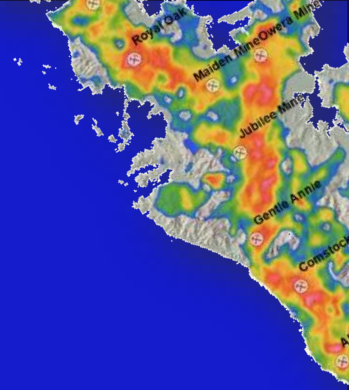
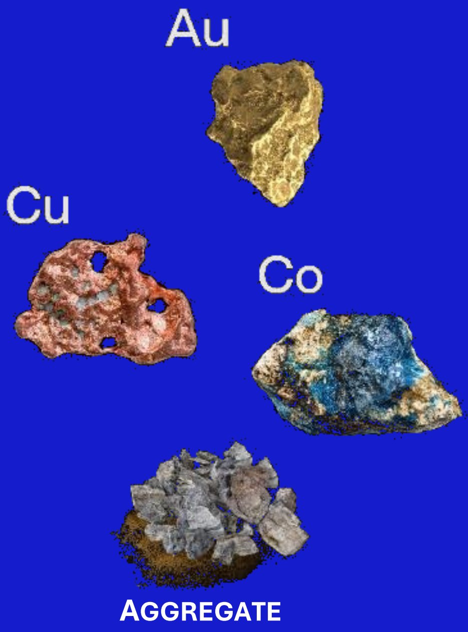


Enhancing Exploration Opportunities:

Development of a New Critical Minerals Website and Web Map Atlas



Presented by:

Matthew Hill

Geologist

And the team:

Kevin Faure

Mark Rattenbury

Jeff Lyall

Kate Osborn

Nicolas Speziali

Hannah Elliot

Andrew Boyes

Matt Sagar

NIWA
Taihoro Nukurangi

GNS SCIENCE
TE PŪ AO

In a relationship

1 July 2025

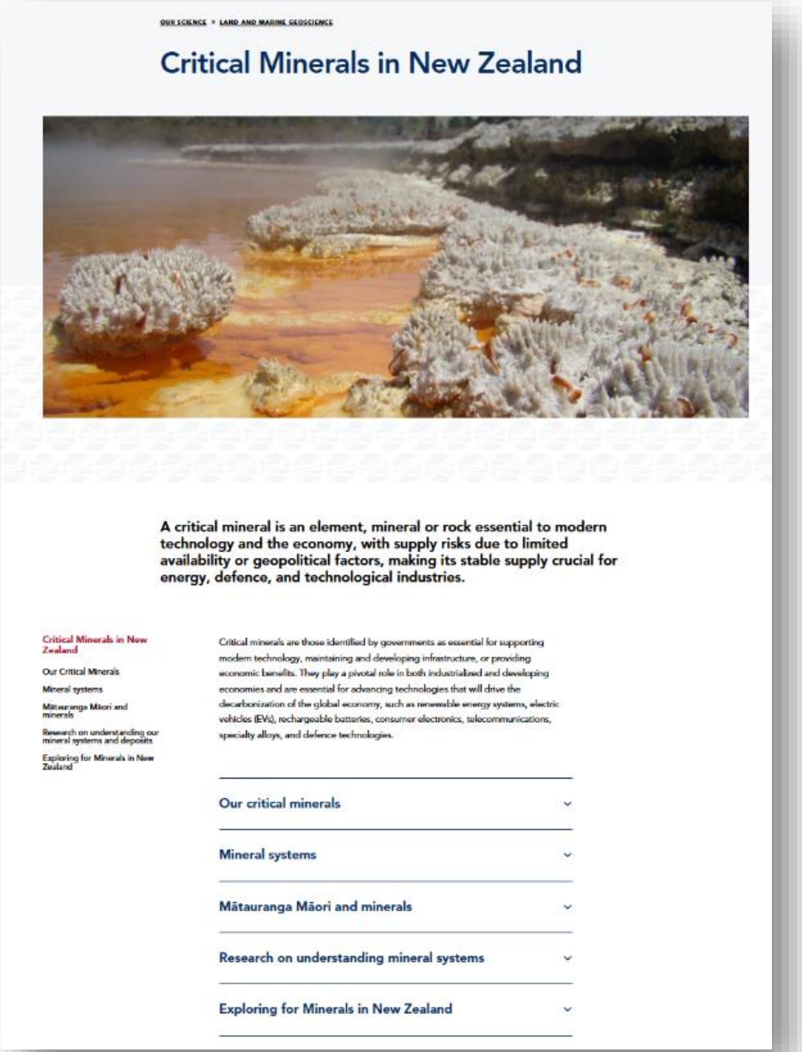
Earth Sciences New Zealand

A Three-Part Presentation:

1. Developing a Critical Minerals Website
2. The Supporting Web Maps
3. Plans for new Mineral Opportunity Modelling

Critical Minerals – A website for New Zealand

- We are developing a dedicated section in our website to showcase New Zealand's critical minerals.
- The content will be presented in a clear, accessible language for a general audience.
- We are tailoring our content for two key audiences:
    1. The New Zealand public – providing accessible information on critical minerals, their uses, and why they matter.
    2. International exploration investors – enabling quick assessment of mineral potential and streamlined access to relevant data.
- For those seeking more depth, we will provide links to detailed scientific resources and interactive web maps.



OUR SCIENCE » LAND AND MARINE GEOSCIENCE

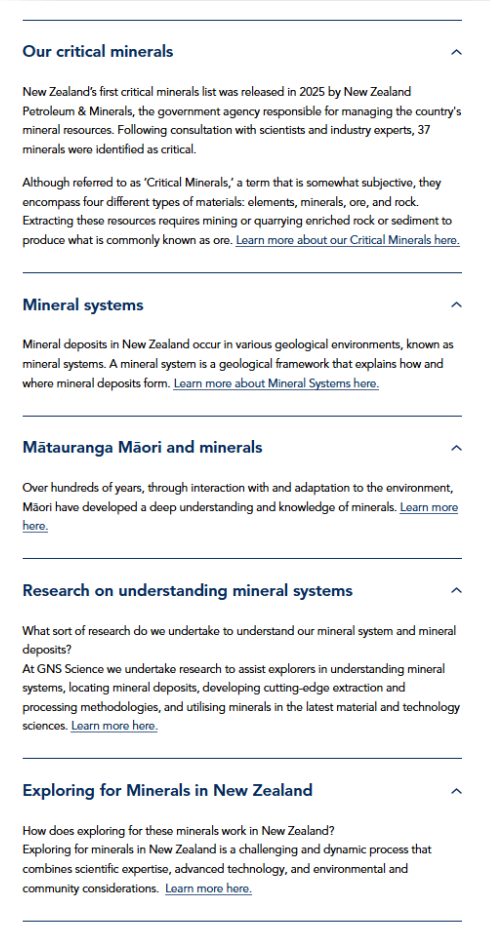
Critical Minerals in New Zealand

A critical mineral is an element, mineral or rock essential to modern technology and the economy, with supply risks due to limited availability or geopolitical factors, making its stable supply crucial for energy, defence, and technological industries.

Critical Minerals in New Zealand
Our Critical Minerals
Mineral systems
Mātauranga Māori and minerals
Research on understanding our mineral systems and deposits
Exploring for Minerals in New Zealand

Critical minerals are those identified by governments as essential for supporting modern technology, maintaining and developing infrastructure, or providing economic benefits. They play a pivotal role in both industrialized and developing economies and are essential for advancing technologies that will drive the decarbonization of the global economy, such as renewable energy systems, electric vehicles (EVs), rechargeable batteries, consumer electronics, telecommunications, specialty alloys, and defence technologies.

Our critical minerals
Mineral systems
Mātauranga Māori and minerals
Research on understanding mineral systems
Exploring for Minerals in New Zealand



Our critical minerals

New Zealand's first critical minerals list was released in 2025 by New Zealand Petroleum & Minerals, the government agency responsible for managing the country's mineral resources. Following consultation with scientists and industry experts, 37 minerals were identified as critical.

Although referred to as 'Critical Minerals,' a term that is somewhat subjective, they encompass four different types of materials: elements, minerals, ore, and rock. Extracting these resources requires mining or quarrying enriched rock or sediment to produce what is commonly known as ore. Learn more about our Critical Minerals here.

Mineral systems

Mineral deposits in New Zealand occur in various geological environments, known as mineral systems. A mineral system is a geological framework that explains how and where mineral deposits form. Learn more about Mineral Systems here.

Mātauranga Māori and minerals

Over hundreds of years, through interaction with and adaptation to the environment, Māori have developed a deep understanding and knowledge of minerals. Learn more here.

Research on understanding mineral systems

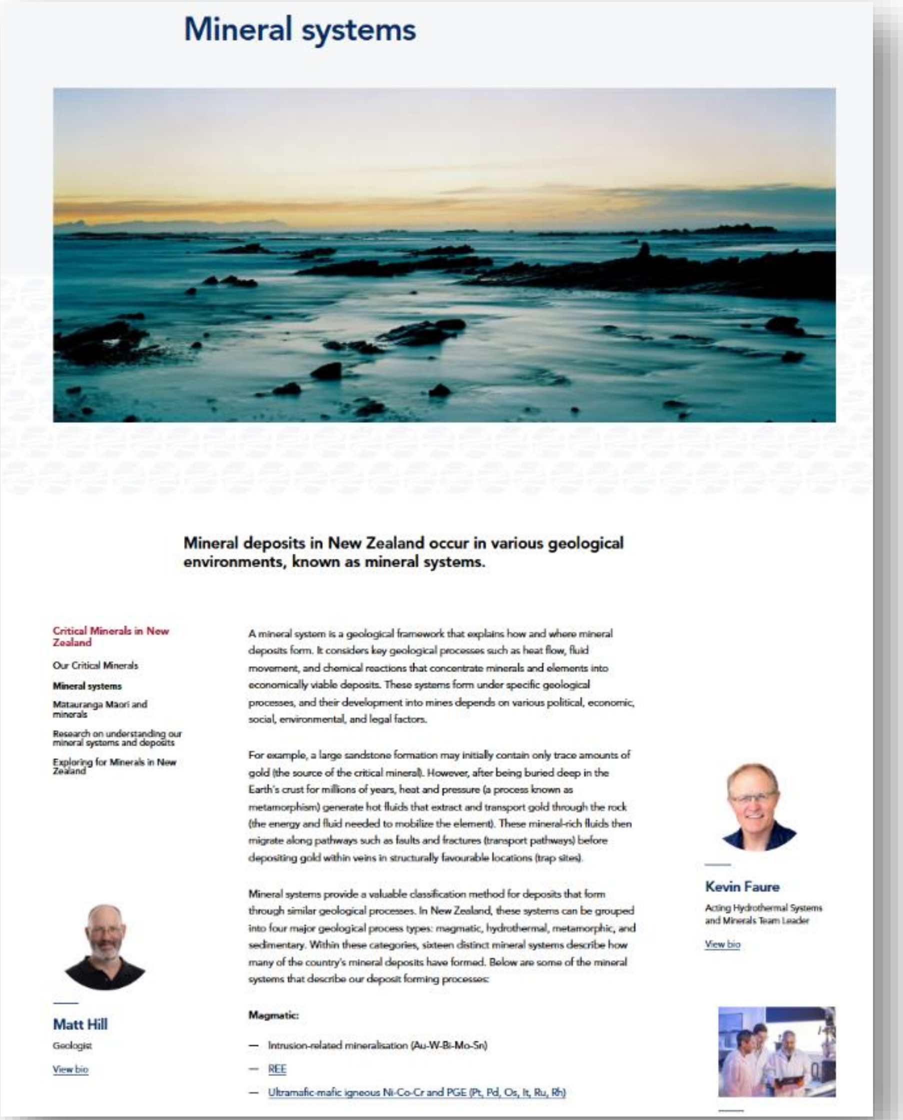
What sort of research do we undertake to understand our mineral system and mineral deposits?
At GNS Science we undertake research to assist explorers in understanding mineral systems, locating mineral deposits, developing cutting-edge extraction and processing methodologies, and utilising minerals in the latest material and technology sciences. Learn more here.

Exploring for Minerals in New Zealand

How does exploring for these minerals work in New Zealand?
Exploring for minerals in New Zealand is a challenging and dynamic process that combines scientific expertise, advanced technology, and environmental and community considerations. Learn more here.

We are planning to release these pages in October 2025

Critical Minerals – Our Mineral Systems



Mineral systems

Mineral deposits in New Zealand occur in various geological environments, known as mineral systems.

Critical Minerals in New Zealand

Our Critical Minerals

Mineral systems

Matauranga Maori and minerals

Research on understanding our mineral systems and deposits

Exploring for Minerals in New Zealand

A mineral system is a geological framework that explains how and where mineral deposits form. It considers key geological processes such as heat flow, fluid movement, and chemical reactions that concentrate minerals and elements into economically viable deposits. These systems form under specific geological processes, and their development into mines depends on various political, economic, social, environmental, and legal factors.

For example, a large sandstone formation may initially contain only trace amounts of gold (the source of the critical mineral). However, after being buried deep in the Earth's crust for millions of years, heat and pressure (a process known as metamorphism) generate hot fluids that extract and transport gold through the rock (the energy and fluid needed to mobilize the element). These mineral-rich fluids then migrate along pathways such as faults and fractures (transport pathways) before depositing gold within veins in structurally favourable locations (trap sites).

Mineral systems provide a valuable classification method for deposits that form through similar geological processes. In New Zealand, these systems can be grouped into four major geological process types: magmatic, hydrothermal, metamorphic, and sedimentary. Within these categories, sixteen distinct mineral systems describe how many of the country's mineral deposits have formed. Below are some of the mineral systems that describe our deposit forming processes:

Magmatic:

— Intrusion-related mineralisation (Au-W-Bi-Mo-Sn)

— REE

— Ultramafic-mafic igneous Ni-Co-Cr and PGE (Pt, Pd, Os, It, Ru, Rh)

Kevin Faure

Acting Hydrothermal Systems and Minerals Team Leader

View bio

Matt Hill

Geologist

View bio

Magmatic:

— Intrusion-related mineralisation (Au-W-Bi-Mo-Sn)

— REE

— Ultramafic-mafic igneous Ni-Co-Cr and PGE (Pt, Pd, Os, It, Ru, Rh)

Hydrothermal:

— Epithermal gold (+ Ag, Cu, Hg) TVZ & Northland

— Exhalative volcanic mineralisation (Au, Cu, Zn, Pb, Li) (i.e. our offshore marine mineralisation) (VMS)

— Porphyry

— Lithium – Pegmatite hosted.

— Skarn and other base metals (Cu, Pb, Sn and Zn)

Sedimentary:

— Alluvial Au

— West Coast mineral sands (Ti, Zr, REE)

— Seafloor Mn nodule and sediment mineral resources

— Clay and pozzolan minerals

— Lithium (HARSH)

Metamorphic:

— Orogenic Au (+ W, Cu, Sb) – Otago / Marlb

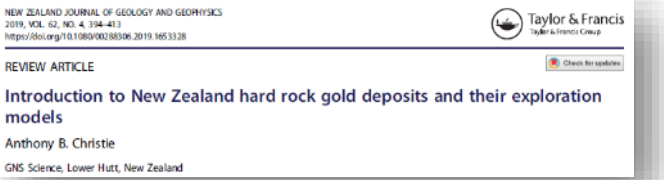
— Orogenic Au (+ W, Cu, Sb) – West Coast

— Silica & graphite

Structural Setting of Gold Mineralization within the Hyde-Macraes Shear Zone, Southern New Zealand

Andrew Allibone,[1,†] Philip Jones,[2] Hamish Blakemore,[2] Dave Craw,[3] Doug MacKenzie,[3] and Jonathan Moore[2]

[1] Rodinian (NZ) Ltd., P.O. Box 758, Wanaka 9343, New Zealand



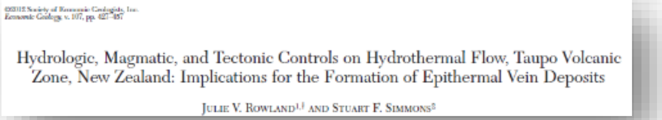
NEW ZEALAND JOURNAL OF GEOLOGY AND GEOPHYSICS
2019, VOL. 62, NO. 4, 394–413
https://doi.org/10.1080/00288306.2019.1653328

REVIEW ARTICLE

Introduction to New Zealand hard rock gold deposits and their exploration models

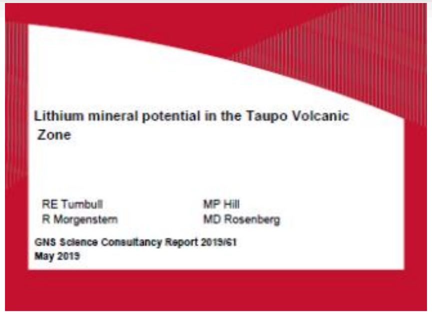
Anthony B. Christie

GNS Science, Lower Hutt, New Zealand



Hydrologic, Magmatic, and Tectonic Controls on Hydrothermal Flow, Taupo Volcanic Zone, New Zealand: Implications for the Formation of Epithermal Vein Deposits

Julie V. Rowland[1,†] and Stuart F. Simmons[2]



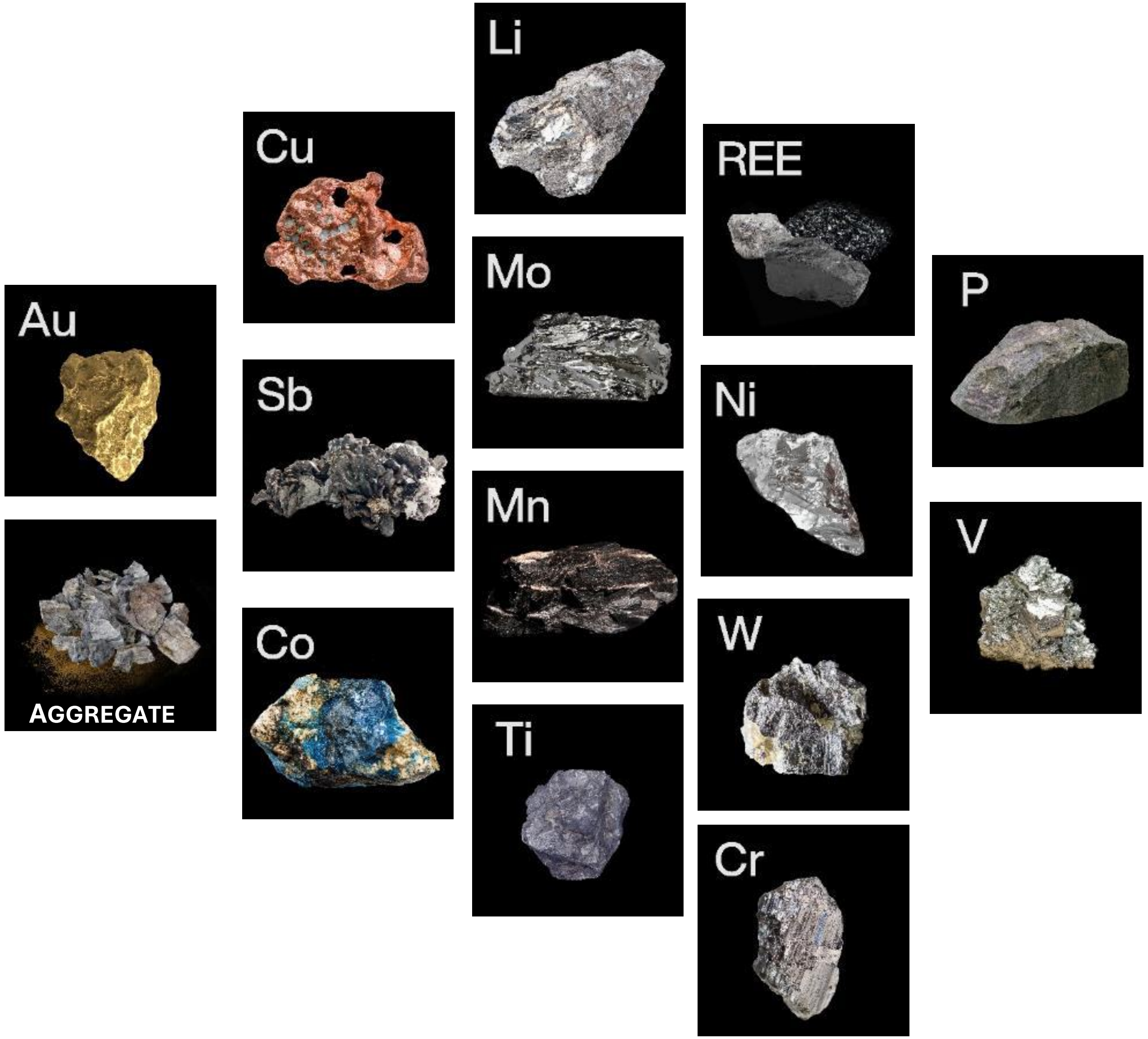
Lithium mineral potential in the Taupo Volcanic Zone

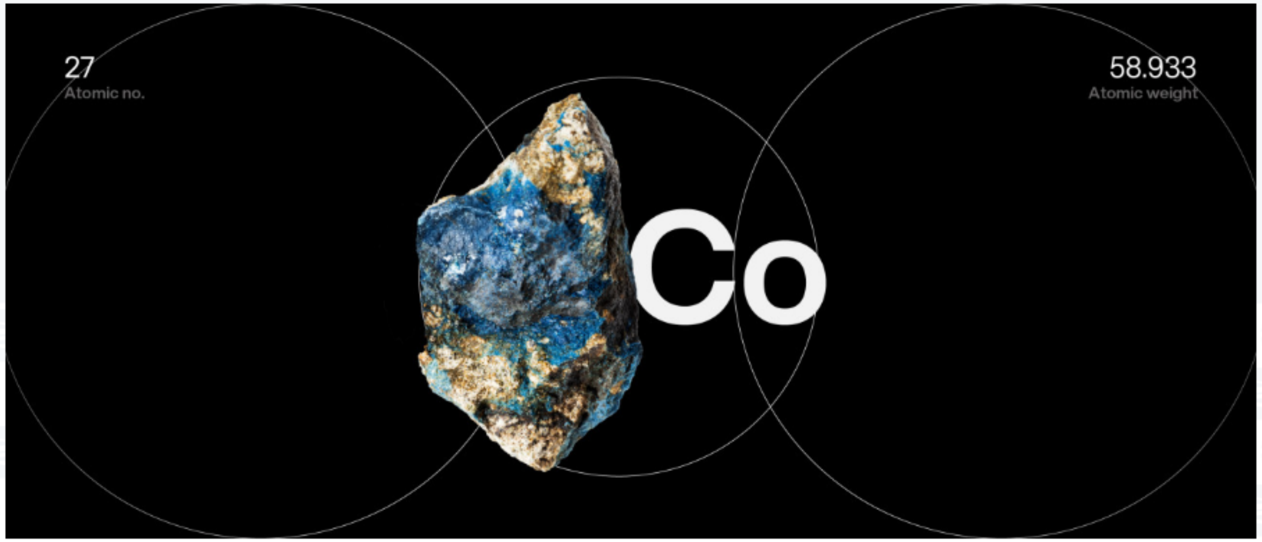
RE Turnbull
R Morgenstern
MP Hill
MD Rosenberg

GNS Science Consultancy Report 2019/61
May 2019

Critical Minerals – Elements, Minerals and Rocks

We have developed detailed information pages about 15 elements, minerals, and rocks.





Cobalt (Co) is a strategic metal essential for modern technology, renewable energy, and industry. It is primarily used in high-performance batteries, superalloys, and catalysts, making it a key element in the transition to a low-carbon economy. Its role in lithium-ion batteries is crucial for electric vehicles (EVs), energy storage systems, and portable electronics

Cobalt in New Zealand

A limited range of cobalt-bearing minerals have been observed in New Zealand and include the following: wairauite, cobaltite, glaucodot and linnaeite. Wairauite was first identified in the Red Hills in Marlborough as minute grains in serpentinite (Challis and Long 1964). Nickel and cobalt have been noted in analyses of ore from copper mines in the east Nelson Dun Mountain Ophiolite Belt.

Any likely future production of cobalt in New Zealand would be as a by-product of mining one of New Zealand's nickel prospects, e.g. Riwaka.

Exploration & Future Prospects

With the growing demand for electric vehicles, renewable energy, and high-tech industries, cobalt exploration is expanding into underexplored regions and deep-sea deposits. Advances in geophysical surveys, remote sensing, and geochemical exploration are helping identify new resources.

Cobalt's unique properties and its critical role in modern technology make it one of the most sought-after minerals today. As the world shifts towards a greener economy, the demand for cobalt will continue to rise, driving further exploration and innovation in sustainable mining practices.

Key uses of Cobalt

Battery Technology
Cobalt is a key component in lithium-ion batteries, improving energy density and battery life, particularly in nickel-cobalt-manganese (NCM) and nickel-cobalt-aluminium (NCA) cathodes used in EVs.

Superalloys
Cobalt-based superalloys are used in jet engines, gas turbines, and aerospace components due to their high-temperature strength and corrosion resistance.

Magnets & Electronics
Cobalt is used in permanent magnets for wind turbines, electric motors, and advanced electronics

Catalysts & Chemicals
Cobalt catalysts are essential in petrochemical refining, synthetic fuel production, and desulfurization processes.

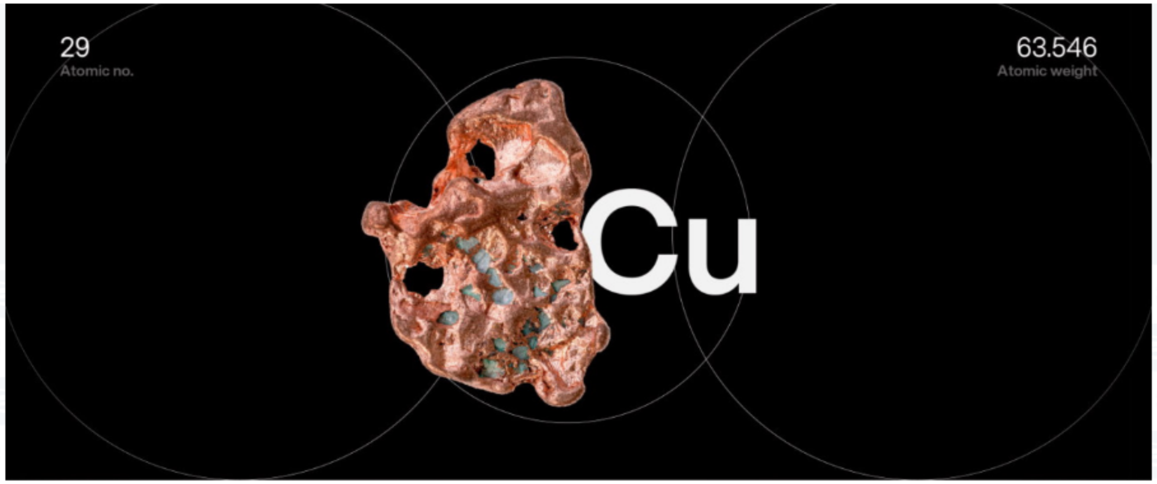
Medical & Biological Applications
Cobalt-60, a radioactive isotope, is used in cancer treatment, sterilization, and medical imaging. Cobalt is also an essential trace element for vitamin B12, necessary for human health.

"The mineral potential of New Zealand" Christie et al. (2024)


The mineral potential of New Zealand – Part 1: Overview of New Zealand's mineral deposits and their resources

AB Christie, MP Hill, RG Barker, SM Rooyakkers, RL Brathwaite, CEJ de Ronde

GNS Science Consultancy Report 2024/62A
July 2024 – Revised September 2024

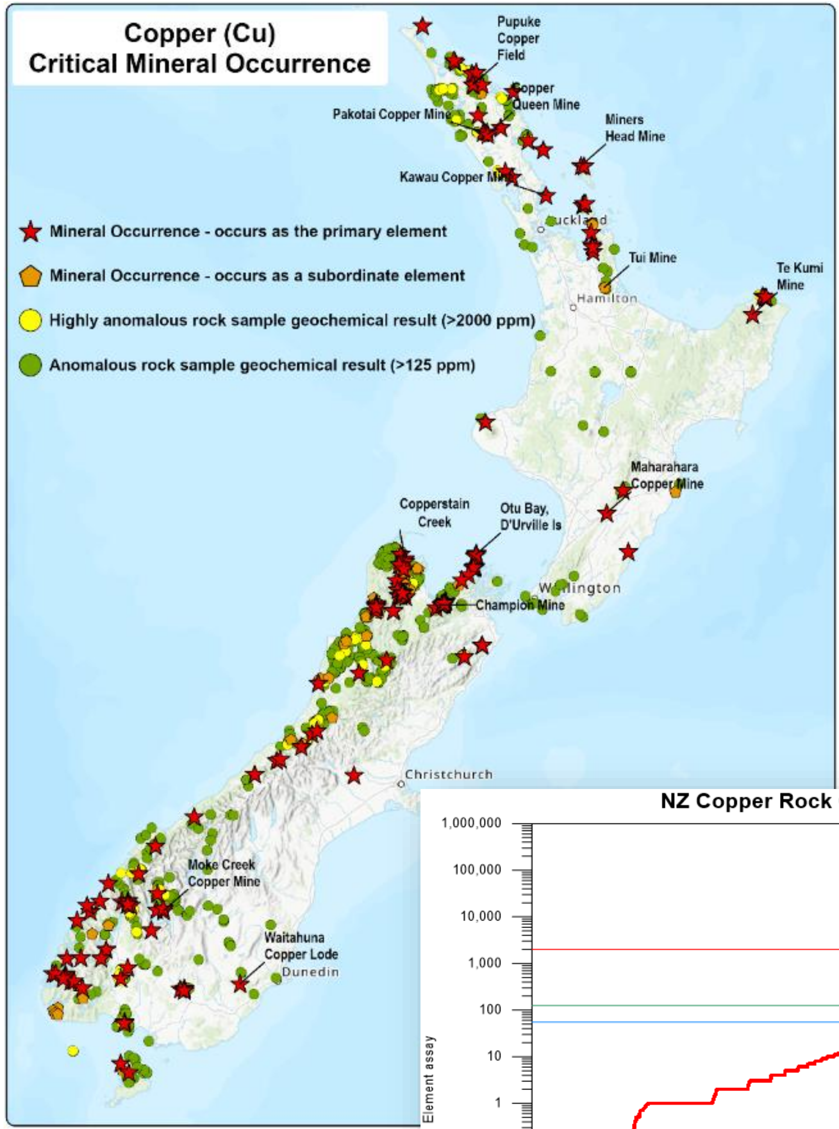


Copper has been an essential material for human civilisation for thousands of years, valued for its unique properties such as high electrical and thermal conductivity, corrosion resistance, and malleability. Today, copper is more important than ever, underpinning modern technology, infrastructure, and the global transition to clean energy.

Copper in New Zealand

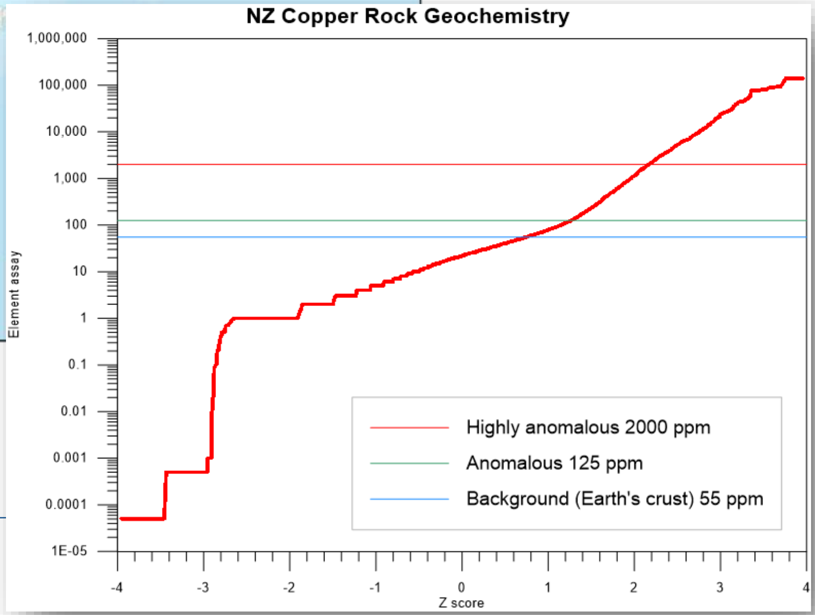
New Zealand has a wide variety of copper type deposits; these have been classified and grouped according to international mineral deposit models: Porphyry Cu, Porphyry Mo-Cu Volcanogenic massive sulphide (VMS), Serpentine-hosted Fe-Cu, Gabbroid-associated Ni-Cu, Intermediate sulphidation epithermal Au, orogenic and Copper skarn deposits. The primary origin and potential genetic classification of some quartz vein and disseminated stratabound/stratiform deposits, particularly in Fiordland, is difficult to determine because of insufficient information.

A little more than 7500 t of copper ore has been mined in New Zealand since the country's first underground mine was opened on Kawau Island in 1842. This production was mainly from volcanogenic massive sulphide (Kawau Island, Pakotai, Pupke, Parakao, Te Kumi, Maharahara, Moke Creek, Waitahuna), Serpentinite-hosted (Dun Mountain, D'Urville Island), Hydrothermal (epithermal) vein (Tui Mine) and Porphyry Cu (Miners Head, Great Barrier Island) deposits.



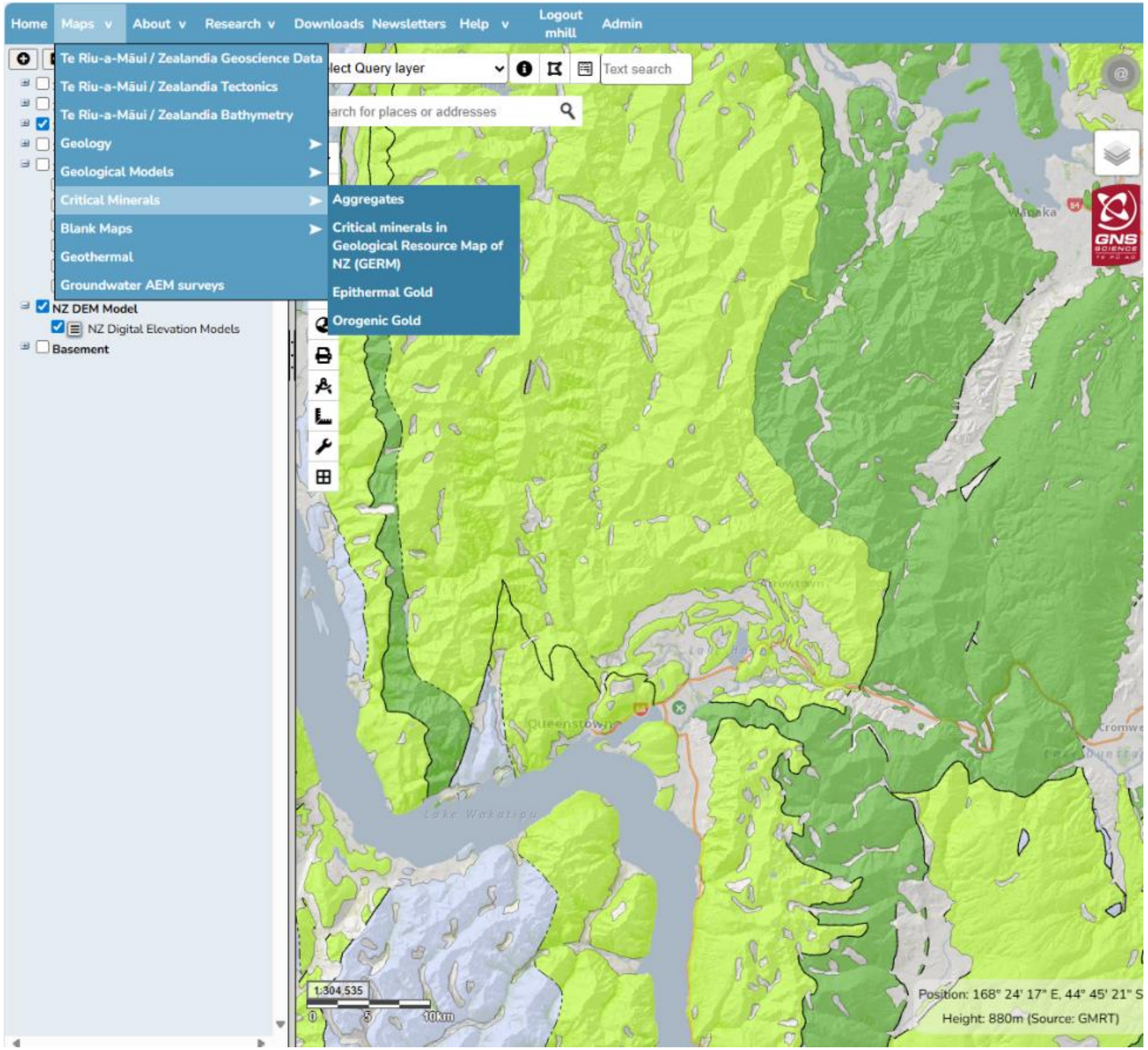
Sourced from the GEological Resource Map of NZ (GERM)

Sourced from: MR4510, REGCHEM, & PETLAB



Critical Mineral Data Atlases

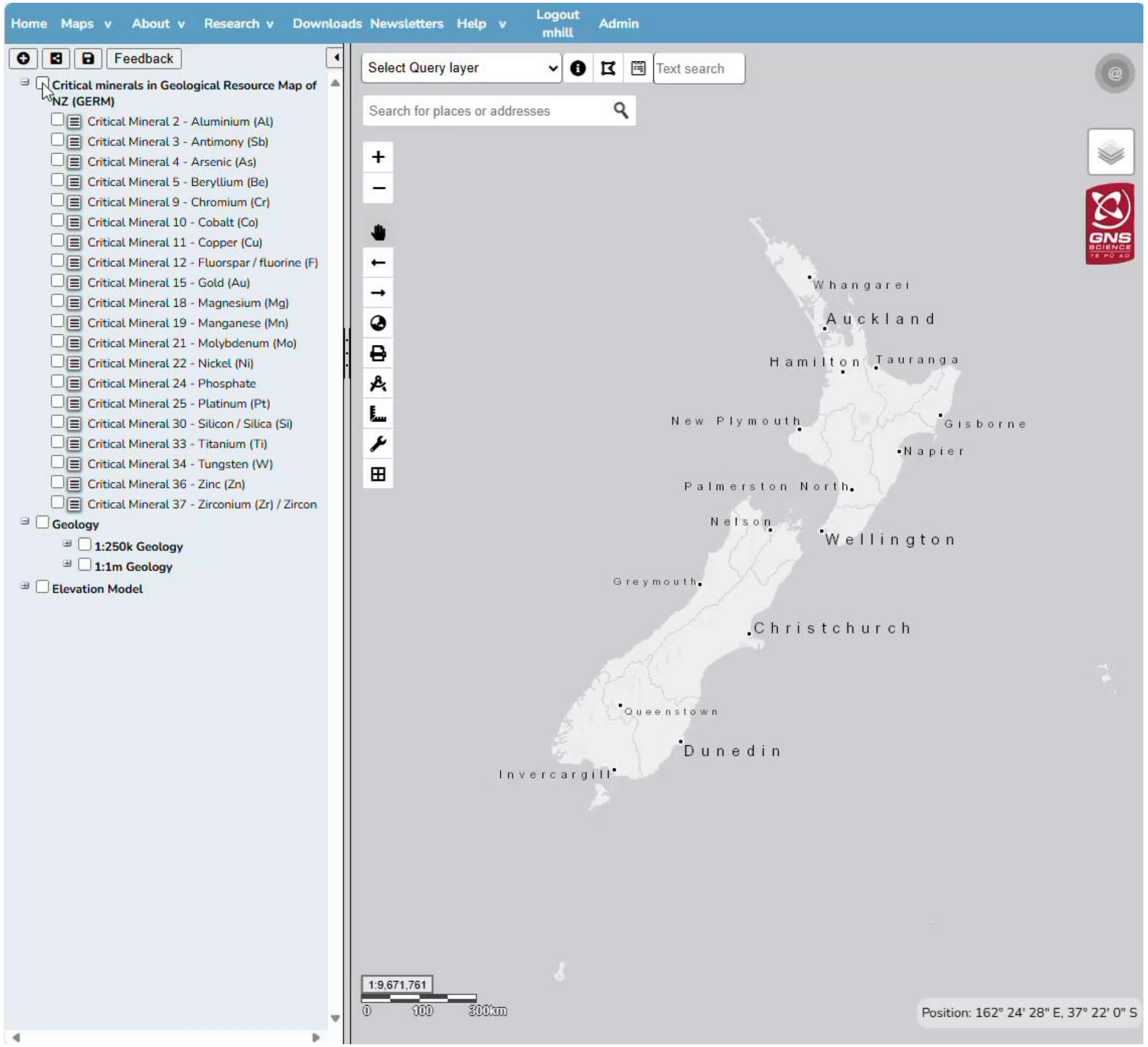
- We are developing a series of web maps to support our critical minerals website.
- These will feature maps about:
    - Mineral occurrence sites (GERM);
    - And, a series of mineral system themed maps.
- Our aim is to make the spatial data accessible and interactive.
- It will be available soon in our *EXPLORE ZEALANDIA* web map system.



Critical Mineral Occurrence

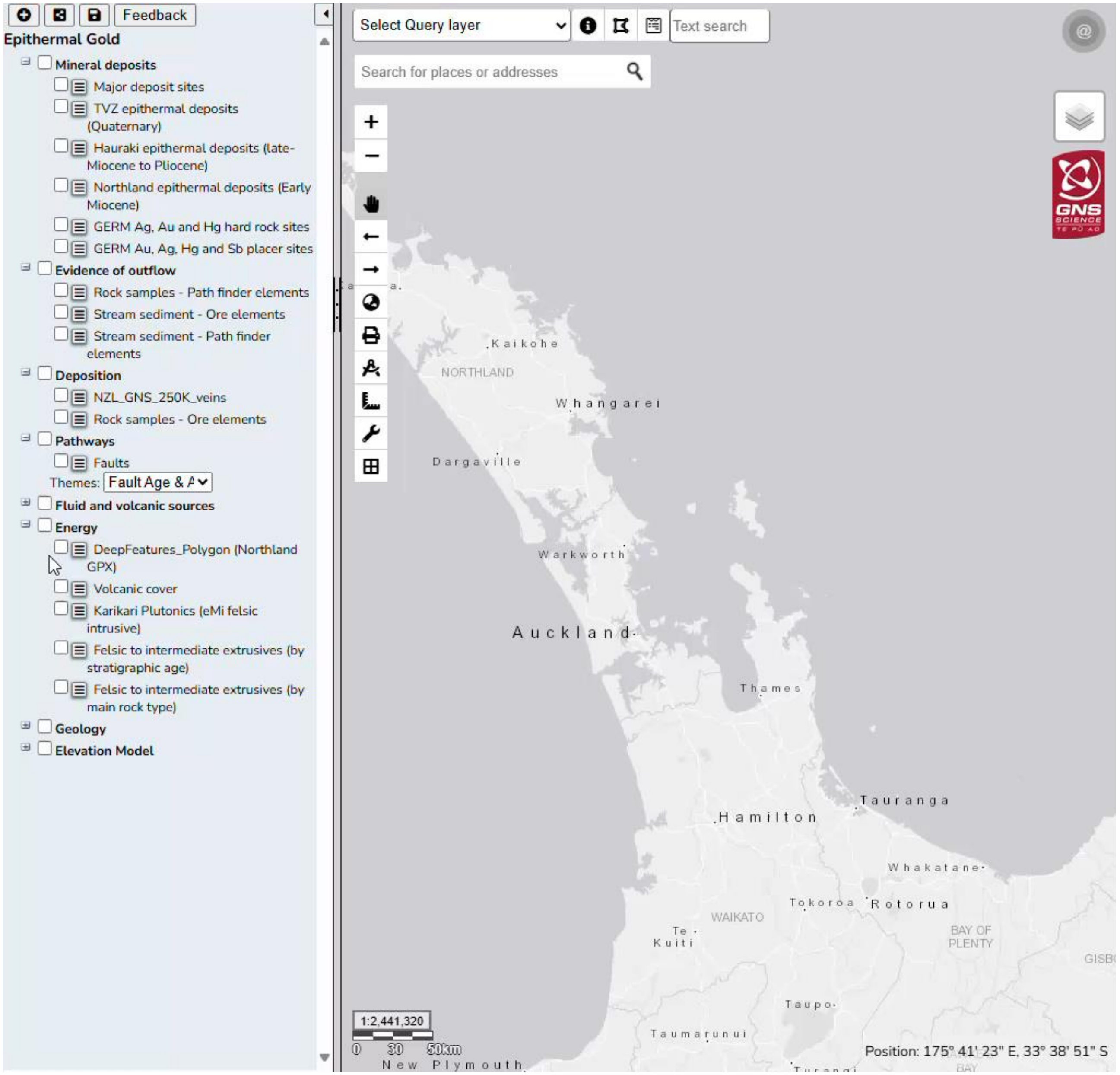
- There are 37 minerals on NZ's first critical minerals list.
- Of those, 22 have occurrences in the GERM database.
- With a few simple queries from that database, our first web map plots those locations.

Feel free to try this one today:



The Epithermal Data Atlas

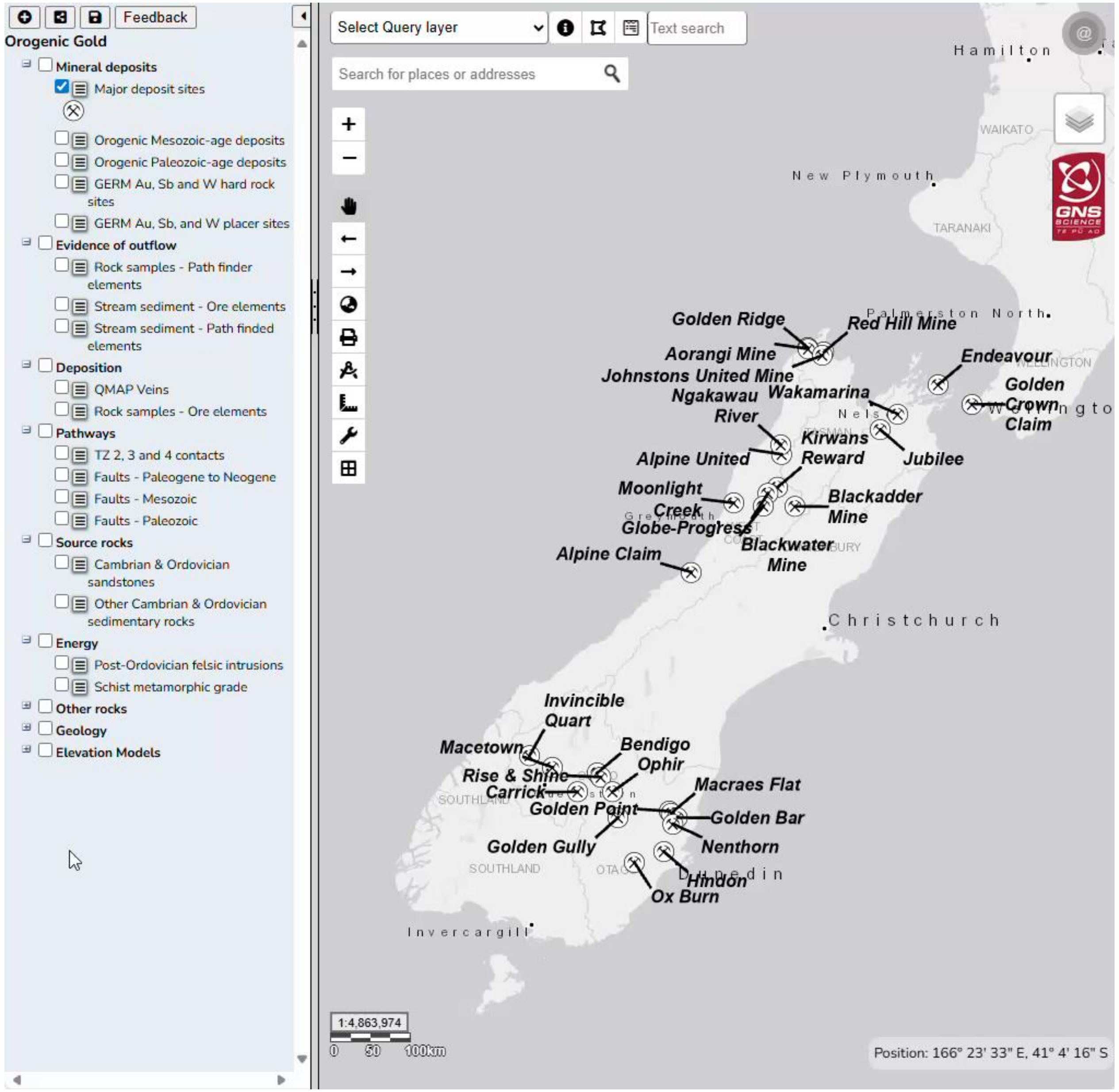
- To provide an overview of regional prospectivity we plan to provide a series of web maps that contain generalised data about the mineral systems controlling our key mineral deposits.
- A user of the map will be able to:
    - Navigate around New Zealand;
    - Turn data layers on and off;
    - And, even stream data into their own GIS.
- We will also be able to update the maps with new data.



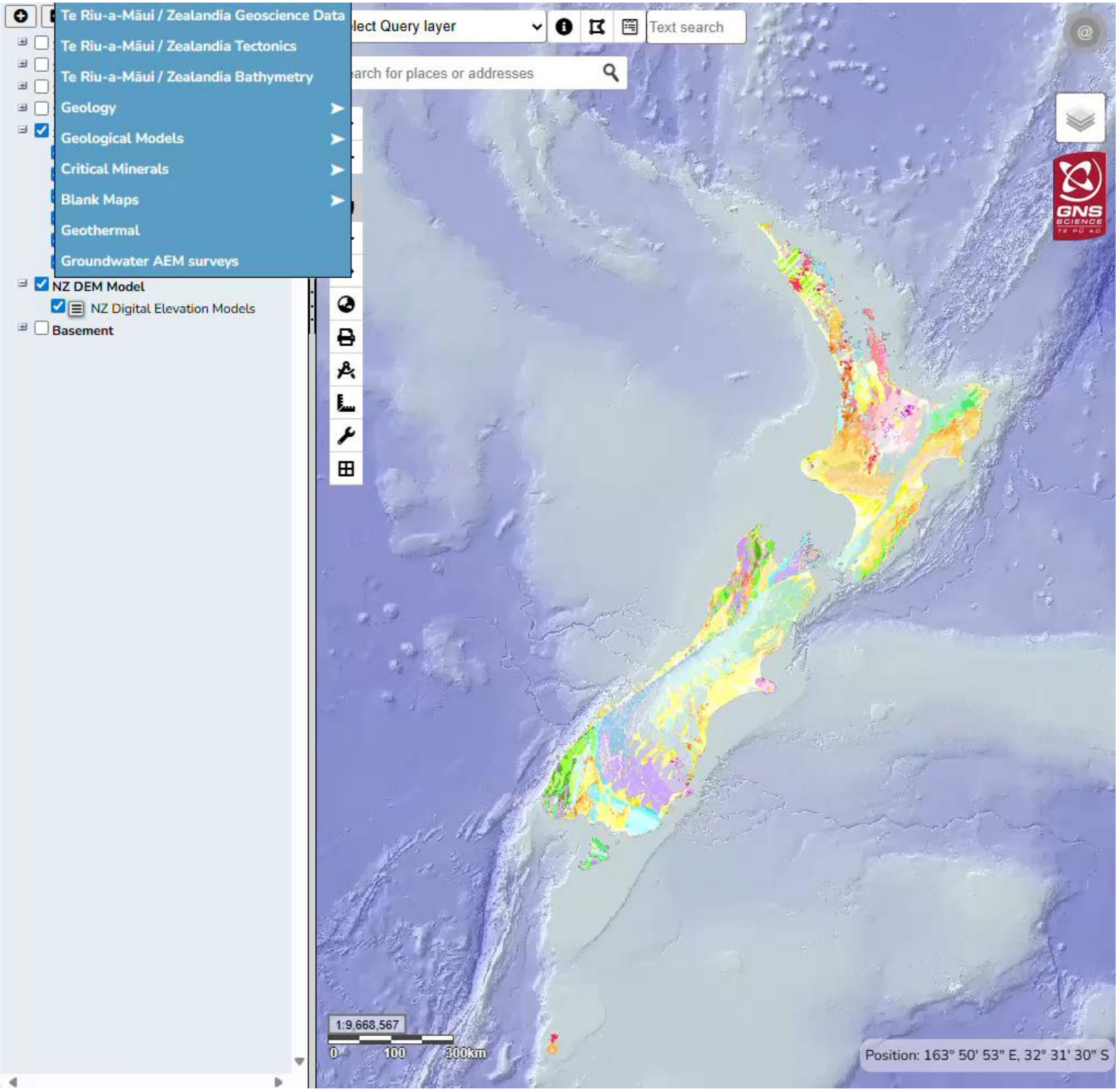
The Orogenic Data Atlas

- Within these maps are queries of information from:
    - The Geological Map of New Zealand (QMAP)
    - The Geological Resource Map of NZ (GERM)
    - Geochemical databases such as Petlab, REGCHEM, and NZP&M (see MR4510).
    - And, other publicly available spatial data.
- There will also be metadata that explains the source and the query used to create the maps.

SQL: ((STRATAGE LIKE '%Or%' Or STRATAGE LIKE '%Cm%') And MAINROCK LIKE '%sandstone%') Or MAPSYMBOL = 'Or.zst1'



You can even create your own custom maps.....

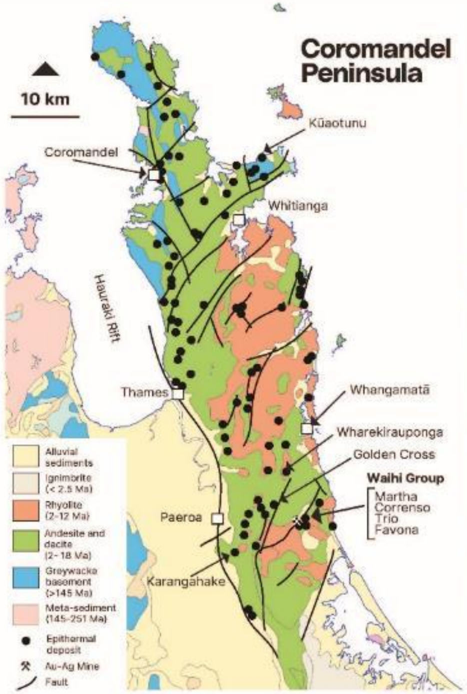


NEW ZEALAND PETROLEUM & MINERALS

Epithermal Gold in the

Coromandel Peninsula, New Zealand

The Coromandel Peninsula's epithermal gold-silver deposits, within the Hauraki Goldfield, have yielded 12 million ounces of gold, with 75% sourced from the world-class Waihi vein system. Underground mining continues at Waihi, and a new underground mine is planned 10 km north at Wharekirauponga.



History

Gold was first officially discovered in New Zealand in 1852 at Coromandel. While early placer deposits were small, they led to the discovery of rich hard-rock quartz veins, with underground mines operating since 1862. The Martha Mine in Waihi, the largest underground mine, closed in 1952, before reopening as an open-pit mine in 1988, then subsequently through underground mining. Elsewhere, modern operations included mining at Golden Cross and Karangahake as well as resource definition at Wharekirauponga, the latter on track to become the next underground mine.

Regional Geology

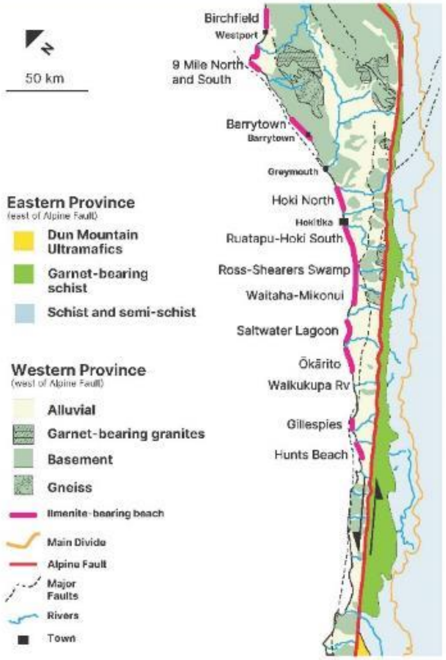
The geological foundation of the Coromandel Peninsula consists of Jurassic-age greywacke, overlain by Miocene to Pliocene subaerial volcanic rocks that were deposited over the last 18 million years as part of rifting at the developing modern Australia-Pacific plate boundary. The region's volcanism, dominated by andesites, dacites, and later rhyolites, ceased around 2 million years ago, shifting southeast to the Taupō Volcanic Zone.

The region has high quality geological maps that are also available as rich GIS digital datasets.

Heavy Mineral Sands on the

West Coast, South Island, New Zealand

Heavy mineral black sands occur along more than 320 km of the South Island's West Coast. These sands contain ilmenite, magnetite, and garnet, with local concentrations of gold, zircon, and rare earth element-bearing minerals, presenting significant exploration and mining opportunities.



History

Interest in these mineral sands dates back to the 1860s gold rush. Government surveys in the 1950s and 1970s confirmed ilmenite potential, followed by private sector exploration in the late 20th century. The 2010s saw renewed interest in garnet, leading to the discovery of major deposits at Westport, Barrytown, Ruatapu, and Hunts Beach. In 2023, Westland Mineral Sands commenced mining at Nine Mile near Westport, and other projects are under development at Barrytown and Ruatapu.

Regional Geology

New Zealand's South Island is divided by the active Pacific-Australian tectonic plate boundary, marked by the Alpine Fault. Displacement of 480 km has occurred since the Miocene, driving rapid uplift of the Southern Alps and resulting in vast erosion and supply of sediment to the coastal plains of the West Coast. Here, ocean currents and wave action concentrate heavy minerals into rich placer deposits.

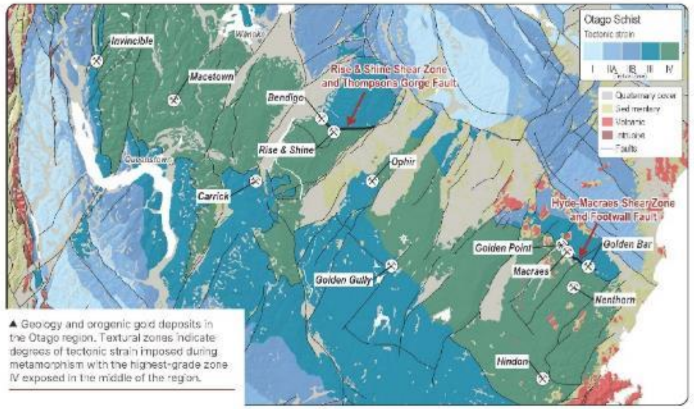
Mineral Deposits

The region hosts placer deposits rich in ilmenite, magnetite, and garnet, with valuable concentrations of gold, zircon, and rare earth element-bearing minerals (monazite, allanite, xenotime). These minerals originate from garnet-bearing schists eroded from the Southern Alps, gold from the West Coast's Ordovician metasediments, and REE-bearing minerals from felsic intrusions. The modern and ancient deposits extend up to 5 km inland.

Orogenic gold in

Otago, New Zealand

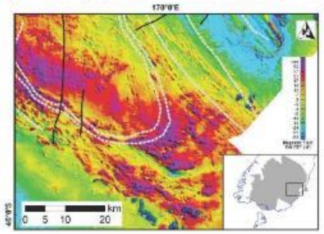
Otago is home to significant orogenic quartz vein and shear zone gold deposits within Mesozoic schist. These deposits primarily consist of quartz veins hosted in shear and fault zones. The largest and most productive deposit is the Hyde-Macraes Shear Zone in East Otago producing over 5 Moz of gold from open pit and underground operations. Nearby, exploration on the Rise & Shine Shear Zone continues to define resources with over 2 Moz of gold identified to date.



▲ Geology and orogenic gold deposits in the Otago region. Textural zones indicate degrees of tectonic strain imposed during metamorphism with the highest-grade zone IV exposed in the middle of the region.

Regional Geology

Gold deposits are found within the Otago schist belt, formed from ancient submarine fan sediments off eastern Gondwana in the Permian to Cretaceous, that were deeply buried and metamorphosed in the Jurassic to Cretaceous. The schist belt trends northwest and doming has exposed higher metamorphic grade schist in the central axis of the belt.

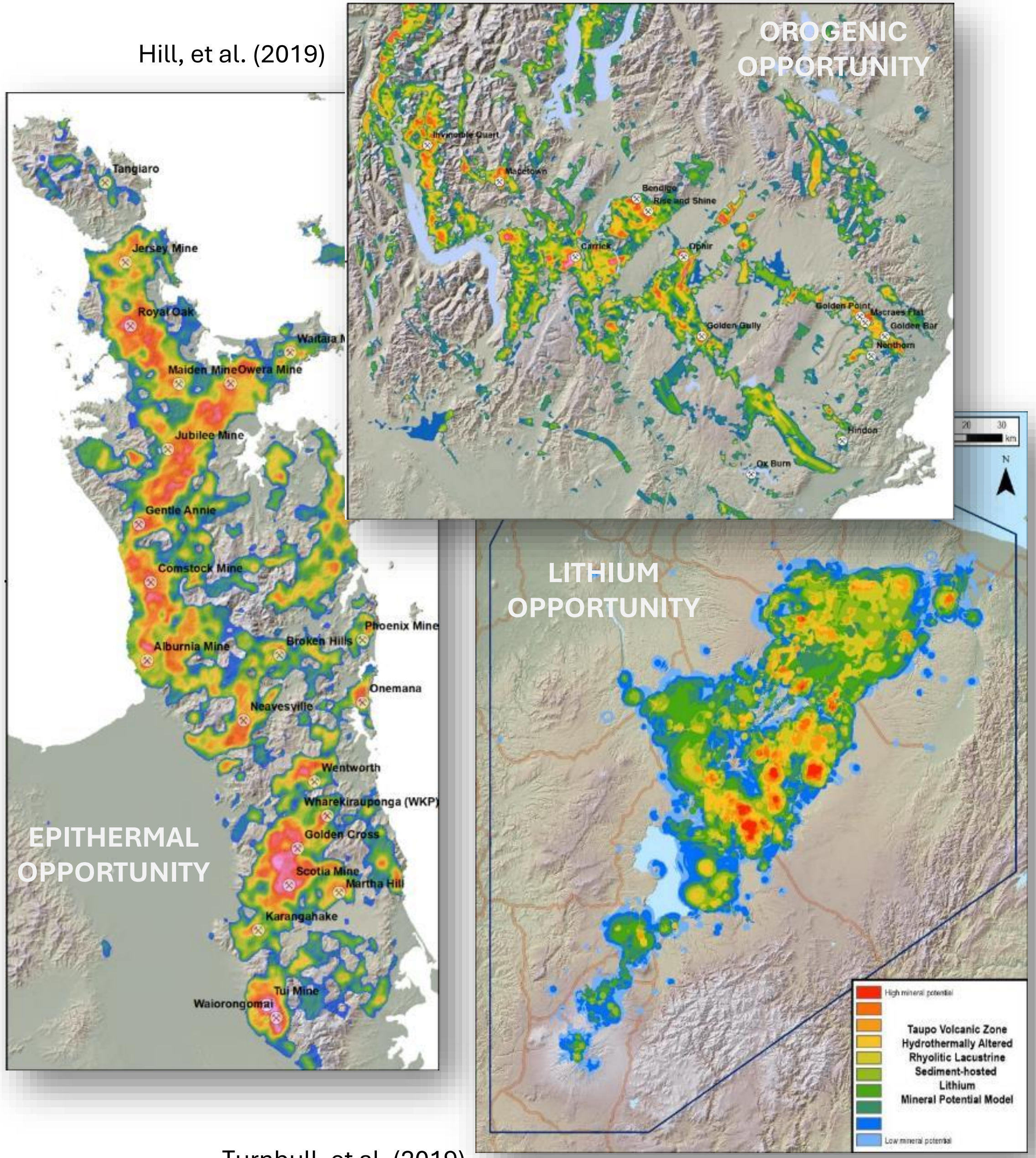


◄ Airborne magnetic map of southeast Otago Schist showing strong anomalies from magnetite-rich schists and recent volcanics. Dashed white lines mark shear zones similar to those at Macraes gold mine. Inset shows government and industry geophysics coverage in Otago.

Mineral Opportunity Modelling

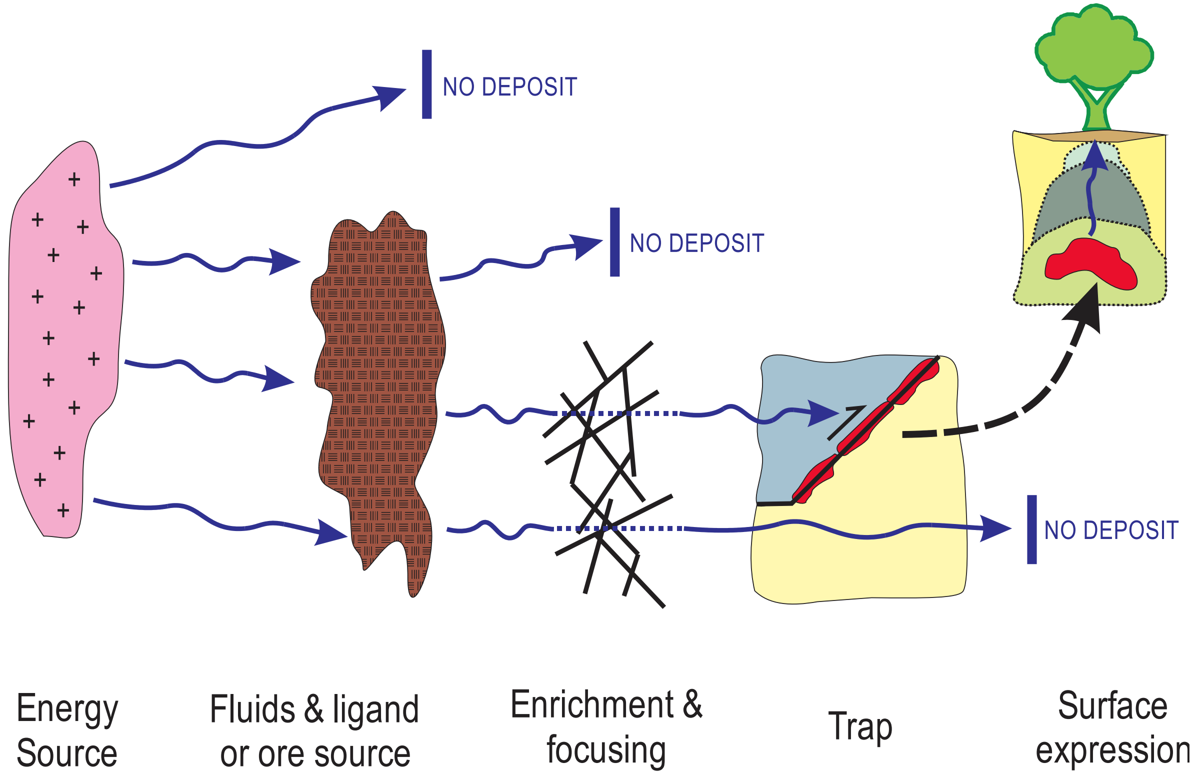
- Technology is allowing exploration companies to create some amazing prospectivity models when there is dense and detailed data available.
- But we're looking to take a step back and focus on national and regional scale prospectivity in the form of mineral opportunity models.
- Our goal is not to identify areas for drill targeting, but to promote exploration fields…
- …and also to determine which datasets are the most critical so we can target our research towards improving them.

Hill, et al. (2019)



Turnbull, et al. (2019)

- Our modelling will use a very simple expert weighted technique guided by spatial statistics.
- At a regional / national scale we're not lucky enough to have large training data sets, consistent and continuous data across whole regions, or hundreds of derivative maps that need a computer to determine correlations.
- So the more sophisticated exploration-scale machine learning and AI methods aren't appropriate.
- Instead, we're taking a mineral systems approach by creating well-defined maps representing:
  - Energy and metal sources
  - Fluid pathways
  - Deposition and trap conditions.



Hill & Partington (2008)

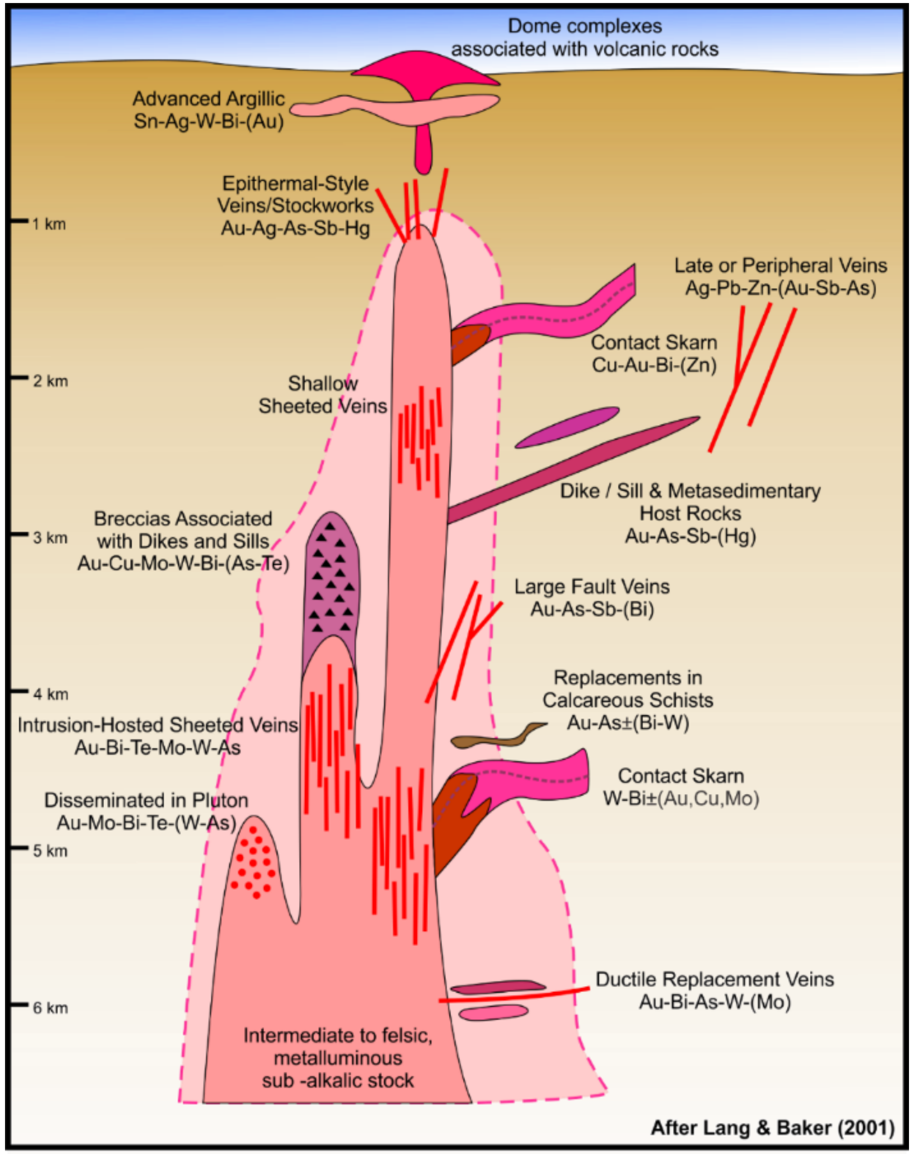
- With the impressive new Pluton Map (PMAP), sub-Quaternary geology, and new isotope and geochronology data available…

  … our new model will be for:

  Intrusion-related mineralisation

- In this system, fluids and metals are associated with the emplacement of metaluminous and highly fractionated felsic intrusions.

- There are several deposit styles; but we'll start with something generic (e.g. disseminated Au-W-Bi-Mo) to test the available data.



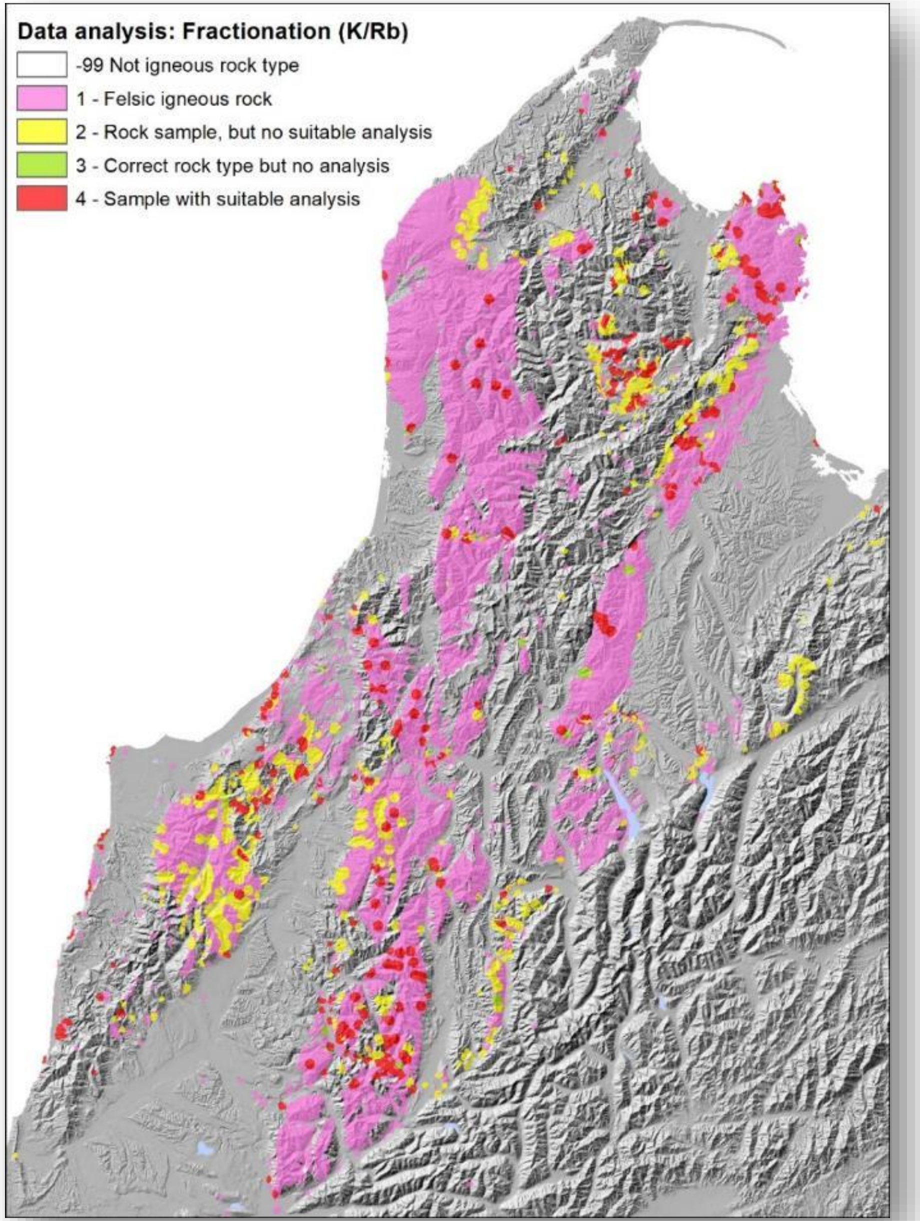
Creating Opportunity

Missing data are exploration opportunities!

- A key outcome of our modelling will be to identify critical data gaps.
- We'll use this to target future research that can deliver the greatest gains for new models and exploration.

For example:

Only 3% of our rock geochemical samples have a Bi analysis, an important IRG pathfinder element.



In summary:

1. We're promoting and educating on the critical minerals of New Zealand.

   → And, we would appreciate your feedback!

2. Our goal is to make information as accessible as possible.

3. The next mineral opportunity model is for the intrusion-related system.

Earth Sciences
New Zealand