Predicative Modelling for Environmental Management and Mineral Exploration - Potential Applications for the Marine Minerals Industry

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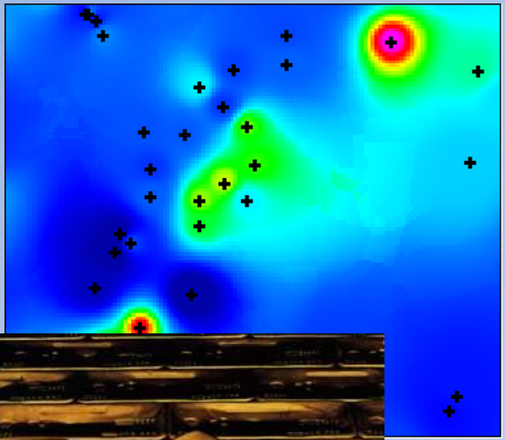

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- Kenex is a business development company focusing on spatial modelling to create new business opportunities.
- Spatial modelling is where we make the connection between data, information, processes, and the ideas of people, to deliver innovative knowledge-based business solutions.
- Adopting and driving the latest GIS technologies, Kenex have undertaken predictive modelling to identify prospective areas for potential mineral deposits, wildlife habitats, and geothermal & wind energy.



Our Services

- Spatial data modelling including mineral prospectivity mapping, wind farm prospectivity mapping and habitat mapping
- Mineral Exploration and industry advice
- Mineral Exploration project management
- Tenement management
- Data management and acquisition
- GIS workshops and training
- Complete spatial business management
- Fund raising and business development

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Potential Applications of Spatial Modelling

- Prospecting for economic minerals (gold, copper, nickel, uranium etc)
- Assessing suitability of land for energy generation such as hydro, geothermal or wind power
- Assessing suitability of land for agricultural/horticultural use
- Environmental assessment
- Endangered species habitat models
- General land management

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What is spatial modelling and why undertake it?

- 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 companies.
- **Save time and money** by putting resources into the most likely places the first time and undertake value / **risk assessment** of assets.

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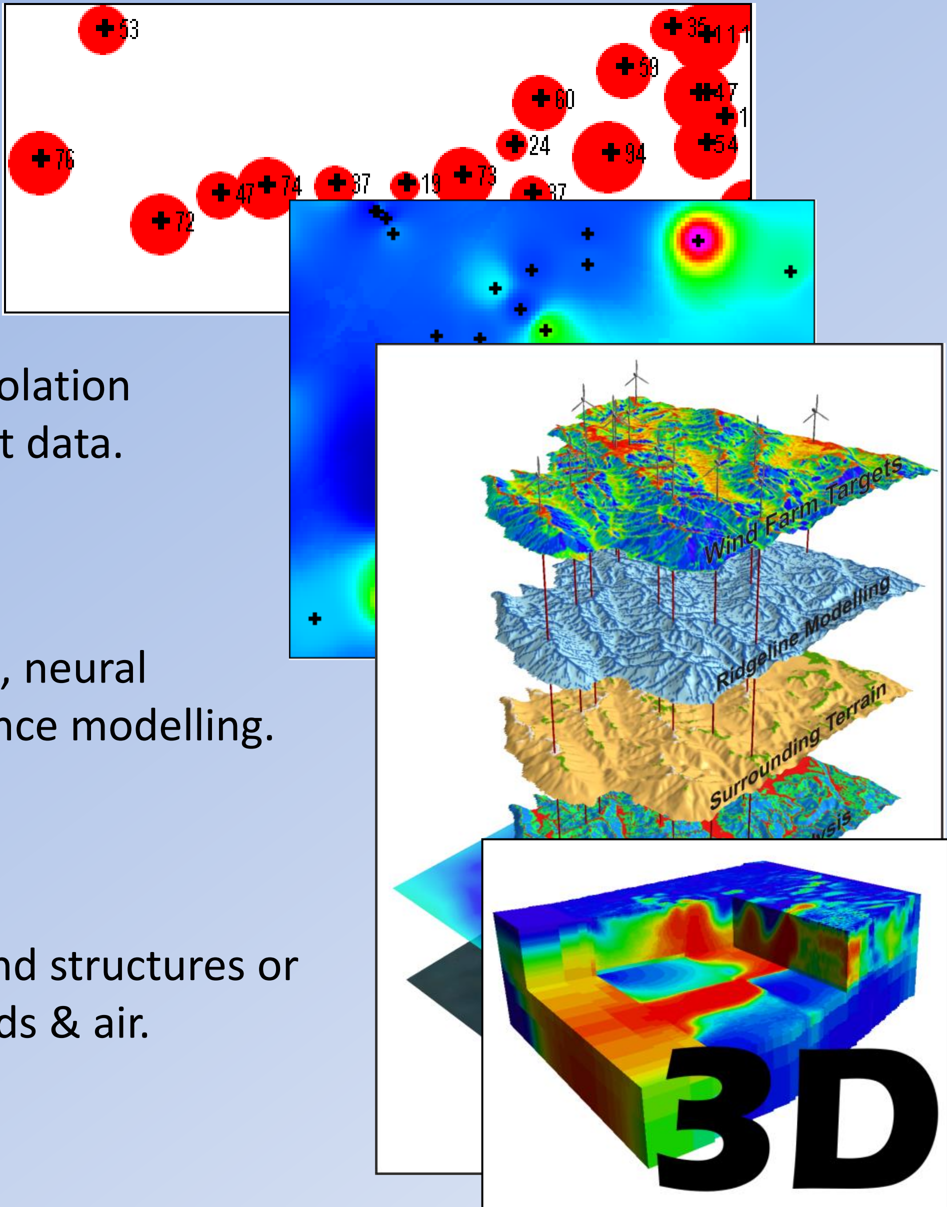
Types of spatial modelling

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 & air.



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Multi Variable Modelling

- **Goal**
  - ***To predict locations where there is a high probability of an event occurring***
- Types
  - Weights of Evidence (data driven)
  - Fuzzy Logic (knowledge driven)
- What you need:
  - A study area
  - Relevant spatial digital datasets over the area of interest compiled into a GIS (e.g. Geological mapping, wind speed data)
  - A training data set (known locations i.e. Existing wind turbines) for Weights of Evidence or expert knowledge for Fuzzy Logic
  - Knowledge about the particular variable you are trying to model

The Modelling Software:

MI-SDM & Arc-SDM from

avantra geosystems & Geological Survey of Canada

Run using...

ArcGIS

MapInfo

encom discover

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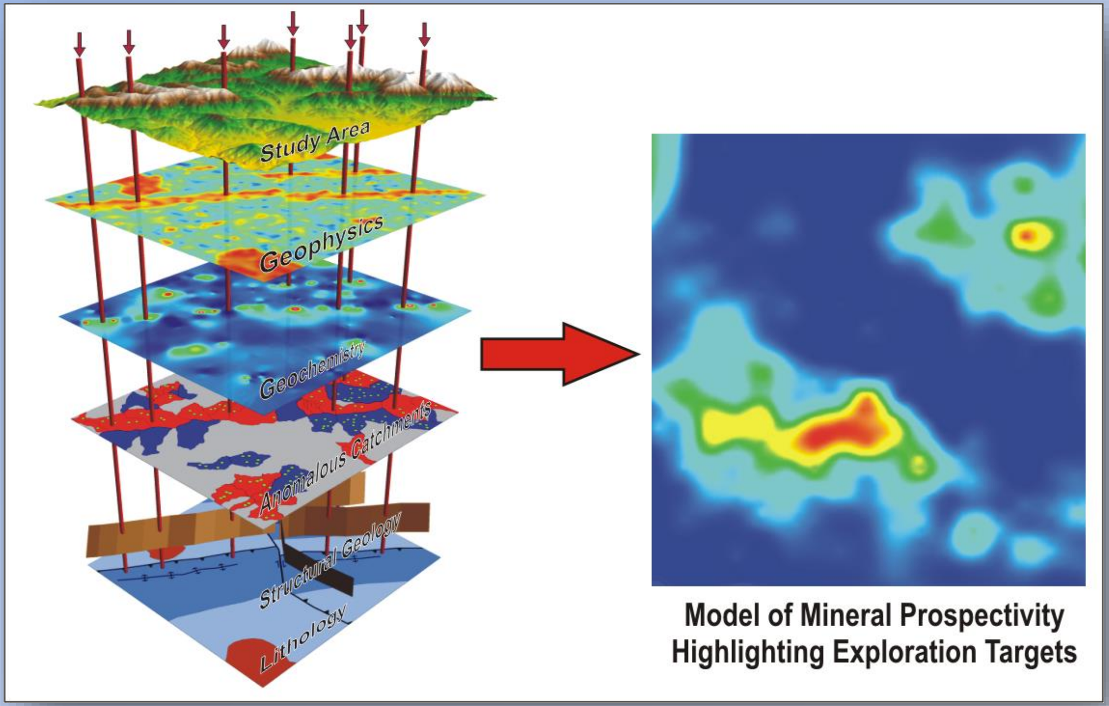
Weights of Evidence

- Basic Method
  - Develop binary or multiclass predictive maps of data relevant to the mineralisation style being modelled
  - Use training data to test predictive maps for spatial correlation
  - Combine selected predictive maps together using weights of evidence statistics to produce a map of probabilities (Prospectivity Map)



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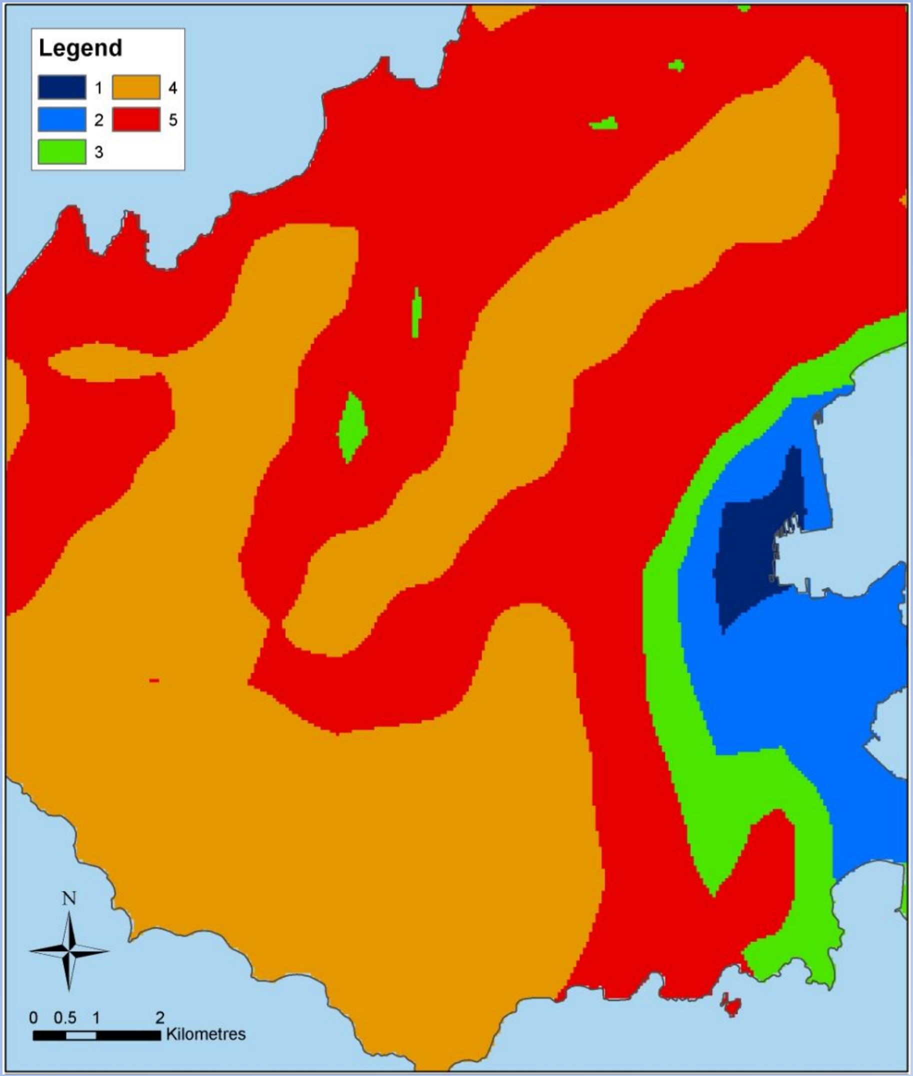
Fuzzy Logic Method



- Create binary or multiclass predictive maps from raw digital datasets
- Assign expert weights to predictive map classes
- Combine weighted predictive maps using Fuzzy operators (AND, OR, Sum, Product or Gamma) to produce a map of probabilities

Class	Description	Weight
1	Not Windy	0.1
2	Slightly Windy	0.2
3	Moderately Windy	0.7
4	Extremely Windy	0.8
5	Very Windy	0.9

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Predictive Modelling for Minerals

- Spatial data modelling allows large scale analysis of data for scoping studies
- Enables direction and focus of exploration and expenditure
- 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.

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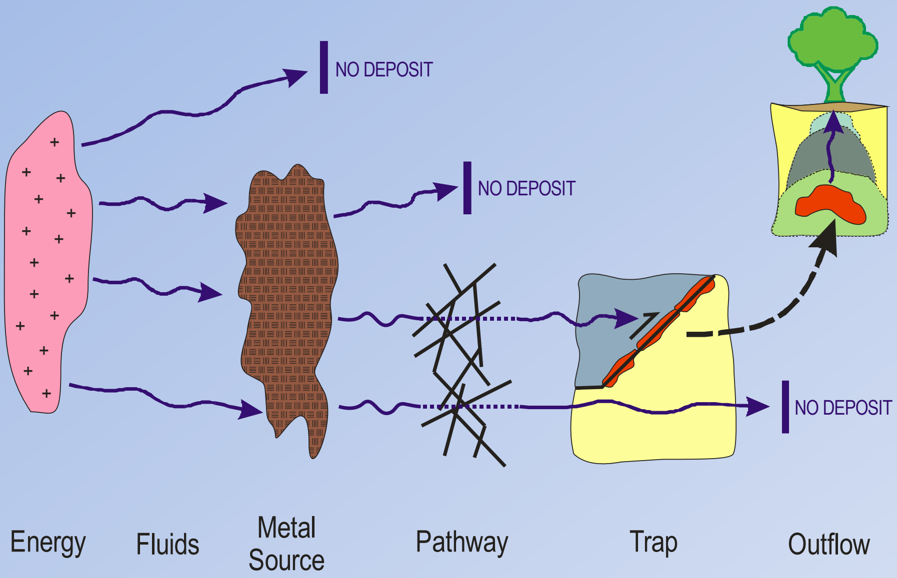
The Mineral Systems Concept

- Essential Geological Components Are:
  - Source of Energy that Drives the System.
  - Sources of Fluids, Metals and Ligands.
  - Pathways so Fluids Can Migrate to Trap Zones.
  - Trap zones (i.e. narrow, effective pathways) in which Fluid is Focused and Fluid Composition is Modified to Allow Concentrated Deposition.
- Ore Deposit Formation is Precluded where a Particular Mineral System Lacks One or More of these Essential Components.



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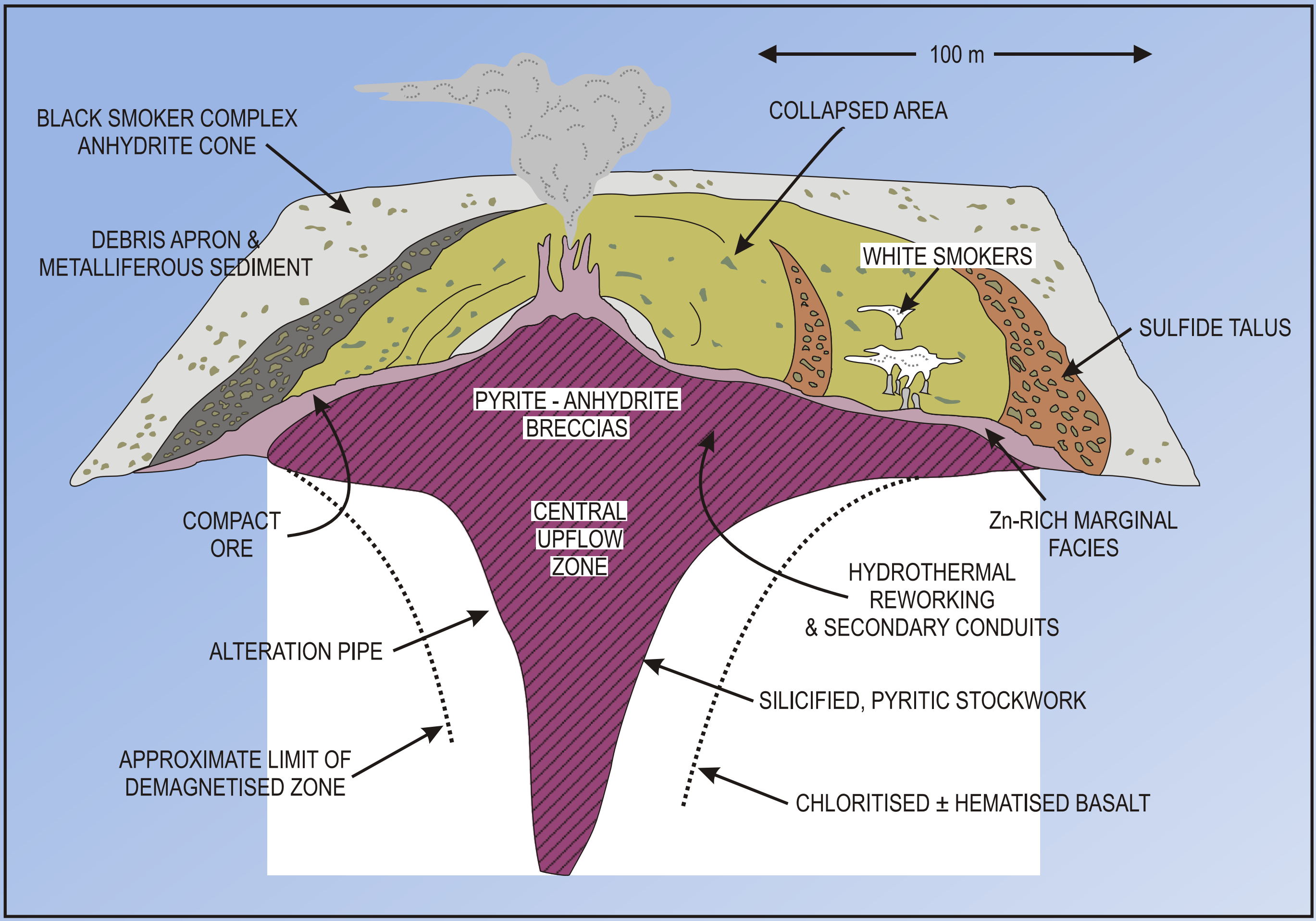
Marine Example – Seafloor Massive Sulphides



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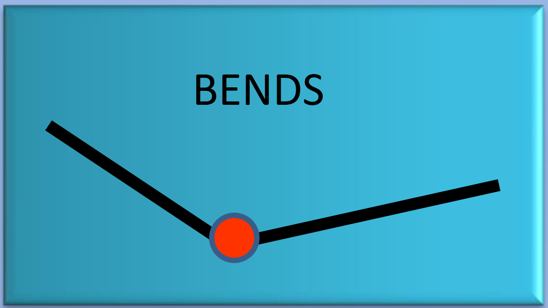
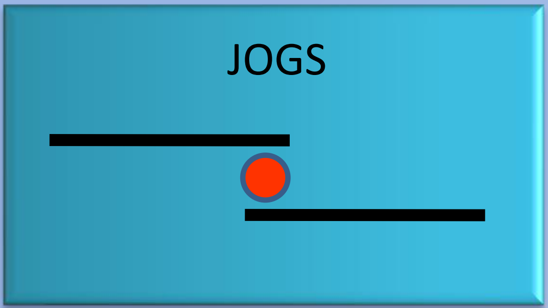
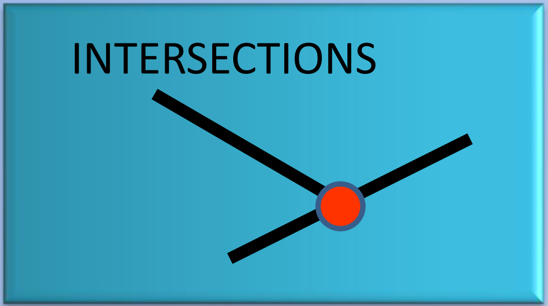
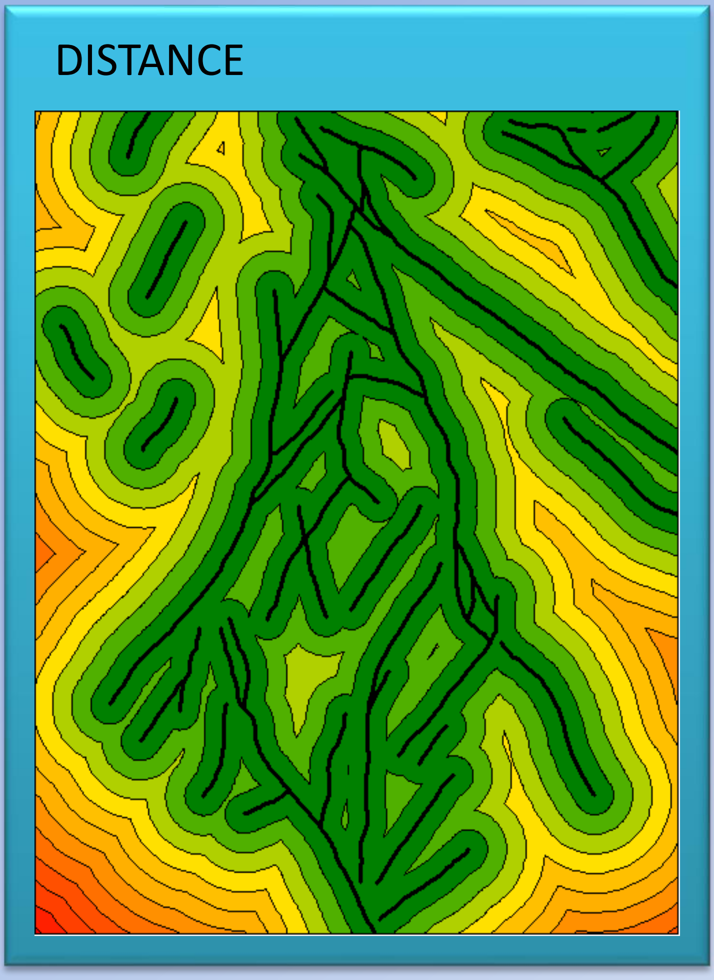
Faults









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.

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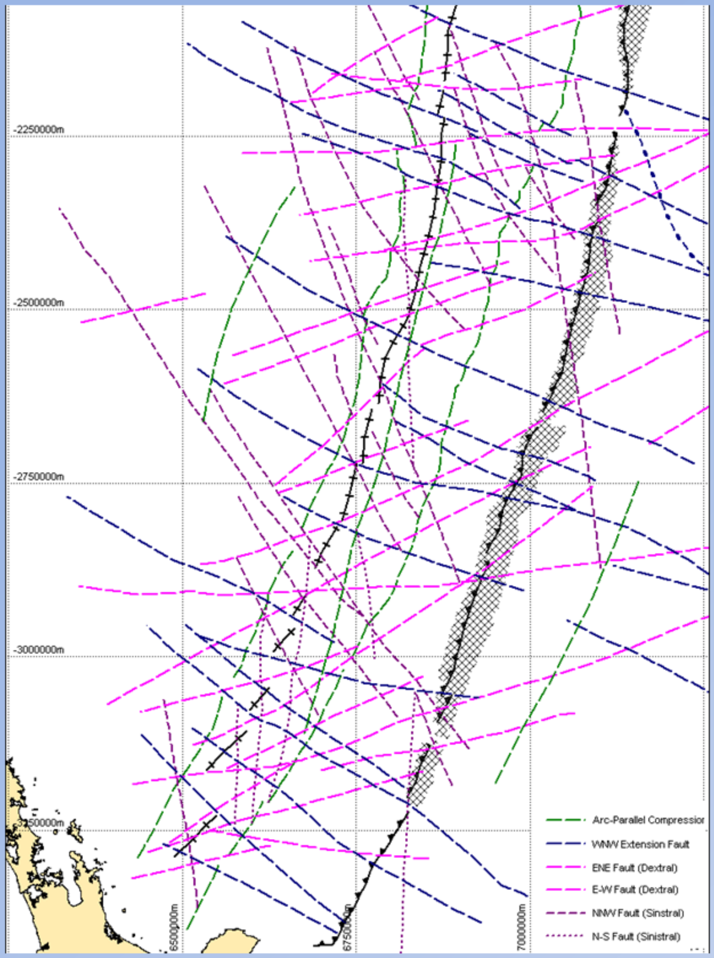
Interpreted Regional scale faulting - Kermadec Arc (New Zealand)



- Correlations of mineralisation with:
- WNW Extensional faults
- ENE Dextral Faults
- EW Dextral Faults
- NNW Sinistral Faults
- N-S Sinistral Faults
- Arc Parallel compression

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Environmental Management

*Image courtesy of Neptune Minerals Plc

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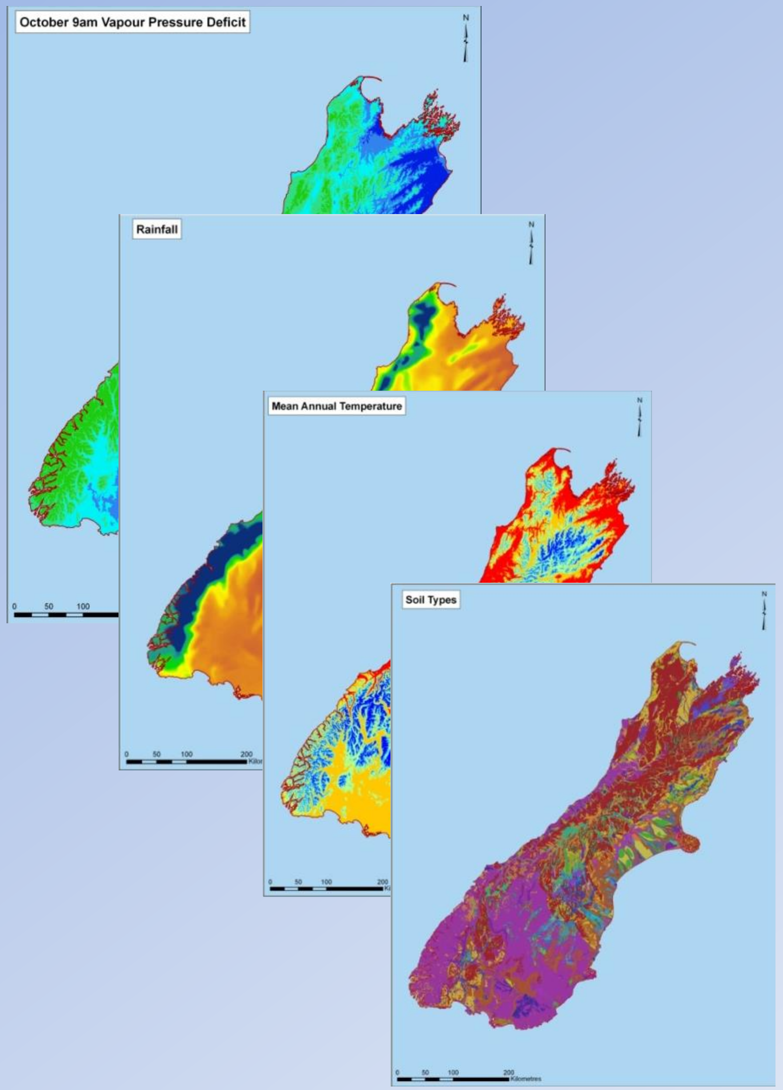
Main Ecological Habitat Factors

- Climate:
  - Rainfall
  - Temperature
  - Solar radiation and Frost
  - Humidity and Water balance
- Vegetation
- Soil:
  - Types
  - pH, Nutrients, Particle size
  - Induration, Permeability and Drainage
- Location features:
  - Elevation
  - Slope and Aspect
- Biological features:
  - Population density and animal movements
  - Food availability and Predators



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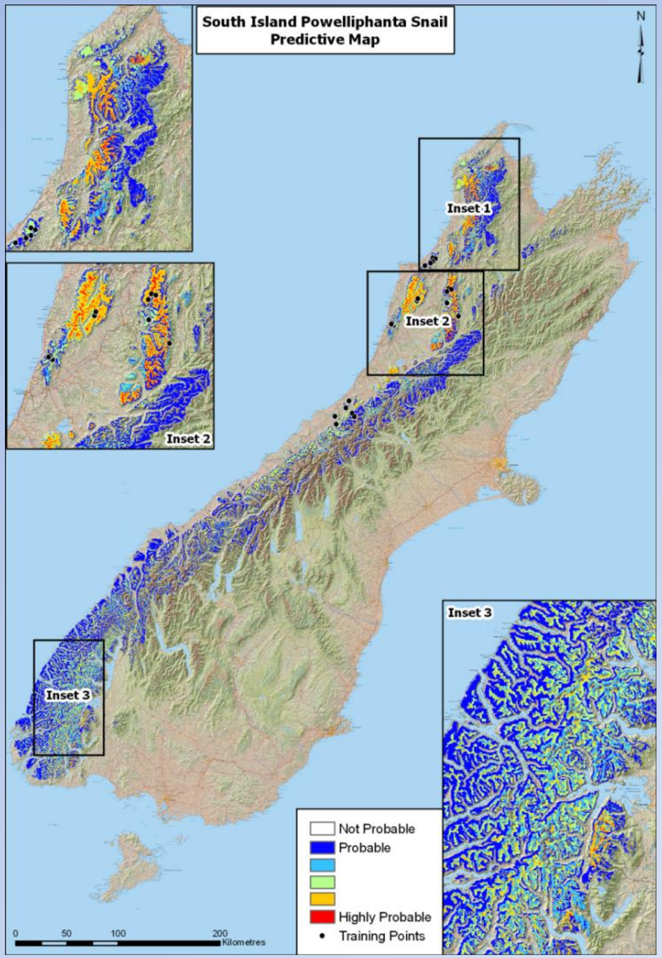
Modelling Results

- Favoured Habitat:
- High altitude;
- Low temperature;
- High rainfall



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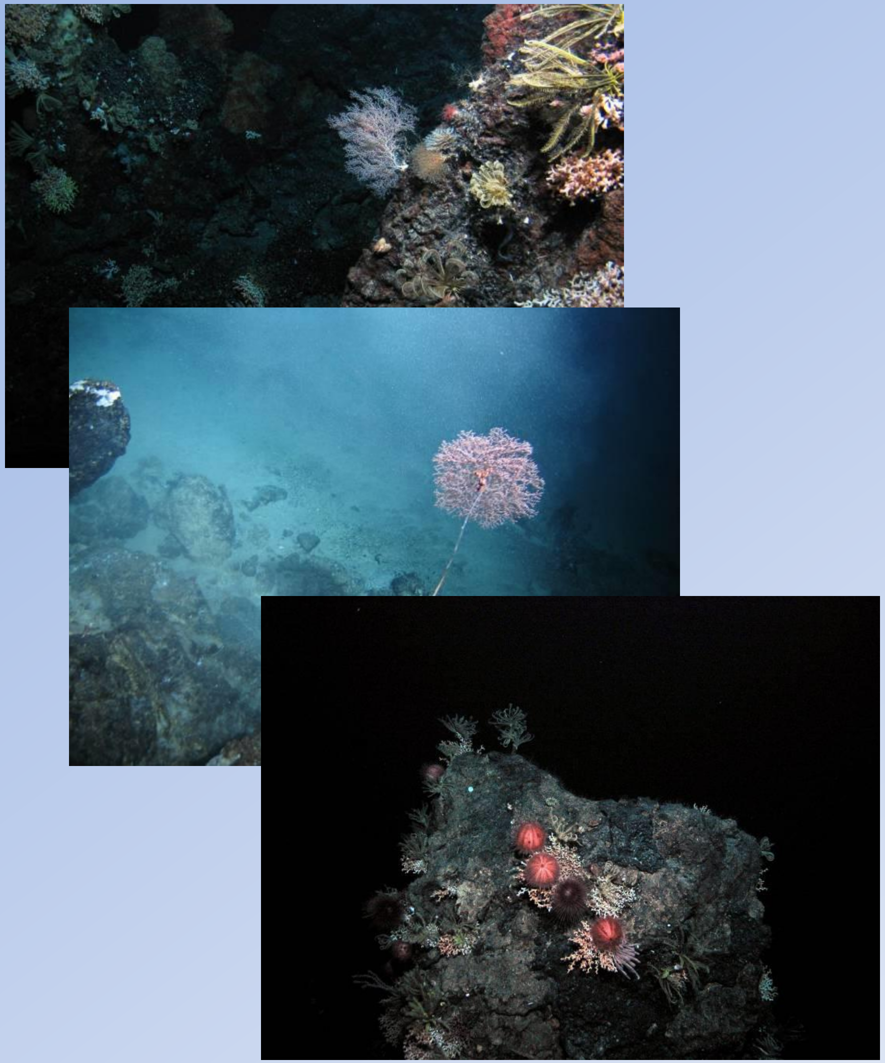
Habitat Modelling in the Marine Environment

- Consideration to:
- Potential Benthic Impacts;
- Potential water column impacts;
- Potential photic zone impacts.



*Images courtesy of Neptune Minerals Plc

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Marine Habitat Modelling Data Requirements

- To undertake effective marine habitat modelling key data sets could include:
  - Bathymetry
  - Substrate information
  - Oceanography
  - Chemistry
  - Biological Information

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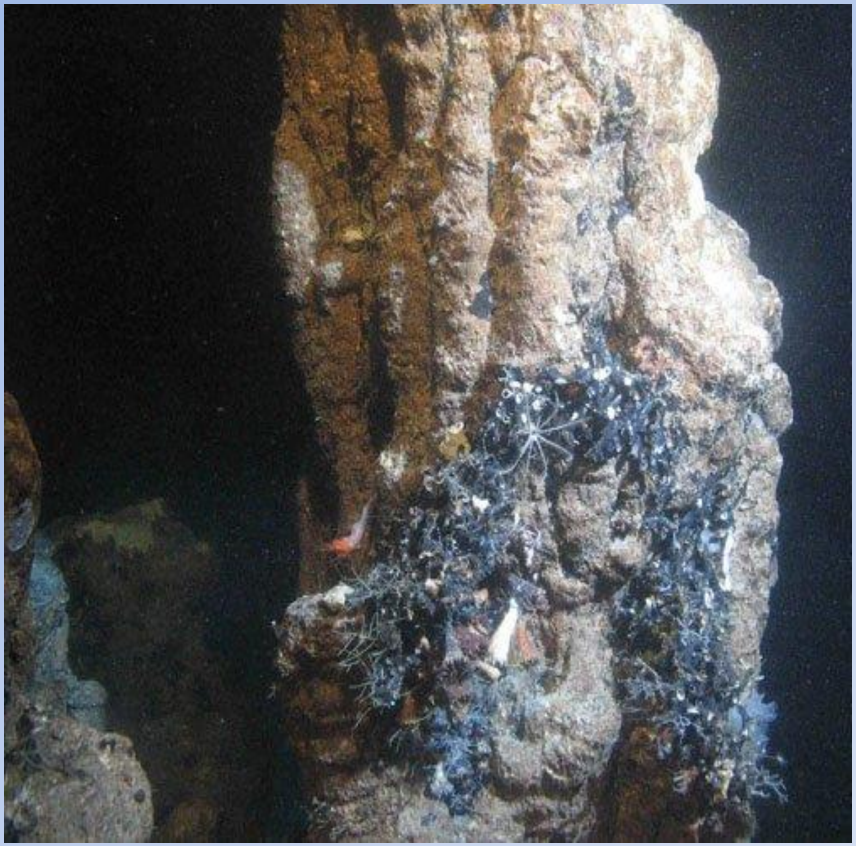
Summary

- Tool to aid traditional methods;
- Allow direction over time and money more effectively
- Take an unbiased view of the project area
- Deals effectively with wealth of data and data overload issues,



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