Mineral Prospectivity Modeller

WP4: Dynamic modeling case study – Preliminary results

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Programme for Sustainable Growth and Jobs

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Funding
The aim of WP4 case study

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

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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 (Receiver 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)
**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

**Issues with the data:**

- 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
Regional-scale Fuzzy model for orogenic Au

Prospectivity map

Fuzzy GAMMA 0.75

Structural control

Lithology

Meta-morphism

Sulfides & Te

EM In phase

Fuzzy GAMMA 0.55

Gravity worms

Major structures

Fuzzy GAMMA 0.60

Cu

Fe

Co

Te
Intermediate overlays

Till Geochemistry

Fuzzy GAMMA 0.6

Structural control

Fuzzy GAMMA 0.55

dst Structure

dst Gravity worms

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Regional-scale prospectivity map

Till Geochemistry

Litho prospectivity

Structural control

App resistivity

Metamorphism

Favorability

0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0

Fuzzy GAMMA 0.75

Orogenic Au deposit

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Belt scale Fuzzy model for orogenic Au

Prospectivity map

Fuzzy GAMMA 0.85

Structural control
Lithology
Meta-morphism
Till geochemistry
EM In phase

Fuzzy GAMMA 0.70

Gravity worms
Major structures

Fuzzy GAMMA 0.85

Cu
Fe
Co
Te
Belt scale prospectivity map

Fuzzy GAMMA 0.8
Camp scale Fuzzy model for Orogenic Au

Prospectivity map

Fuzzy GAMMA 0.85

Structural control
Cu indications
Au indications
Sulfides
EM In phase

Magnetic worms
Structures
Cu
Fe
Co

Lithology
Cu indications
Au indications

Fuzzy GAMMA 0.70
Fuzzy GAMMA 0.85

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Intermediate overlays

Co in till
Cu in till
Fe in till

Till geochemistry
Fuzzy GAMMA 0.85
Favorability
- 0.9 - 1.0
- 0.8 - 0.9
- 0.7 - 0.8
- 0.6 - 0.7
- 0.5 - 0.6
- 0.4 - 0.5
- 0.3 - 0.4
- 0.2 - 0.3
- 0.1 - 0.2
- 0.0 - 0.1

Structural control
Fuzzy GAMMA 0.7
Favorability
- 0.9 - 1.0
- 0.8 - 0.9
- 0.7 - 0.8
- 0.6 - 0.7
- 0.5 - 0.6
- 0.4 - 0.5
- 0.3 - 0.4
- 0.2 - 0.3
- 0.1 - 0.2
- 0.0 - 0.1

dst to structures
dst to mag worms
Camp scale prospectivity map

EM In Phase

dst Au indications

structural conrol

Till geochemistry

dst Cu indications in line till

Favorability

0.9 - 1.0

0.8 - 0.9

0.7 - 0.8

0.6 - 0.7

0.5 - 0.6

0.4 - 0.5

0.3 - 0.4

0.2 - 0.3

0.1 - 0.2

0.0 - 0.1

5 km

Fuzzy GAMMA 0.85
Receiver Operating Characteristics (ROC) validation


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 points 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
Comparison – Regional vs. Belt scale

• 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
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.
• However: 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.