

Modelling of mafic Ni-Cu-PGE and porphyry Cu-Au prospectivity throughout Southland, New Zealand

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Kenex Knowledge Systems (NZ)

A graphic consisting of several thin, curved lines in shades of grey and red, flowing from left to right and tapering off towards the right side of the slide.

Kenex

Acknowledgements

Lodestar Resources Limited

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Shaun Clements

Grange Resources Limited

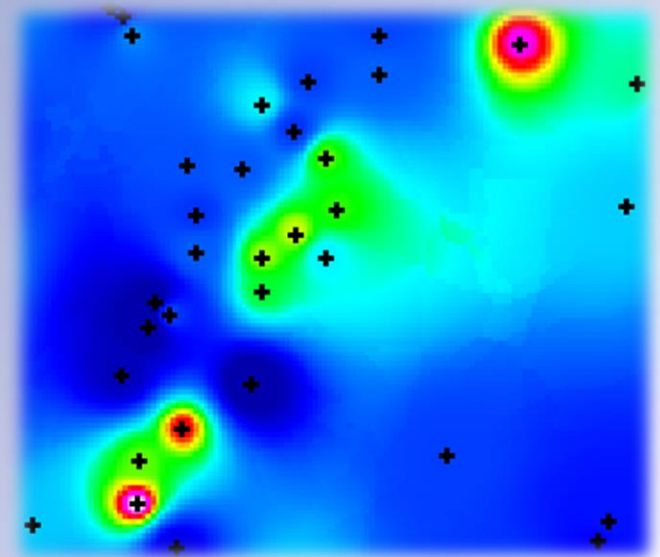
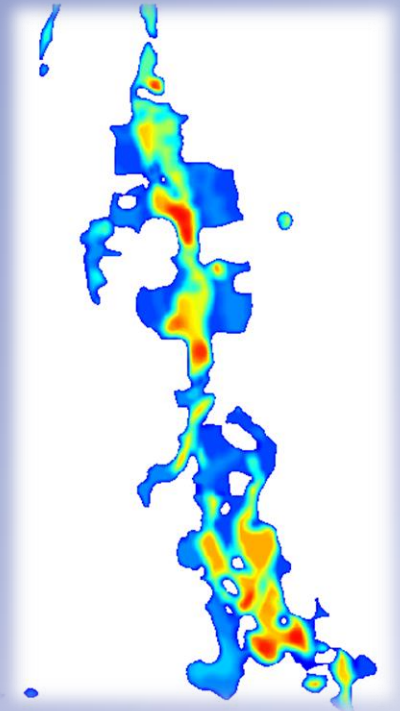
Barry MacDonell – MacDonell & Associates

GNS Science & Crown Minerals

and Avantra Geosystems (MI-SDM software)

Outline

- What is spatial data modelling?
- The Fuzzy Logic method
- Mineral Systems Concept
- Mafic Cu-Ni-PGE & Porphyry Cu-Au
- GIS techniques
- Prospectivity of Southland
- Using the results...



Why undertake spatial modelling?

- It allows you to combine spatial data and knowledge in a way to manage and **target more effectively**.
- Modelling can be a **non-bias view of data** which in some cases is an important process in moving forward and away from preconceptions.
- Takes advantage of the **wealth of digital data** available in the industry and deals with **data overload** issues that plague many explorers.
- **Save time and money** by putting resources into the most likely places the first time and undertake value / **risk assessment** of assets.

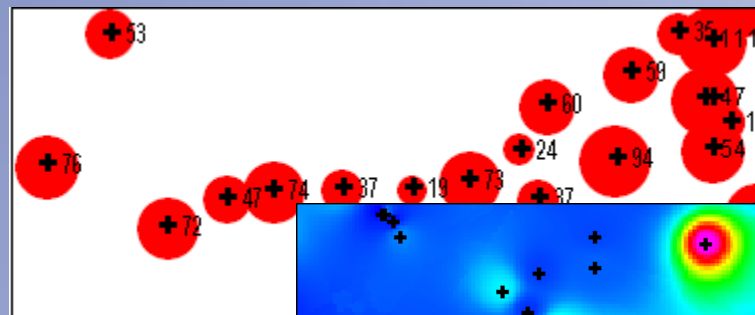
**Spatial data modelling allows large scale
analysis of data for scoping studies**



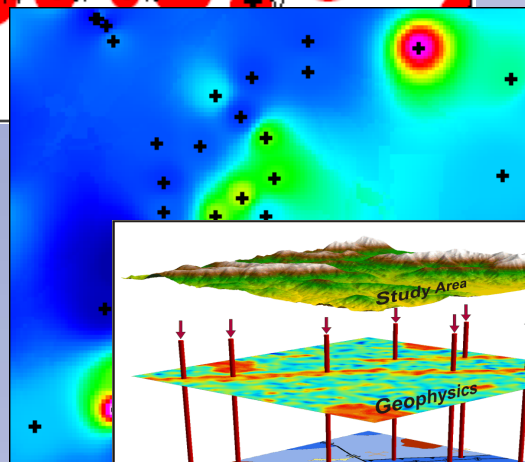
**Mineral Discoveries Are Typically Made By The 5th-7th
Person / Company Covering The Ground**

Types of modelling

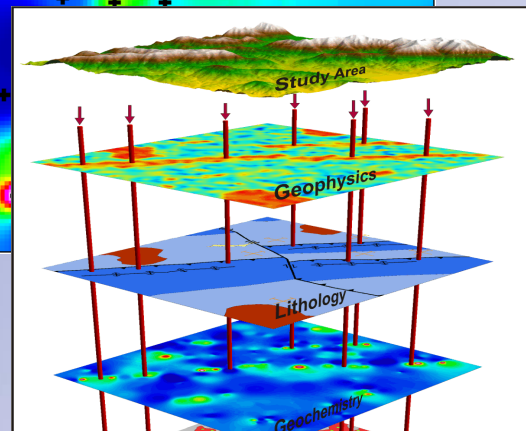
Illustrated maps that highlight important features or values.



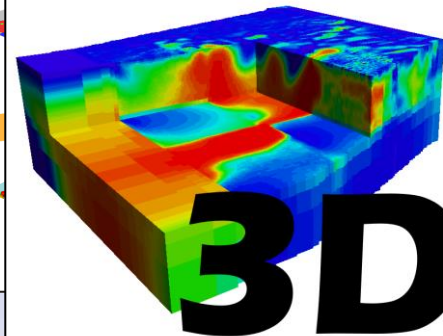
Basic single layer modelling using interpolation to estimate values between known point data.



Multi-variable models: Fuzzy logic, neural networking, and weights of evidence modelling.



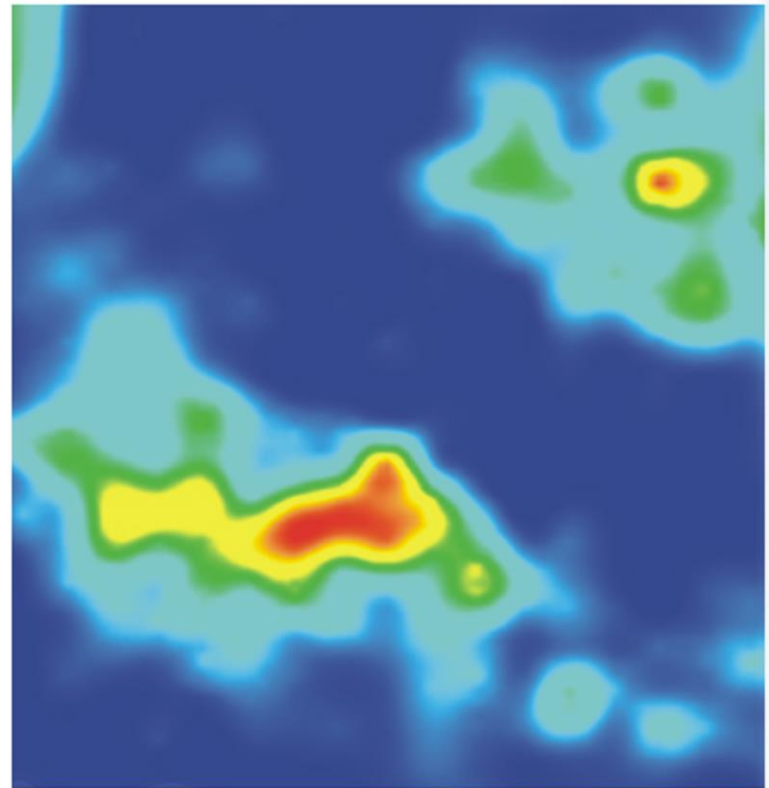
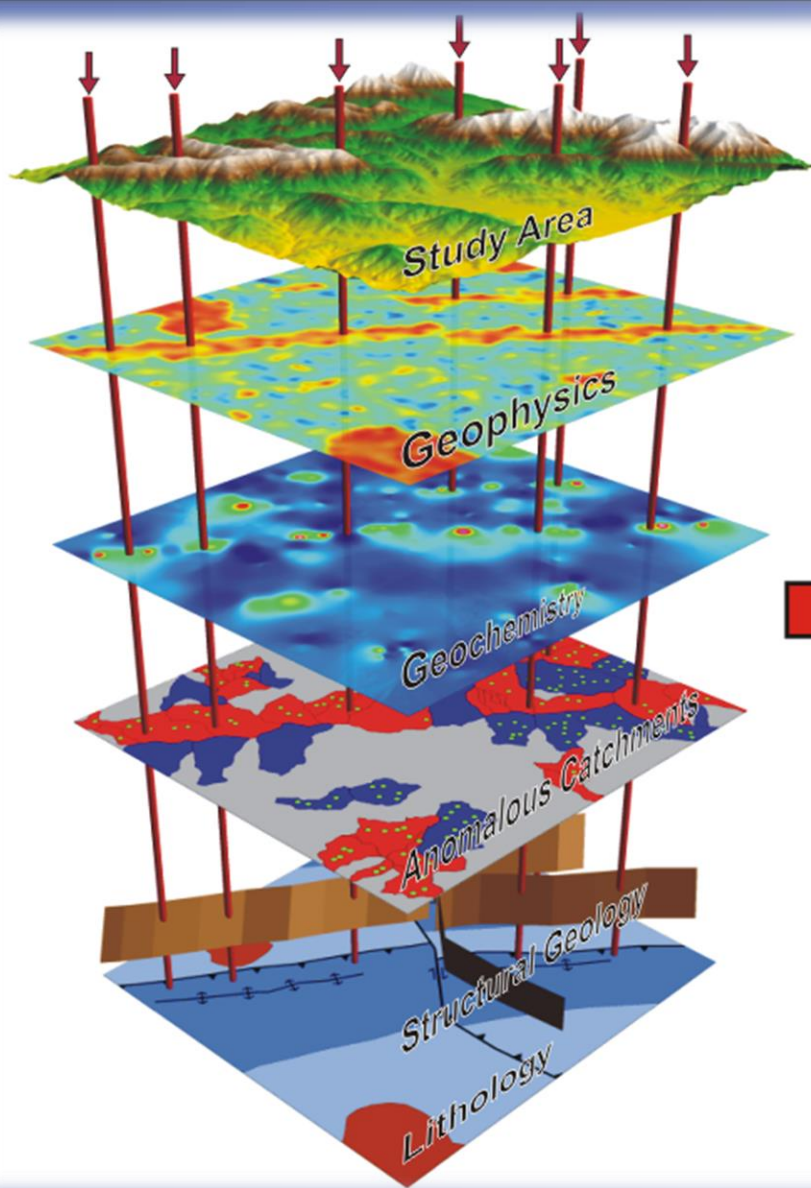
3D modelling of underground structures or or 4D flow modelling of fluids & minerals.



GOAL: To predict locations where there is a high probability of a mineral deposit.

BASIC METHOD:

- Compile all available digital data into a GIS and develop maps of data related to the mineral system being modelled (e.g. mafic intrusive lithologies);
- Use training data to weight mapped data in the model – Weights of Evidence modelling;
- Or, use expert defined values between 0 and 1 to weight the importance of mapped data in the model – e.g. Fuzzy Logic Modelling;
- Combine evidential maps together using WoE or Fuzzy Logic operators to produce a “response grid” or predictive map.



**Model of Mineral Prospectivity
Highlighting Exploration Targets**

Fuzzy Logic Spatial Modelling

- Fuzzy Logic modelling was chosen for Southland due to limited training data – i.e. very few significant hard-rock mineral occurrences or historic mines.
- A easily understood method for combining exploration datasets using subjective judgement.
- The method relies on expert opinion to derive weights that rank the importance of the mapped variables.
- Each map variable is weighted using a fuzzy membership function (0 - low weighting, 1- high weighting).
- Maps are then combined using fuzzy operators to produce predictive maps.

MAP 1

0.25	0.75	0.5
0.5	0.75	0.25
0.5	0.25	0.25



0.25	0.5	0.75
0.75	0.75	0.5
0.25	0.25	0.25

MAP 2

0.44	0.87	0.87
0.87	0.94	0.62
0.62	0.44	0.44

SUM

0.25	0.5	0.5
0.25	0.75	0.25
0.25	0.25	0.25

AND

FUZZY OPERATORS

0.25	0.75	0.75
0.5	0.75	0.75
0.25	0.25	0.5

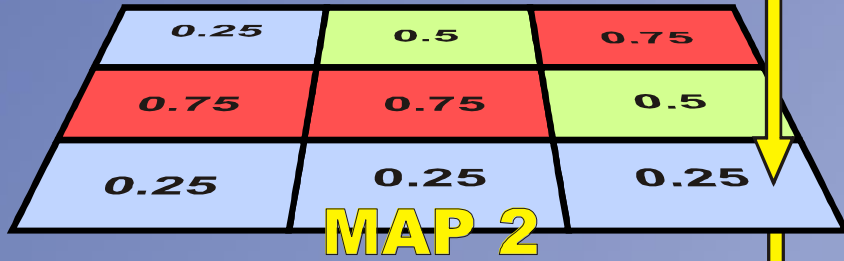
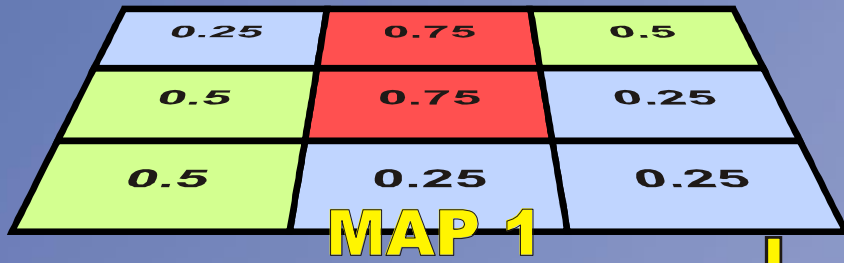
OR

0.57	0.28	0.17
0.57	0.73	0.17
0.17	0.28	0.17

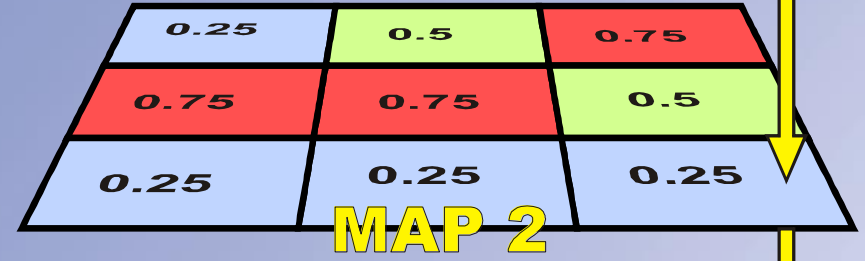
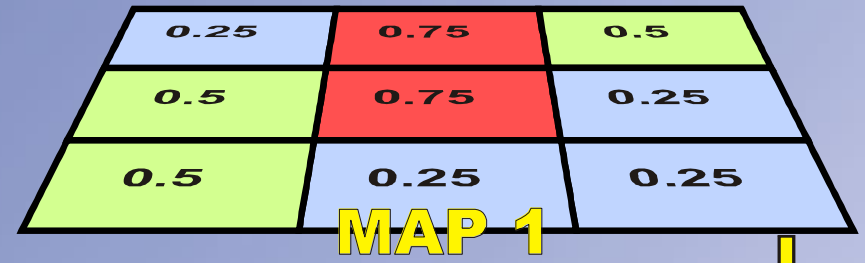
GAMMA

0.06	0.37	0.37
0.37	0.56	0.12
0.12	0.06	0.06

PRODUCT

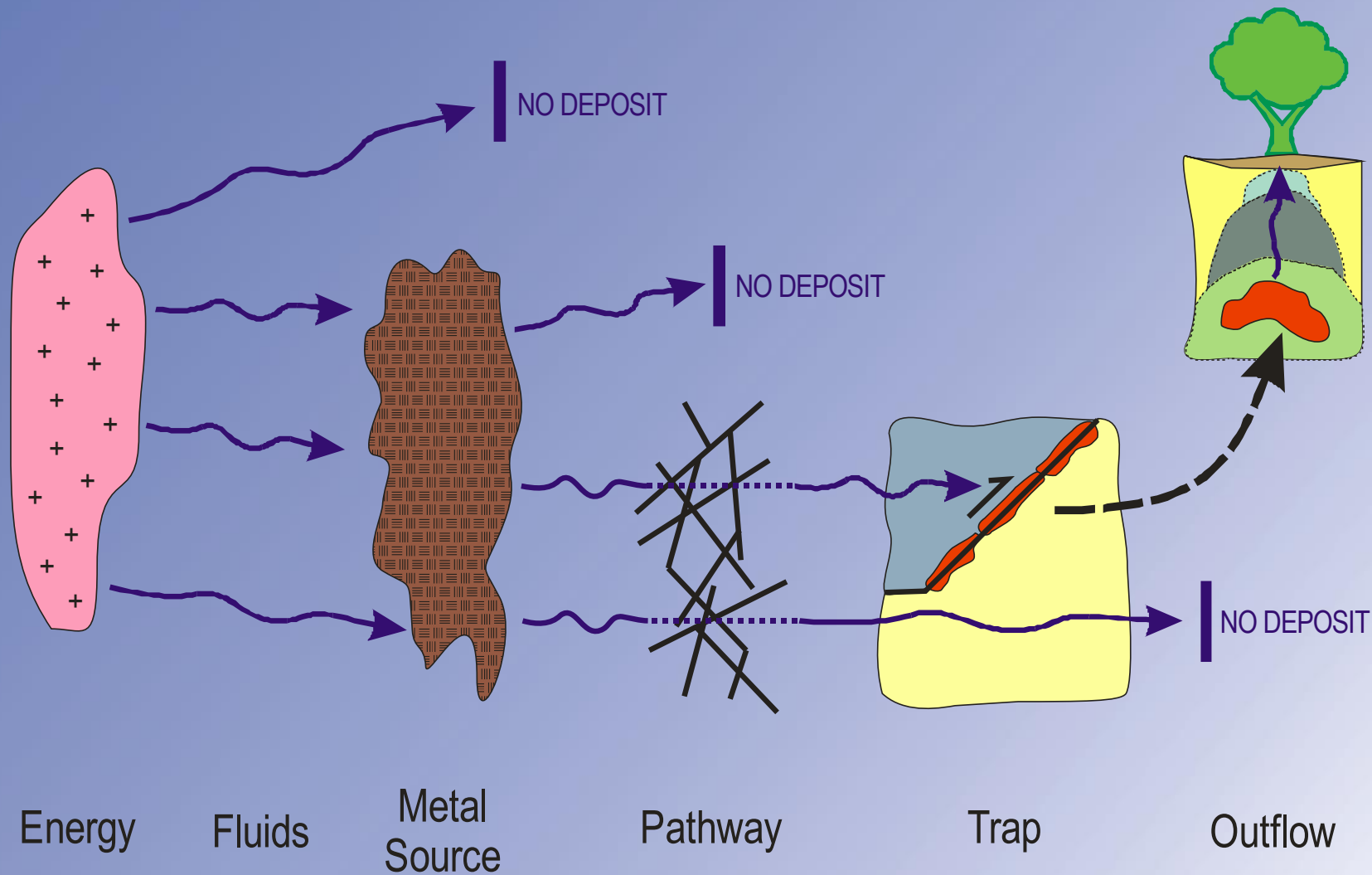


Fuzzy OR = Max(Theme1, Theme2)



Fuzzy SUM = 1-[(1-Theme1) x (1-Theme2)]

The Mineral Systems Concept



The GIS Modelling Software

MI-SDM from:

aVantra
geosystems

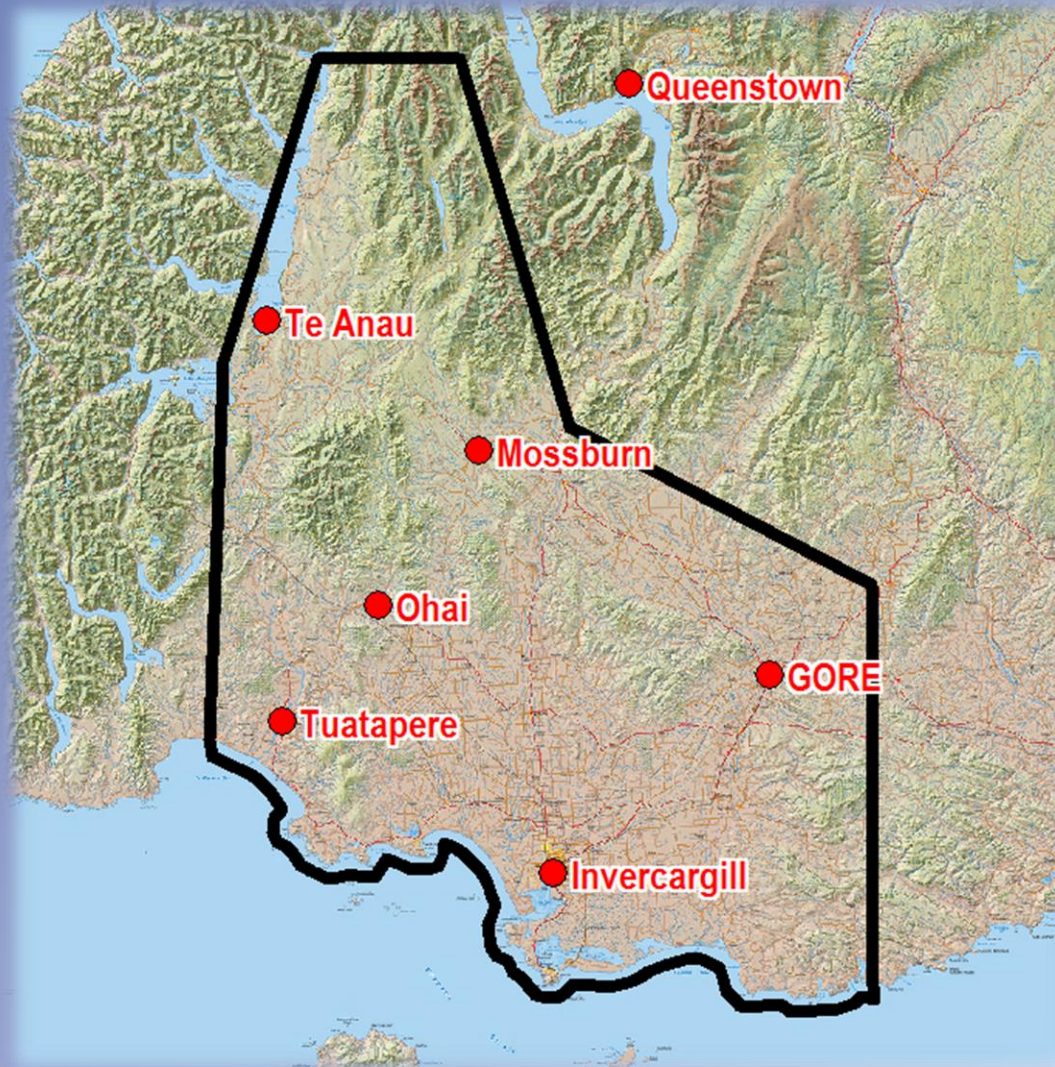


Deposits in Southland

- Geological data suggests potential for both mafic Ni-Cu-PGE mineralisation AND porphyry Cu-Au mineralisation.
- Southland has so much potential and has undergone such little modern exploration – only 6 published hard-rock drill holes!
- Great potential in Southland to discover big hard-rock and significant alluvial deposits in areas not yet fully explored.
- Millions of dollars worth of exploration funding and mine development would be spent in the Southland region and throughout New Zealand.

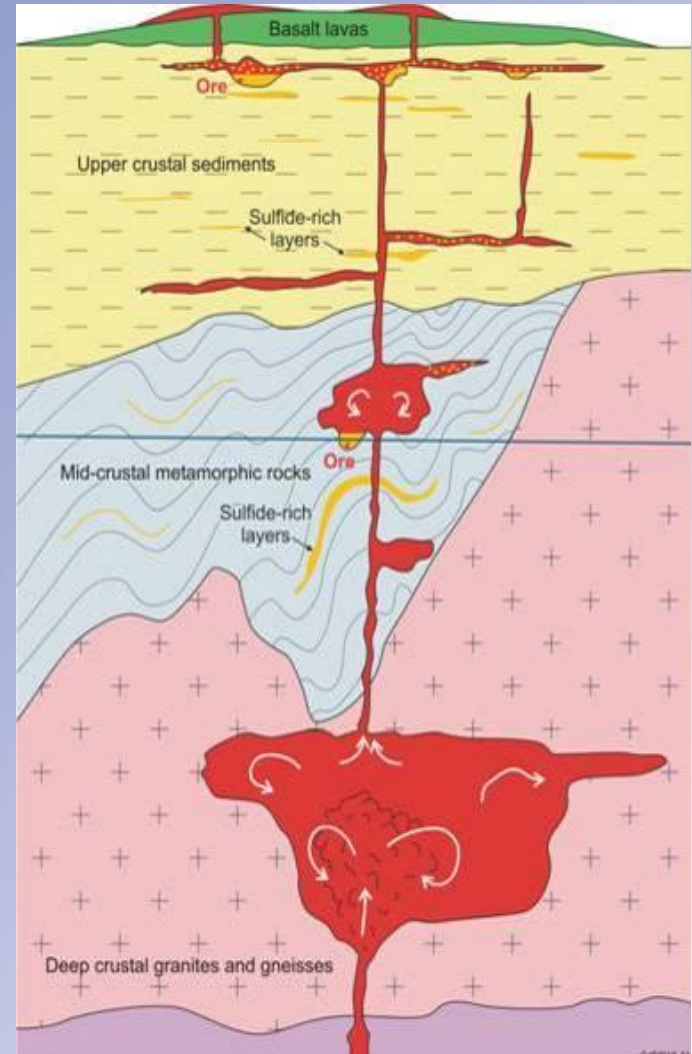


The Southland Study Area



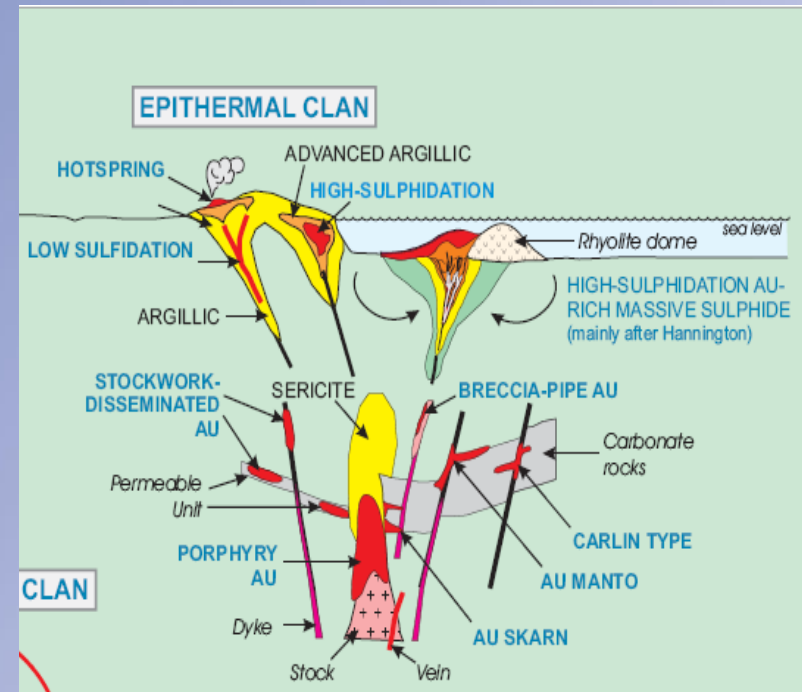
Mafic Ni-Cu-PGE Mineralisation

- Energy & Source
 - Mafic intrusions (sills, dykes, etc.)
 - Hard rock occurrences of PGE, Ni, Cu
 - Anomalous basins for Ni, or Pt
- Fluids
 - Fractional crystallisation indicating transport from source.
 - Any other mapped geological features that might indicate younging direction or mafic layering.
- Trap
 - Large intrusive bodies
 - Sulfide rich host rocks
 - Rocks & soils anomalous in Cu, Ni, or Pt
- Outflow
 - Mineralised mafic rocks or sulfides
 - Economic grade Ni, Pt, or Pd locations



Porphyry Cu-Au Mineralisation

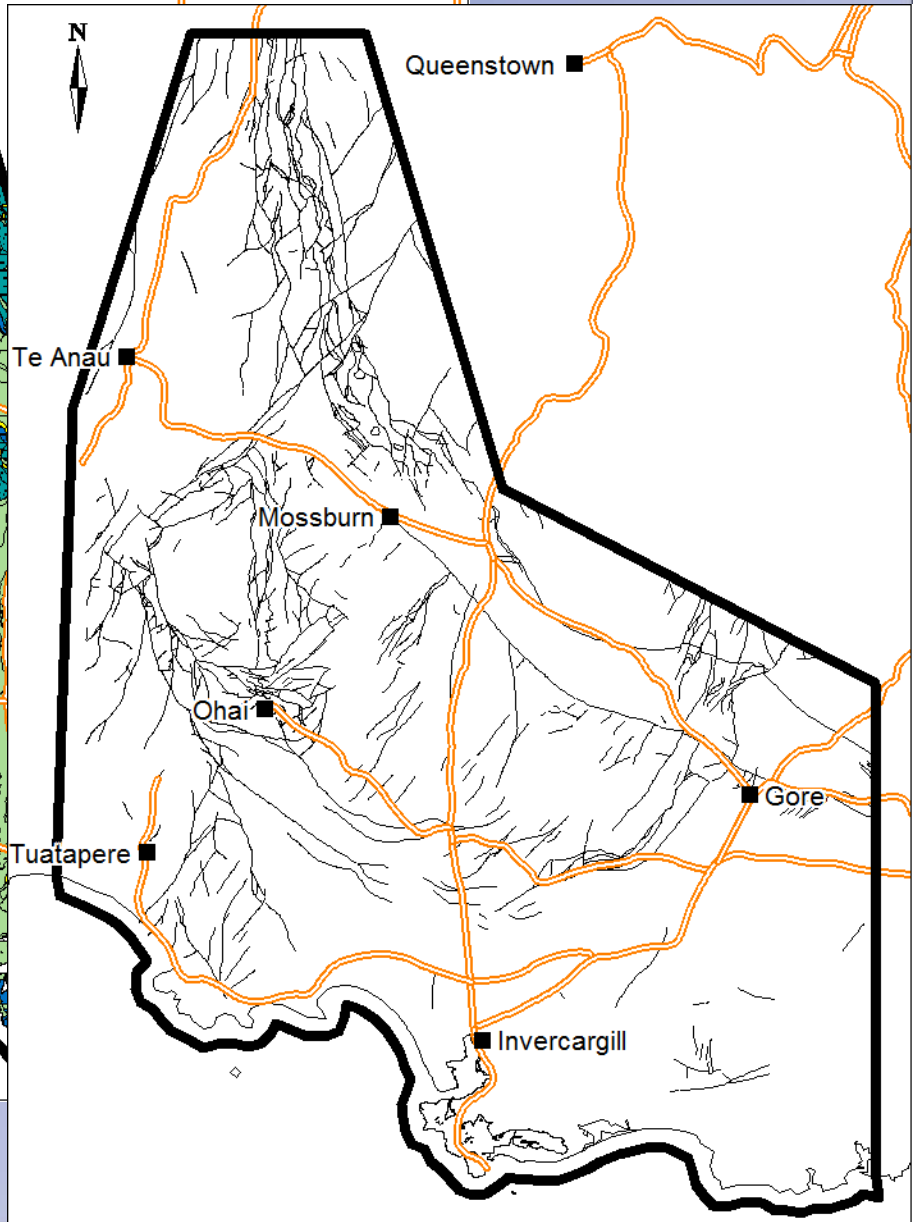
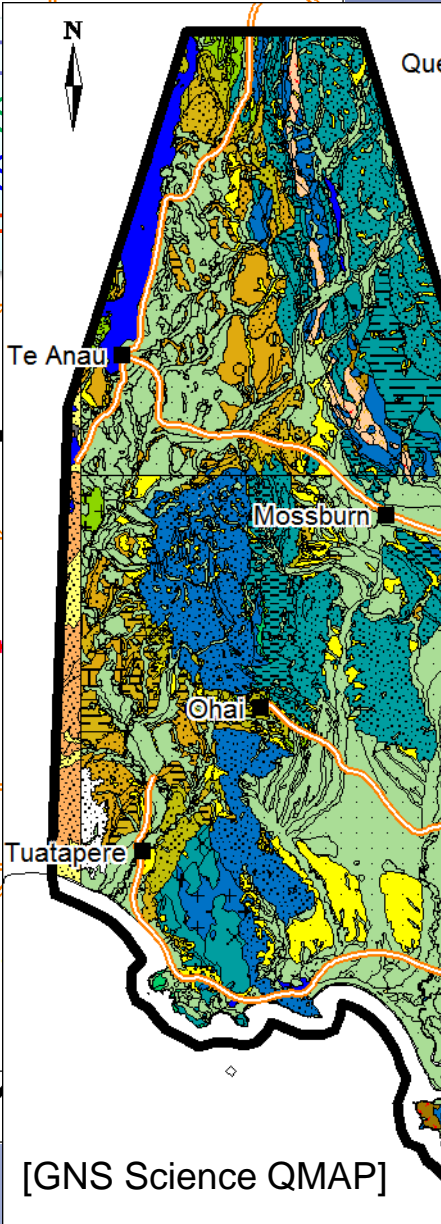
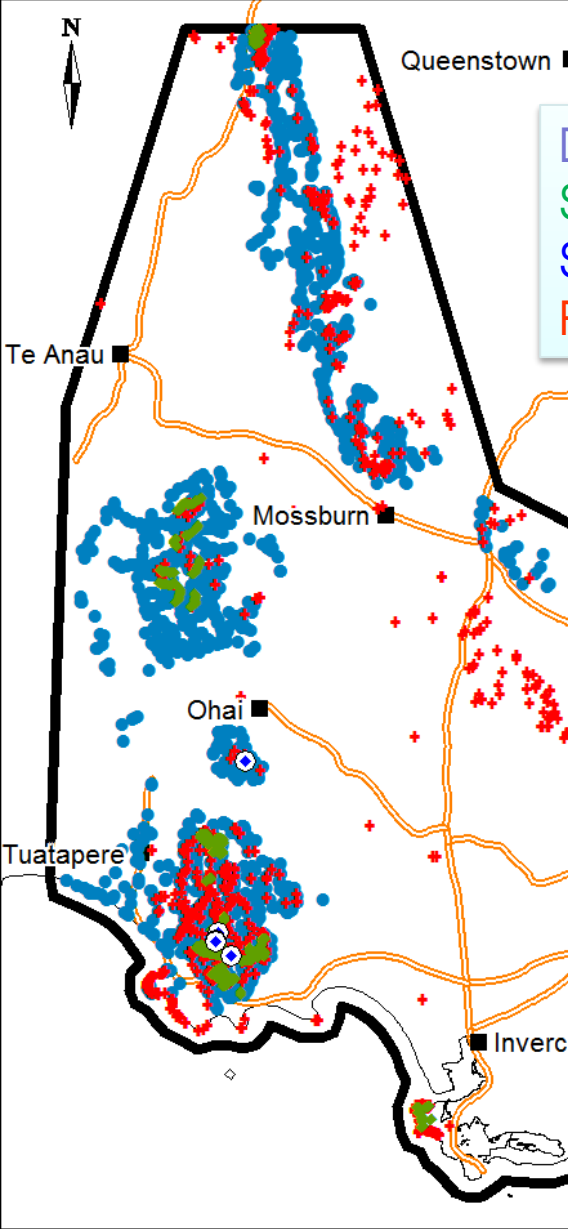
- Energy / Source
 - Intermediate intrusives (metal source)
 - Contemporaneous volcanics (near surface)
 - Anomalous basins for Cu, Mo, or Au
 - Intrusive age (older than host for mineralisation)
- Fluids
 - Faults & other structural controls
 - Carbonates that act as chemical pathways
- Trap
 - Fertile diorites, pegmatites, fertile intrusives
 - Rocks and soils anomalous in Au, Cu, or Mo
- Outflow
 - Economic grades of Cu, Au, or Mo
 - Alteration zones



Data sources

- GNS Science – QMAP geological mapping.
- Crown Minerals – Historical records of past exploration results and interpretations.
- Data entry – In-house at Kenex where possible for data not in a digital format.
- Experts – Geologists, research scientists, exploration managers.
- Company records and new work – e.g. mapping, sampling and drilling.





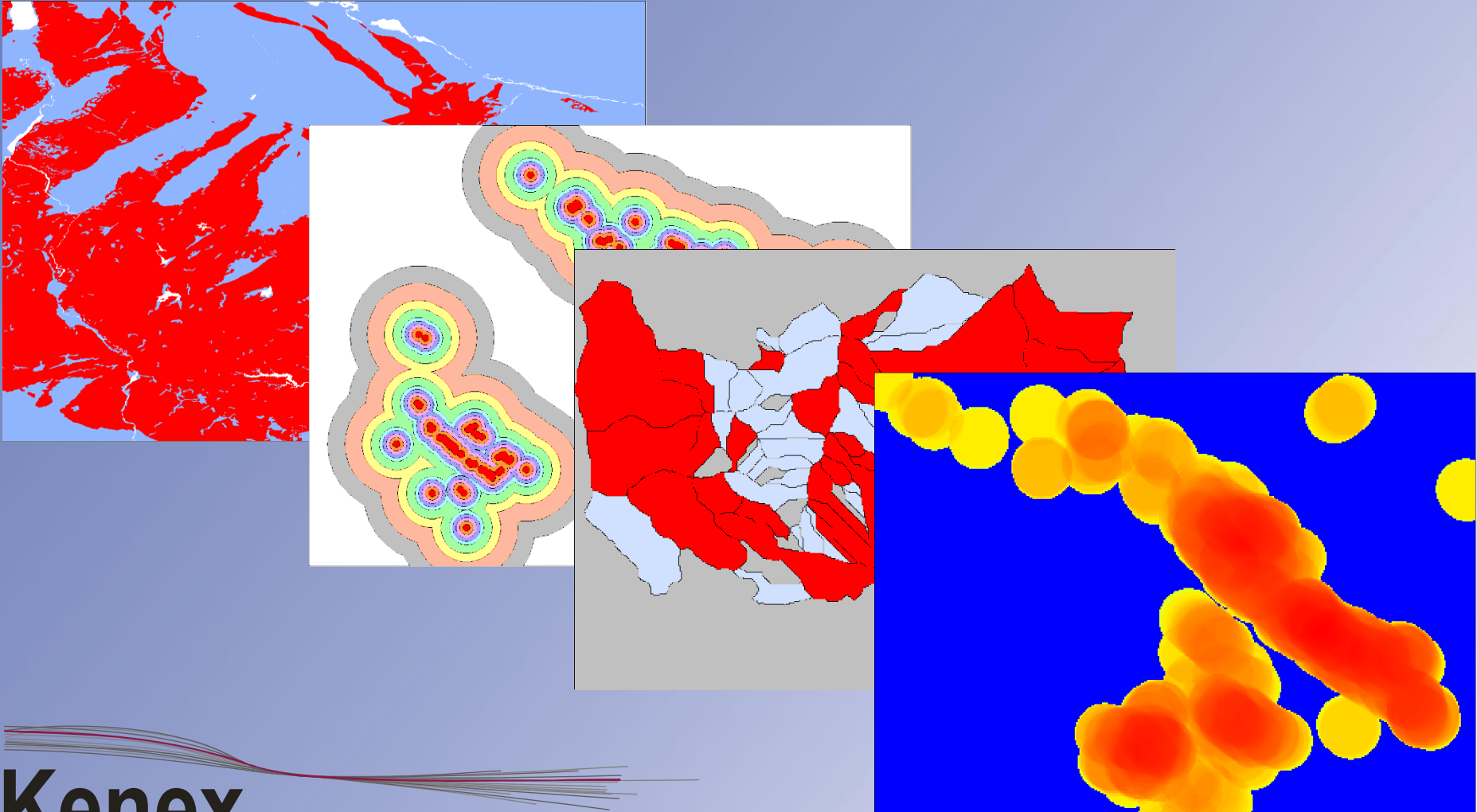
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Geological maps for the model

From 44 data sets:

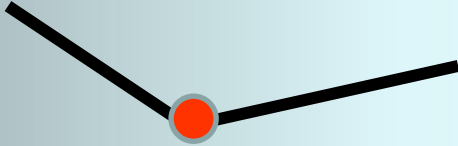
- 16 maps were created for the porphyry Cu-Au model
- 15 maps were created for the mafic Ni-Cu-PGE model
- These included lithological, geochemical, structural, and orogenic geological maps.
- Southland is lacking good regional geophysical data, detailed fractionation and source data for the intrusives and many areas have not been tested for the right elements in geochemical surveys.

Example model maps.....



Faults

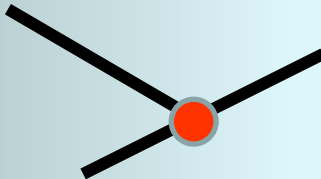
BENDS



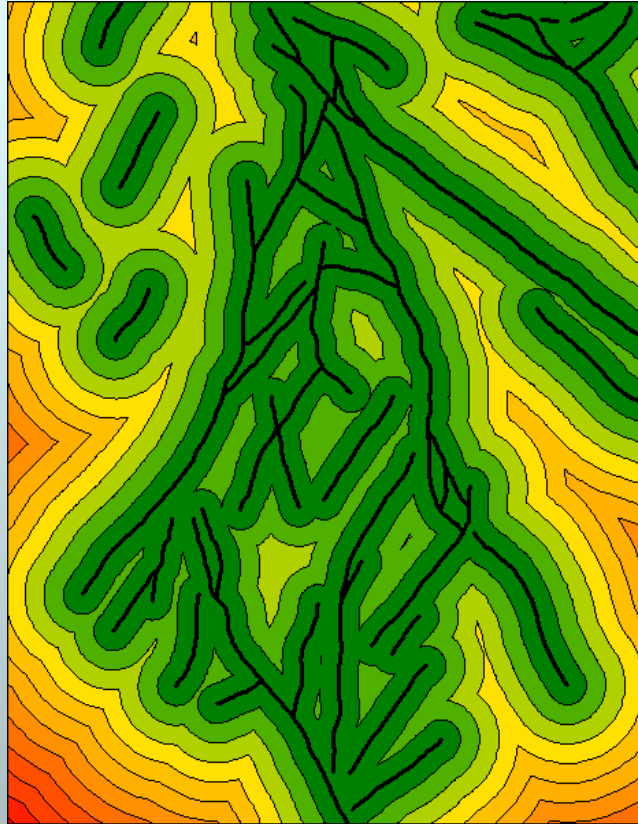
JOGS



INTERSECTIONS



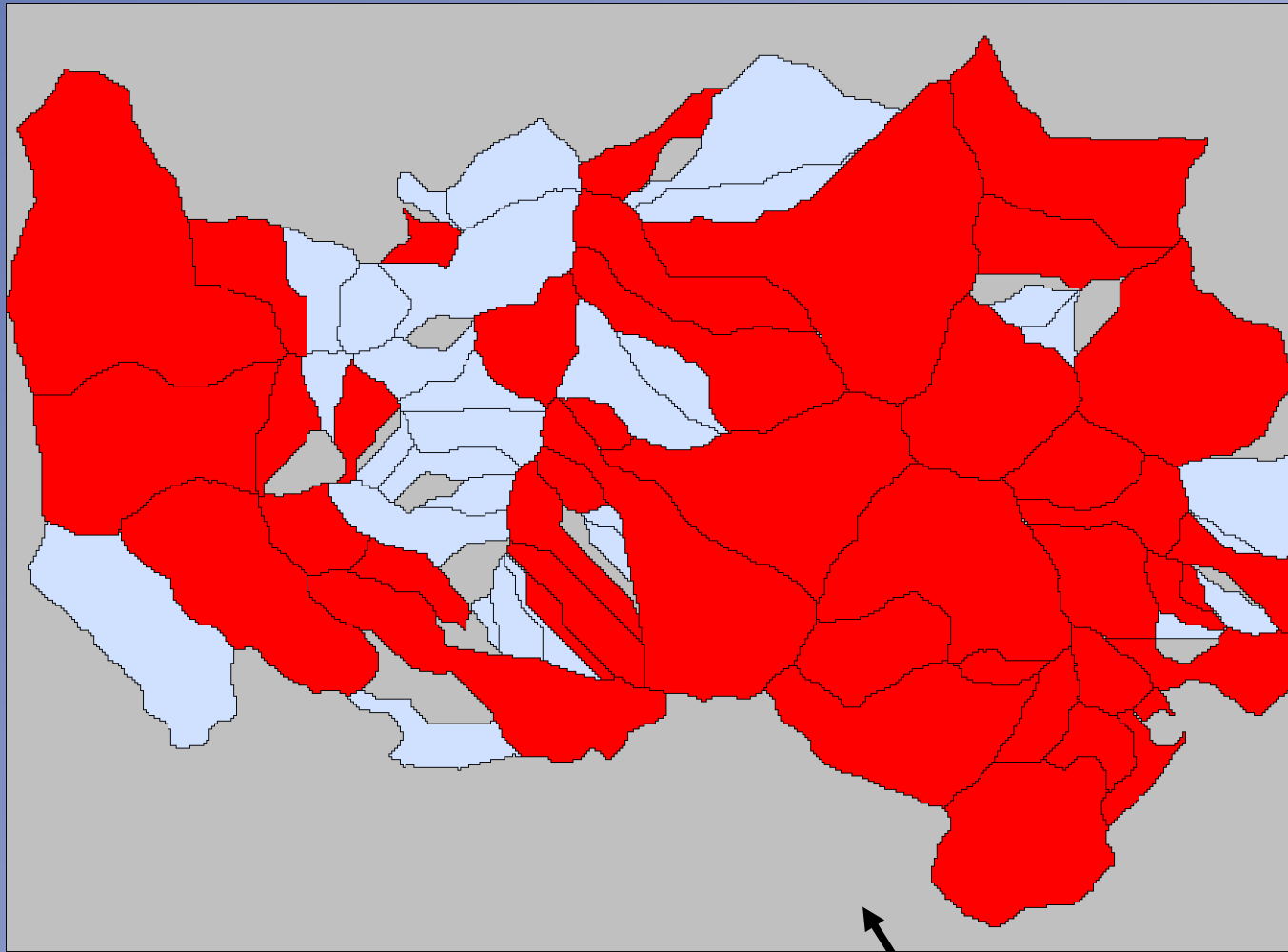
DISTANCE



Methods:

- Faults are analysed as conducts for fluid.
- Bends, jogs, and intersections are located using spatial analysis.
- Distance from faults known to be fracture zones.
- Key fault locations, distances, and conditions are buffered and converted to a grid for the model.

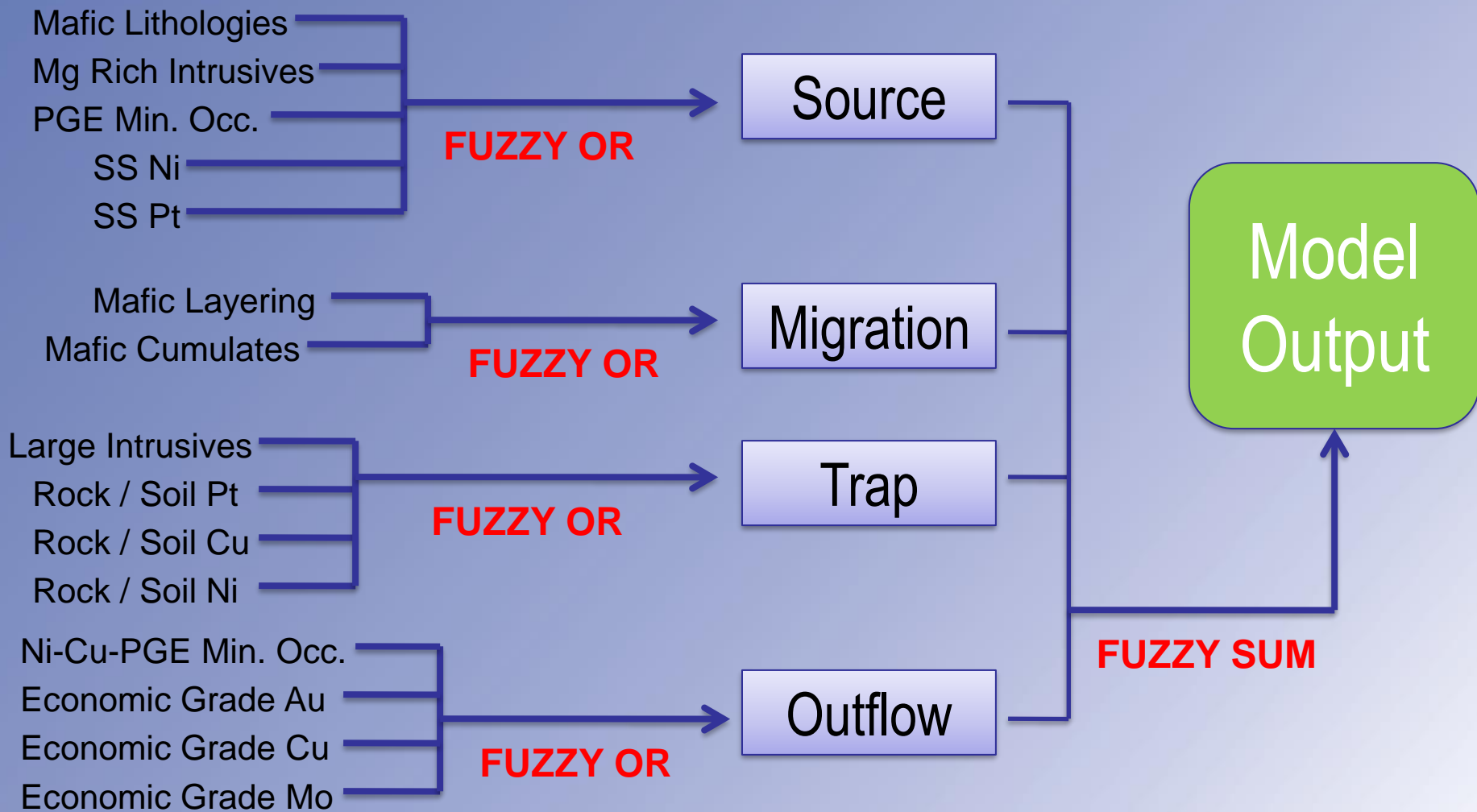
Stream Sediment



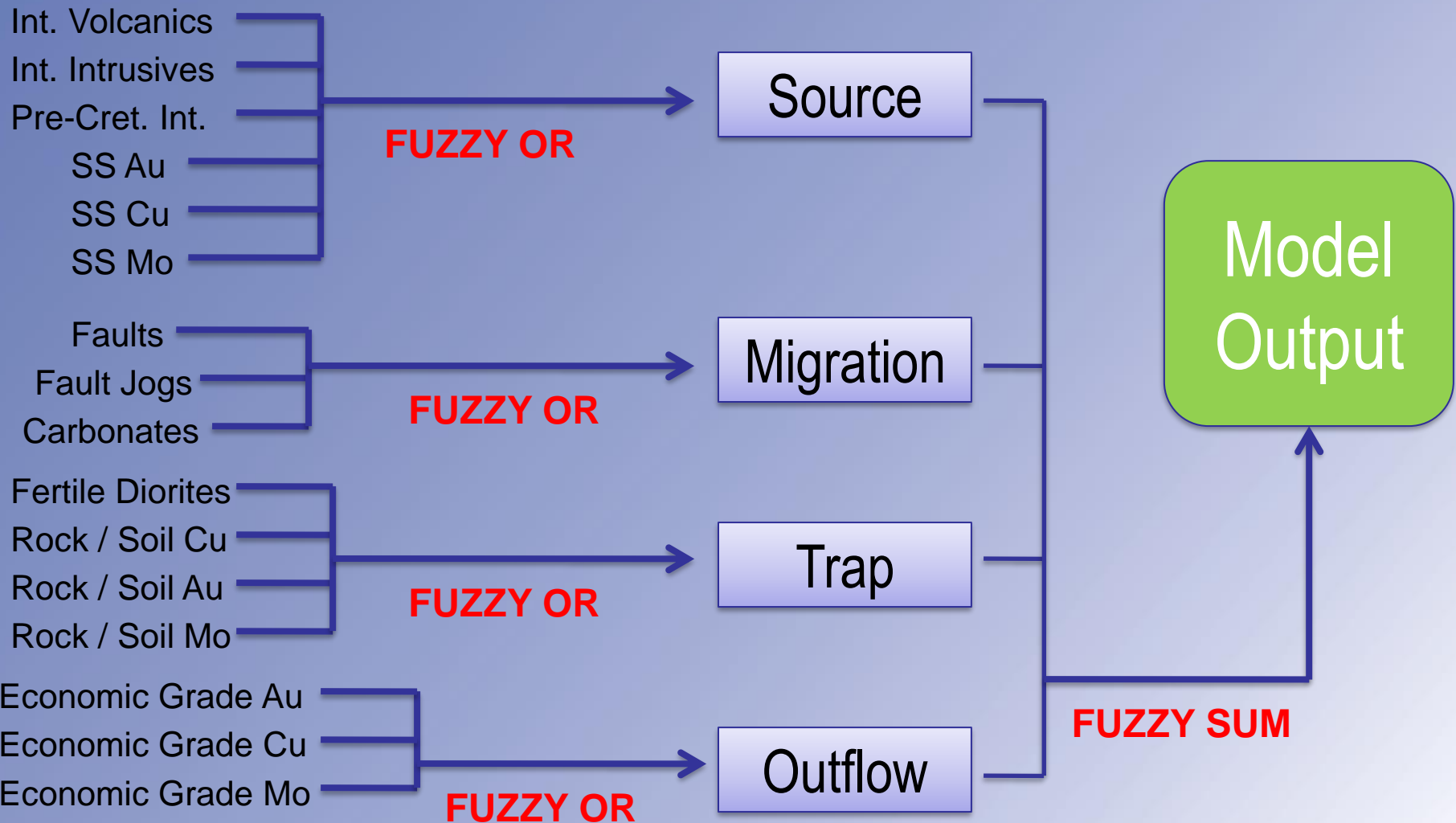
Methods:

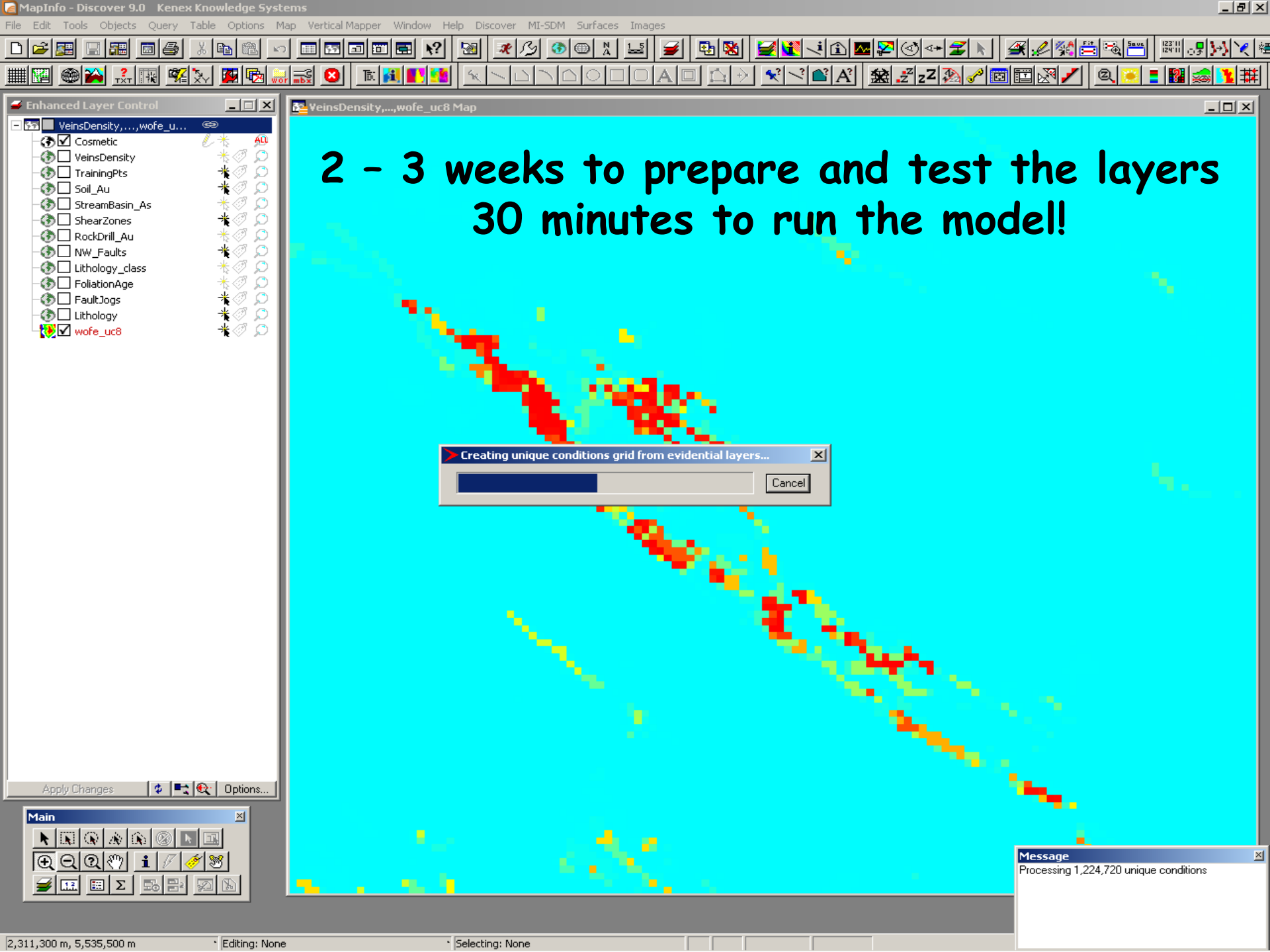
- Locate and define anomalous stream sediment samples.
- Create basin boundaries from DTM using gridding tools.
- Apply maximum or average geochemistry to basins.
- Classify basins into either anomalous or non-anomalous and apply expert weighting values.

Mafic Ni-Cu-PGE Decision Tree



Porphyry Cu-Au Decision Tree





2 - 3 weeks to prepare and test the layers
30 minutes to run the model!

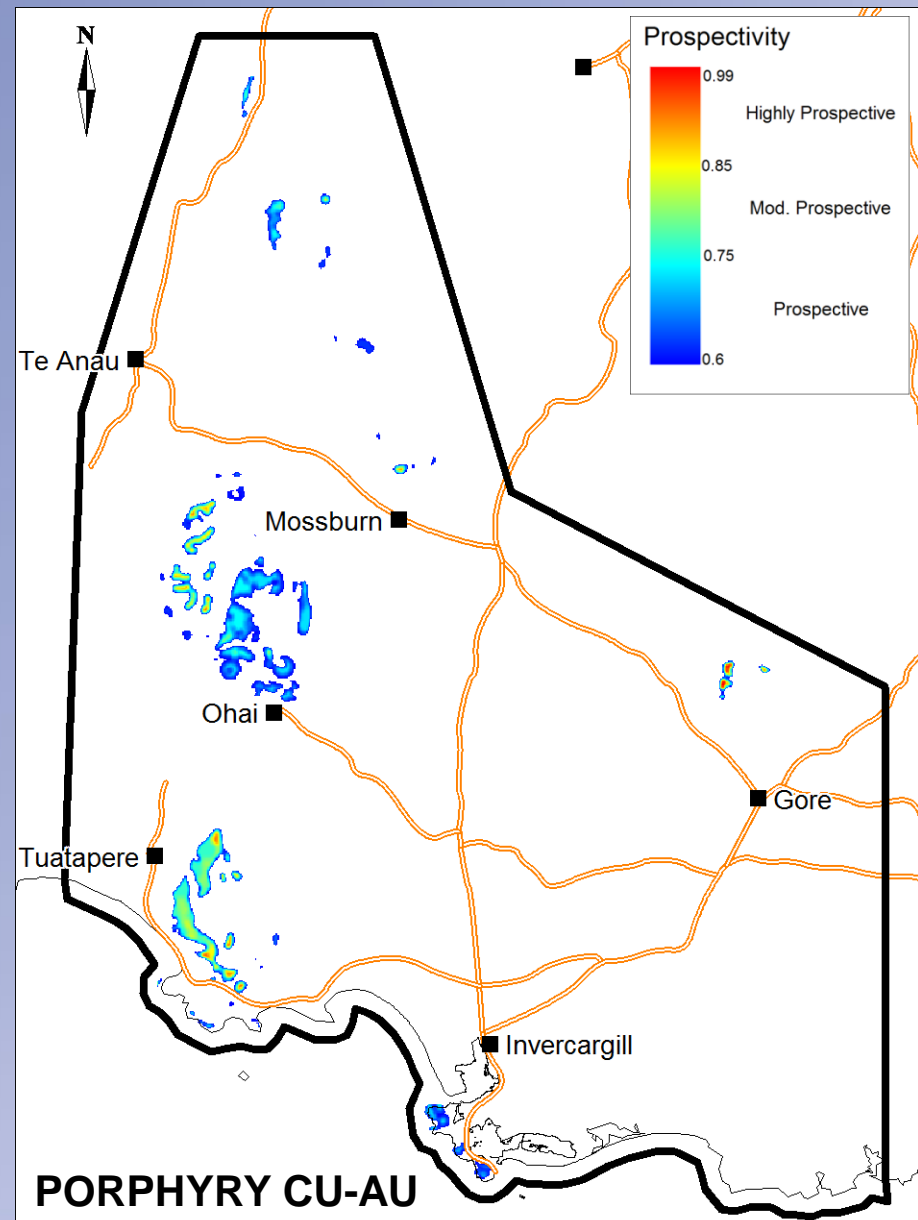
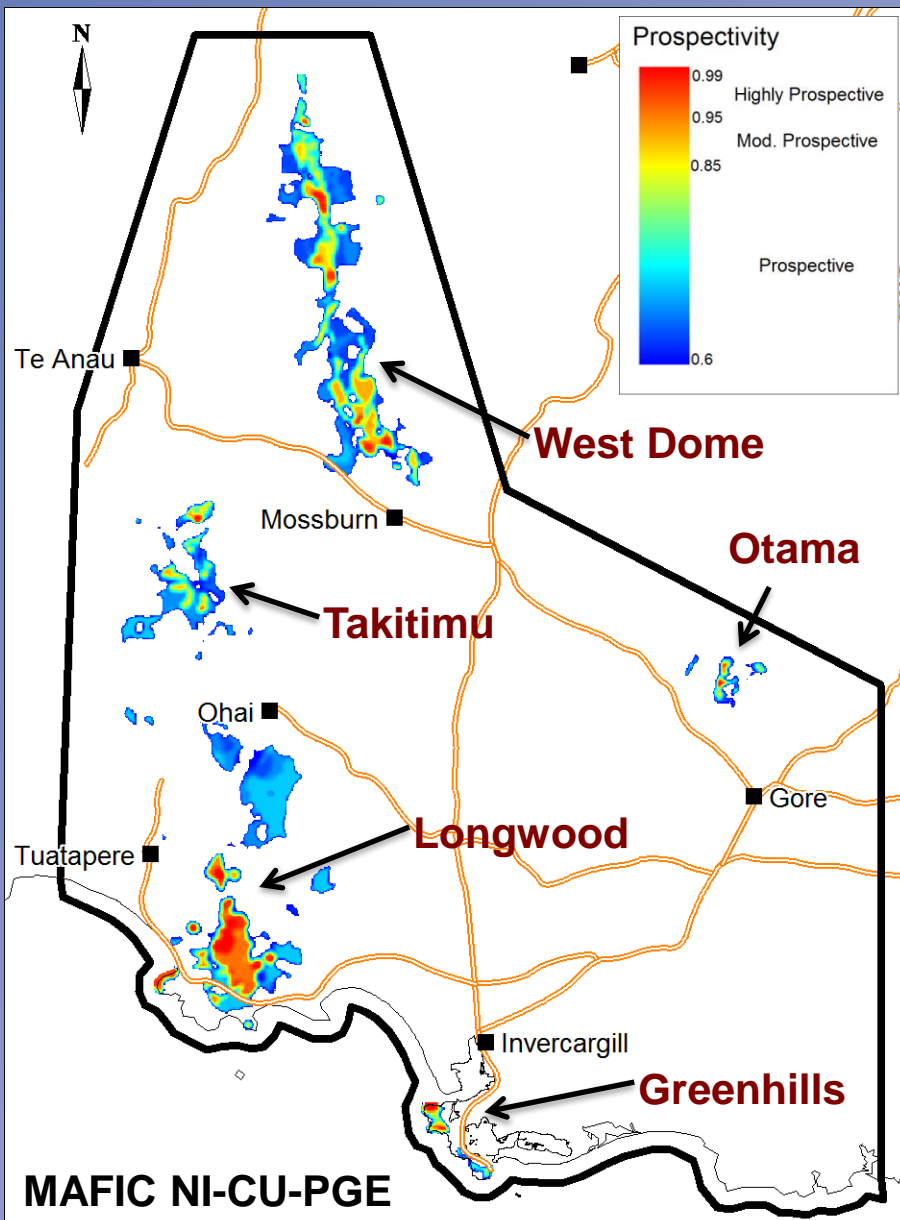
Creating unique conditions grid from evidential layers...

Message
Processing 1,224,720 unique conditions

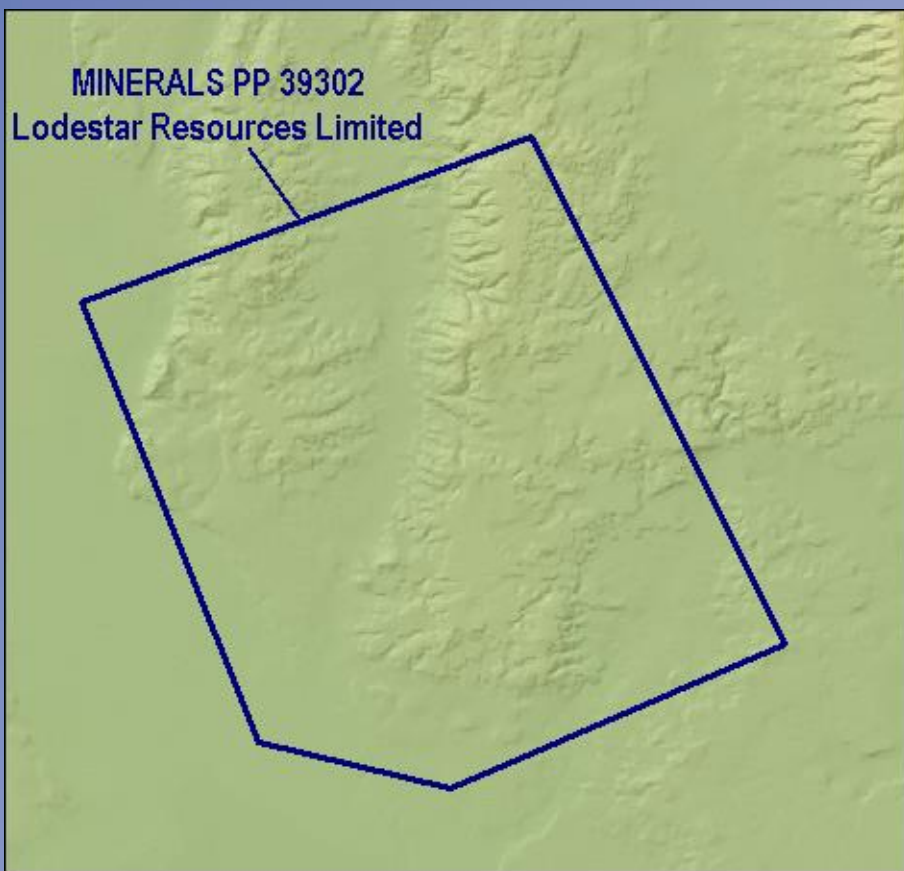
- VeinsDensity,....wofe_u...
- Cosmetic
- VeinsDensity
- TrainingPts
- Soil_Au
- StreamBasin_As
- ShearZones
- RockDrill_Au
- NW_Faults
- Lithology_class
- FoliationAge
- FaultJogs
- Lithology
- wofe_uc8

Main

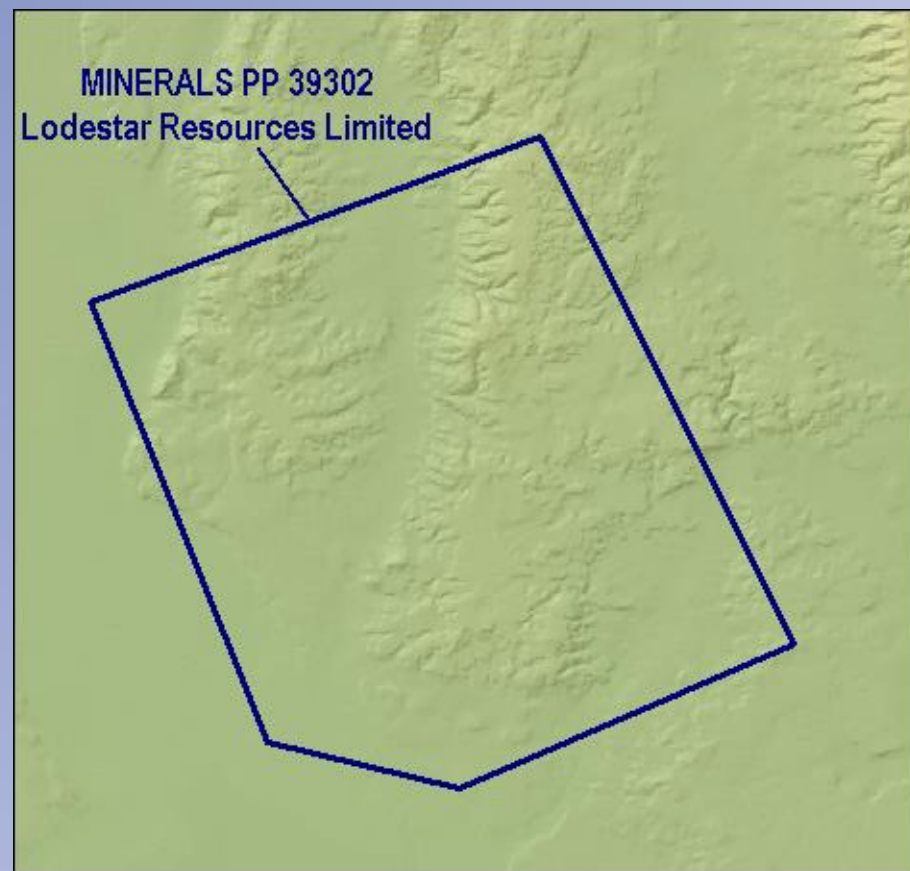
Prospectivity Maps



Results for Otama Region

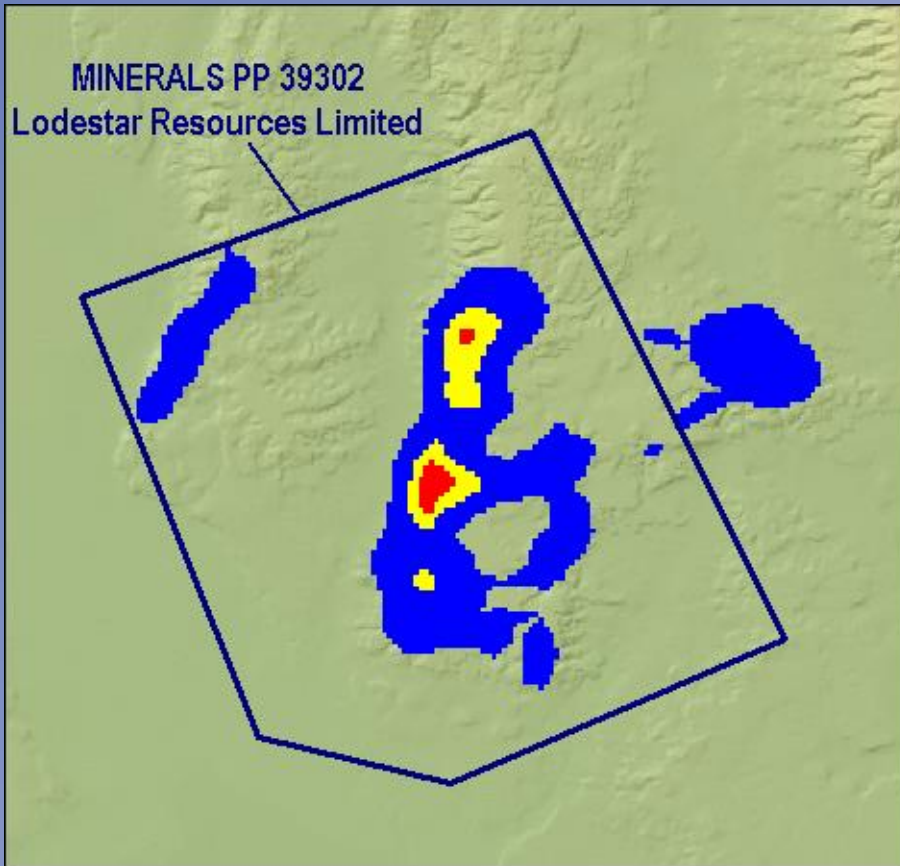


MAFIC NI-CU-PGE

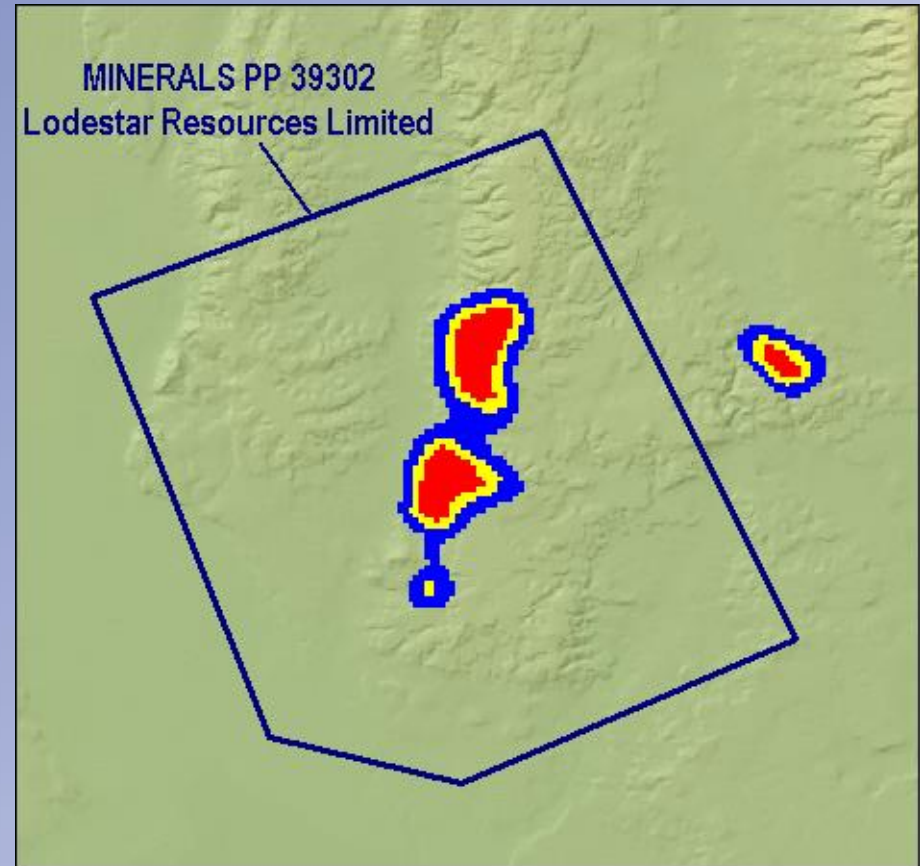


PORPHYRY CU-AU

Results for Otama Region



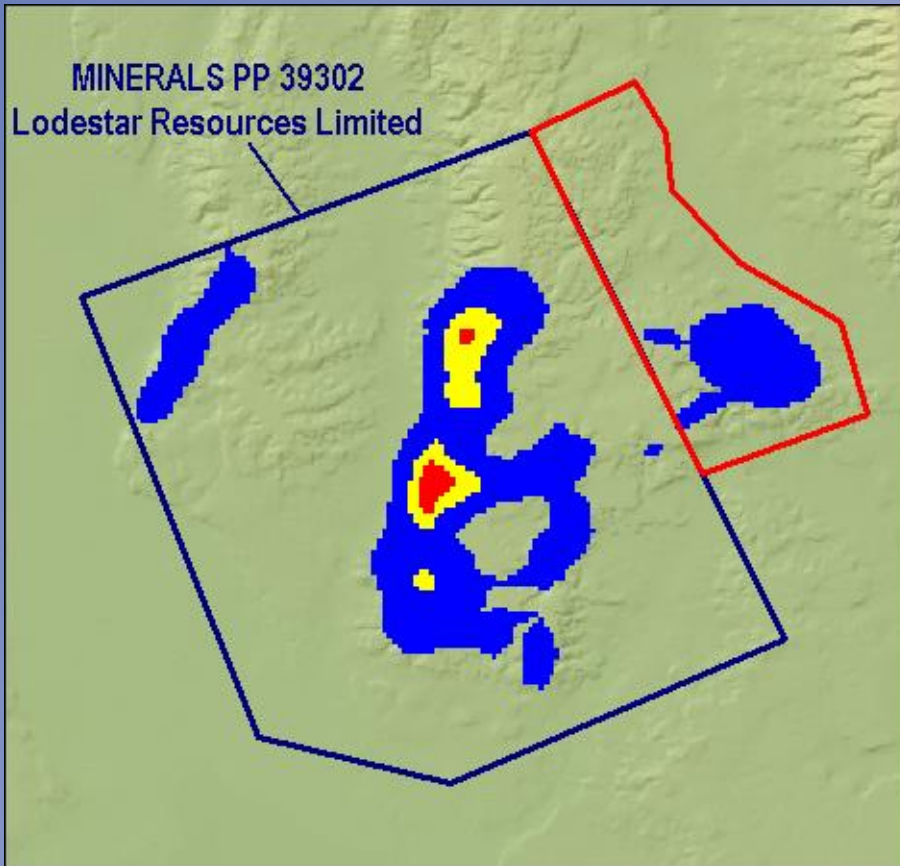
MAFIC NI-CU-PGE



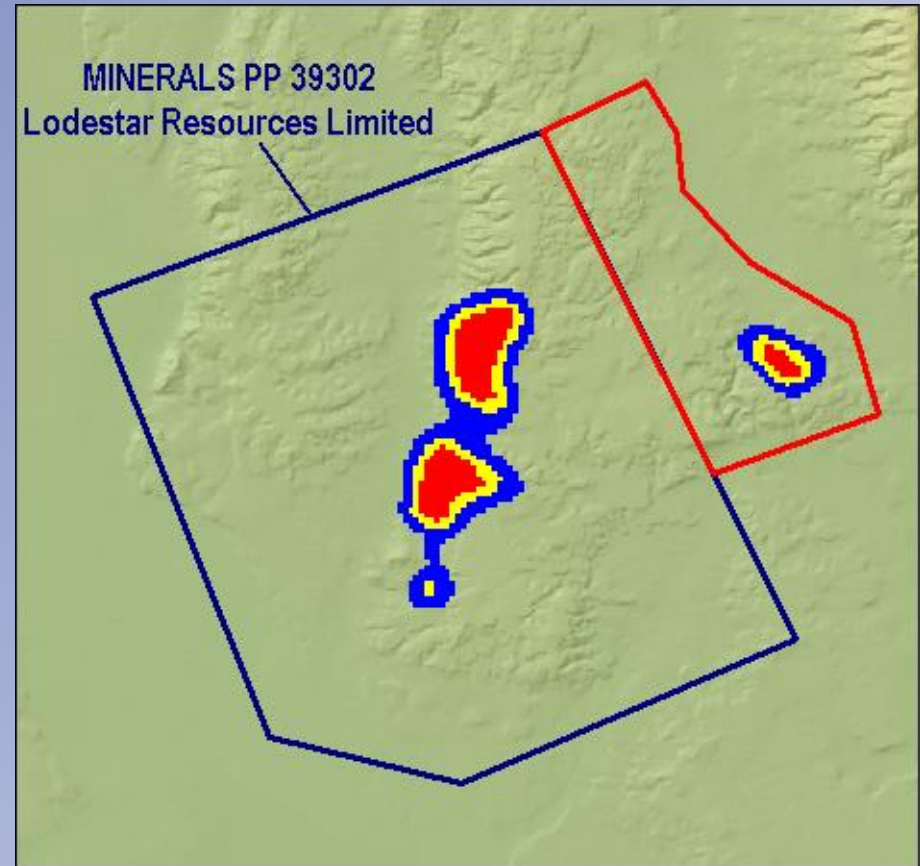
PORPHYRY CU-AU

PROSPECTIVE AREA OUTSIDE OF
CURRENT PERMIT

Results for Otama Region



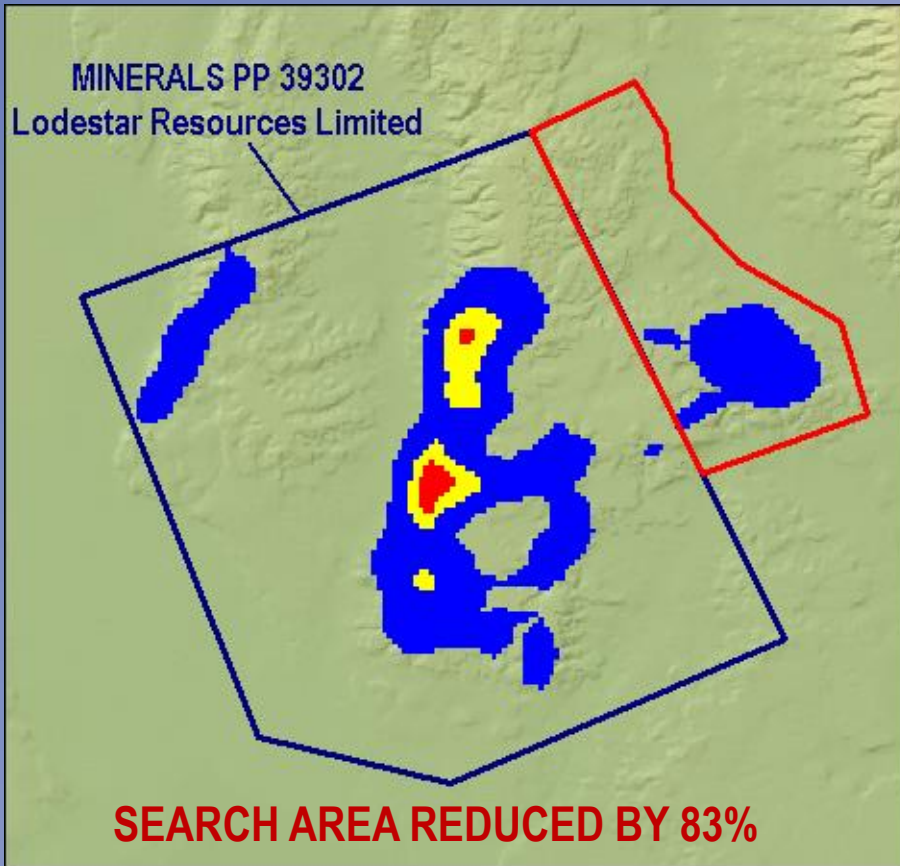
MAFIC NI-CU-PGE



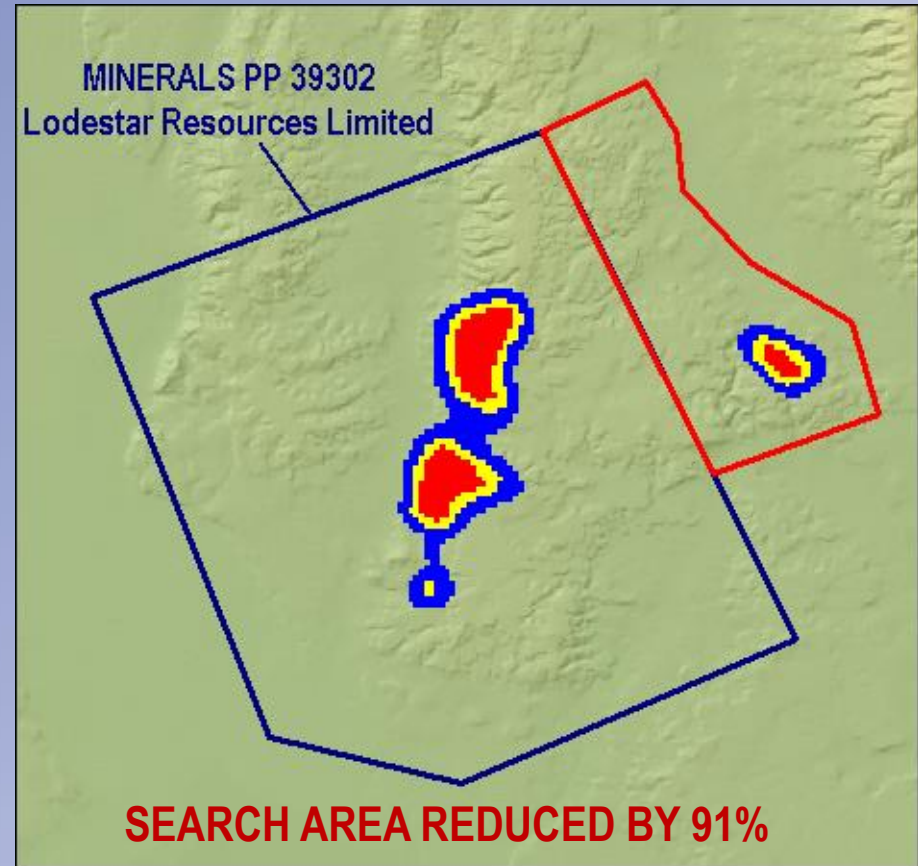
PORPHYRY CU-AU

TENEMENT ACQUISITION TO
CAPTURE GROUND

Results for Otama Region



MAFIC NI-CU-PGE

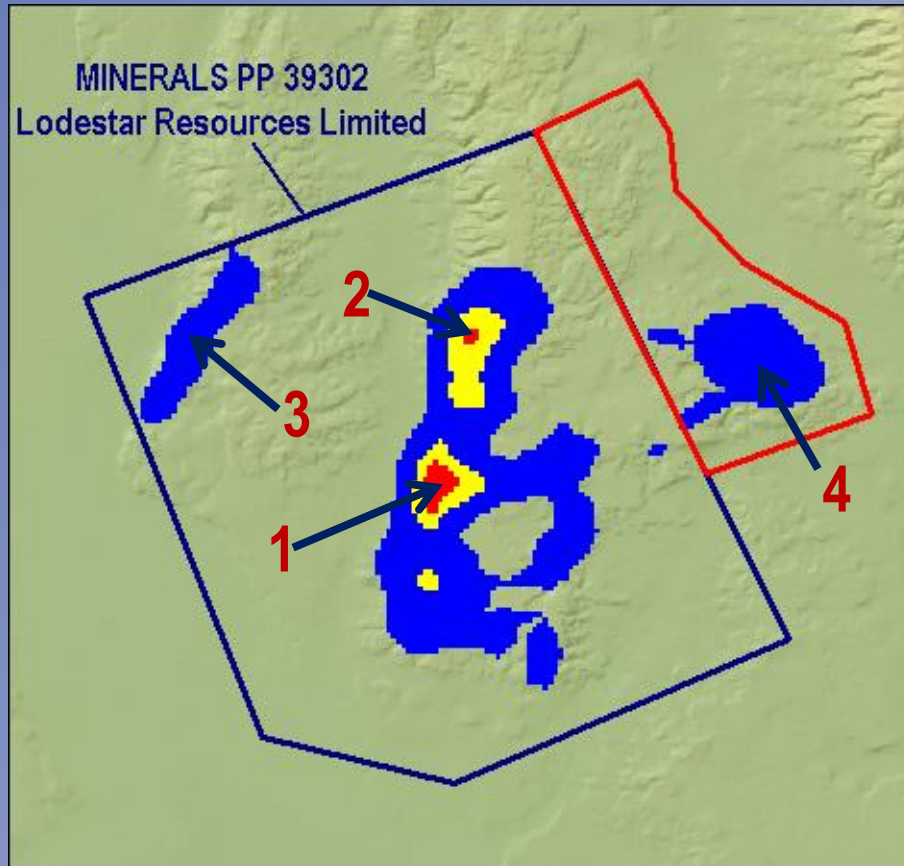


PORPHYRY CU-AU

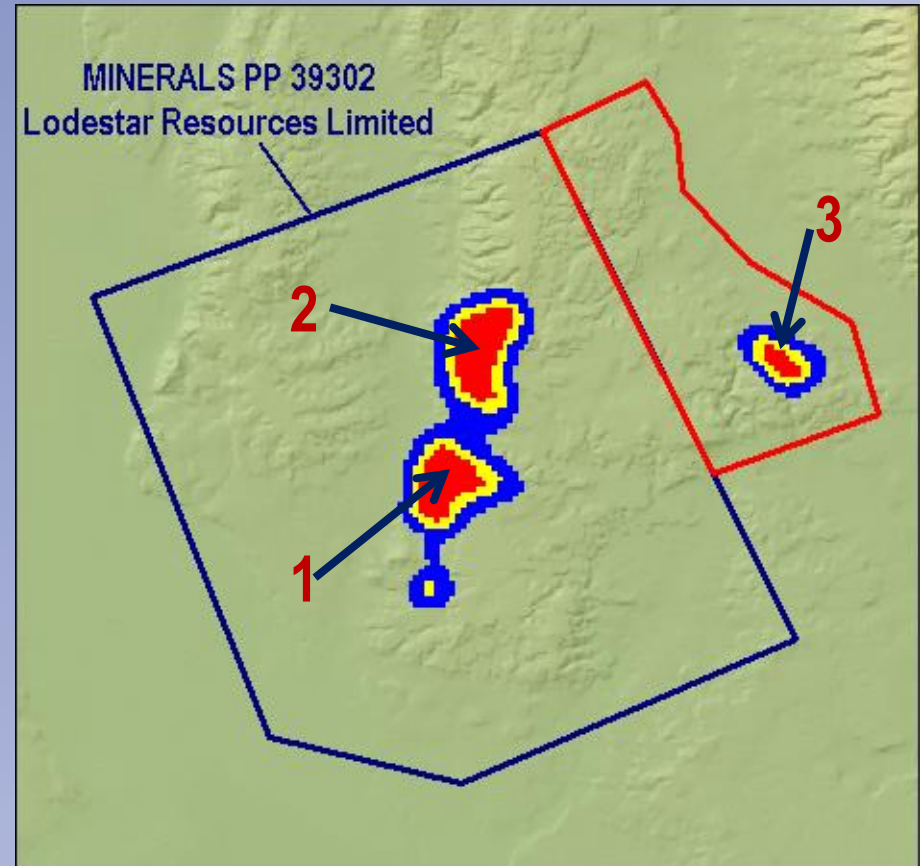
SOIL SURVEYS, GEOPHYSICS,
DRILLING OR 3D MODELLING
OVER PROSPECTIVE REGIONS

Kenex

Results for Otama Region



MAFIC NI-CU-PGE



PORPHYRY CU-AU

TARGET RANKING

Conclusions

- Fuzzy Logic spatial data modelling has been used to assess the prospectivity of Southland.
- The Mafic Ni-Cu-PGE and Porphyry Cu-Au mineralisation systems have been modelled.
- Longwood, Takitimu, West Dome, Otama and Greenhills are all prospective for mafic Ni-Cu-PGE.
- Longwood (west), Takitimu, Otama and Greenhills are all prospective for porphyry Cu-Au.
- This spatial modelling can be used for exploration management e.g. permit applications, soil sampling or drill hole targeting.



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Creating opportunities in the spatial world