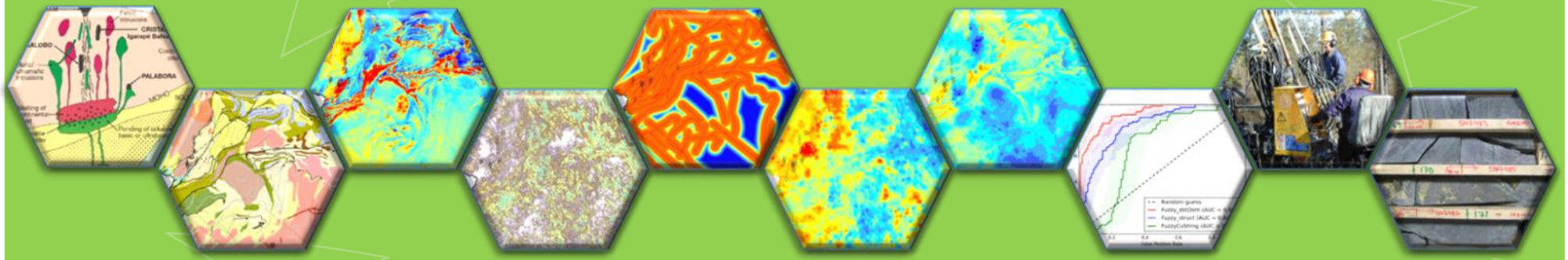
Mineral Prospectivity Modeller

WP4: Dynamic modeling case study – Preliminary results



Niiranen, T, Nykänen, V., MPM-project group

3.5.2018

Programme for Sustainable Growth and Jobs

Leverage from the EU 2014–2020

European Union
European Regional Development Fund

Funding

国家海洋局第二海洋研究所
Second Institute of Oceanography,SOA

AngloAmerican

Kenex
Creating opportunities in the spatial world

Sakumpu Exploration Oy

S2R S2 Resources

De Beers
Group of Companies

AGNICO EAGLE
FINLAND

NEW BOLIDEN

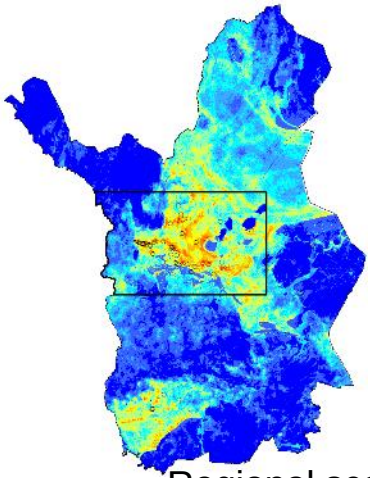
Programme for Sustainable Growth and Jobs

Leverage from the EU 2014–2020

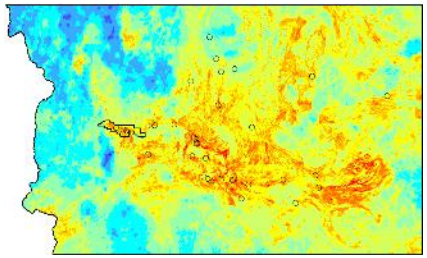
European Union
European Regional Development Fund

GTK

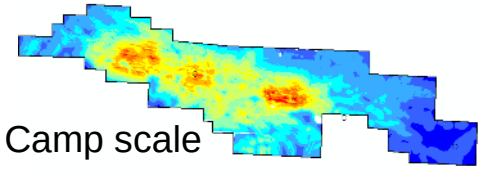
The aim of WP4 case study



Regional scale



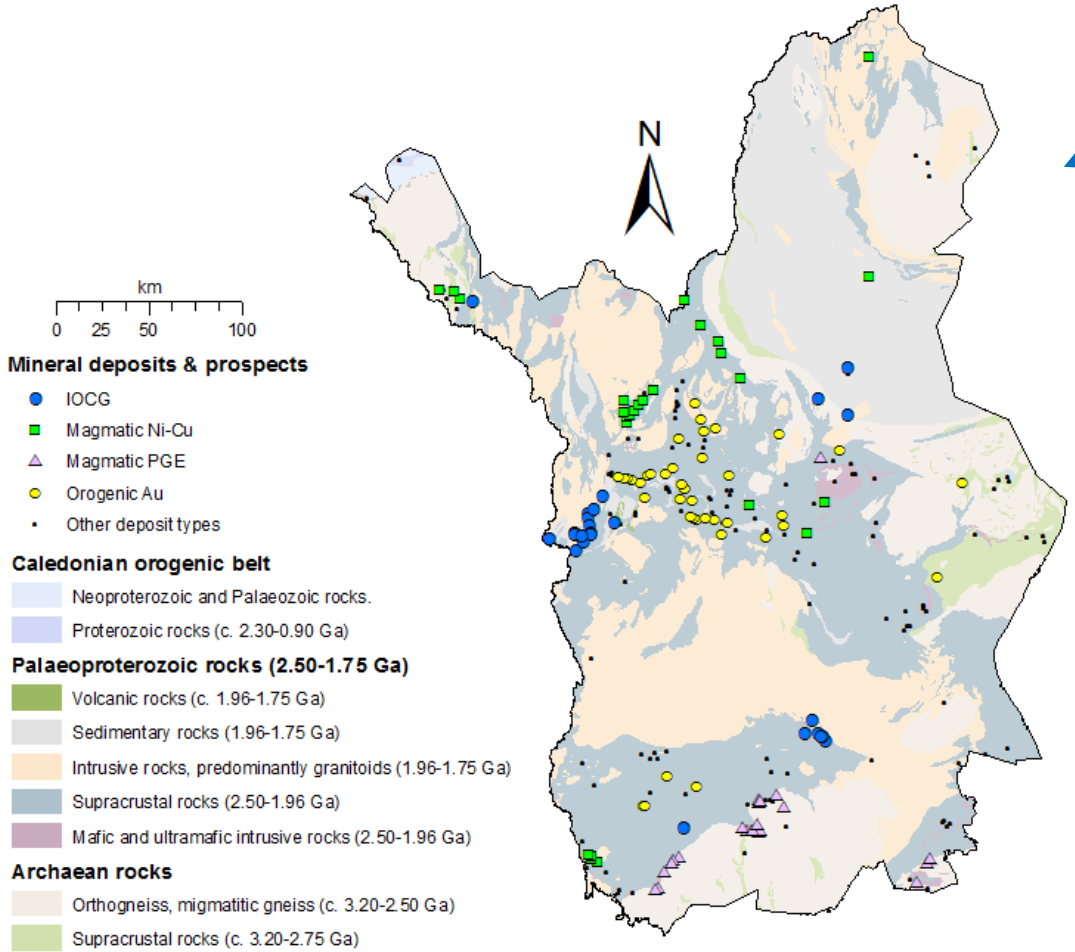
Belt scale

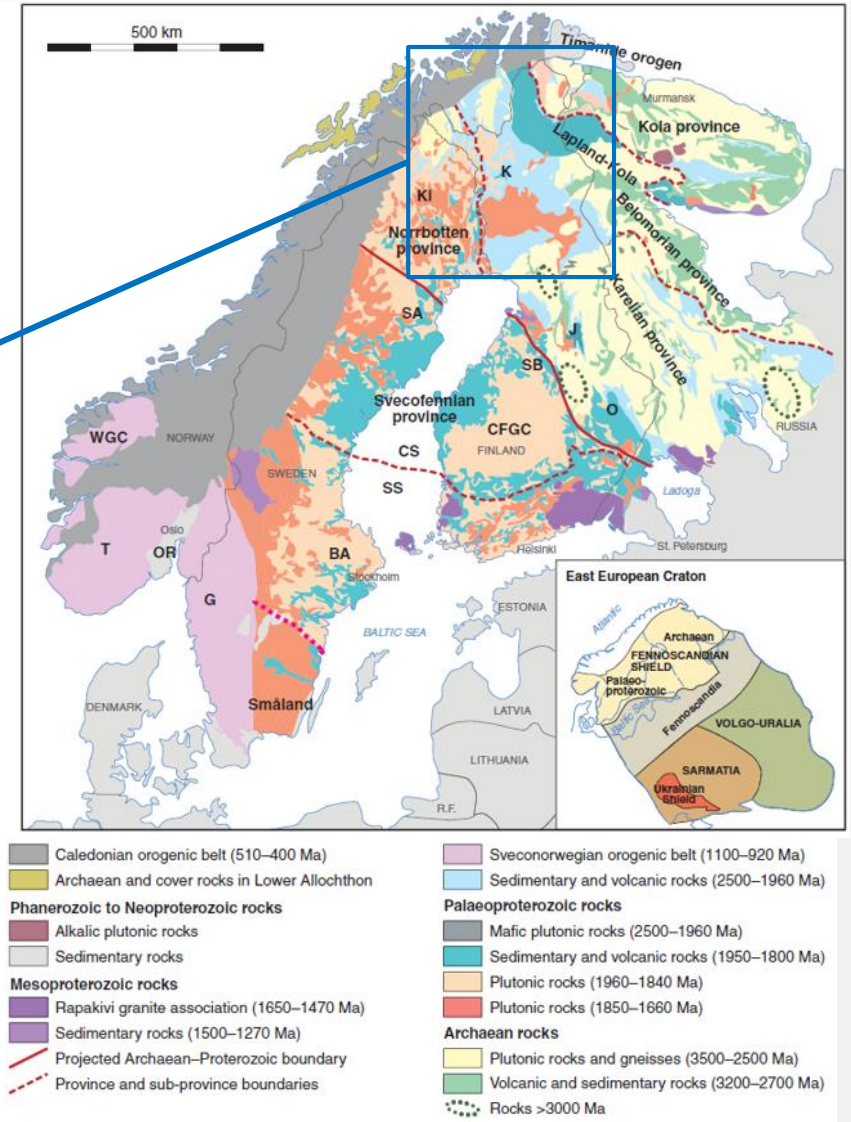


Camp scale

- Demostrate the MPM tools and demo-data sets
- Illustrate the scalability of prospectivity modeling
- Case study focuses on Orogenic gold deposits

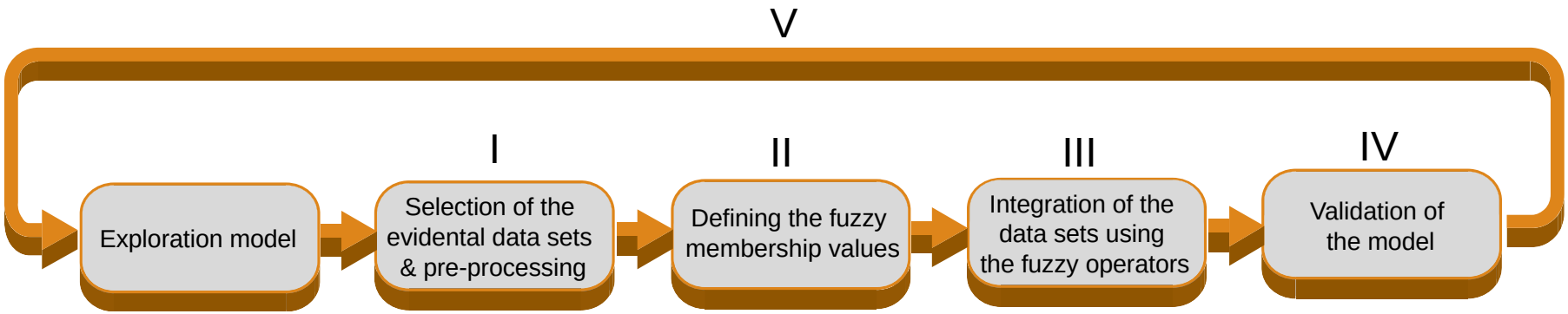
Study area





Koistinen et al. (2001), Lahtinen (2012)

Knowledge driven approach – Fuzzy Logic method



- Exploration model based on Orogenic gold definition (e.g. Groves et al. 1998)
- I: Data selection based on exploration model
- II: Data rescaled into common scale (i.e. 0 to 1) using Fuzzy membership tool
- III: Data integration using various fuzzy operators (OR, AND, SUM, PRODUCT, GAMMA)
- IV: Model validation (Reciever Operating Characteristics method used)
- V: Refine & Repeat as necessary

The data

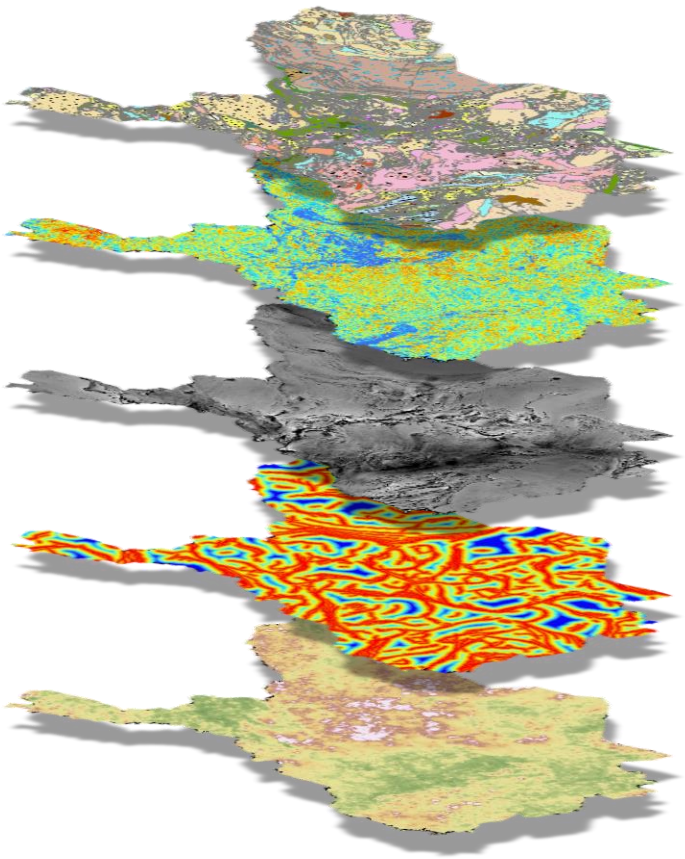
Regional scale model:

- High resolution airborne geophysics, regional till geochemistry, regional gravity data, derivatives of the GTK's Digital bedrock Map 1:200 000

Belt scale model:

- same data set as in regional scale model added with higher resolution ground gravity data

The Regional scale data set is provided with MPM-tools as a demo data set (however, higher resolution data used in case study)



Programme for Sustainable Growth and Jobs
Leverage from the EU 2014–2020
European Union
European Regional Development Fund

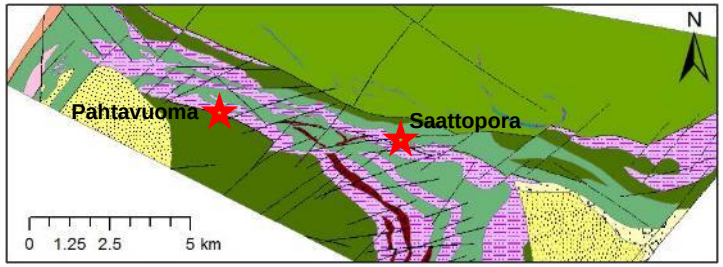
The camp scale data

Outokumpu Oyj carried out exploration & mining in the area during 1970s to 1990s – resulting geodata to GTK in mid-00s

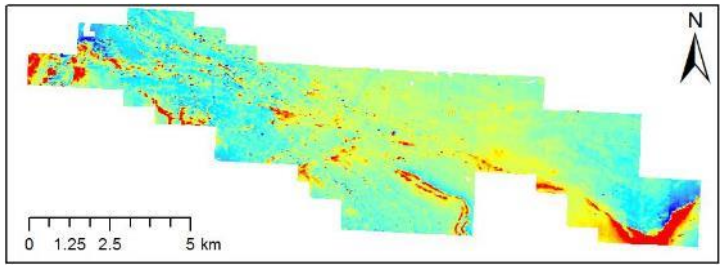
- Ground geophysics (magnetic, EM)
- Line till data
- Drill hole data (c. 750 drill holes)
- Outcrop, trenching, detal map data

<u>Issues with the data:</u>

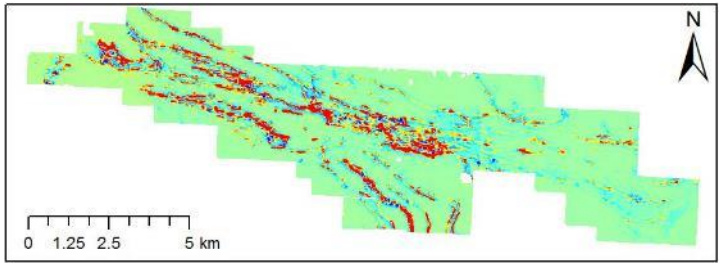
- Old analytical methods
- Much of the data cannot be converted to rasters (other than ”distance” or ”density” rasters)
- Clustering of data around the known deposits



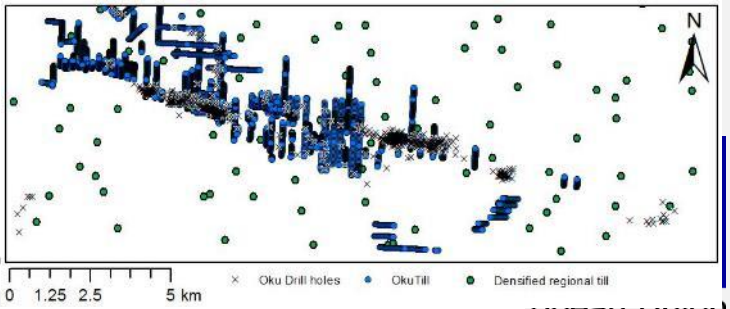
Detailed bedrock map



Ground magnetic data

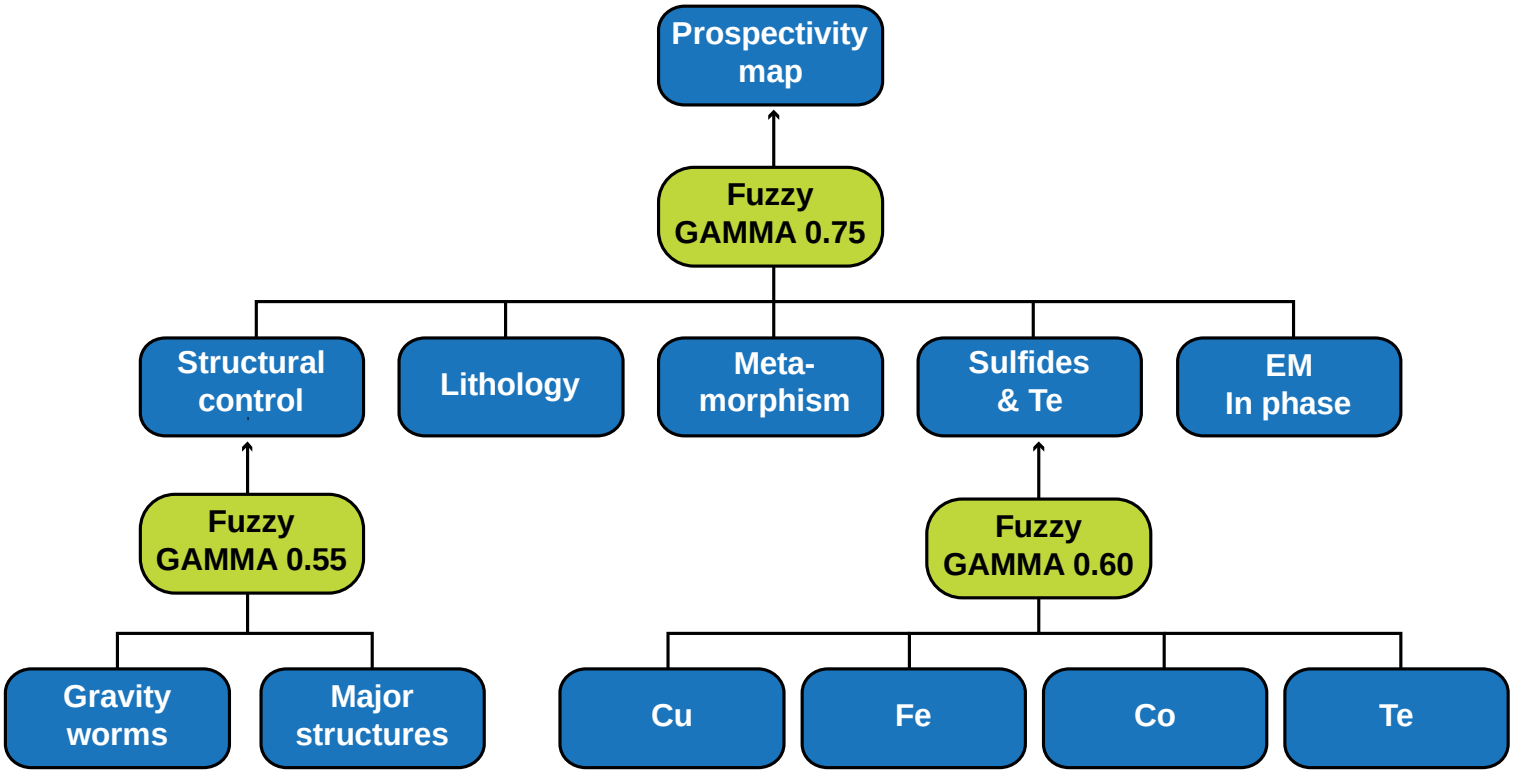


Ground EM-data

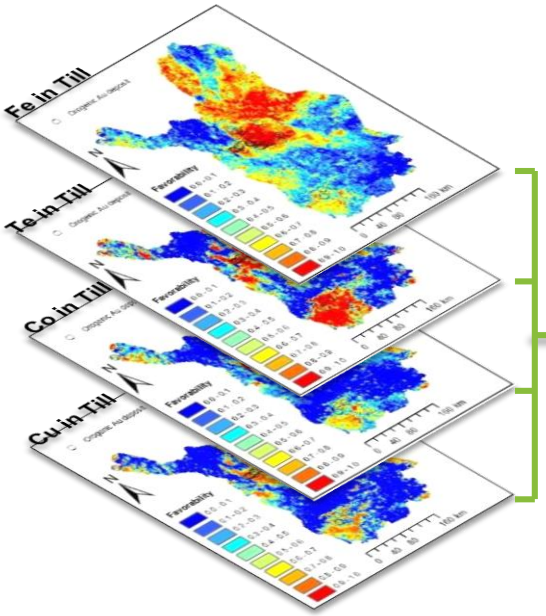


Detailed till, drill holes, outcrop etc.

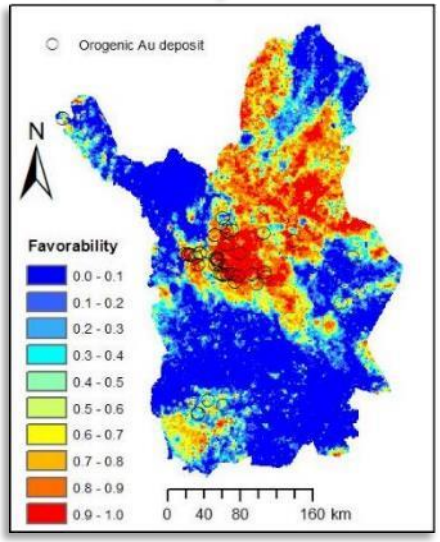
Regional-scale Fuzzy model for orogenic Au



Intermediate overlays

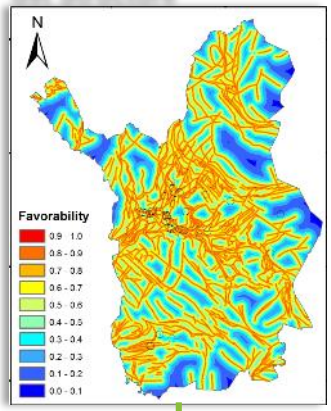


Till Geochemistry

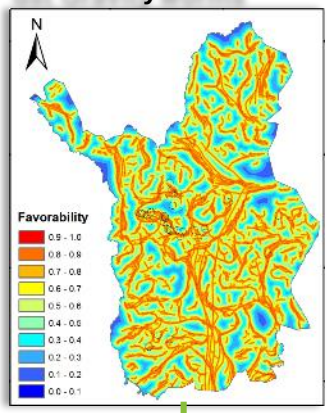


Fuzzy GAMMA 0.6

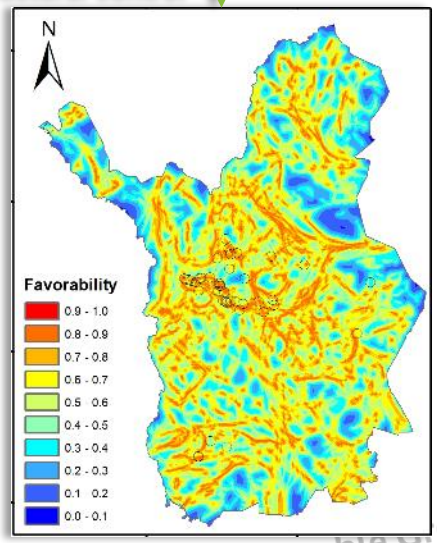
dst Structure



dst Gravity worms



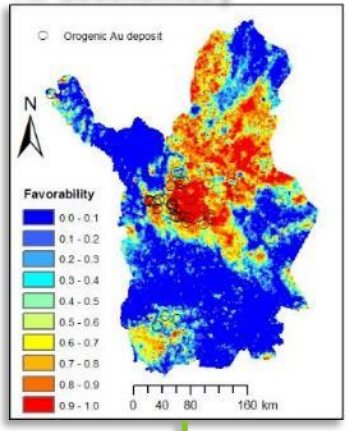
Structural control



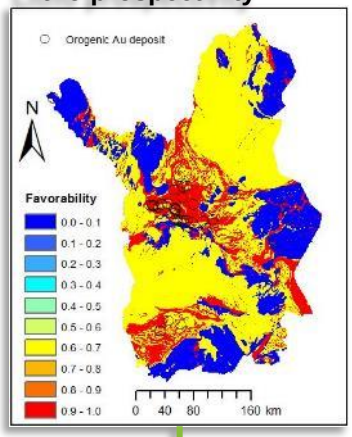
Fuzzy GAMMA 0.55

Regional-scale prospectivity map

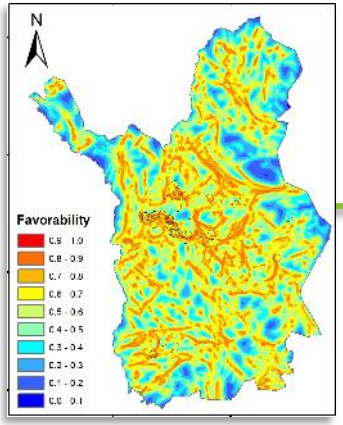
Till Geochemistry



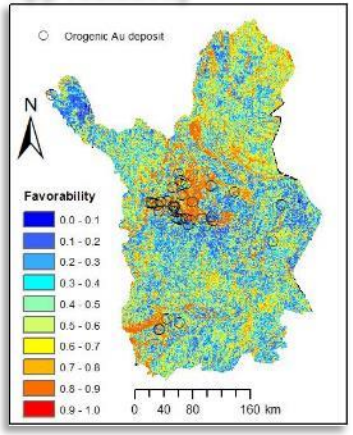
Litho prospectivity



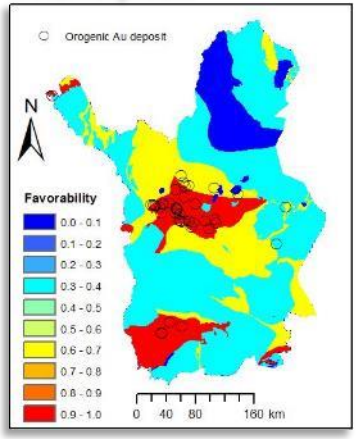
Structural control

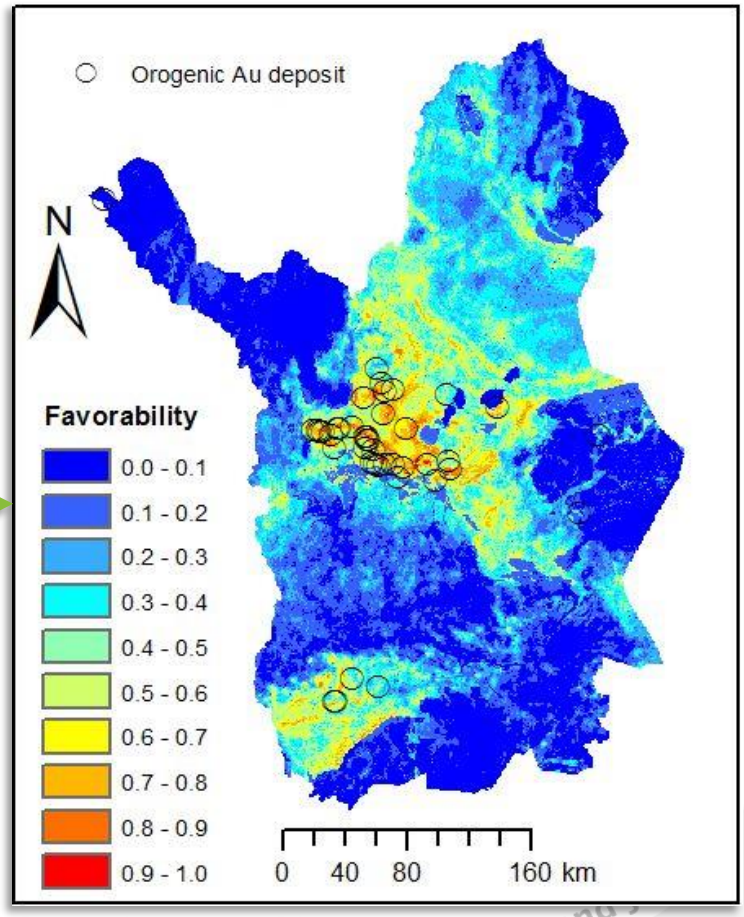


App resistivity



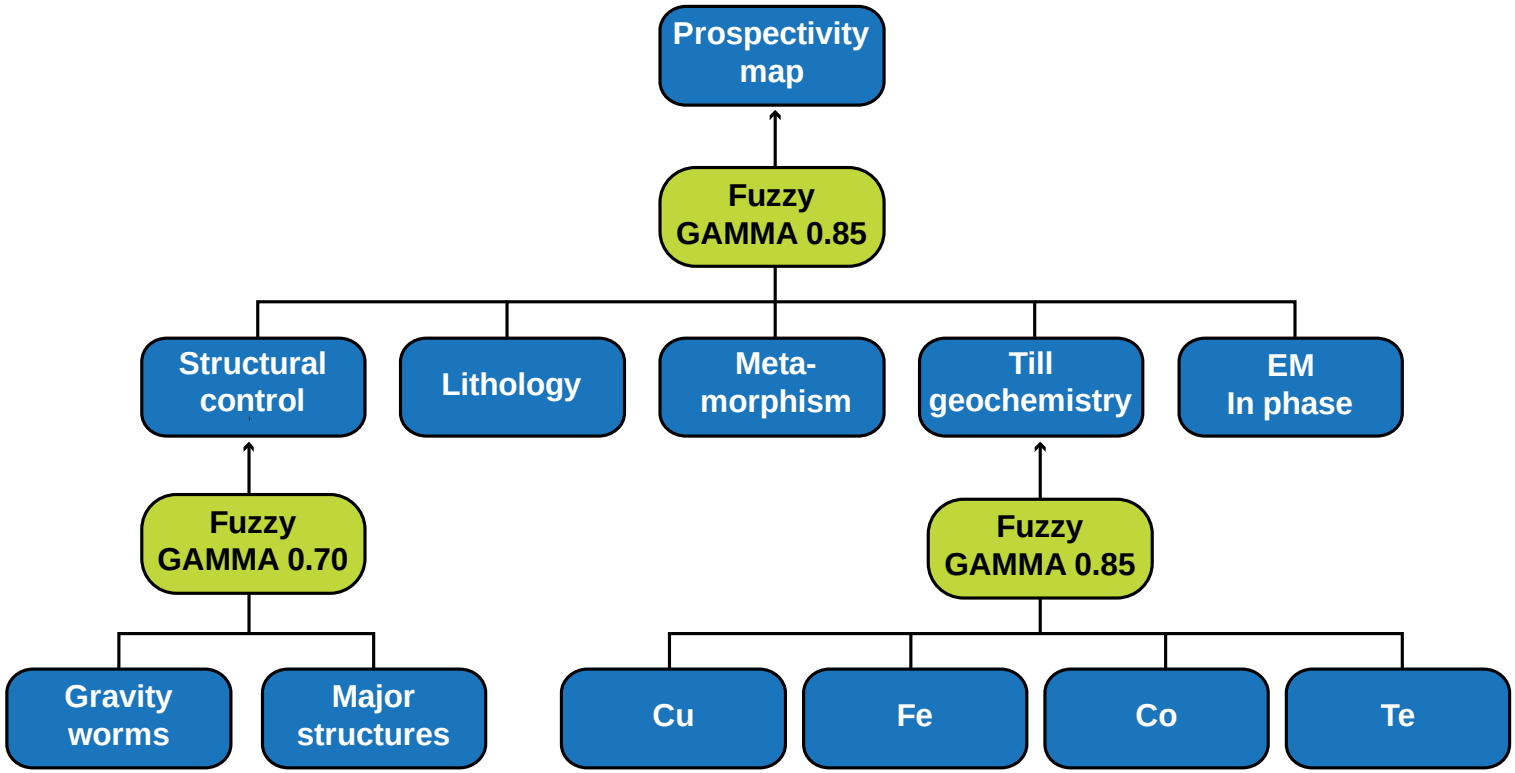
Metamorphism



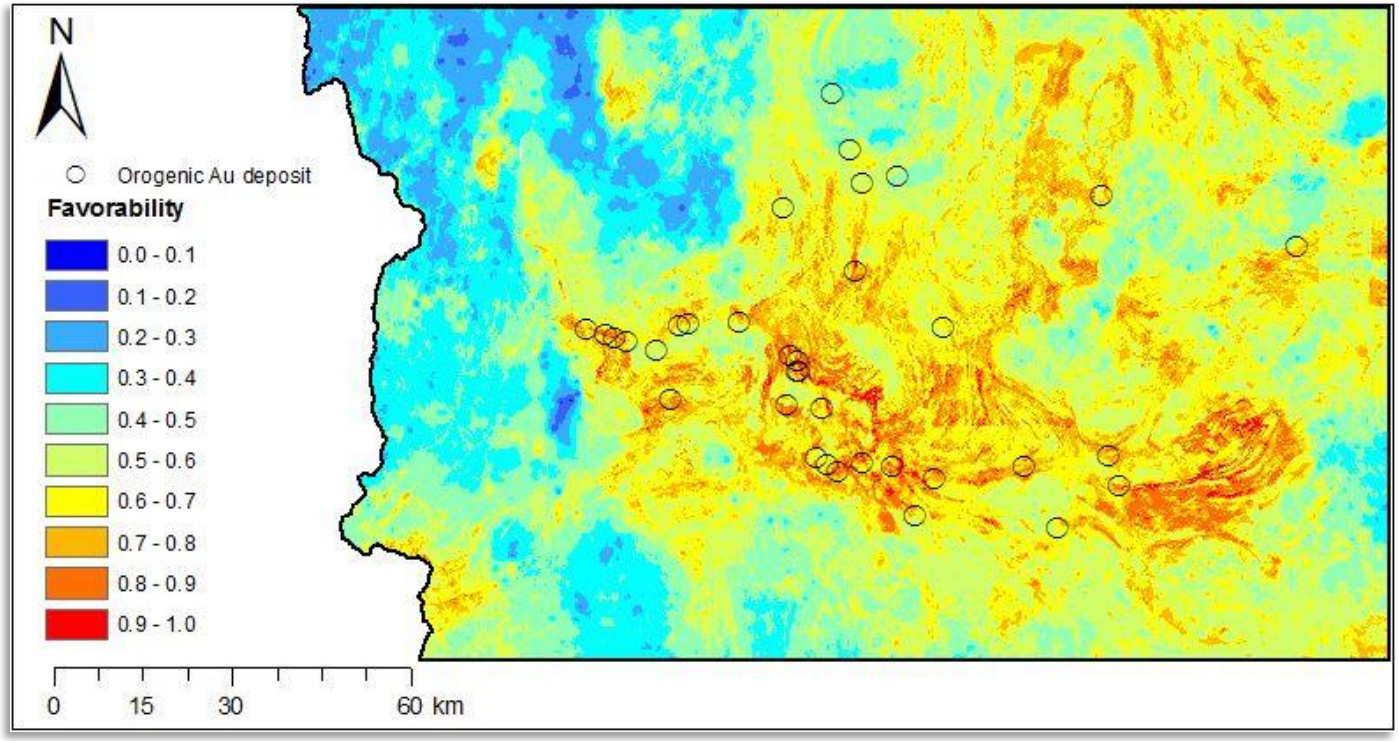


Fuzzy GAMMA 0.75

Belt scale Fuzzy model for orogenic Au

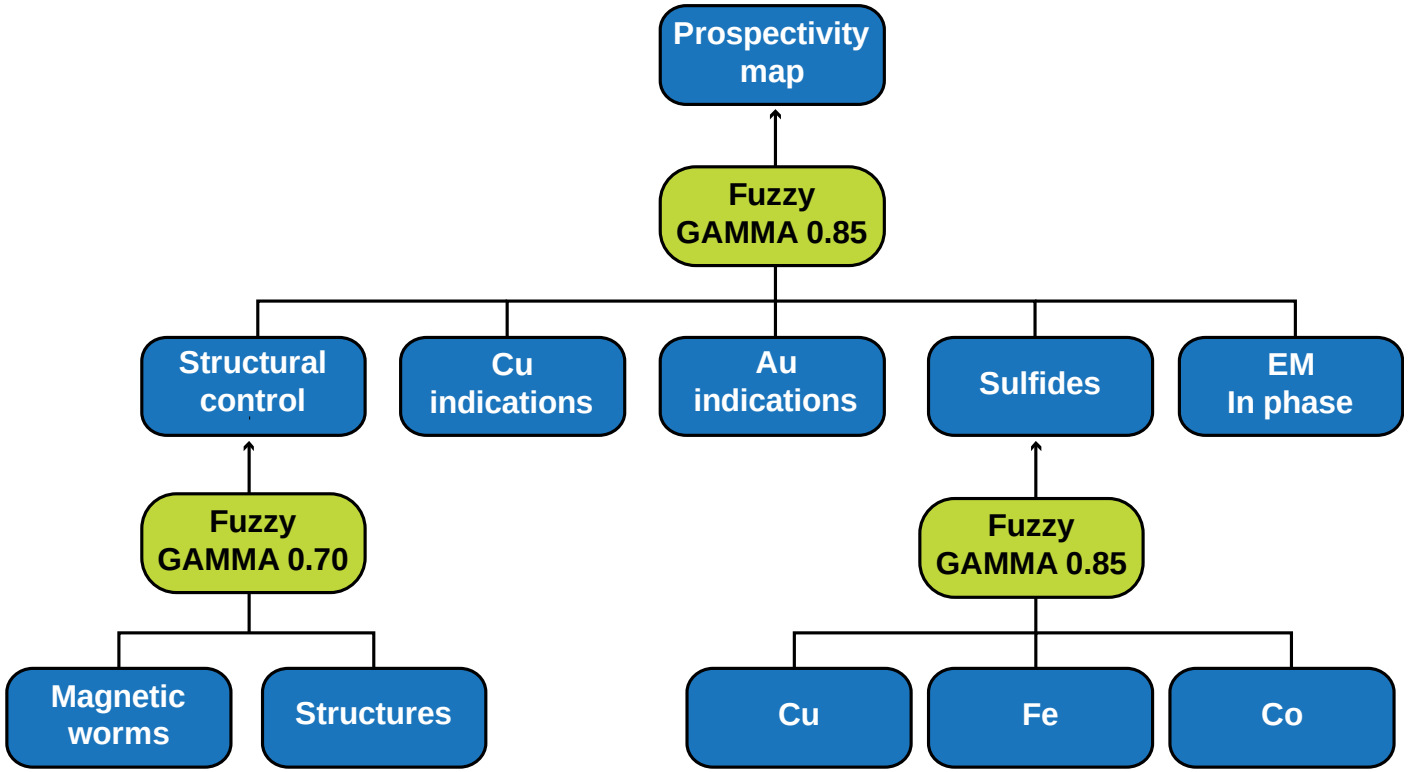


Belt scale prospectivity map

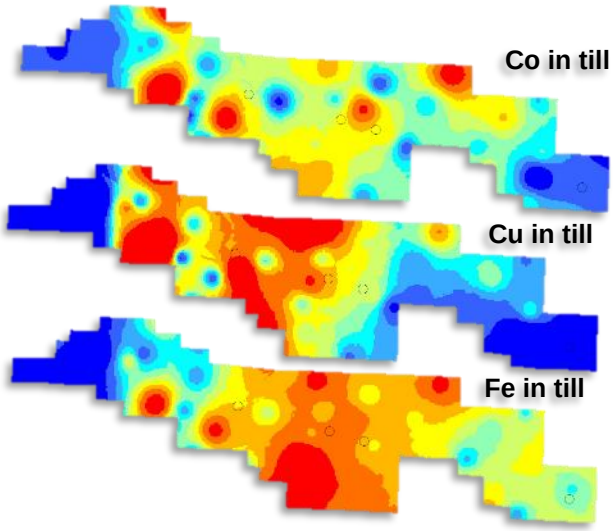


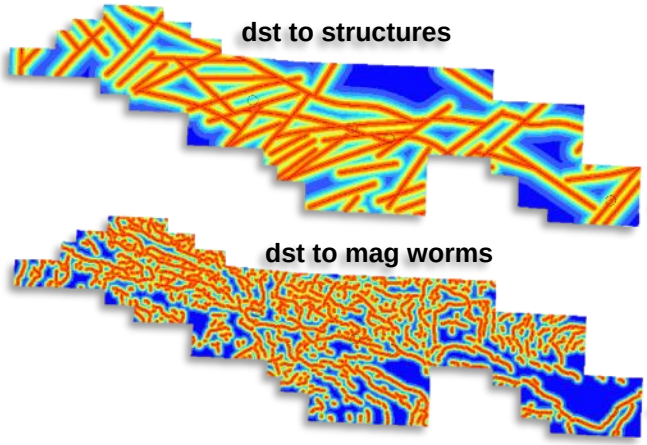
Fuzzy GAMMA 0.8

Camp scale Fuzzy model for Orogenic Au

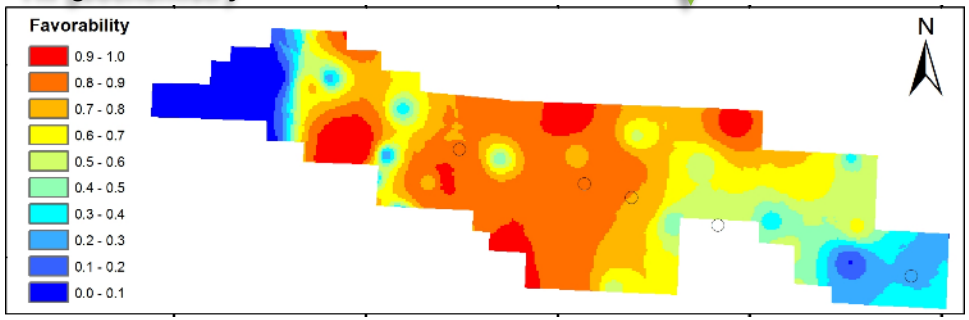


Intermediate overlays



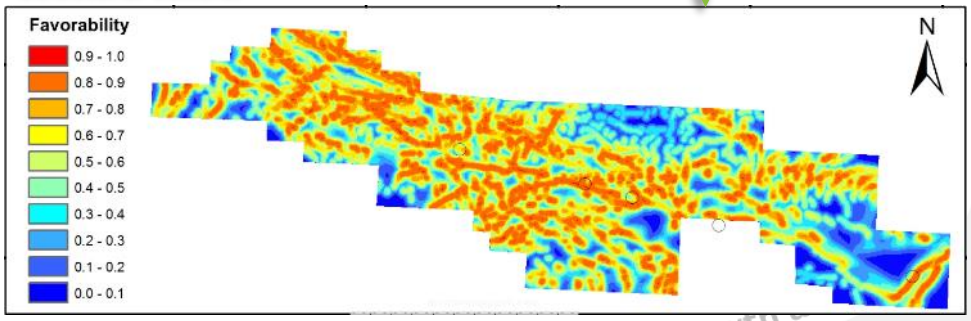


Till geochemistry



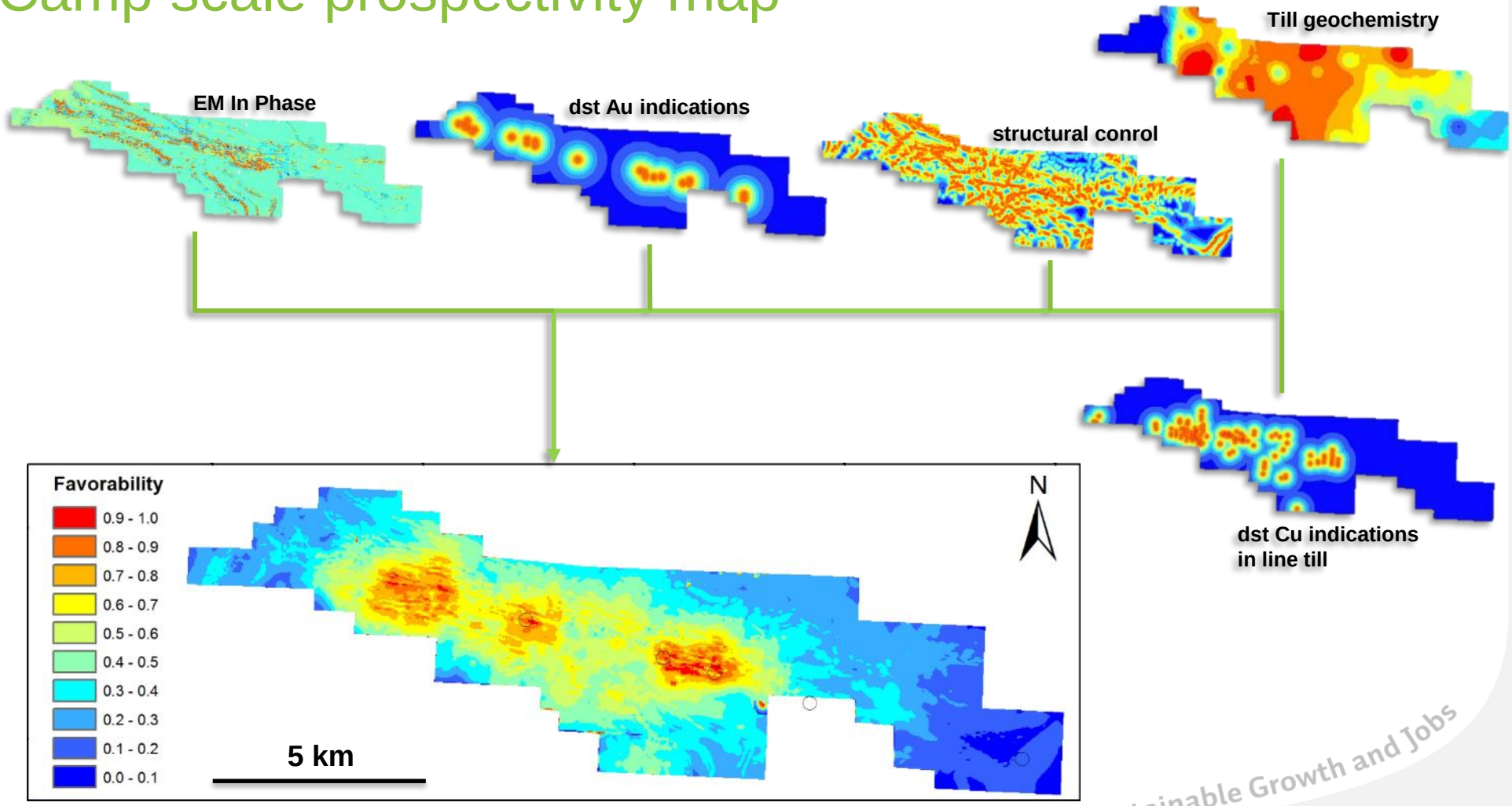
Fuzzy GAMMA 0.85

Structural control



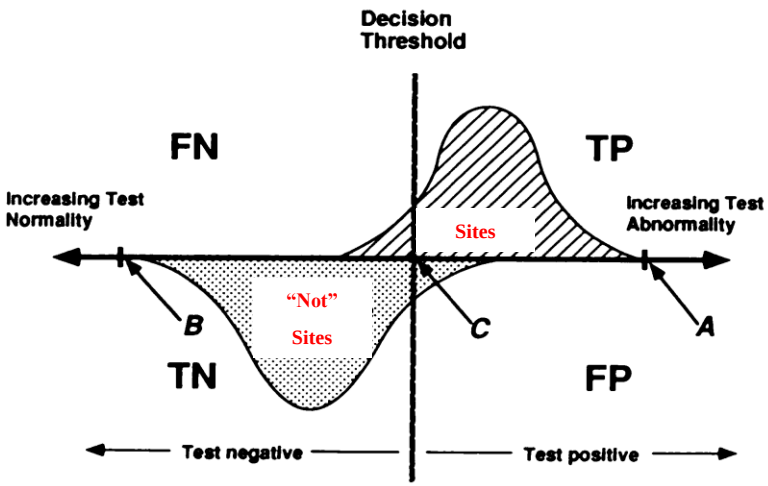
Fuzzy GAMMA 0.7

Camp scale prospectivity map

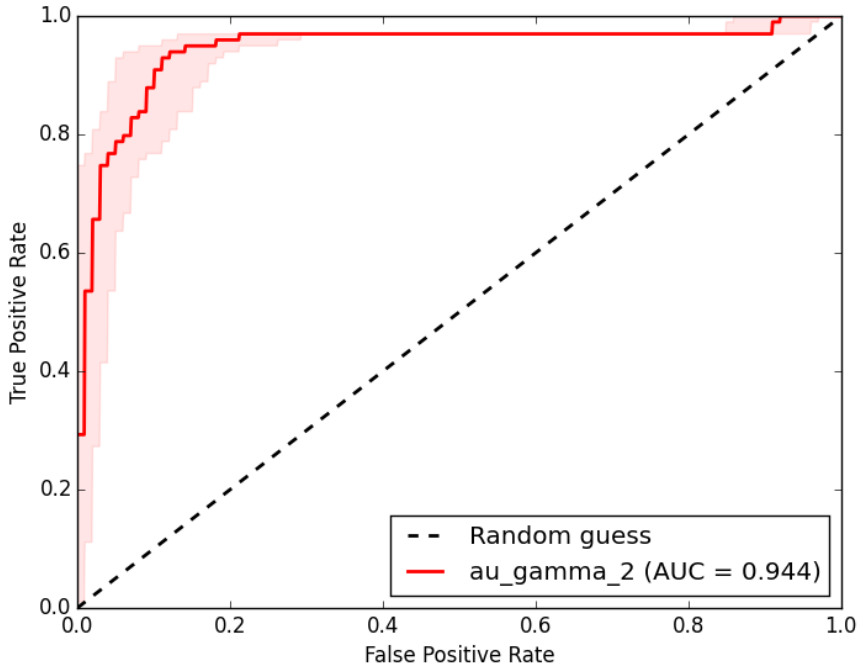


Fuzzy GAMMA 0.85

Reciever Operating Characteristics (ROC) validation



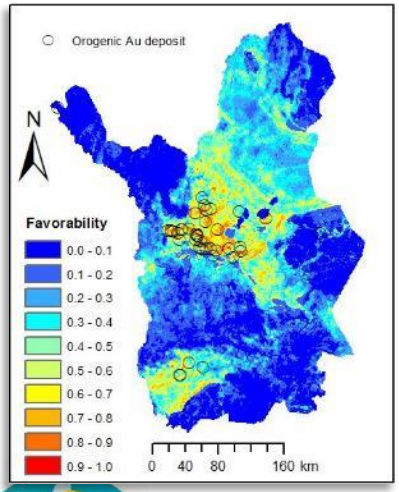
Brismar, 1991, American Roentgen Ray Society: v 157, p. 1119-1121.



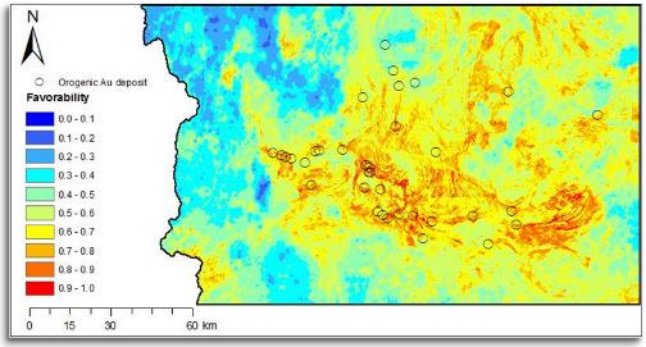
AUC = Area Under Curve
AUC 0.5 -> random result / no correlation
AUC 1 -> perfect test

Model Validation

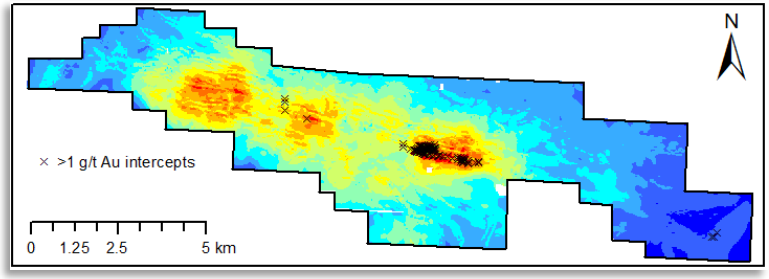
- Validation using MPM Receiver Operating Characteristics (ROC) –tool
- Known orogenic gold deposits used as true positives for regional & belt scale models (randomly generated poits used as true negatives in each case)
- Au intercepts from drilling data for target scale models
- ROC-validation was also used for intermediate & Fuzzy Member layers to guide modelling



AUC = 0.91



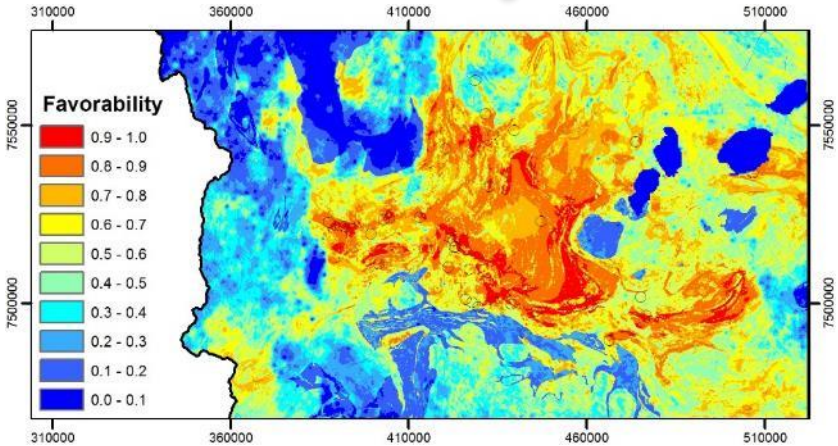
AUC = 0.84



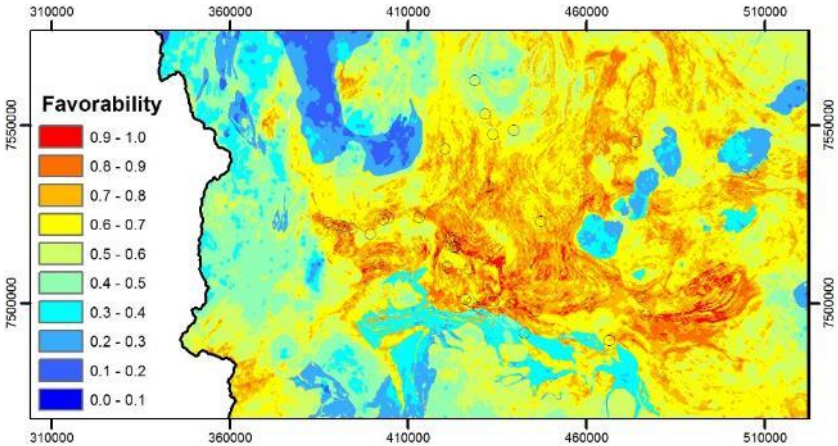
AUC = 0.94

Comparison – Regional vs. Belt scale

Regional scale model



Belt scale model

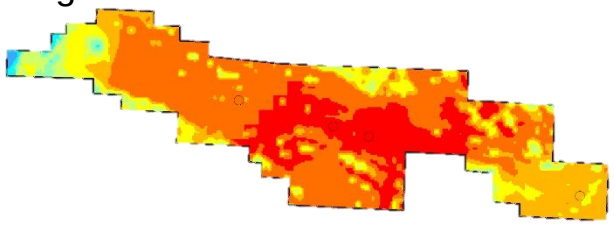


- The models and parameters are the same
- Higher resolution gravity data in belt scale
- Changes in Gamma-operator values
- Changes in midpoints computing the Fuzzy Member layers due to changed data spread

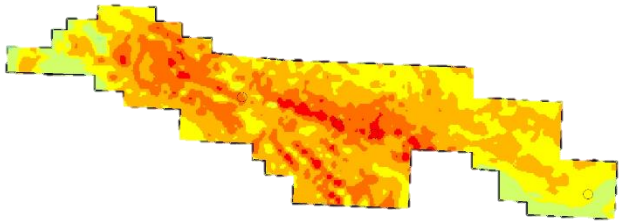
Comparison – Camp scale vs. Regional & Belt scale

- Completely different data set for camp scale
  - higher resolution geophysics & till geochemistry
  - Point data (e.g. trenching, bedrock obs) used
  - Clustering of data around known deposits
- Camp scale model similar, but different model compared to other models

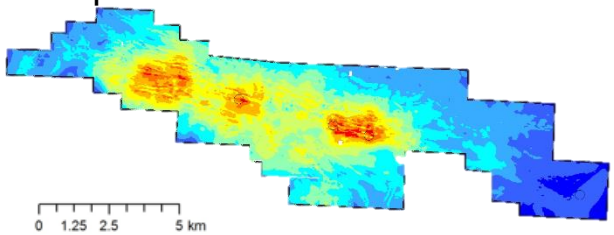
Regional scale model

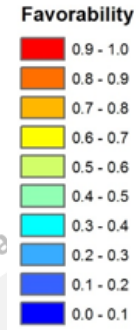


Belt scale model



Camp scale model





Summary & Conclusions

- The exercise shows that the prospectivity modeling is a scalable, fast, and cost effective method in all the stages of an exploration project - from selecting the most prospective belts to outlining drilling targets
- A model can be easily adjusted for different scales and and fairly easily to different data sets
- <u>However:</u> we recommend that one should always adjust the Fuzzy Membership and Fuzzy Operator parameters moving from broader to tighter areas – *even if the data sets in both are the same* (i.e. effect of data spread)
- In camp scale work the clustering of collected data is a major problem for prospectivity modeling