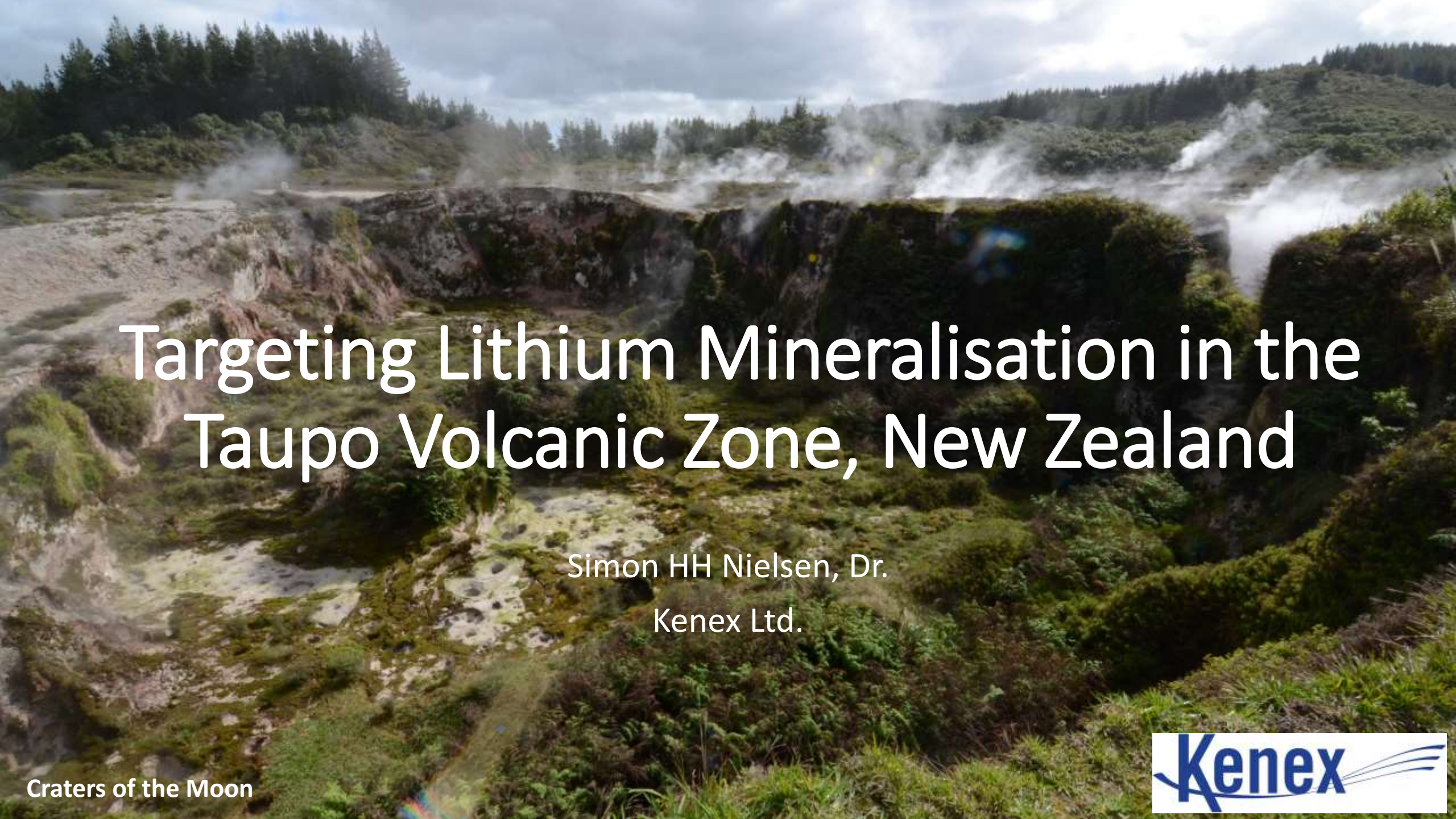


Targeting Lithium Mineralisation in the Taupo Volcanic Zone, New Zealand

Simon HH Nielsen, Dr.

Kenex Ltd.

Craters of the Moon

Background

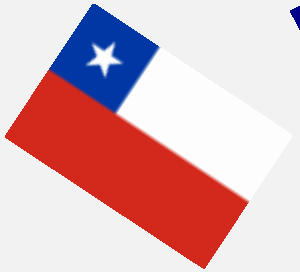
- GNS Science was contracted by NZ Petroleum and Minerals to model New Zealand's potential for lithium mineralisation (MR5544)

- One **fuzzy logic** model was made, **combining two mineral systems** over all of New Zealand at 100 m resolution

- **Kenex objective**: To focus the targeting on the Taupo Volcanic Zone at 25 m resolution, using the mineral system model for **hydrothermally altered rhyolitic lacustrine sediment-hosted deposits**.

Why lithium?

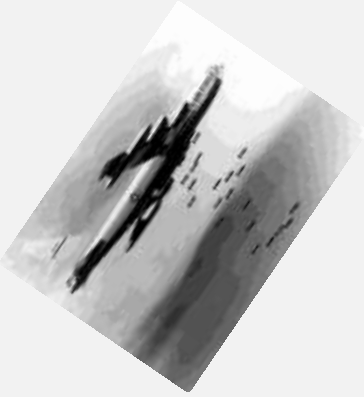





From Wikipedia, USGS and elsewhere…

- Lithium is a highly reactive **industrial metal**, having been commercially produced since 1923, mainly for glass making
- Used since WWII for high-temperature airplane greases, and in tritium generation for atomic bombs during the Cold War
- **Battery production** is becoming the second-most important use of lithium, and **demand is increasing**…
- Extracted from pegmatites since 1900 in the US, from brines since the 1960s
- Produced from brines mainly in South America and China, Australia is the biggest producer of pegmatite-derived Li
- New Zealand could secure its own strategic reserves.



Outcome of the nationwide Li potential model

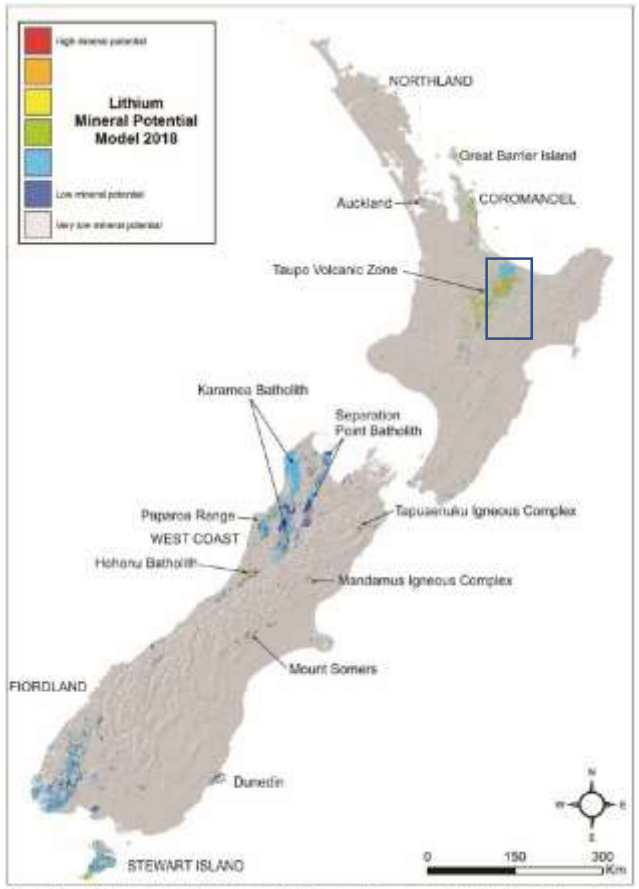


Figure 5.16 The lithium mineral potential map of New Zealand showing the potential for lithium mineralisation in pegmatites and hydrothermally altered, rhyolitic, lacustrine sediments. Warm colours represent higher potential.

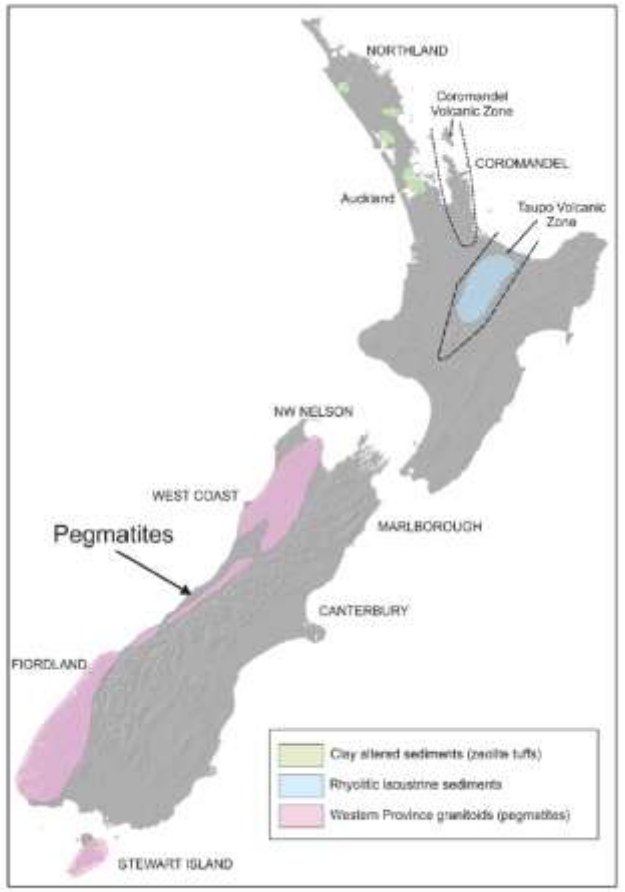


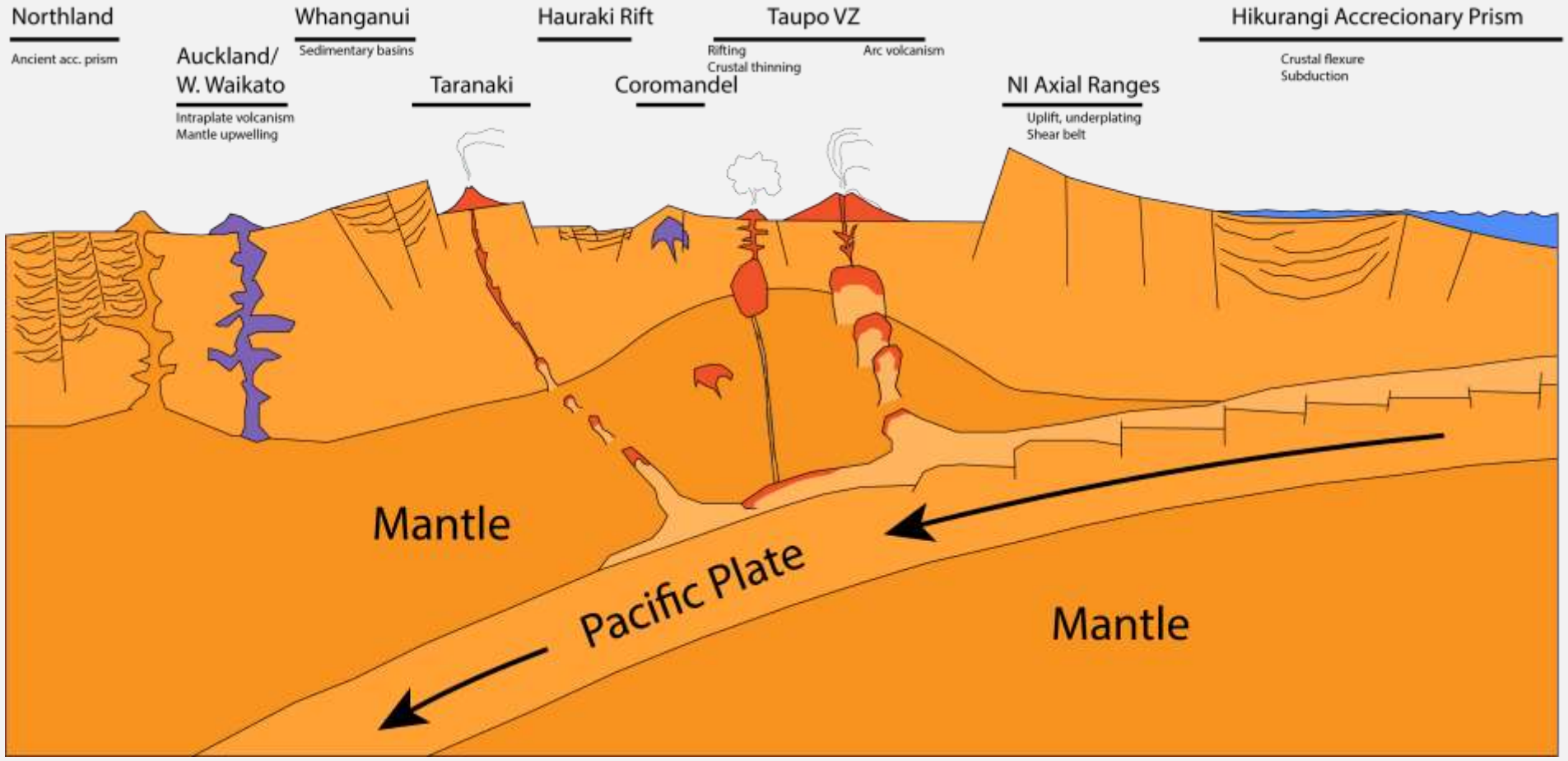
Figure 2.5 The location of pegmatites (hosted within Western Province granitoids), rhyolitic lacustrine sediments, and clay altered sediments in New Zealand. The outline of the Coromandel Volcanic Zone and the Taupo Volcanic Zone are from Cole and Spinks (2009).

Mineral system models for Li largely **separated by island**:

- Pegmatite Li potential in the South Island
- Geothermal and hydrothermal Li potential in the North Island

Figs from Turnbull *et al.* (2018)

Transect through the North Island



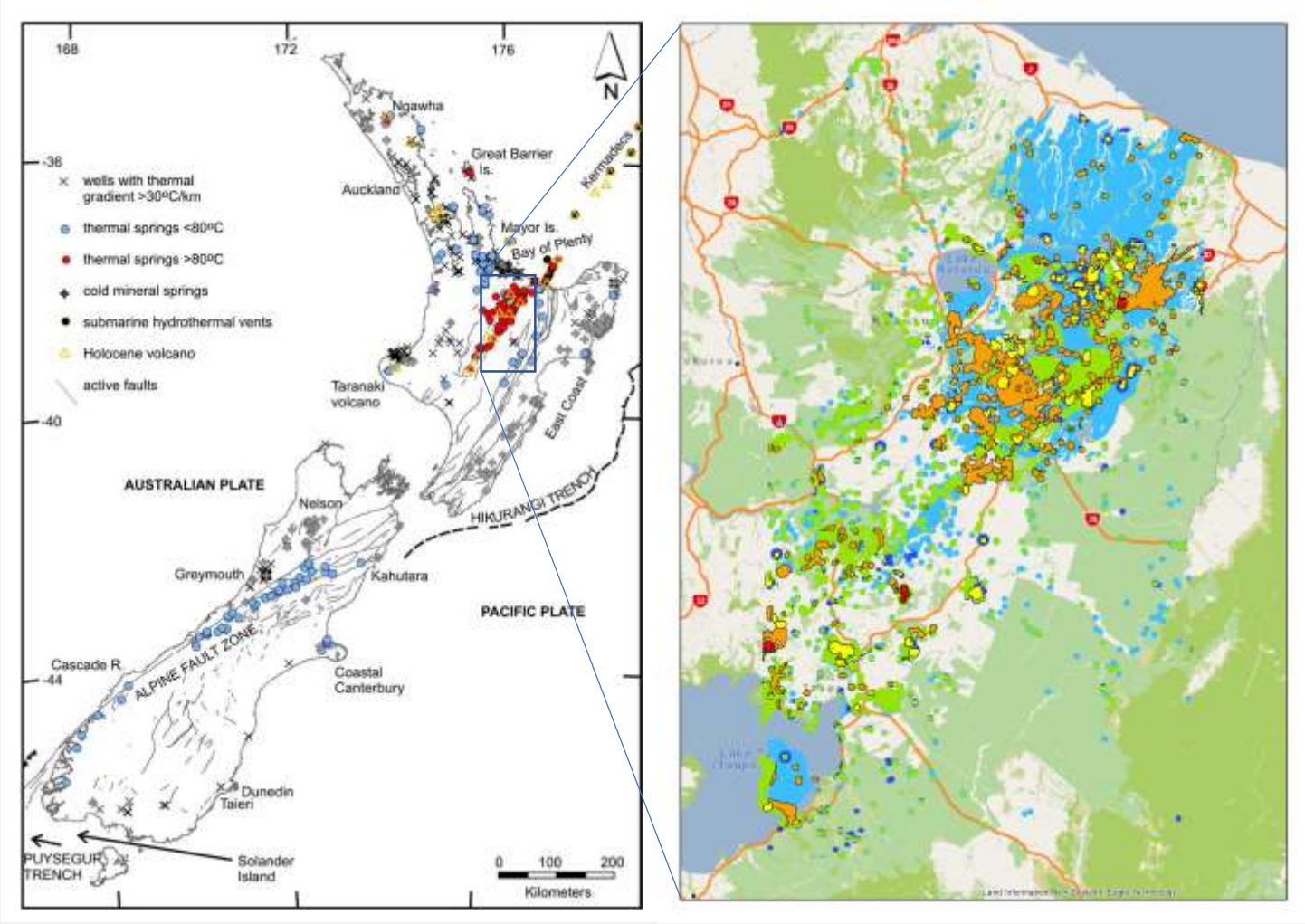
Based on Reye, Christenson & Faure (2010)

Geothermal activity and Li in New Zealand

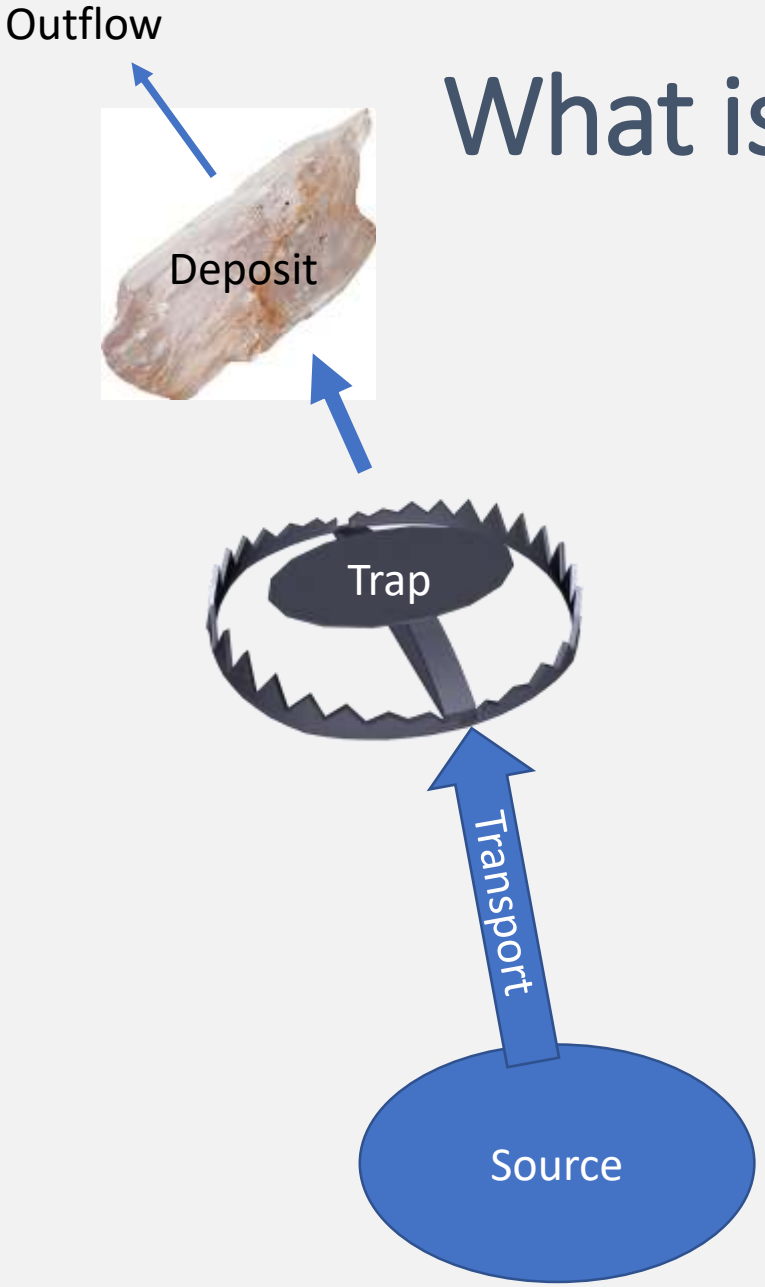
- Hot springs largely concentrate in the Taupo Volcanic Zone
- Plenty of lithium potential in the Taupo Volcanic Zone
- **Targets are broad**
- Resolution is relatively low
- Benefits from focusing the model and isolating targets in hydrothermally altered rhyolite lacustrine sediments.

Reye, Christenson & Faure (2010)

Data from Turnbull *et al.* (2018)

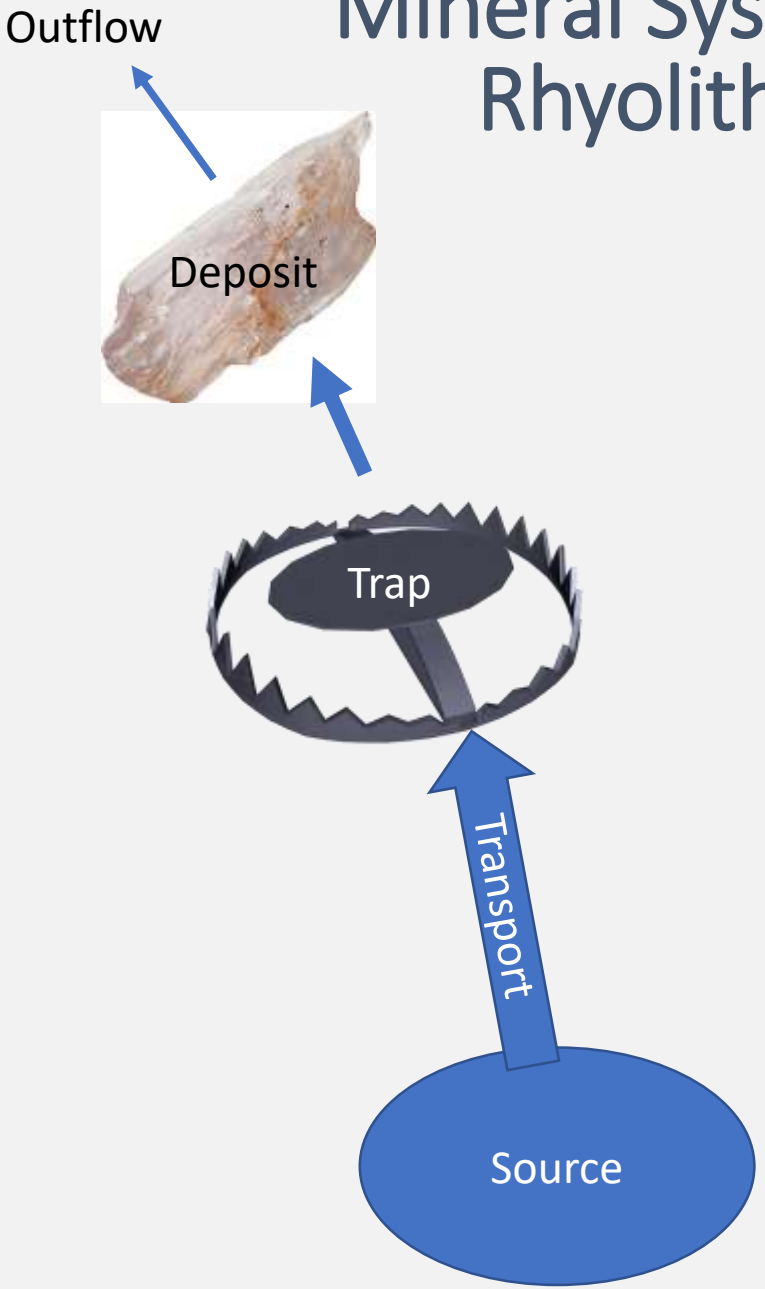


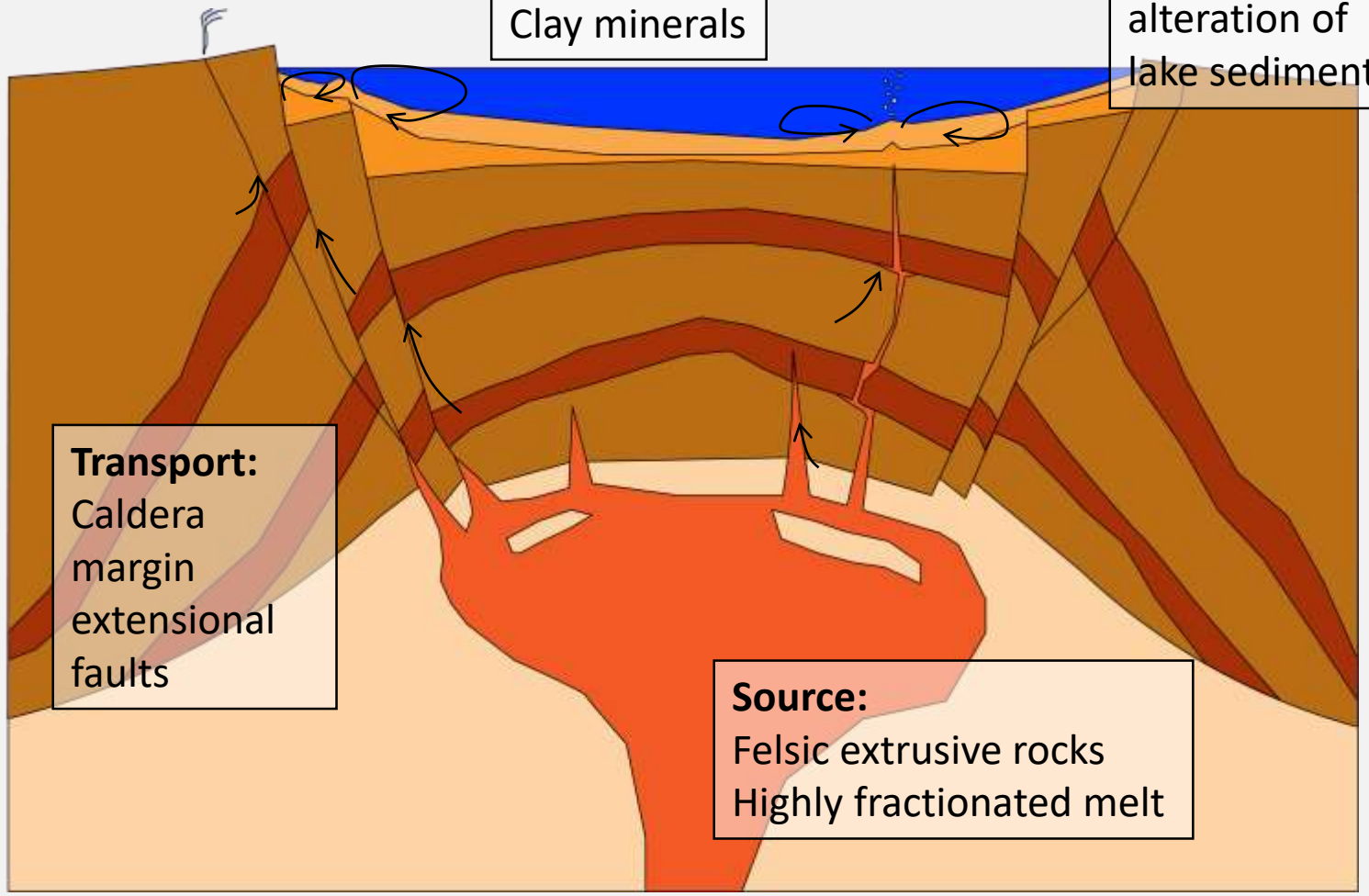
What is a Mineral System Model?



- Helps explorers consider the entire geological system
- Deposits are small, but the processes generating them are large (Wyborn, 1994)
- Mineralising fluids originate at a **source**, are **transported** and focused along a path, and **trapped** to form **deposits**
- Just like Petroleum Systems, the mineral system components must be in place before the fluids start moving.

Mineral Systems Model, Hydrothermally Altered Rhyolithic Lacustrine Sediment-hosted Li





Deposition and outflow:
Hydrothermal alteration of lake sediments

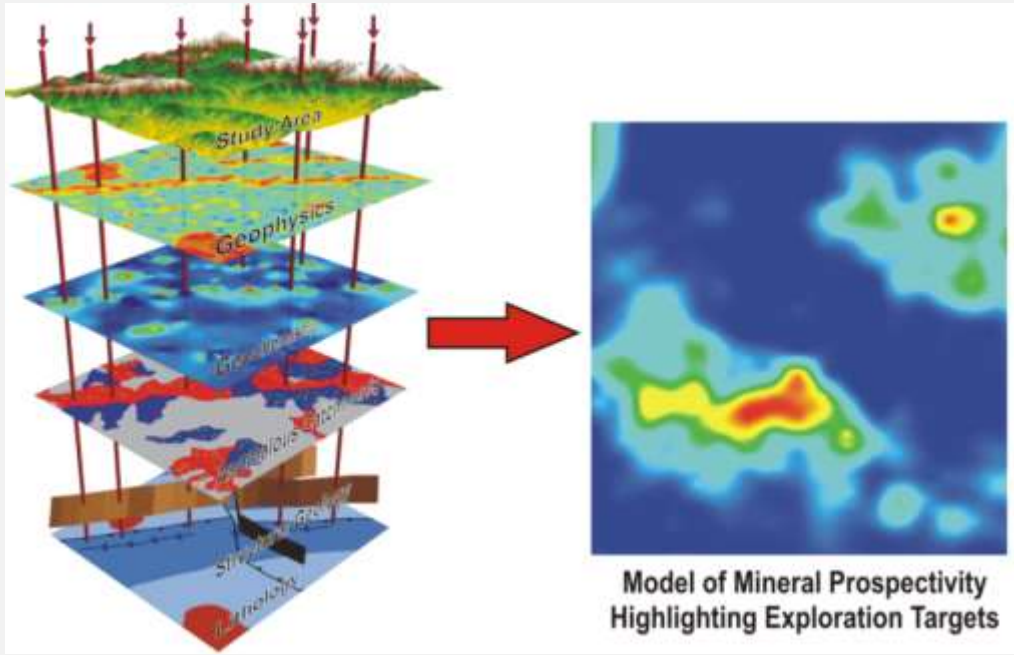
Trap:
Clay minerals

Transport:
Caldera margin extensional faults

Source:
Felsic extrusive rocks
Highly fractionated melt

Mineral Potential Modelling with Fuzzy Logic

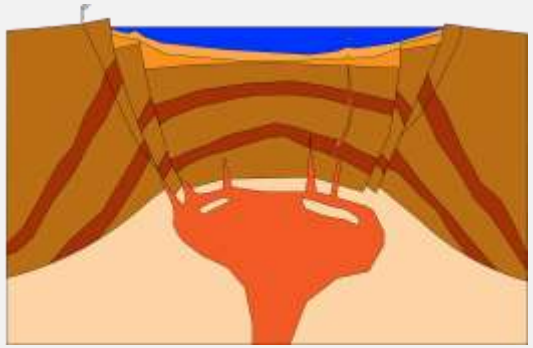
- **GIS-based data integration** method that combines spatial data using **expert knowledge** or statistics
- Each **predictive map** is divided into weighted areas with (degrees of) **favourable** or **unfavourable** conditions
- The maps are superimposed, the weights combined, and **the areas with highest combined weights are best**!



- **Fuzzy logic** introduces a **degree of truth**, as opposed to Boolean “true” or “false”
- Maps are assigned weights of **0 - 1**, and combined with Fuzzy Operators (Fuzzy AND, Fuzzy OR, Fuzzy SUM…)
- Geological data is generally combined with a **Fuzzy Gamma of 0.9**, which is mostly Fuzzy SUM with a little bit of Fuzzy Product…

Critical Processes, Lacustrine Hydrothermal Li

Compiling data in a **spatial data table** with the mineral system model in mind



	Critical processes	Targeting features	Mappable criteria
Deposit, outflow	Weathering and erosion	Geochemical dispersion in soils	Soil sample geochemistry (Mineral Reports)
		Geochemical dispersion in streams	Stream sample geochemistry (Mineral Reports)
	Enrichment distal to source	Vectoring to Li-enriched source rocks	Rock chip PFE (Mineral Reports)
Trap	Change in chemical conditions	Hydrothermal alteration	Sampled sediments and rocks (QMAP, Petlab)
		Crystallisation of Li bearing minerals	Rock chip Li (Mineral Reports, Petlab)
		Crystallisation of accessory minerals	Petlab acc. minerals
Transport and focussing	Lake sediments	Specific rock types subjective to hydrothermal alteration and lithium enrichment	Mapped lacustrine sediments and samples (QMAP/Petlab)
	Cenozoic regional extension	Normal faulting	QMAP faults
	Extensive fractionation	Geochemistry (K/Rb)	Geochemistry (K/Rb, Mineral Reports, Petlab)
Source of energy, fluids and ligands	Continentally derived felsic magma	Igneous rock types	QMAP intrusive suites
	Geothermal activity	Currently active geothermal areas	Mapped geothermal fields (GNS/councils)

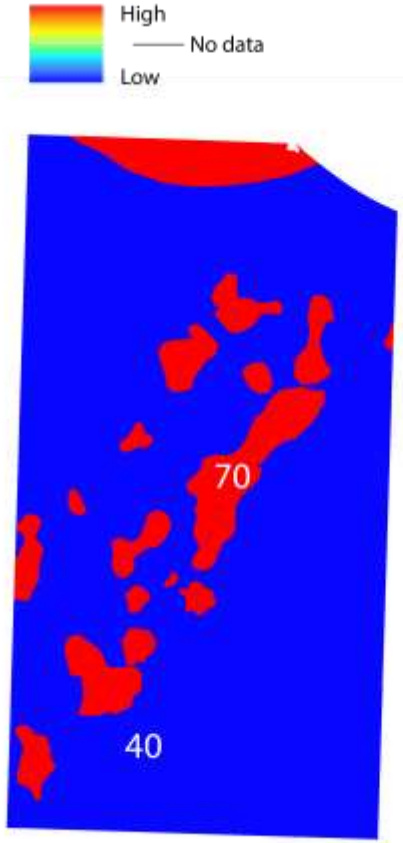
Based on Turnbull *et al.* (2018)

Maps Tested, Lacustrine Hydrothermal Li

Available data rarely covers entirely all the variables we would like to test.

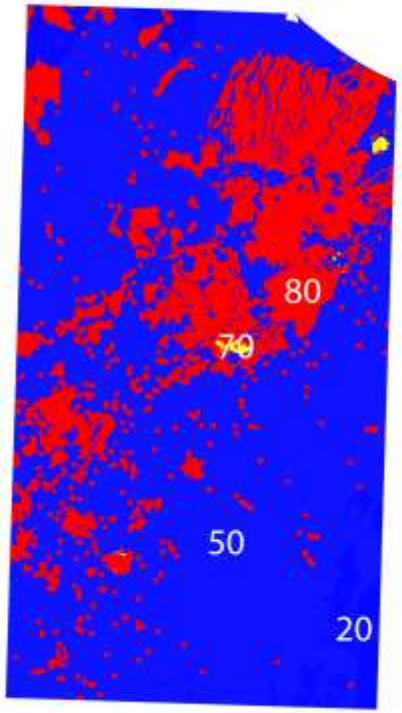
Targeting Features	Mineral System Component	Map	Class	Category	Score
Magmatic Source	**Source**	l1mgsofuz	5	Felsic Intrusive	**85**
			4	Rhyolite	**80**
			3	Dacite	**70**
			2	Quaternary Cover	**50**
			1	Other Geology	**20**
Geothermal Activity		geothfuz	2	Current Activity	**70**
			1	No Current Activity	**45**
Extensive Fractionation	**Transport**	l1frakrbfuz	4	Highly fractionated felsic rock	**70**
			3	Fractionated felsic rock	**65**
			2	Non-fractionated felsic rock	**35**
			1	Other Geology	**50**
Faults		faults_fuz	2	Near fault	**70**
			1	Not near fault	**50**
Lake Sediments		lacufuz	2	Mapped lacustrine sediment	**65**
			1	Not lacustrine sediment	**45**
Accessory minerals	**Trap**	l1acminfuz	2	Accessory mineral in rock description	**65**
			1	No acc. min. described	**50**
Li bearing minerals		lifuz	3	Anomalous Li	**80**
			2	Non-anomalous Li	**35**
			1	No sample	**50**
Trap rocks		l1tproxfuz	2	Trap rock sampled	**70**
			1	No trap rock sampled	**50**
Hydrothermal alteration		l1sedrxfuz	2	Hydrothermal alteration of sed.	**90**
			1	No hydrothermal alteration	**45**
Li enrichment	**Deposit**	rxpfe25m	3	Anomalous PFE	**80**
			2	Non-anomalous PFE	**40**
			1	No sample	**50**

Predictive Map Generation, Source



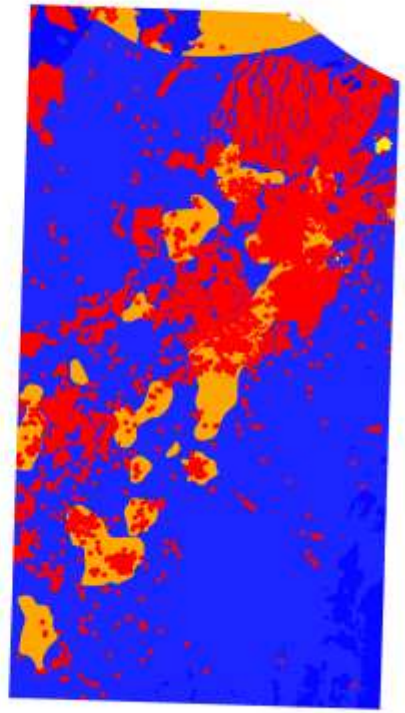
Geothermal source areas

+



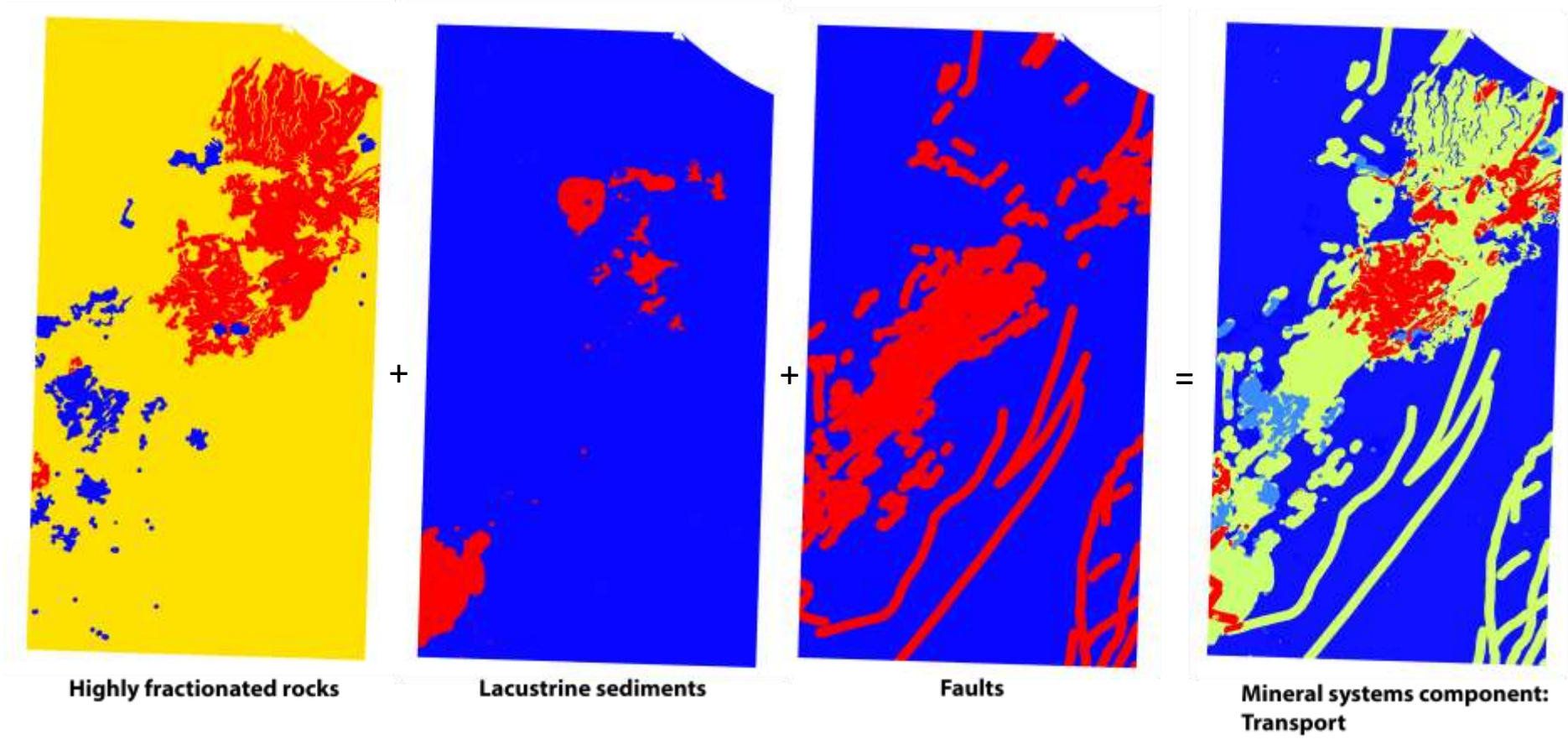
Igneous source rocks

=

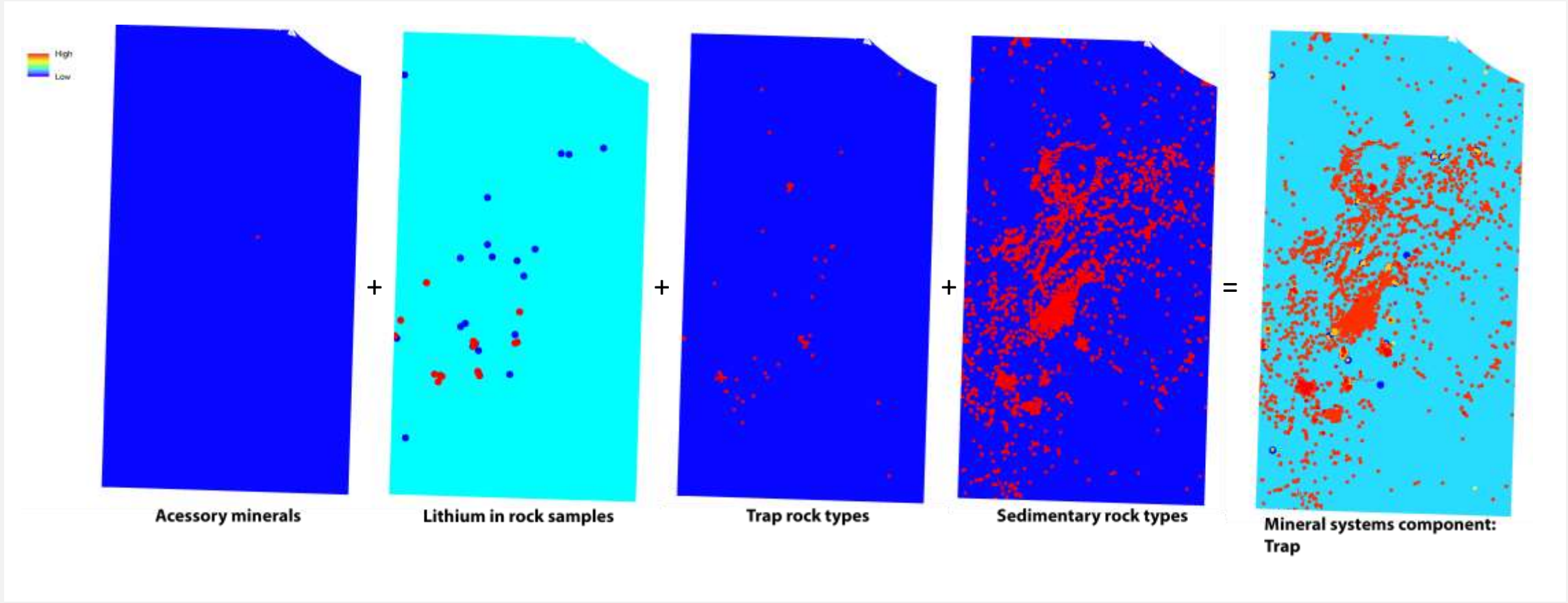


Mineral systems component: Source

Predictive Map Generation, Transport

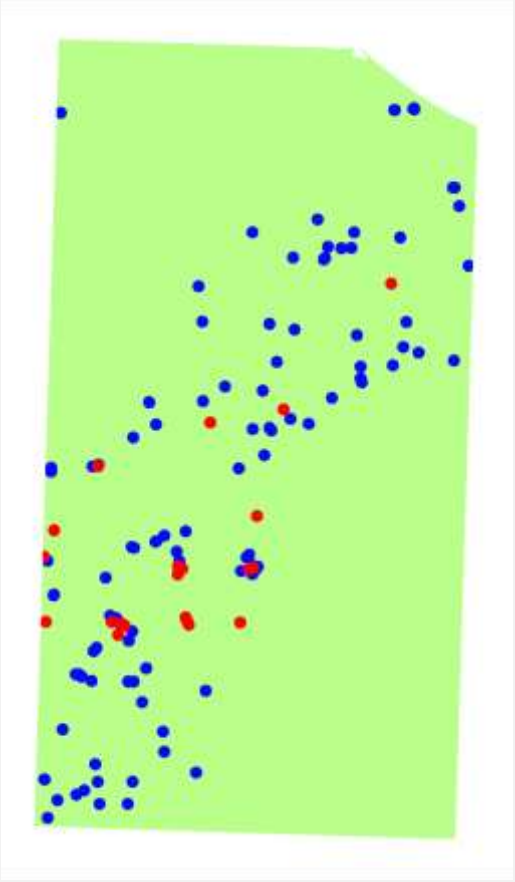


Predictive Map Generation, Trap

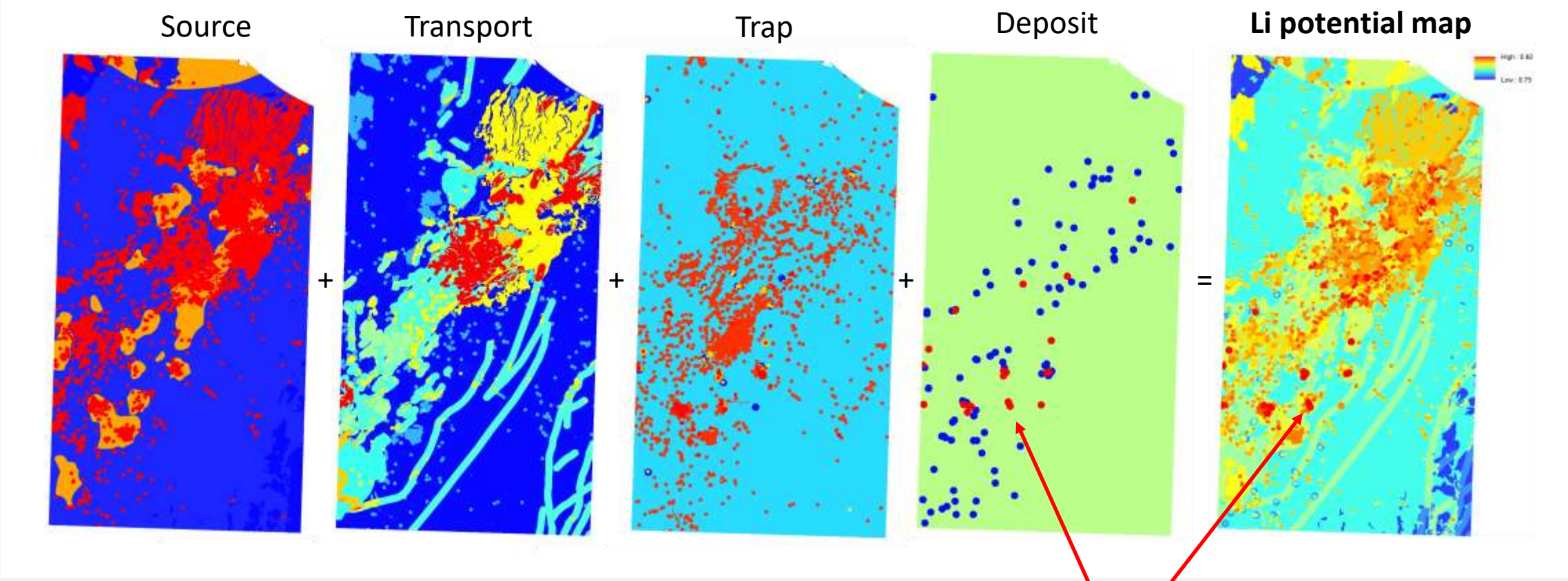


Predictive Map Generation, Deposition

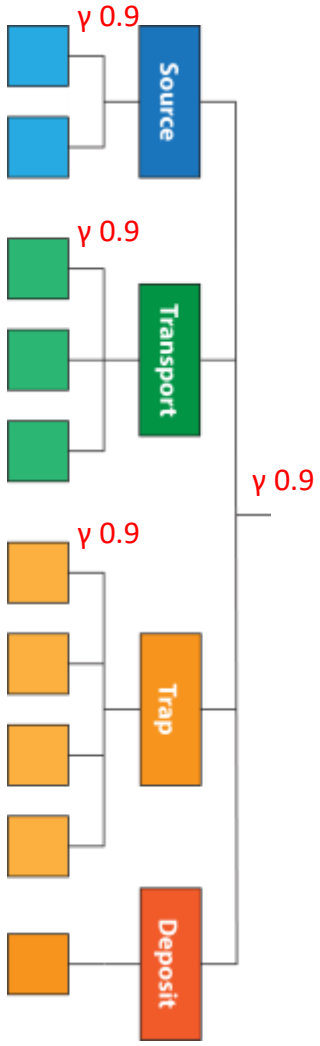
- Rock chips of pathfinder elements
- No other deposition predictive map, **pathfinders = single deposition component**.

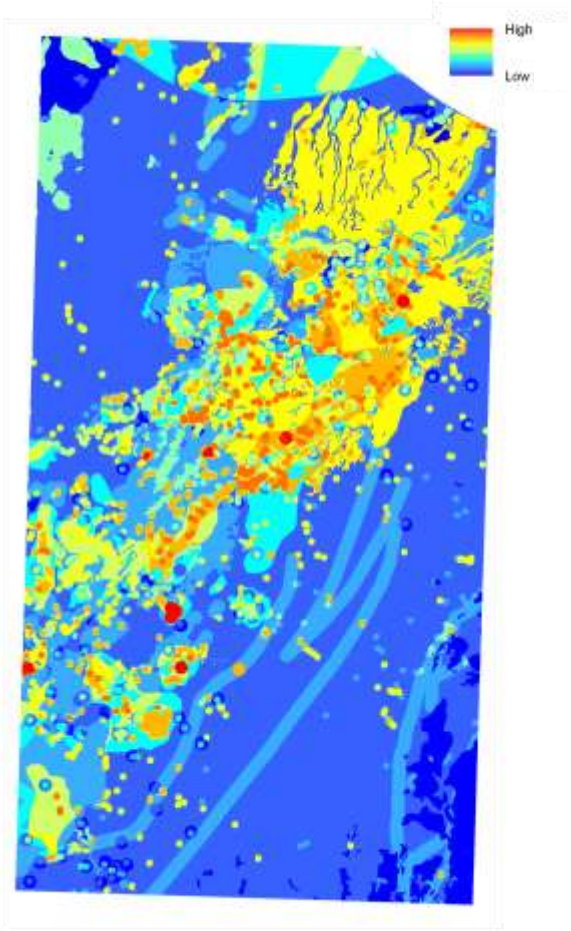


Lacustrine rhyolitic lithium fuzzy model

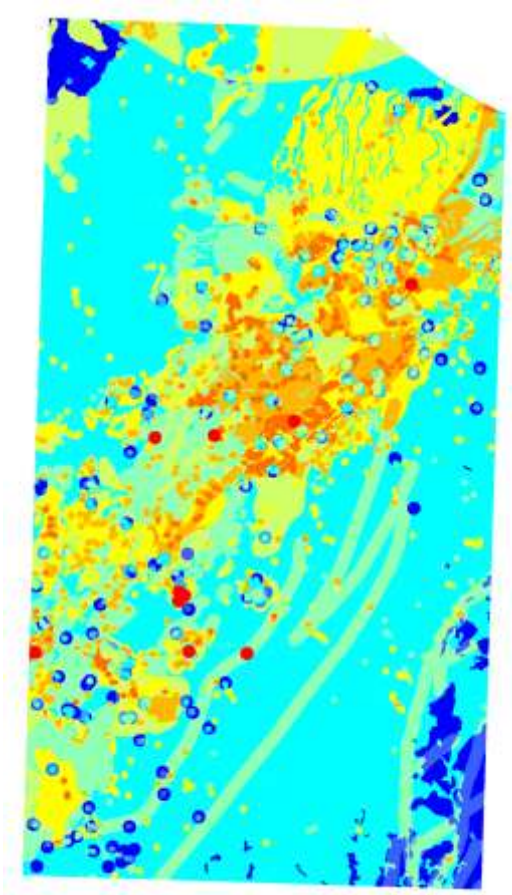


Predictive maps for Li





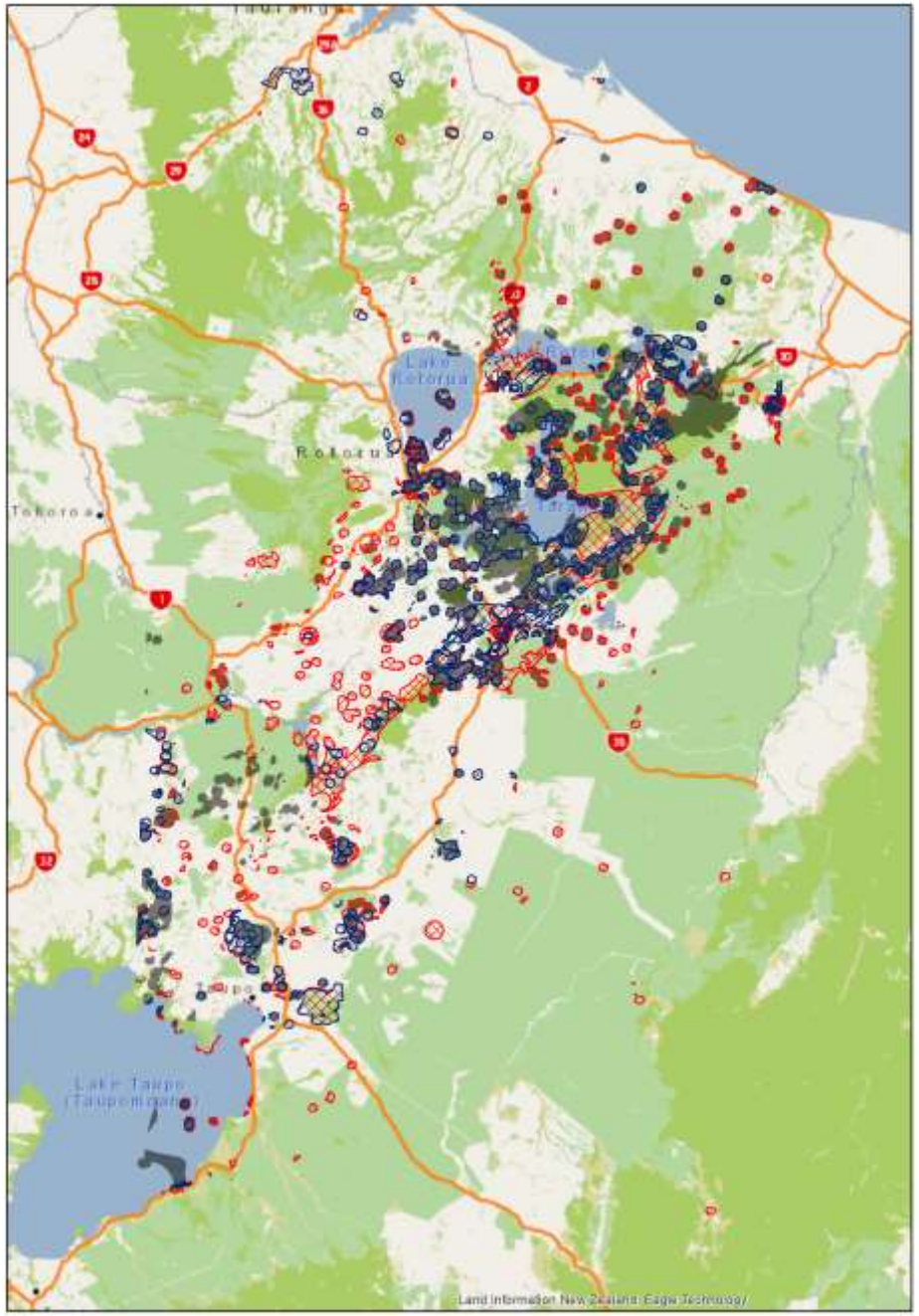
3-tier model



4-tier model

Results

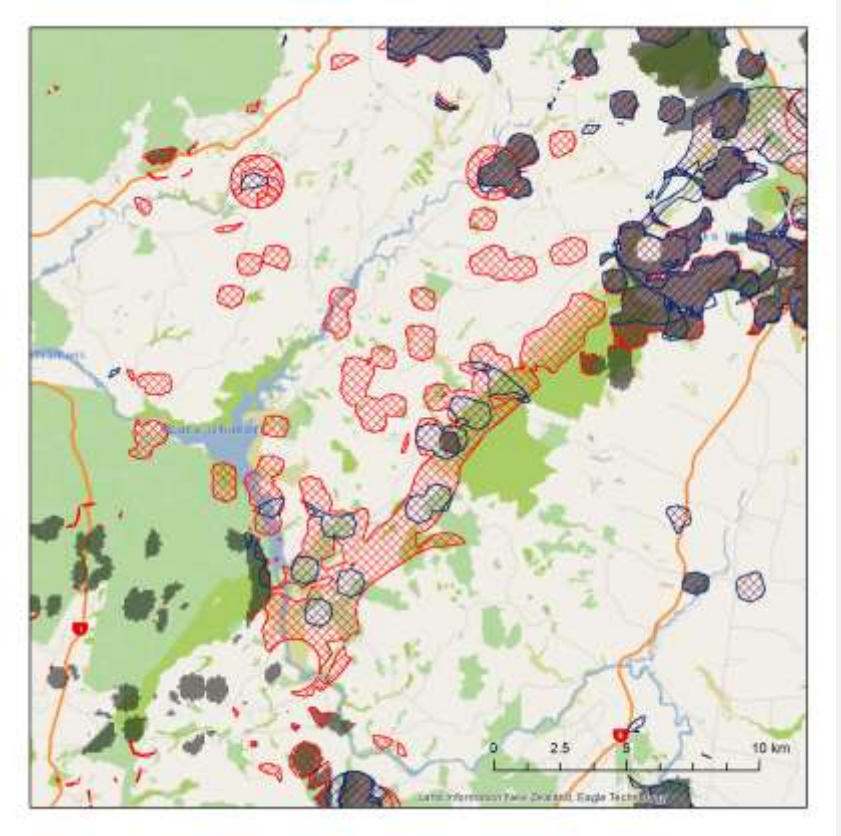
- Large targets near Lake Rotoma and Lake Tarawera in original model (solid black) reduced in 3-tiered model (cross-hatched red), and even more so in flat model (hatched blue)
- New targets in the Waikite Valley, Waiohau rhyolite and in the Tauhara dacite, while targets around Kinleith Forest are not picked up
- Target distribution in general is strongly influenced by sampling.



Conclusions

+ Focusing the Li potential model on a single mineral system and in a relevant study area will tighten up targets

- The model data is not scalable, so increasing resolution makes little difference.



Future work:

- Add geophysical data (scalable)
- Add more sample data!
- Research other mineral systems.

Acknowledgements

Thanks to GNS for generating the original model, especially Rob Reeves and Matt Hill for data and discussions, and to colleagues at Kenex for comments and data preparation.