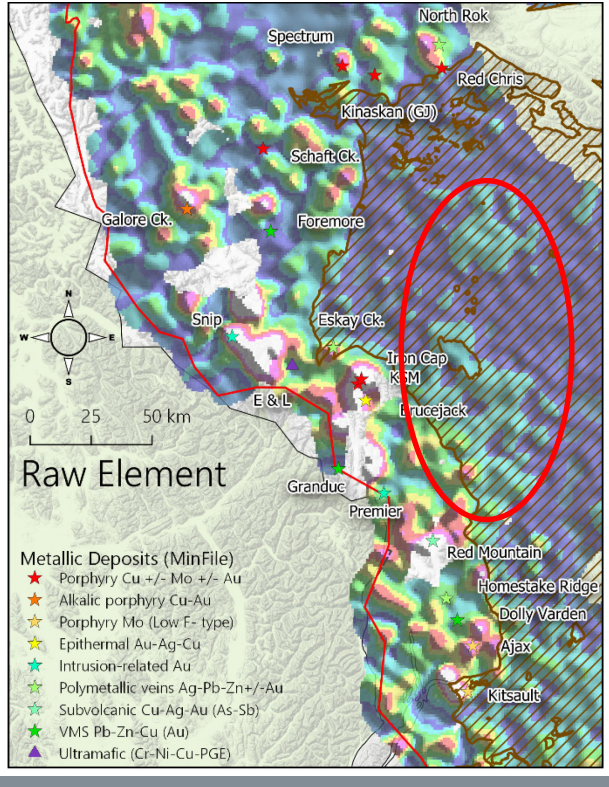


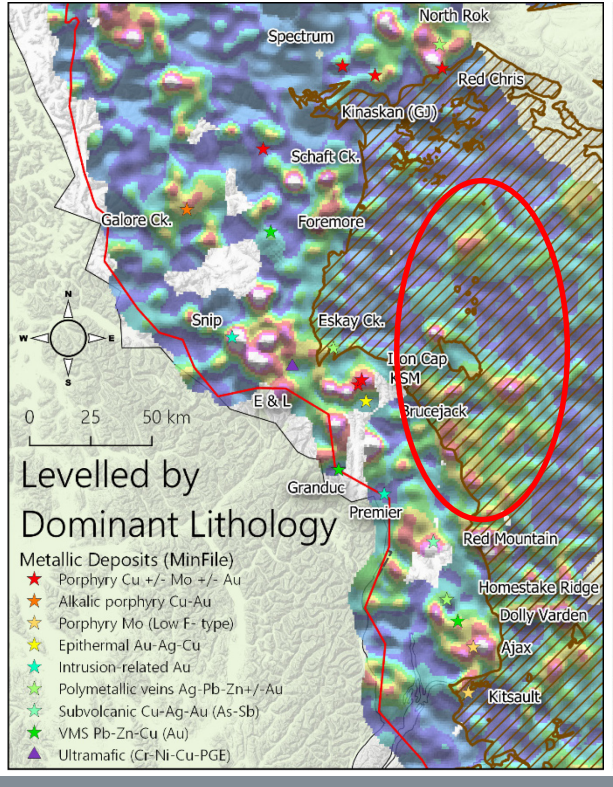


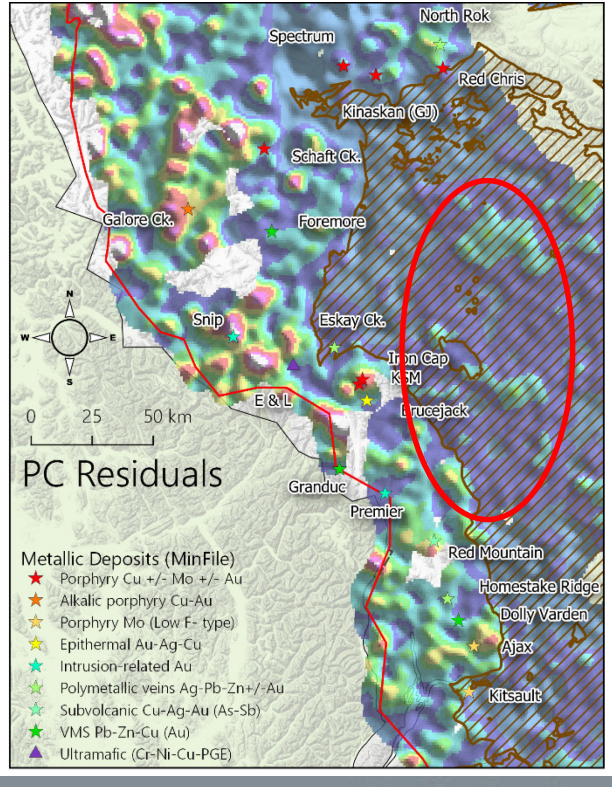


Porphyry Cu - Golden Triangle

Weighted Sums Models (Cu, Au, Bi, Mo, Te, As)

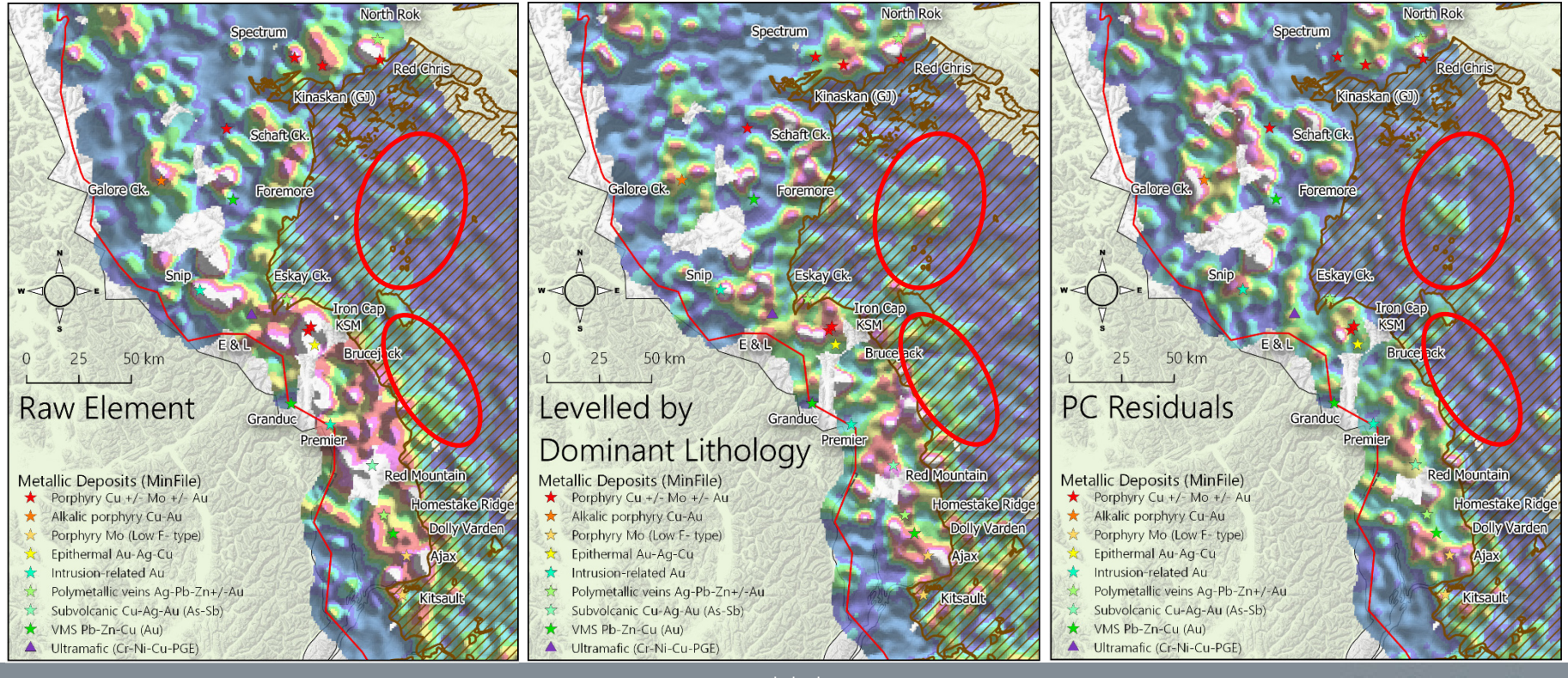




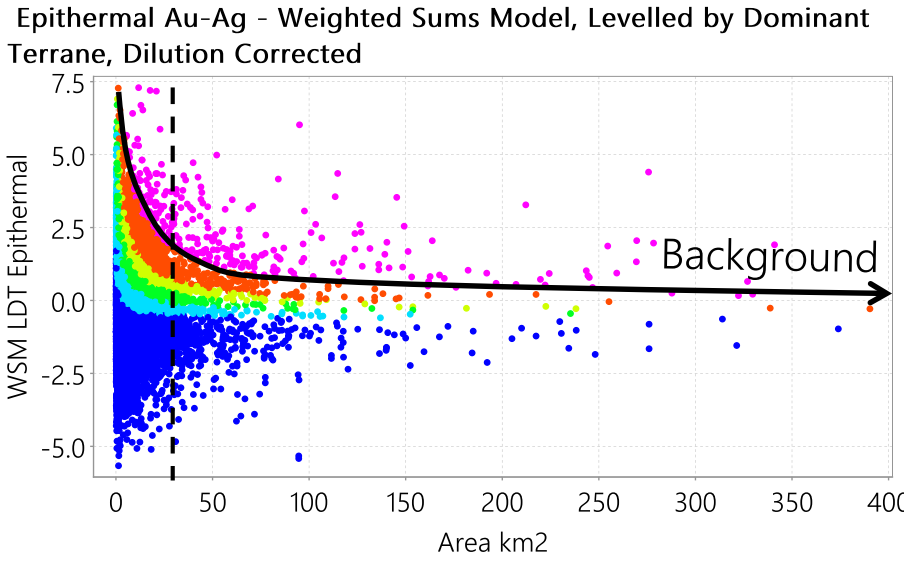


Epithermal Au-Ag - Golden Triangle

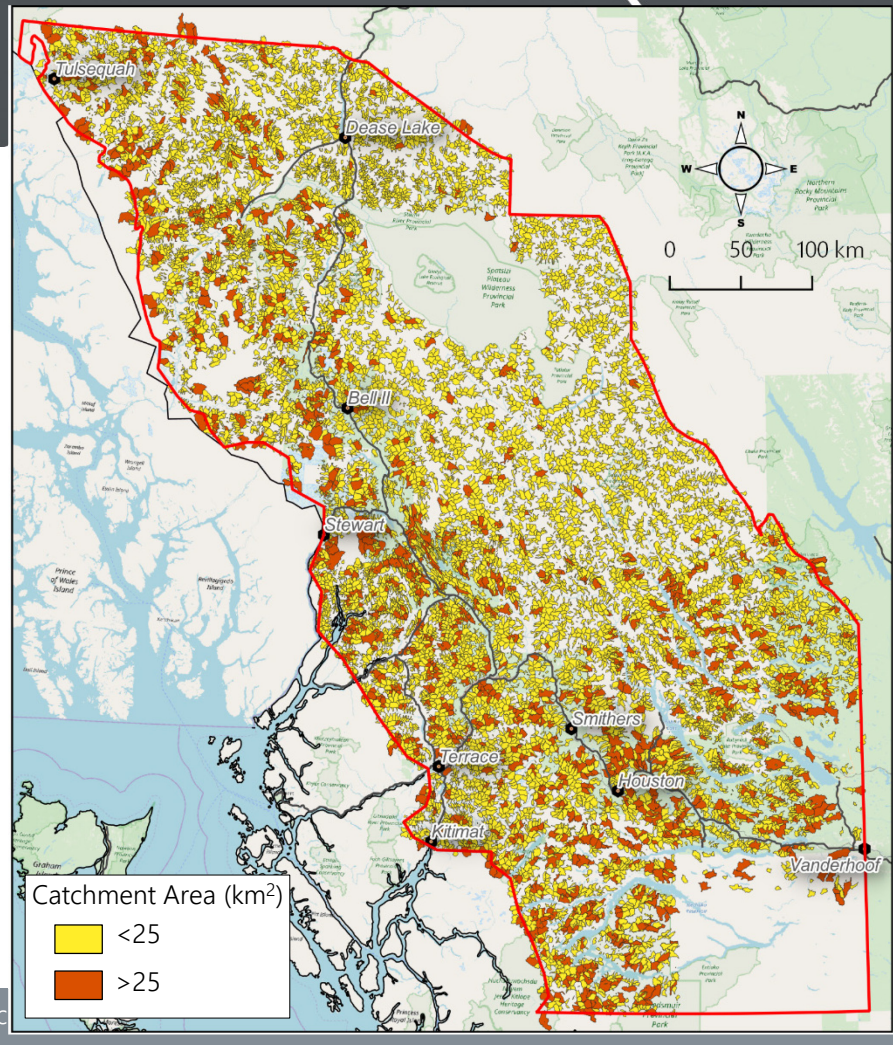
Weighted Sums Model (Au, Ag, Sb, As)



Sampling Effectiveness

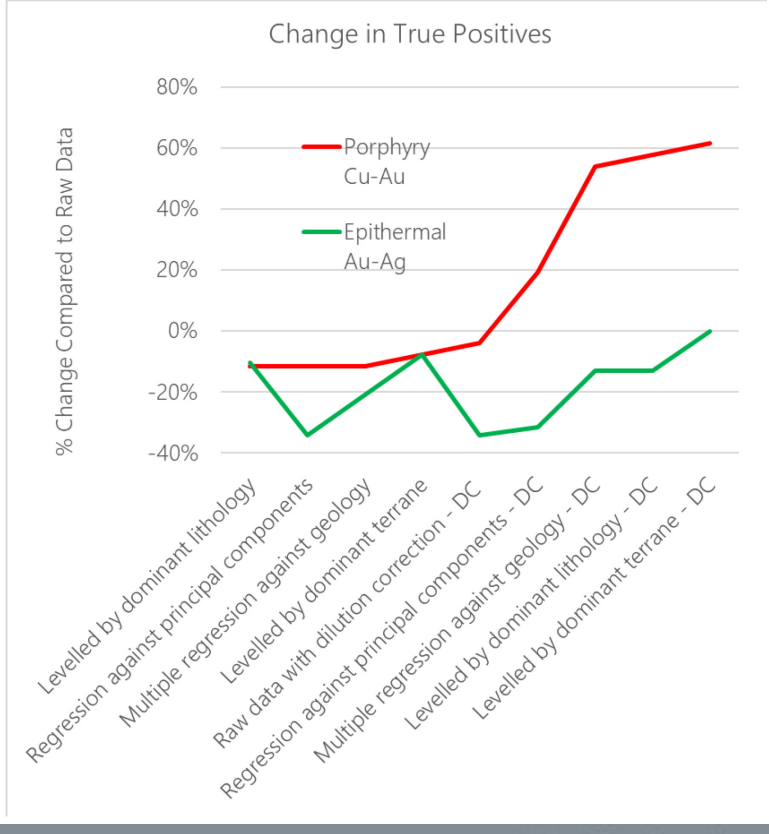


Catchment basins >25 km^2 are strongly affected by dilution and so not effectively sampled



Method Validation

- Data processing methods were validated against MINFILE producers, past producers, developed prospects and prospects
- **True Positives:** Proportion of Porphyry Cu and Epithermal Au-Ag deposits captured by the 90th percentile of data treatment method



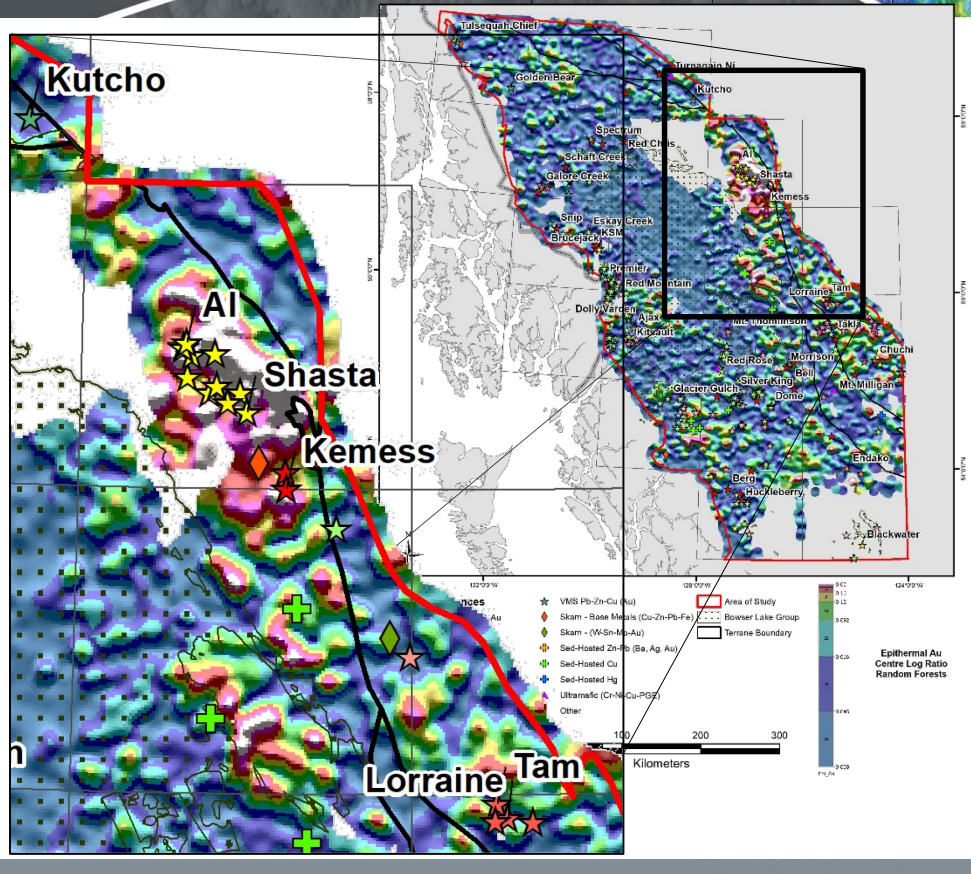
<u>SUMMARY:</u>

Data treatments are most successful where the key elements in the deposit specific WSM are strongly influenced by lithology or metal scavenging.

e.g. Cu is more affected by lithology and scavenging than Au…

Random Forests (Advanced Data Analysis)

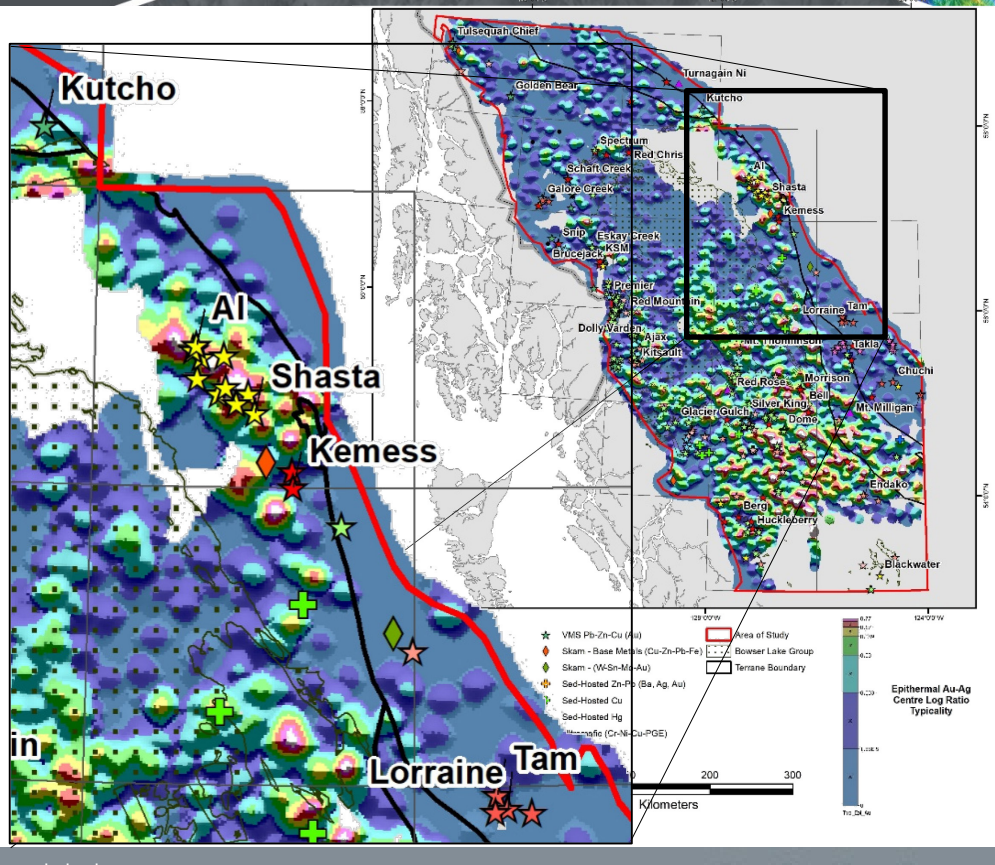
- Supervised learning approach using principal components as inputs
- Minimizes user bias
- Training data set consisted of known Past Producers, Advanced Prospects and Prospects from MINFILE
- Determines probability that a data point belongs within a particular mineral deposit class Harris and Grunsky (2015)



Example: Epithermal Au-Ag prospectivity

Allocation / Typicality (Advanced Data Analysis)

- Similar supervised learning approach using principal components as inputs
- Determines the probability that a data point belongs within a particular mineral deposit class
- Typicality indices are significantly different from the result obtained using random forests
- a site may not belong to any of the classes, whereas other classification methods "force a fit"



Example: Epithermal Au-Ag prospectivity

Conclusions

- Levelling geochemical data for lithological and/or metal scavenging effects results in an improvement in mineral deposit targeting, but conventional approaches rely on detailed and accurate geology
- The use of principal components allows an interpretation of lithological and secondary scavenging effects *without reliance on external data*
- Levelled data produce more effective weighted sums models but this is still an "expert"-driven approach subject to user bias
- Supervised learning approaches such as allocation/typicality and random forests generate prospectivity maps that are purely data-driven and remove user biases

Thank You

CSA Global

Mining Industry Consultants

dennis.arne@csaglobal.com

matthew.bodnar@csaglobal.com

EXPLORATION | RESOURCES | MINING | TECHNOLOGY | CORPORATE

CSA Global is a leading geological, mining and management consulting company which provides high quality solutions to our clients in the global minerals industry. Our staff include geologists, mining engineers, project managers, data management professionals and technical personnel.

2017 AUSTMINE AWARD WINNER
CRAIG SENGER EXCELLENCE IN EXPORT AWARD

Follow Us On: