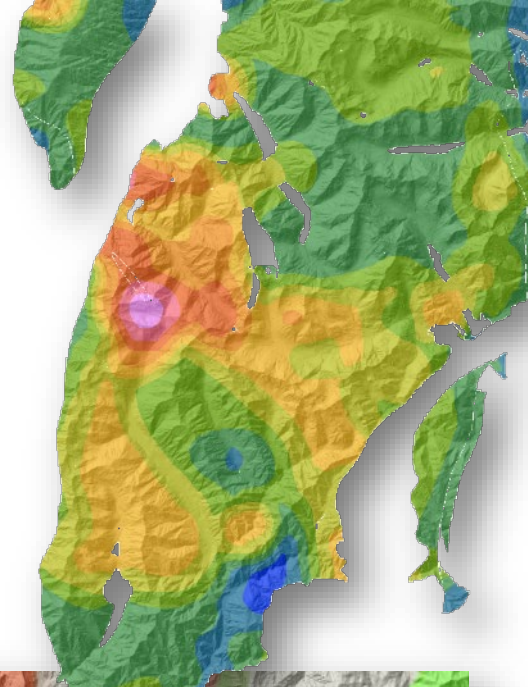
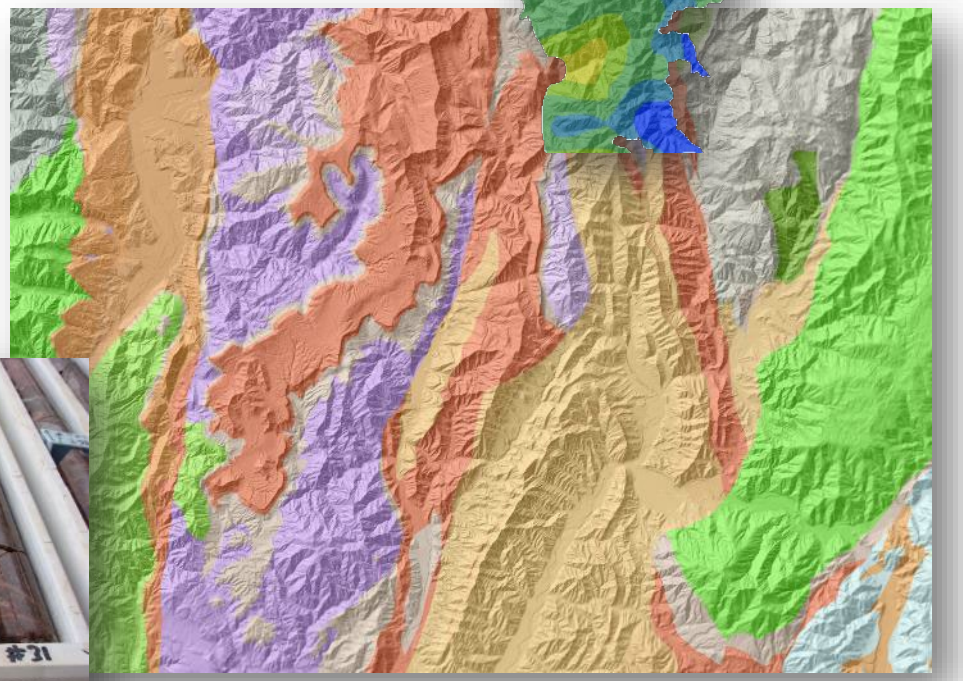
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Regional mineral opportunity analysis of intrusion-related mineralisation in New Zealand







Presented by:

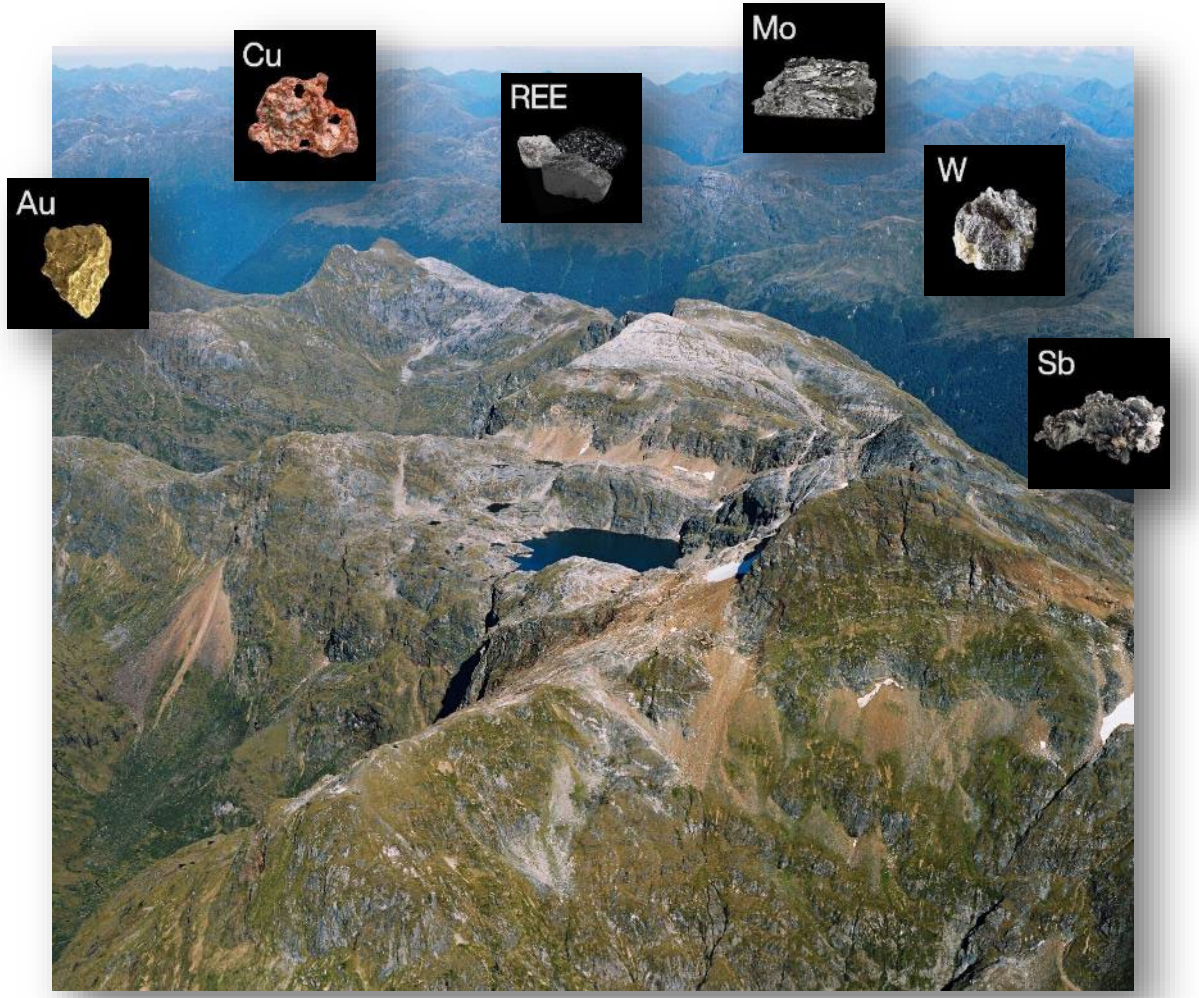
Matthew Hill

24 August 2026

And collaborators: Mark Rattenbury, Kevin Faure, Matt Sagar, Tony Christie, Rose Turnbull, and Regine Morgenstern

Can we identify areas of New Zealand where the geological conditions are favourable for intrusion-related mineralisation?

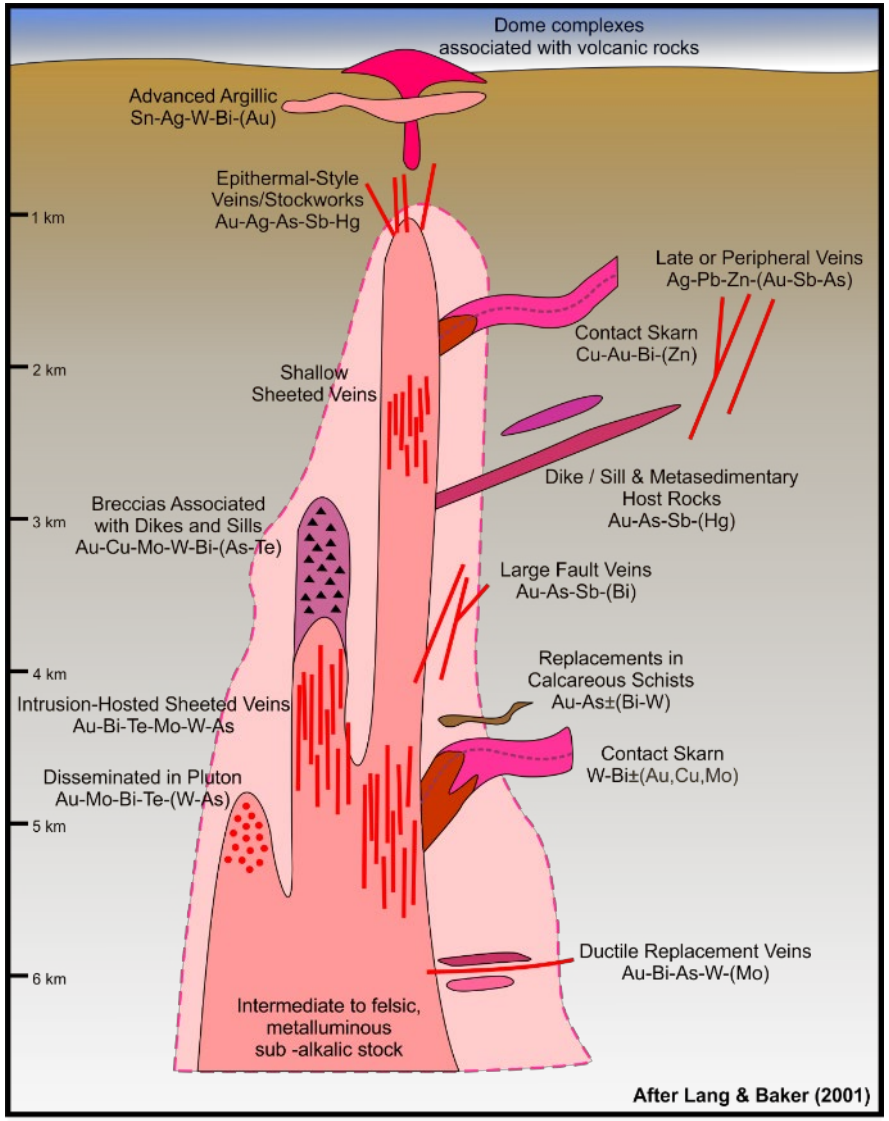
- Yes, we have developed a preliminary regional-scale opportunity model that combines mappable components of the intrusion-related mineral system.
- It has identified areas with favourable conditions for intrusion-related critical mineralisation.
- Understanding the distribution of geological observations will allow us to make improvements to underlying interpretations which can support exploration and our knowledge of critical mineral potential.



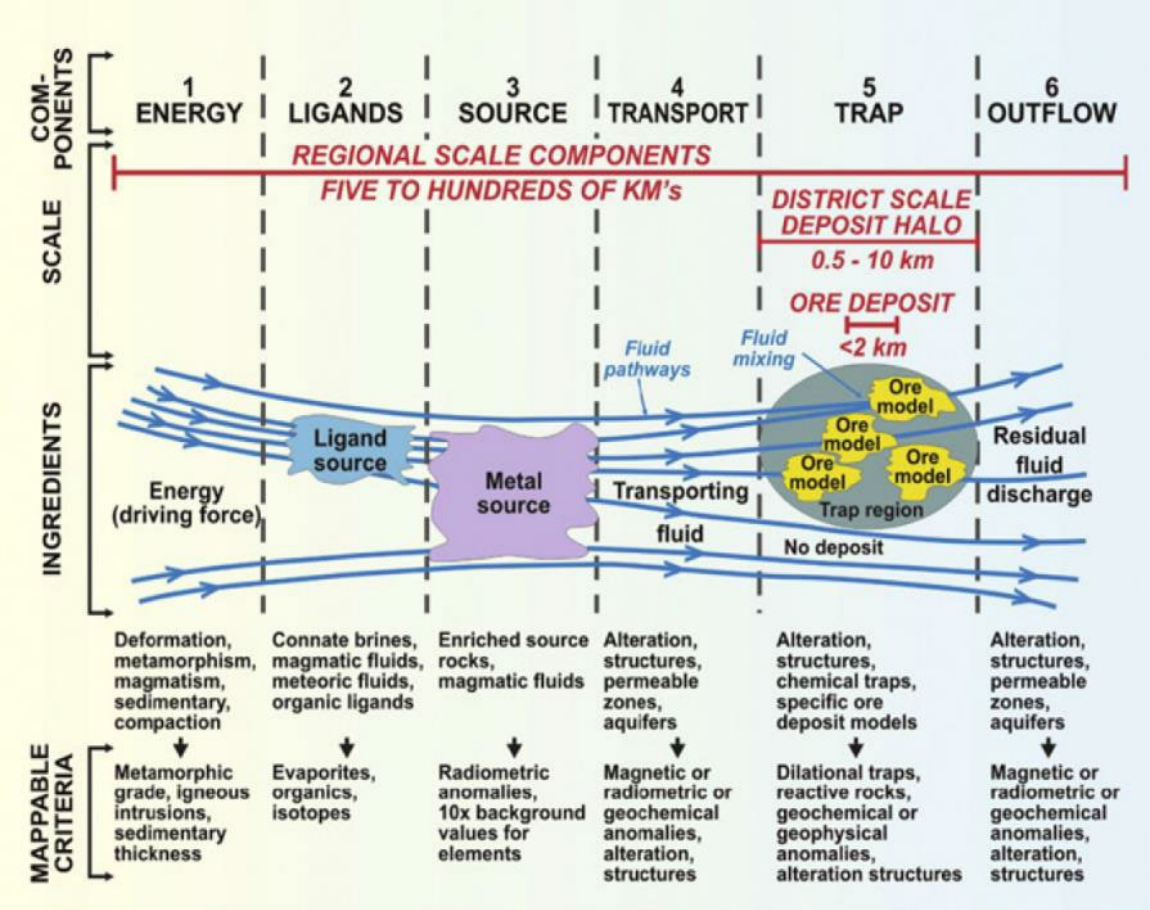
Merrie Range, Southland (Lloyd Homer)

What are Intrusion-related Deposits?

- Mineralisation associated with the emplacement of highly evolved intrusions in the crust.
- The deposit styles and critical minerals are highly variable and depend on emplacement depth, fractionation, pluton source, and interaction with the country rock.
- They are associated critical mineral occurrences of Au, Bi, Mo, W, Cu, Sb, Zn, As, & Te.
- The main areas of this mineralisation in New Zealand are the Tasman and Westland regions.
- Our regional-scale research is initially aiming to determine areas where there could be opportunity for any of these deposit types.



Understanding through the Mineral System Concept

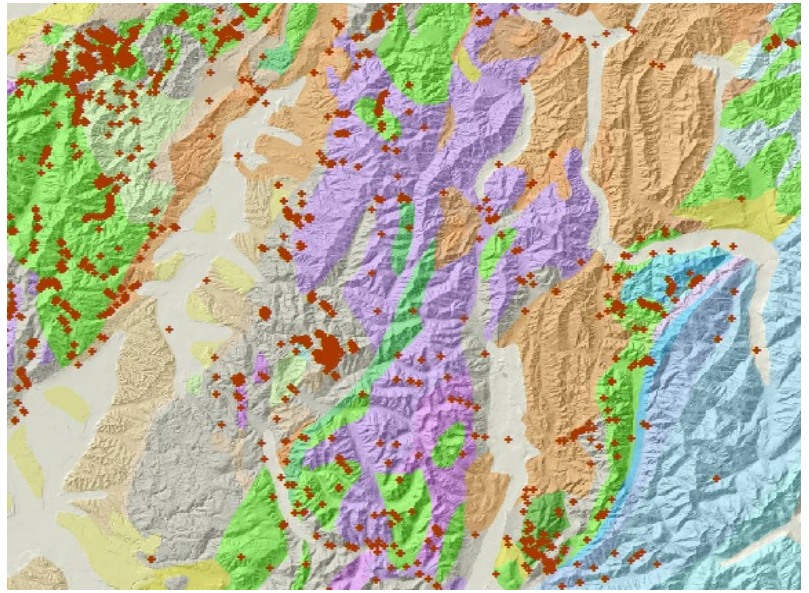


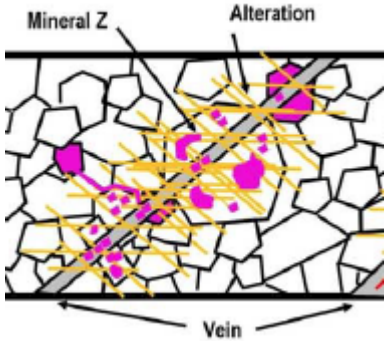
Knox-Robinson & Wyborn (1997), from Hagemann et al. (2016)

- **Energy:** Heat from the intrusion drives hydrothermal circulation and chemical reactions.
- **Source:** Metals and ligands are supplied by the intrusion and/or mobilised from the surrounding country rock.
- **Transport:** Pressure and stress creates fractures and permeability, allowing metal-bearing fluids to migrate.
- **Trap:** Fluid–rock interactions cause metals to precipitate in reactive rocks or structural traps.
- **Outflow:** Surface expressions of the mineral system include alteration, geochemical anomalies, and deformation.

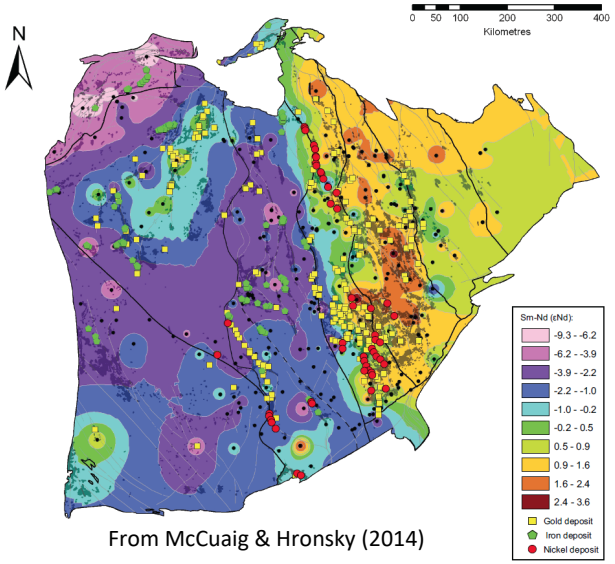
Mappable Criteria

- Mappable criteria are parts of the mineral system that we have geological data for and that can be represented spatially.
  - ❖ For example, intrusions and exploration geochemistry can be mapped in a GIS and used to understand the regional opportunity.
- For some mappable criteria data is sparse. In this case, we used that data as a guide to determine if it correlates with well known mineralisation, and if so, consider obtaining new data.
  - ❖ For example, bismuth geochemistry is sparse in our sample databases.
- Some components of the mineral system are conceptual or cannot currently be represented reliably at a regional mapping scale. They help us understand the mineral system, but are not usually suitable for regional or exploration-scale modelling.
  - ❖ For example, major crustal boundaries inferred from isotope studies or mineral-scale processes recorded in crystal lattices.





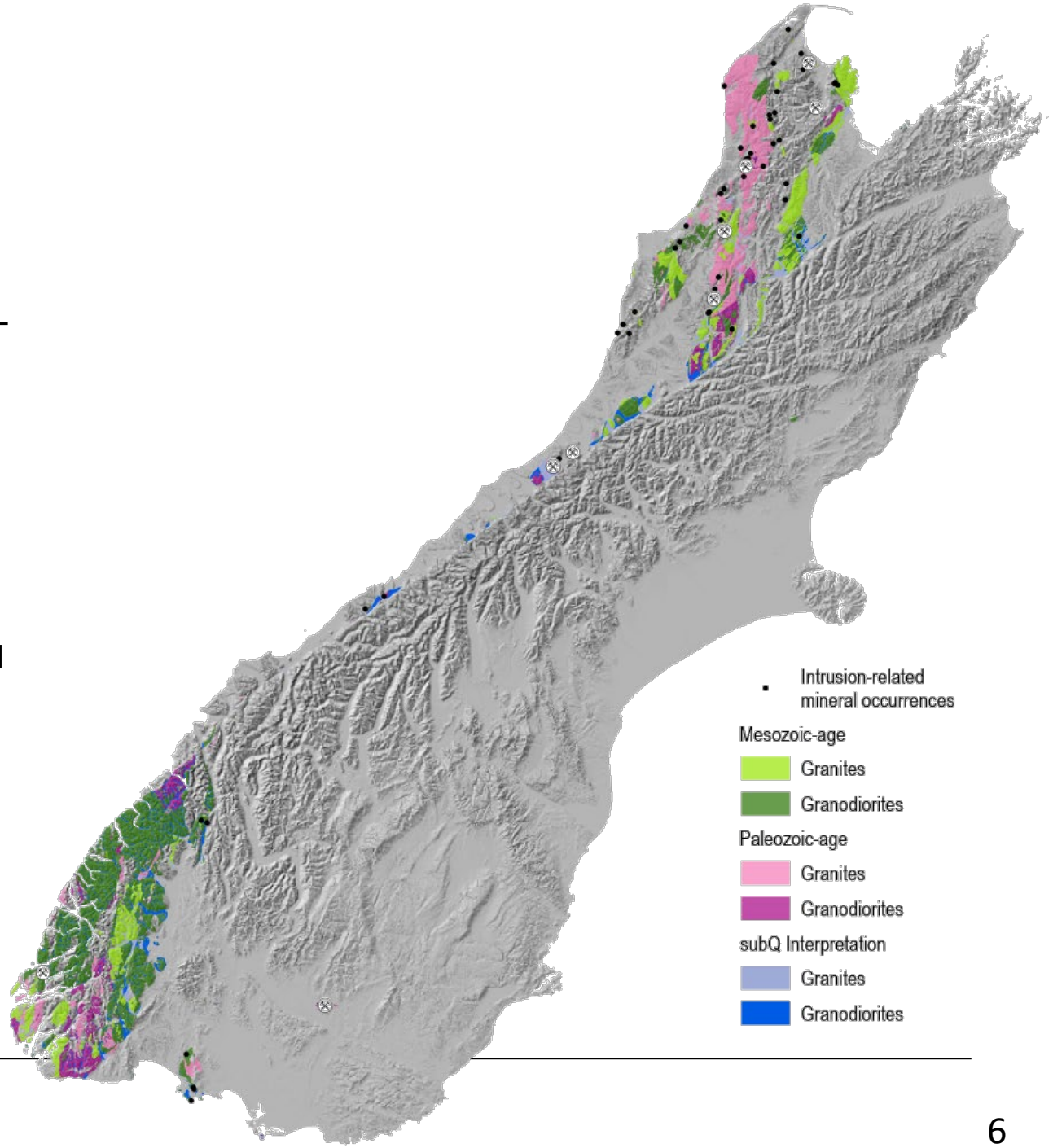
From Morgenstern et al. (2017)



From McCuaig & Hronsky (2014)

Energy:

- The primary energy source is the heat released by felsic intrusions emplaced into the crust.
- Intrusion-related heat drives hydrothermal circulation and fluid–rock reactions in the surrounding crust.
- The intrusion provides heat and may contribute fluids and metals, while emplacement generates pressure, stress and permeability that facilitate hydrothermal circulation.
- South Island felsic intrusions can be grouped into Mesozoic and Paleozoic age granitic, granodiorite, dioritic rocks. These can be mapped from our national geological database.
- There is also the new sub-Quaternary geological map of the South Island that interprets the basement geology below the recent surface cover material.

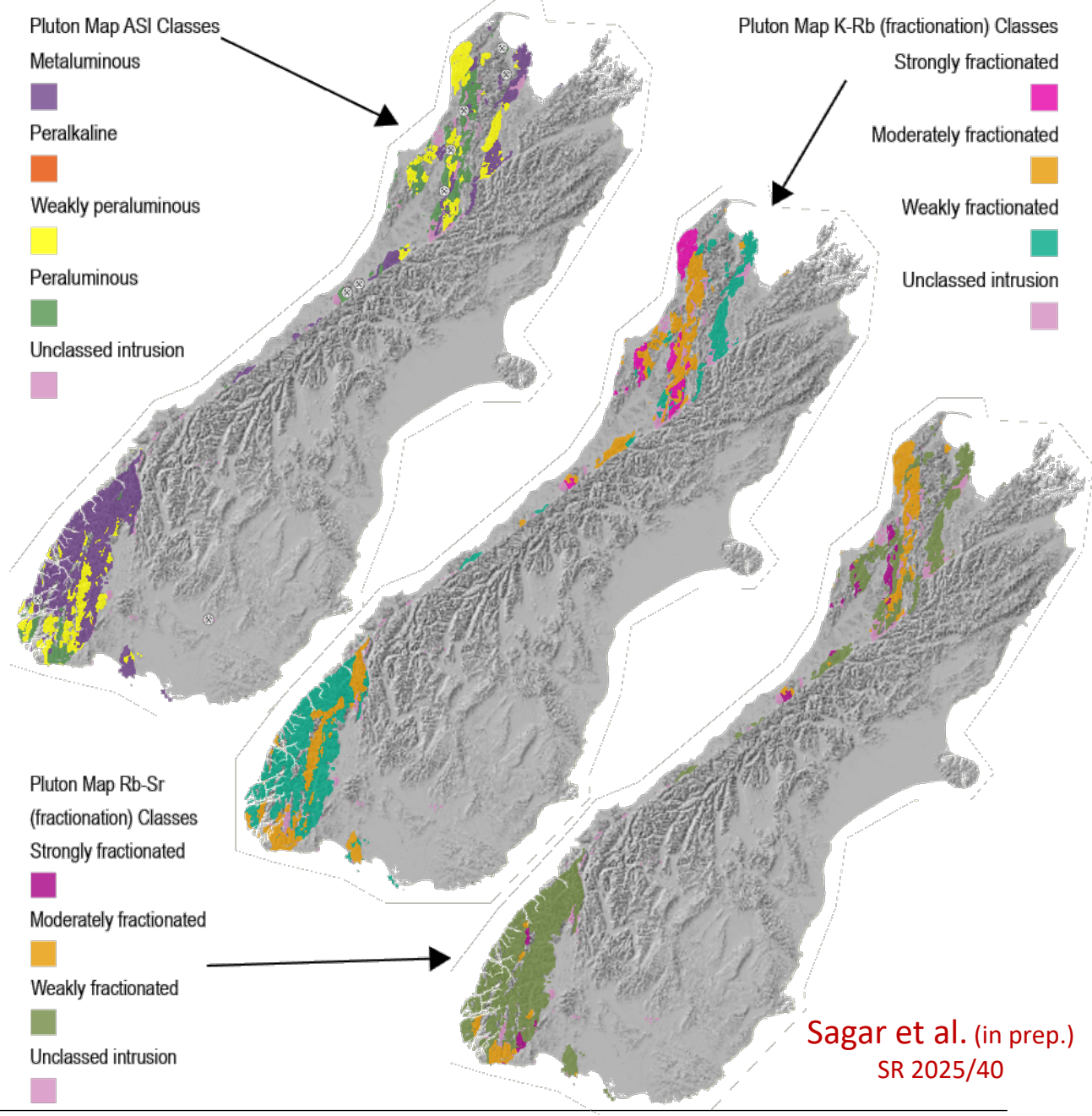


Rattenbury (2025)
SR 2025/25

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Fluid and Metal Source:

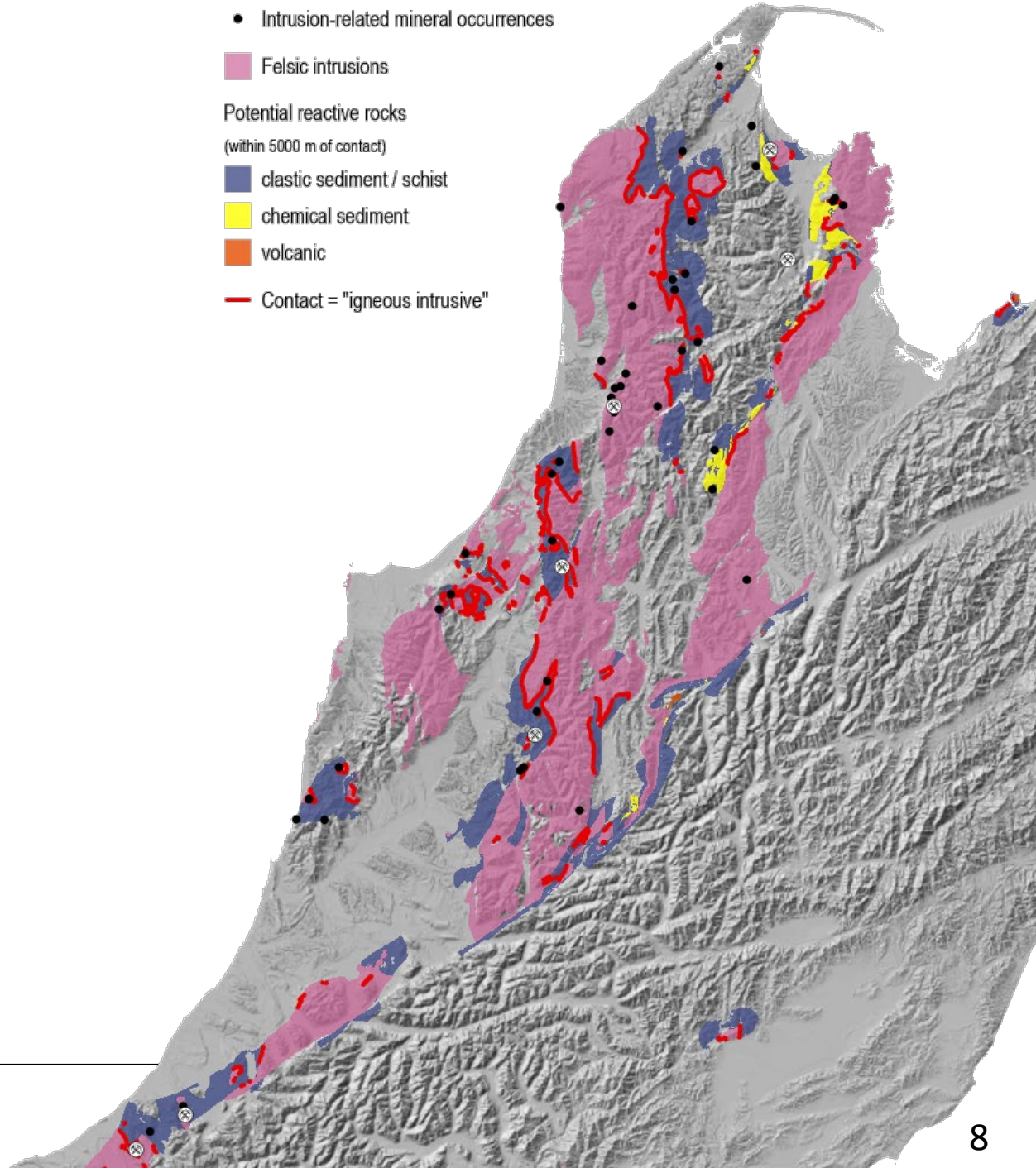
- Hydrothermal fluids are the principal agents responsible for transporting metals from their sources to sites of mineralisation.
- Highly evolved felsic intrusions can release magmatic-hydrothermal fluids that contain H_2O, CO_2, S, Cl, F, B, and metals such as Cu, Mo, Sn, W, Au, Pb and Zn.
- There is an amazing new dataset called **Pluton Map** that categorises our South Island intrusions.
- From Pluton Map and Petlab we have mapped granite petrogenetic indicators such as:
  - ASI – characterises alumina saturation and provides information on magma composition and potential metal/ligand behaviour;
  - K-Rb and Rb-Sr ratios – indicators of magmatic differentiation and fractionation, helping identify evolved systems approaching volatile-rich fluid exsolution.



Sagar et al. (in prep.)
SR 2025/40

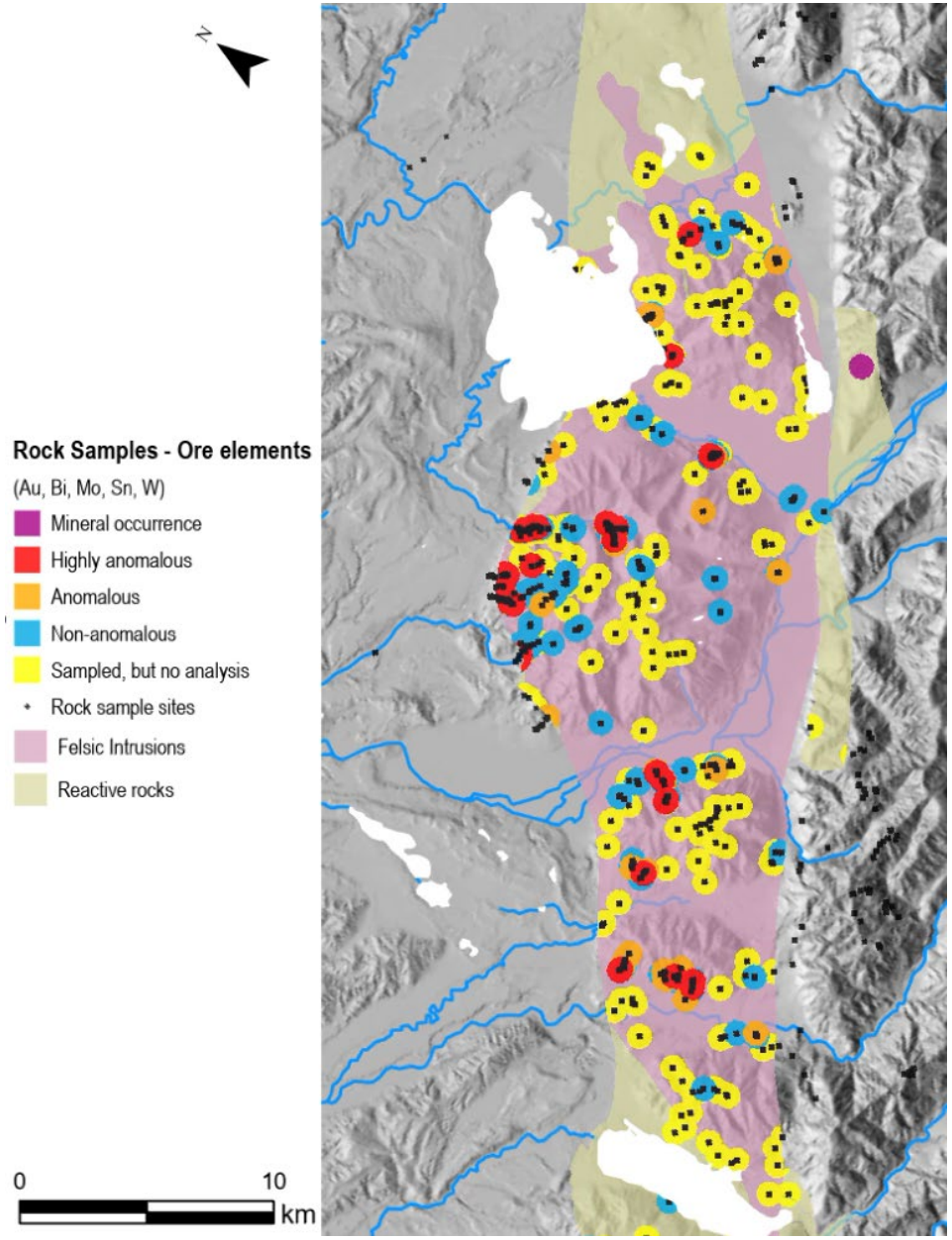
Trap:

- When intrusion-related fluid encounters a suitable environment, e.g. a change in temperature, pressure, pH, redox state, sulphur activity or host-rock chemistry, metals may precipitate and become concentrated within the host rock.
- Mineralisation doesn't only occur within the intrusion itself; it may develop in reactive or structurally prepared country rock adjacent to the intrusion.
- We can determine where intrusion-adjacent reactive rocks could occur using the geological map data:
    - This analysis determines reactive rocks such as clastic sediments, limestone, or volcanic deposits that are adjacent to younger intrusions and have a "igneous intrusive" contact type (not faulted).
    - These contacts are extended by ~5 km into the reactive rock unit as a first-order estimate of the potential trap zone.



Surface Expression:

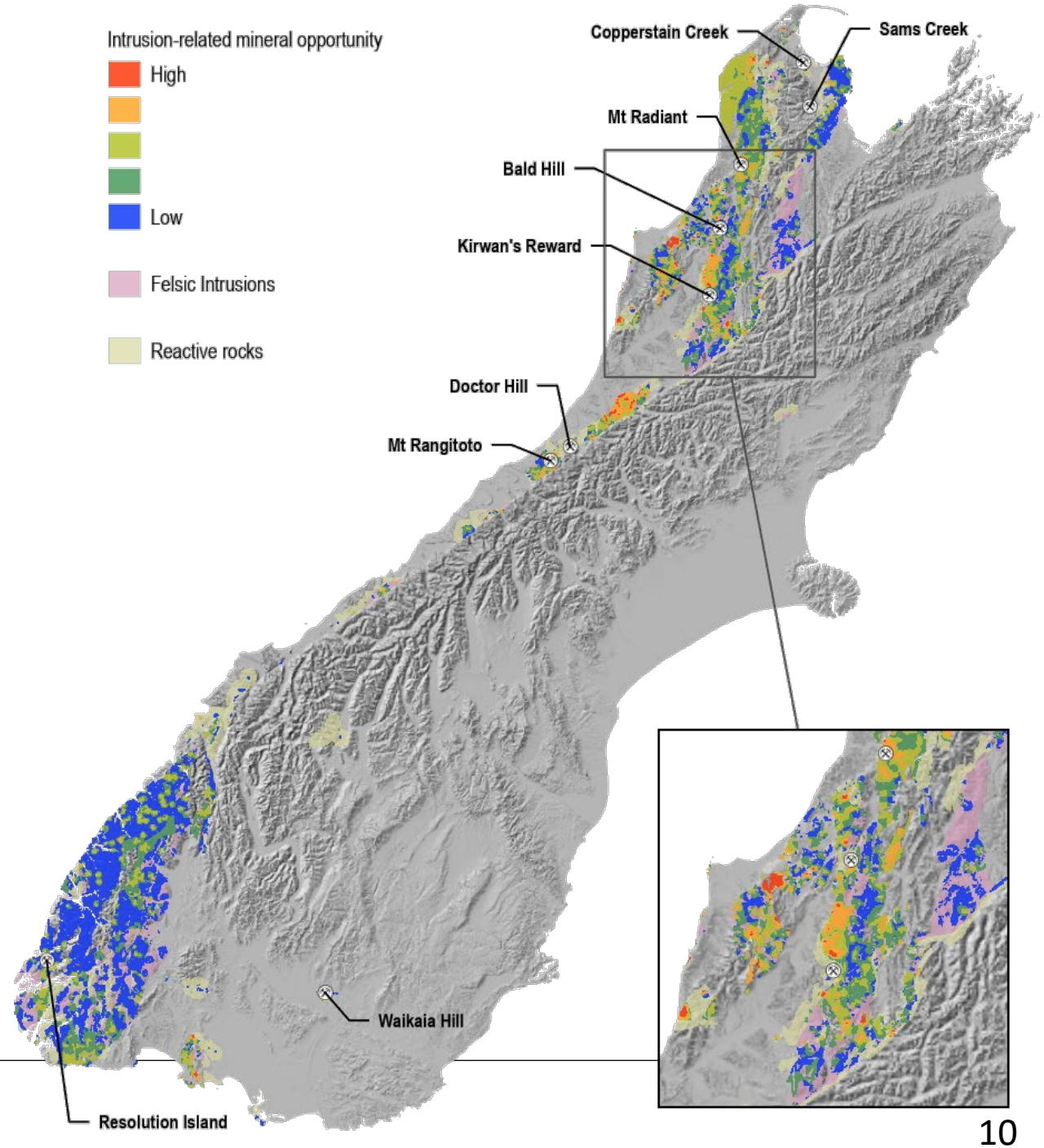
- Geochemical analysis of rocks and stream sediments provides important evidence for targeting buried or concealed mineralisation.
- We use industry exploration data to map both anomalous and background geochemical distributions.
- In our analysis we divide these into ore-related elements as well as pathfinder elements to understand not only where critical minerals are deposited, but also the broader mineral footprint.
- There are still a lot of data gaps: places not yet explored, data not digitised from exploration reports, or existing samples not analysed for all the ore and pathfinder elements.



Mineral Opportunity Model

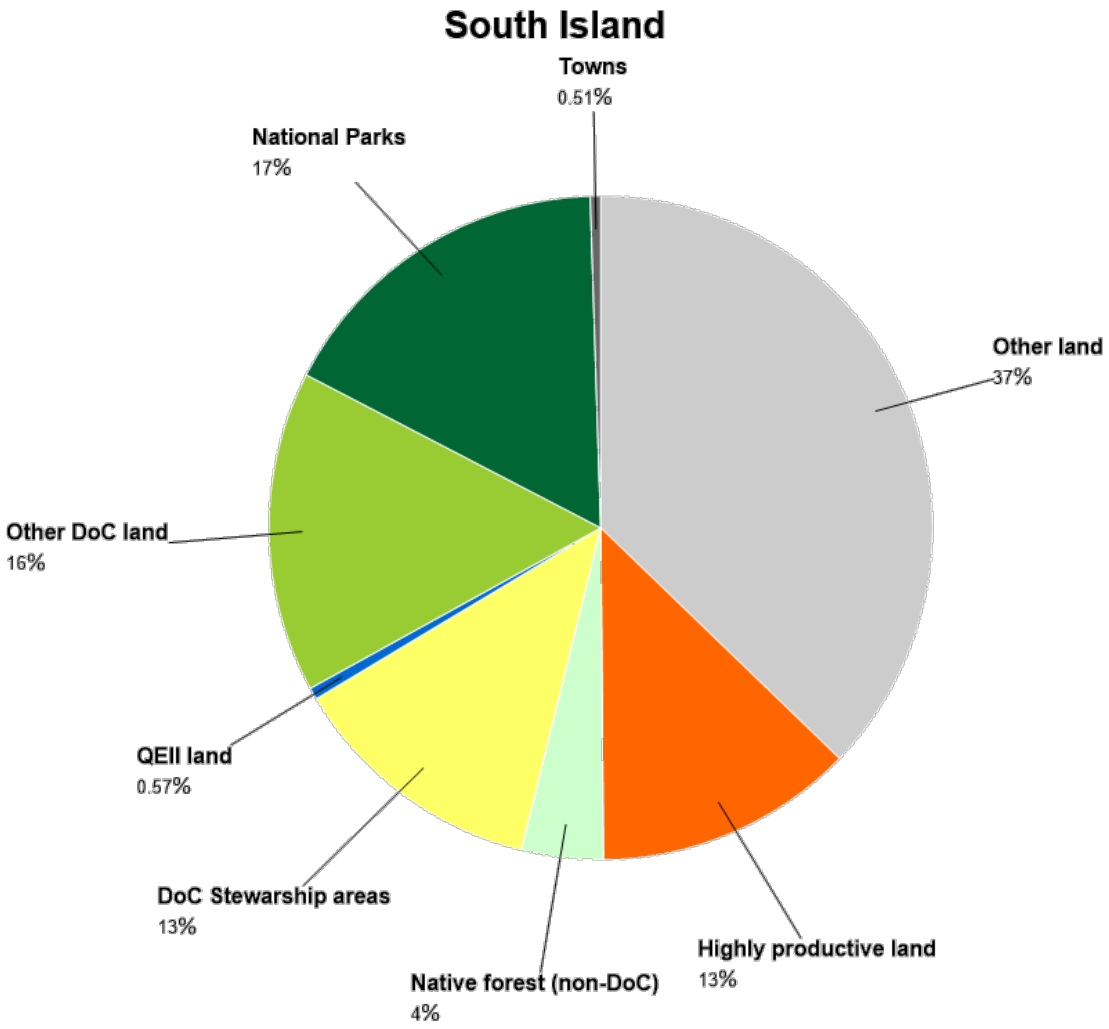
To understand areas where favourable mineralisation criteria spatially coincide, we can combine our mappable criteria datasets in a spatial model.

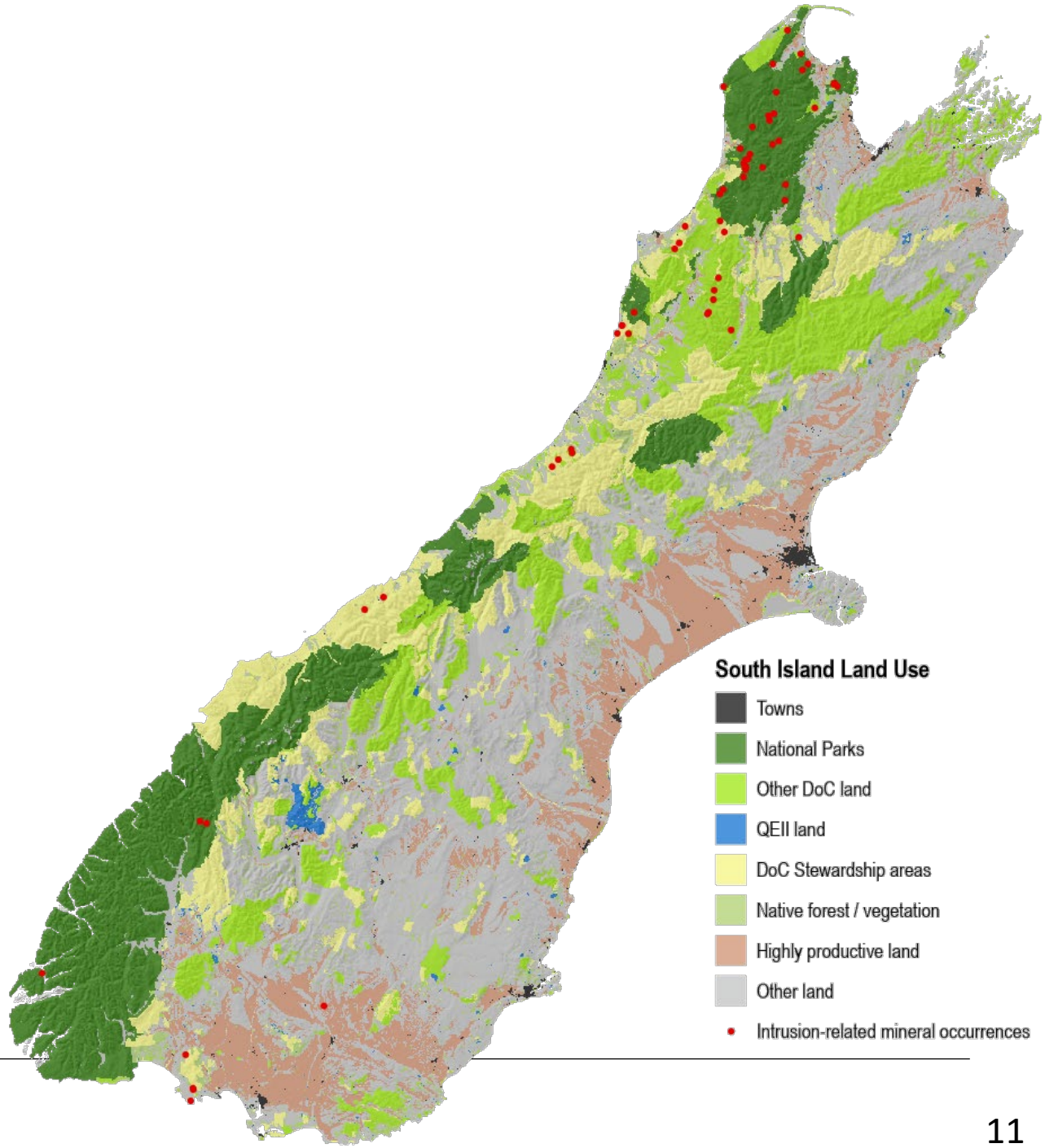
- We used a simple weighted model as machine learning techniques were not suitable due to limited training data.
- The model identifies regional areas of geological opportunity and has a good spatial correlation with known mineralisation.
- This model is useful for regional assessment of prospectivity and for review of existing mappable datasets that are relevant to the mineral system.
- The scale and type of source data mean that at this stage the model is most suitable for regional-scale assessment.



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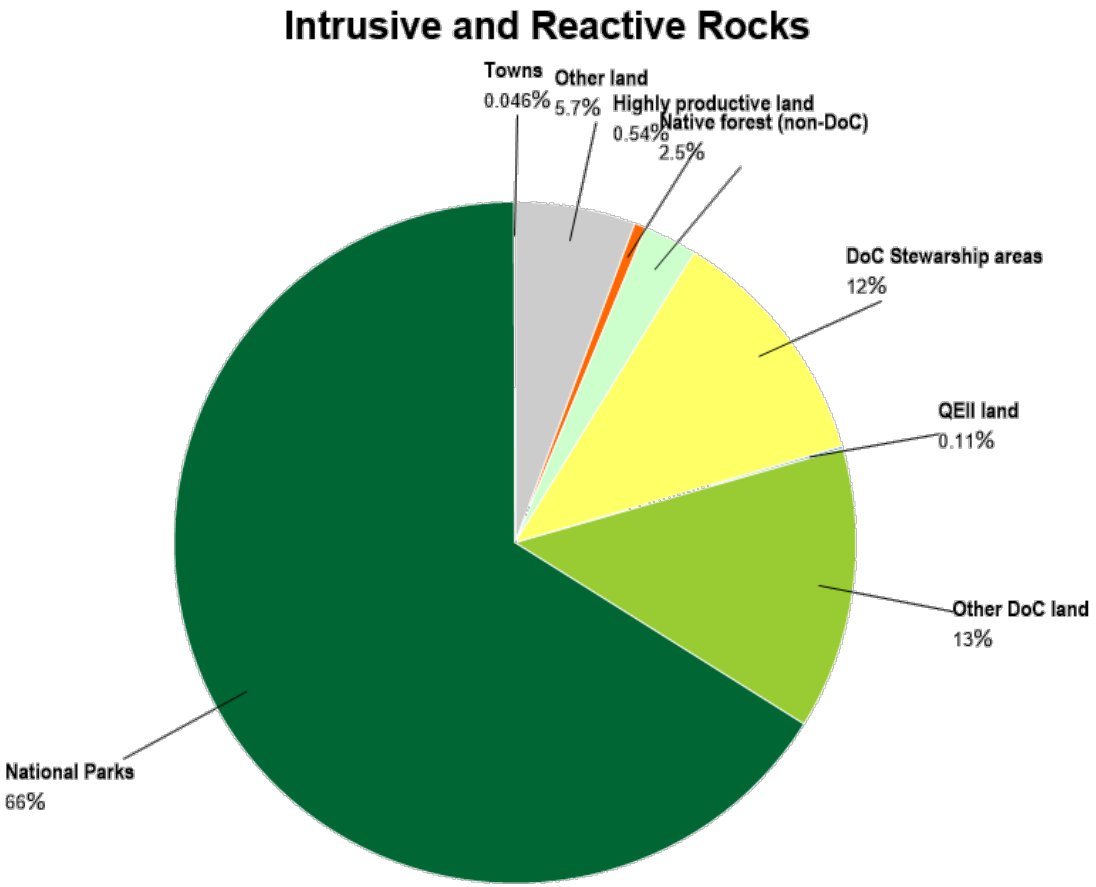
South Island Land Use

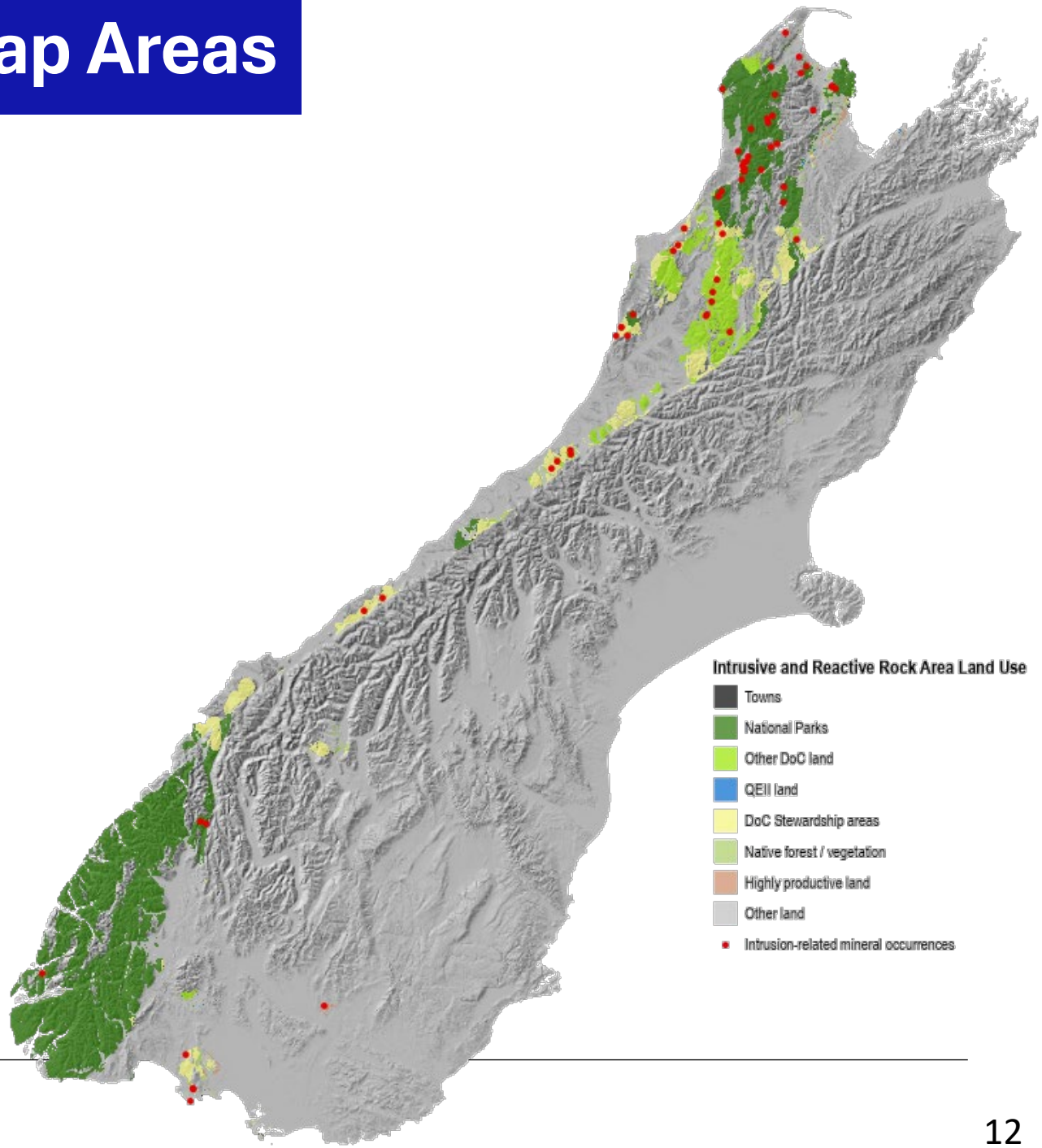




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Land Use Within Source and Trap Areas





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What is Missing from the Model?

- Our preliminary regional-scale modelling and data assessment will be refined over the next 12 months.
- Future research is aiming to review and map:
  - Intrusion emplacement depth;
  - 3D extent of intrusions and contact boundaries;
  - Alteration through analysis of geophysical datasets;
  - Structural features related to emplacement and mineralisation;
  - Relationships between intrusive granite petrogenetic indicators and metallic mineralisation.
- These will provide more comprehensive coverage of the mineral system.

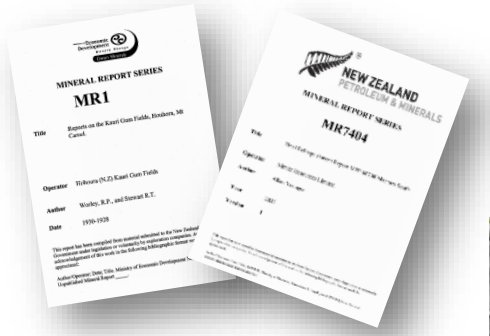


J. Forsyth

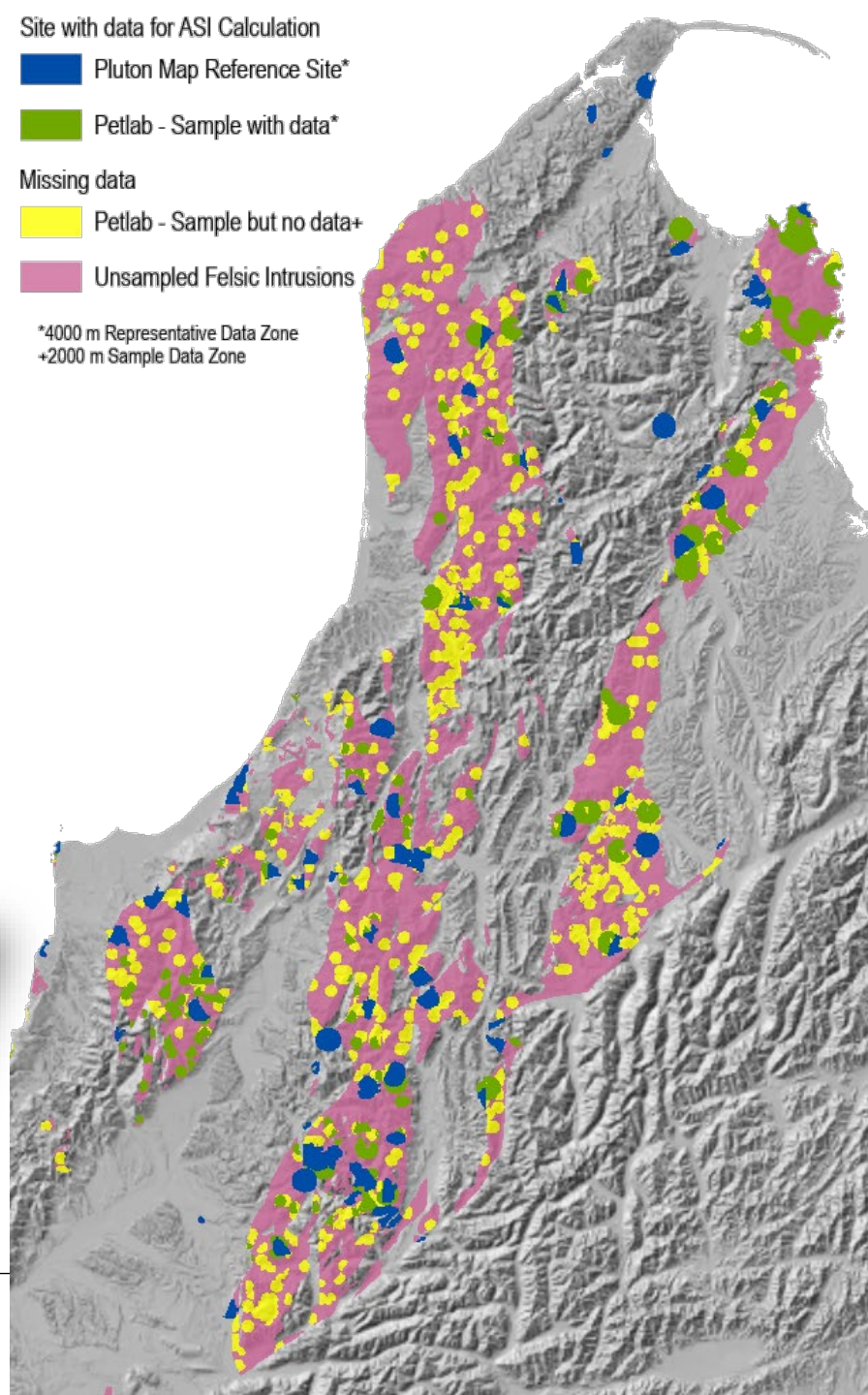
Missing data = Exploration Opportunity

- An initial review of the spatial coverage and sample distribution indicates where existing interpretations could be improved through new data acquisition.
- For example:
  - In this mapped area, 84% of the intrusions are not covered by a ‘sample zone’. But 20% is represented by existing rocks samples that could be analysed.
  - Only 14% of exploration rock samples have a Bi analysis, an important pathfinder element.
- There is still a wealth of information located in historic exploration reports and research mapping data.

Missing data are exploration opportunities!



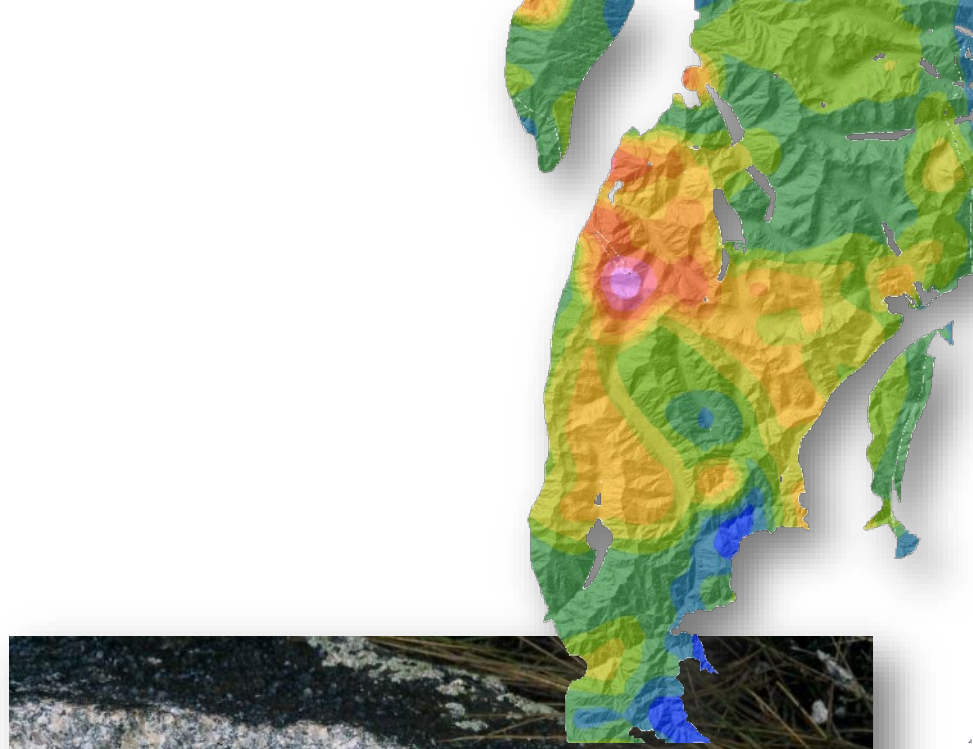
There are >5,700 reports dating back over 100 years.



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Summary

- The South Island contains significant geological opportunity for intrusion-related mineralisation.
- But land use is an important exploration consideration.
- We have mapped and characterised intrusive rocks by age, type and geochemistry to identify those most favourable for generating mineralising fluids and hosting deposits.
- There is a lot of missing data… but these are exploration opportunities!
- We'll be continuing to develop mappable criteria at regional scales to better understand the mineral system and opportunities.
- Our data will be available through a web map for easy visualisation, as well as with direct data access for use in GIS and other software.





M. Turnbull

ESNZ Lunchtime Breakout Session - Monday

We are holding a lunchtime breakout session today in the Rimu Boardroom for explorers and mining companies.

We're keen to hear from industry about the high-level geological questions you'd like answered to help you be more successful in exploration.

What are the key geological uncertainties or knowledge gaps that are limiting exploration and discovery?

All delegates from exploration and mining companies are welcome to attend. Please bring your lunch along.

If you’re involved in exploration or mining, we’d really like to hear from you. Please join us in the ***Rimu Boardroom*** at lunchtime.

M. HILL



...are we going in the right direction?



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