

# The mineral value chains in battery industry –from exploration to beneficiation

31.8.2023 Aleksi Salo  
Namibian Mining Expo 2023

# Geological Survey of Finland Is an Expert in Geological Resources

Impartial and objective research information and services



Climate change



Energy transition



Circular economy

## Key figures

Founded in **1885**

**450** experts

**100+** peer-reviewed scientific publications

Research agency operating under the Ministry of Economic Affairs and Employment

In **6** locations in Finland

**300+** ongoing research projects

**250+** customers

**71 %** cooperation with GTK has led to new innovations, solutions, or practices\*



international project activities on all continents

# Together with our Finnish and Global Partners, We Are Building a Sustainable and Carbon-Neutral Future



# Strategy

CLIMATE CHANGE

WATER

URBANIZATION

ELECTRIC TRAFFIC

ENERGY DISRUPTION

CARBON NEUTRAL SOCIETY

**PURPOSE:  
FOR EARTH  
AND FOR US**

ECOSYSTEMS

MATERIALS AND  
CIRCULAR ECONOMY

FINLAND'S VIRTUAL CONCEPT

FOCUS AREAS

INFORMATION  
SOLUTIONS

CIRCULAR ECONOMY

BATTERY MINERALS

WATER  
MANAGEMENT

Solutions to accelerate  
the transition to sustainable  
and carbon-neutral world

VALUES

BRAVELY CURIOUS  
AND INNOVATIVE

MORE TOGETHER

APPRECIATIVE  
AND RESPONSIBLE

# Sustainability

We have prioritised five UN sustainable development goals (SDGs) on which we can have the most significant impact through our activities.



- Water management in mining
- Groundwater reserves
- Industry process waters



- Geothermal energy
- Site selection for nuclear plants and the final disposal of nuclear waste
- Offshore wind farms



- Circular economy
- Technology development
- Raw materials



- Metal and mineral production chain value
- Recyclability and traceability of raw materials
- Reducing and reusing waste
- Considering sustainability in procurement



- Research and education partnerships
- Exporting competence research data and research methods to developing countries
- Combining competence in different scientific fields and methods

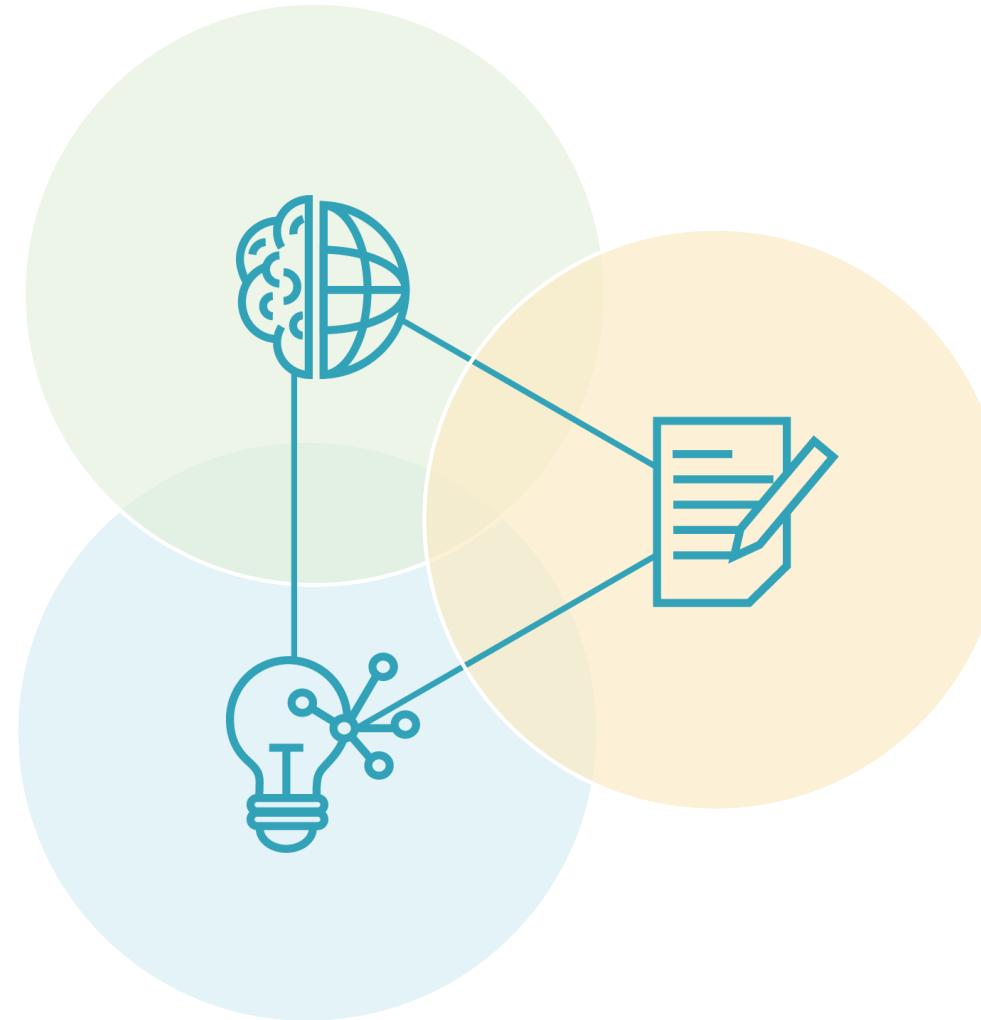
# Synergic Roles

## Geoscience Information

Provides, gathers, refines and distributes geoscience information. As a part of the ecosystem develops information capital and improves the utilization possibilities of data and knowledge.

## Science and Innovations

As an active operator in the ecosystem, provides scientific results and innovations which address key challenges.

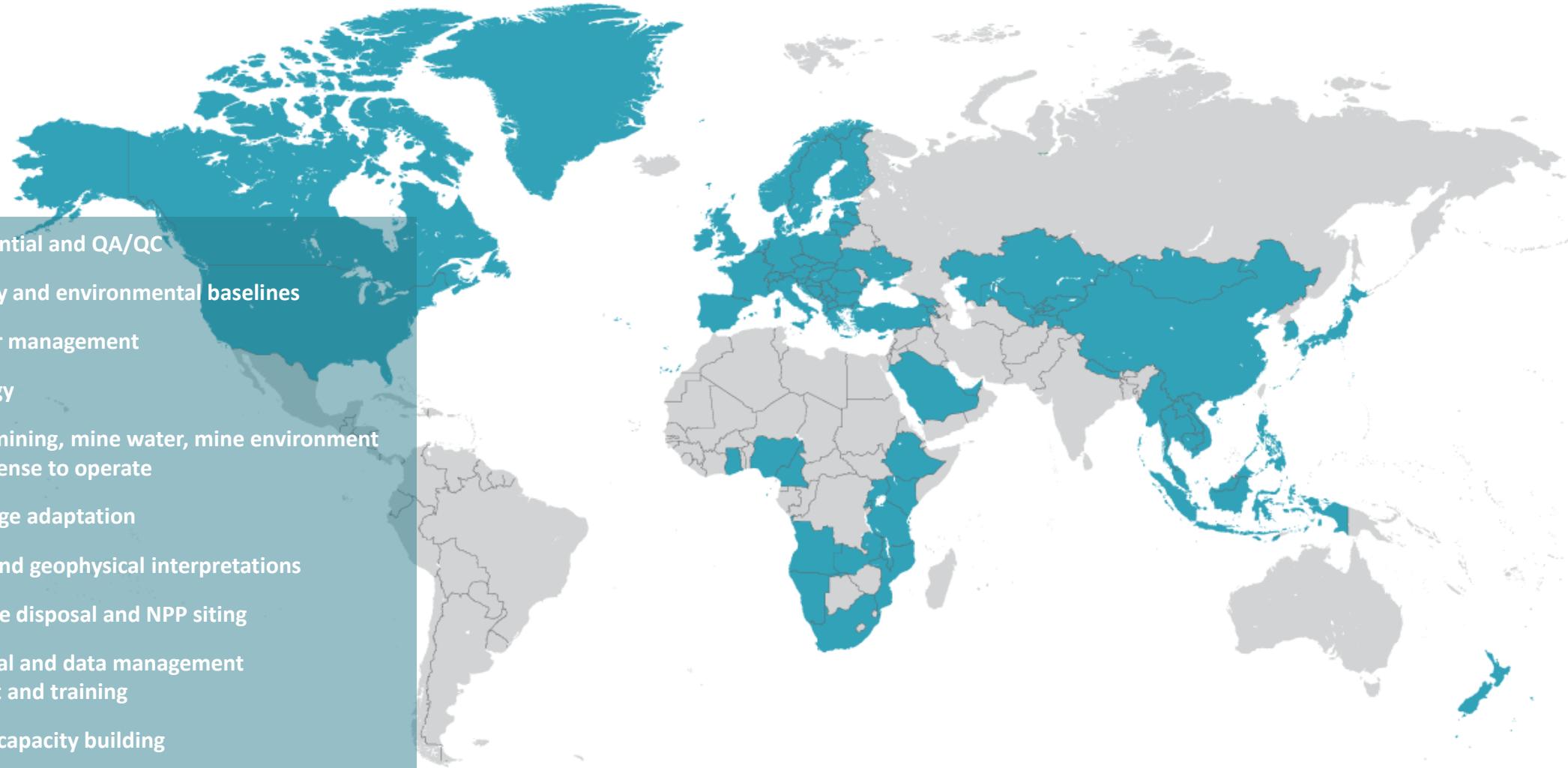


## Customer Solutions

Provides and develops customer solutions based on high-level expertise and data.

# International Project Activities

- Mineral potential and QA/QC
- Geochemistry and environmental baselines
- Groundwater management
- Urban geology
- Sustainable mining, mine water, mine environment and social license to operate
- Climate change adaptation
- Geophysics and geophysical interpretations
- Nuclear waste disposal and NPP siting
- Organizational and data management development and training
- Institutional capacity building



# Geological survey as a service provider for the mineral value chain

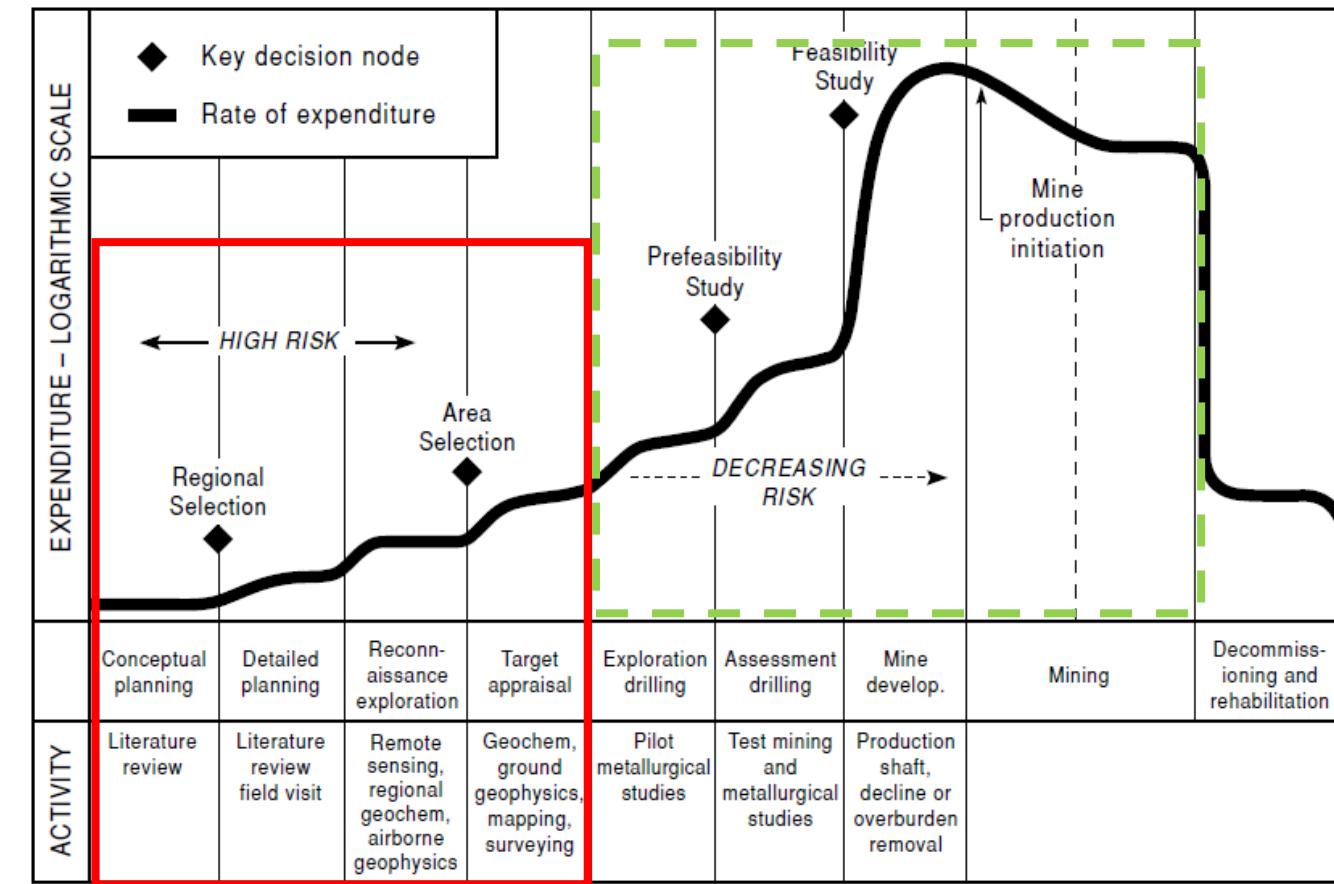
GTK provides services and support to all stages of exploration and mining

Decreasing risk and providing value for projects

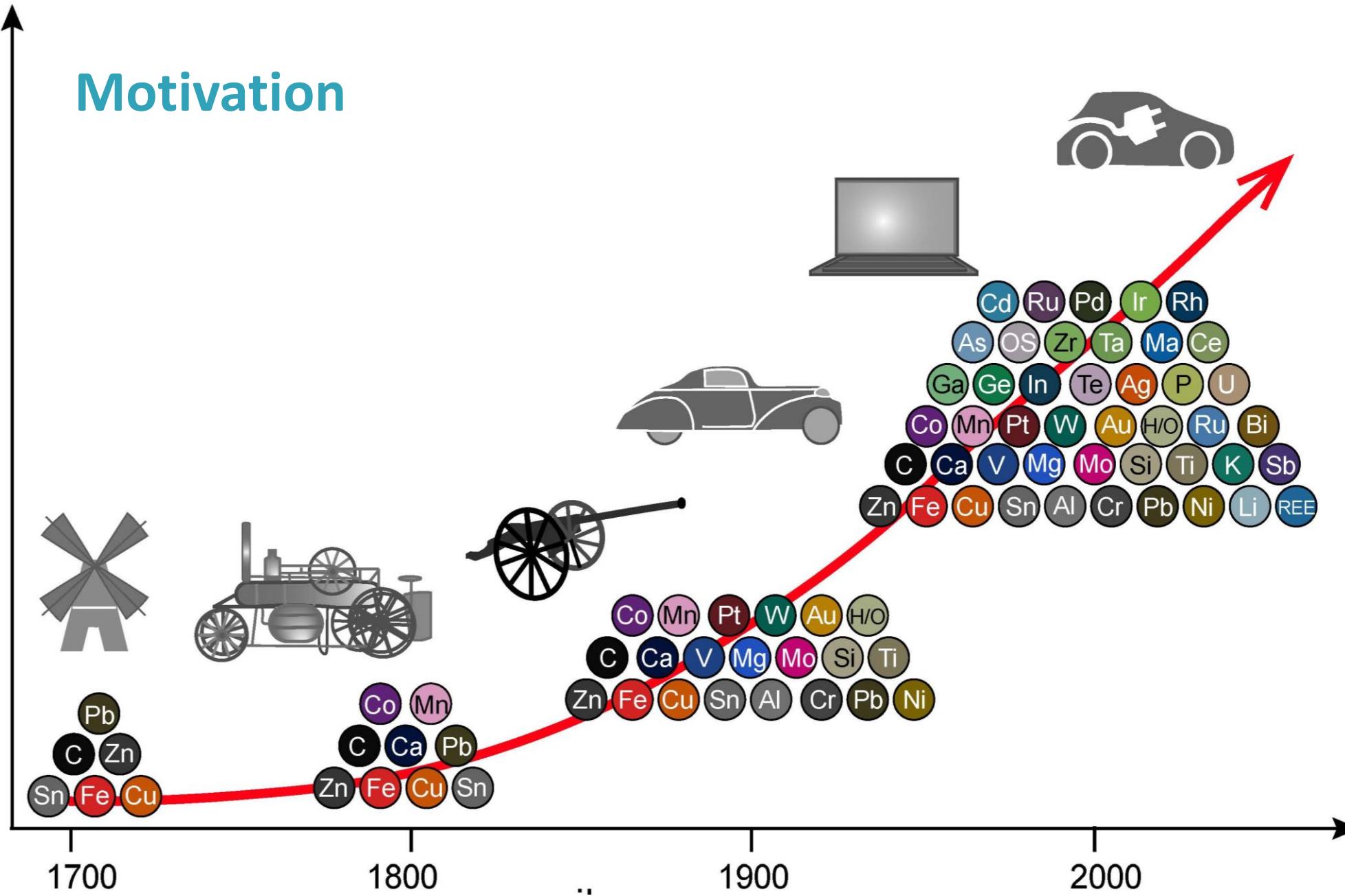
Expert and laboratory services for scientific needs

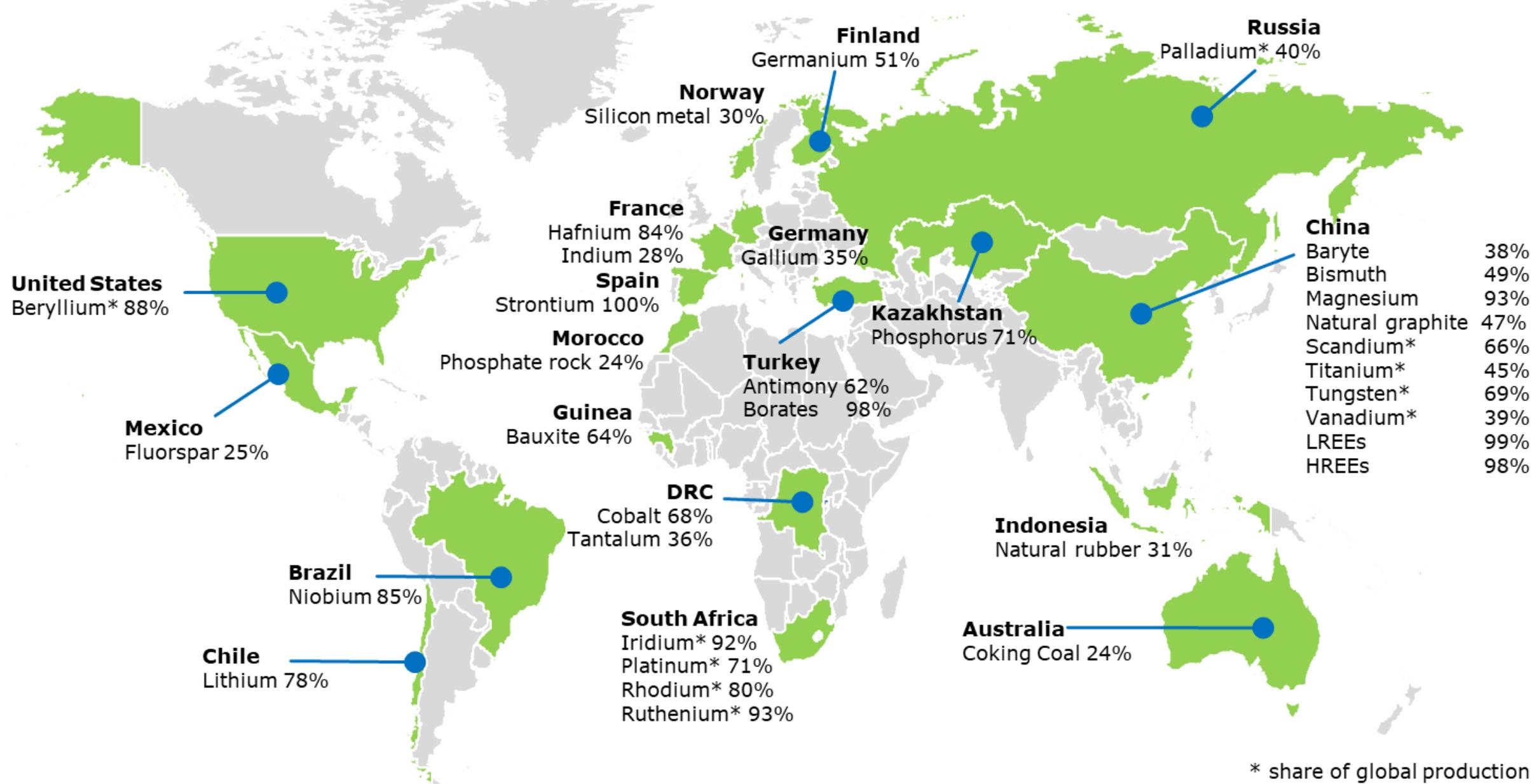
Pilot and bench scale processing

National sample archive and geological data management

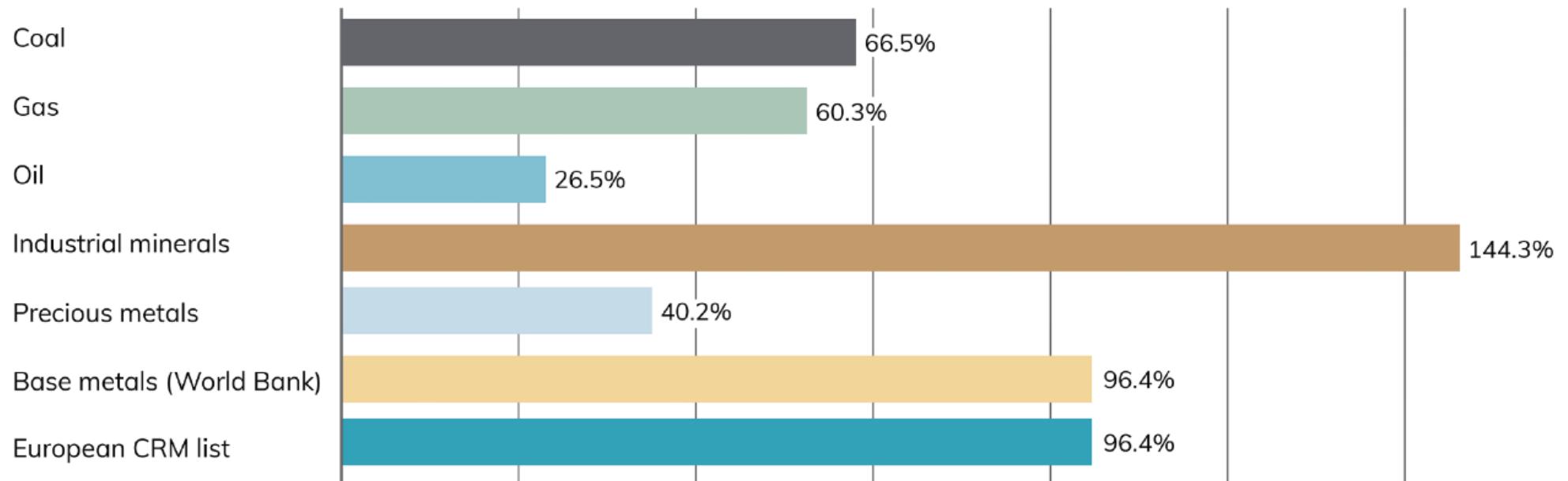


# Motivation





## Global production increase 2000 to 2018

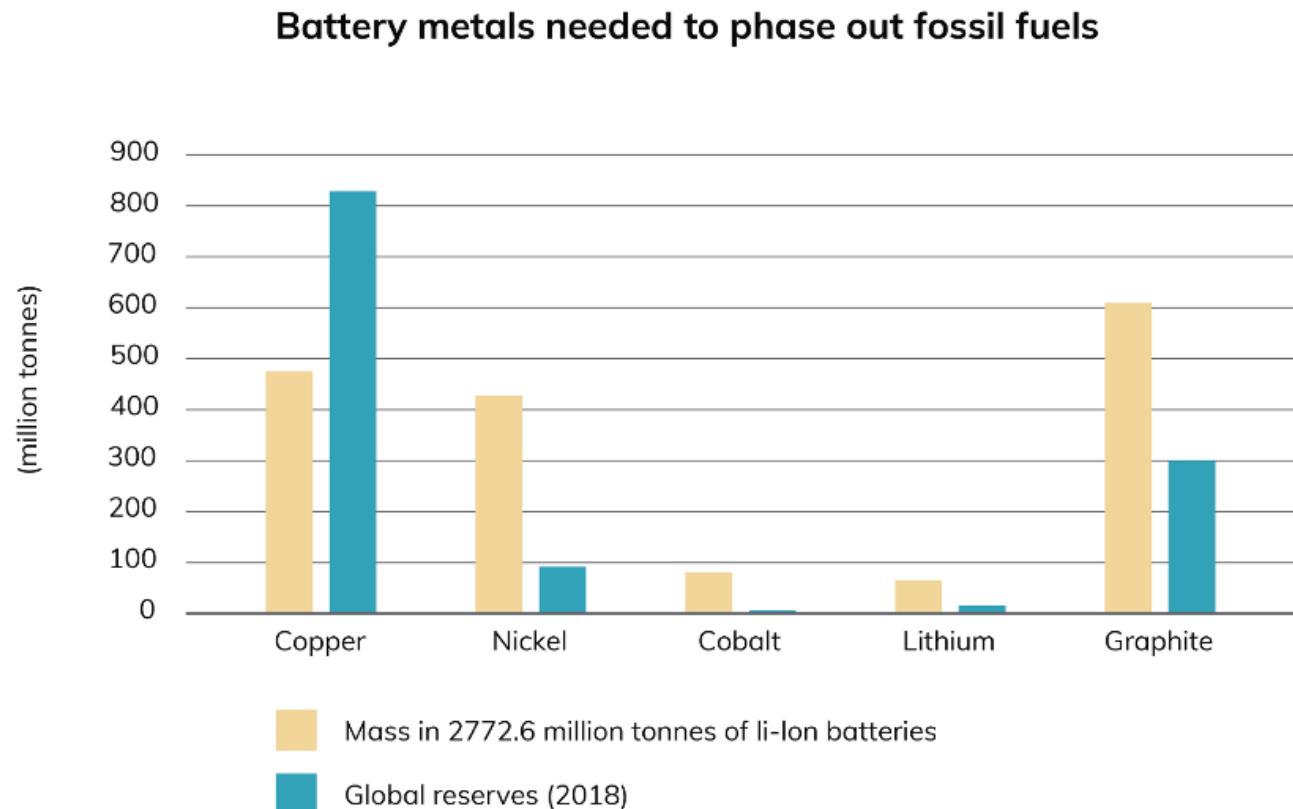


Simon Michaux: Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossil Fuels

# Need for minerals will grow with the green transition

*"Copper has been produced historically 700Mt. Increasing demand means that this corresponds to the next 25 years. It is clear that electrification demand requires new primary production."*

Director, Science & Innovation, Saku Vuori/GTK



Estimated mass of metals to manufacture one generation of Scenario F Electric Vehicle Li-Ion batteries and Lithium Ion battery banks for power storage stations required for Scenario F compared to global reserves. (Source: USGS Mineral Statistics for global reserves)

Simon Michaux: Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossil Fuels (Scenario F)  
31.8.2023

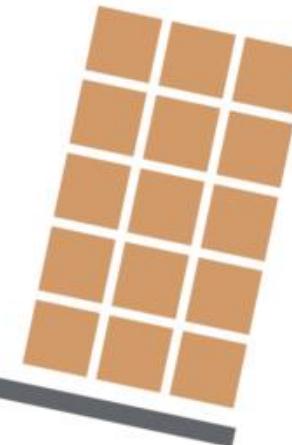
# Material need for green transition

## Metal levels towards low-carbon world

**~3 billion tons of metal/minerals**  
is needed for the transition  
to low-carbon world  
**by 2050\***



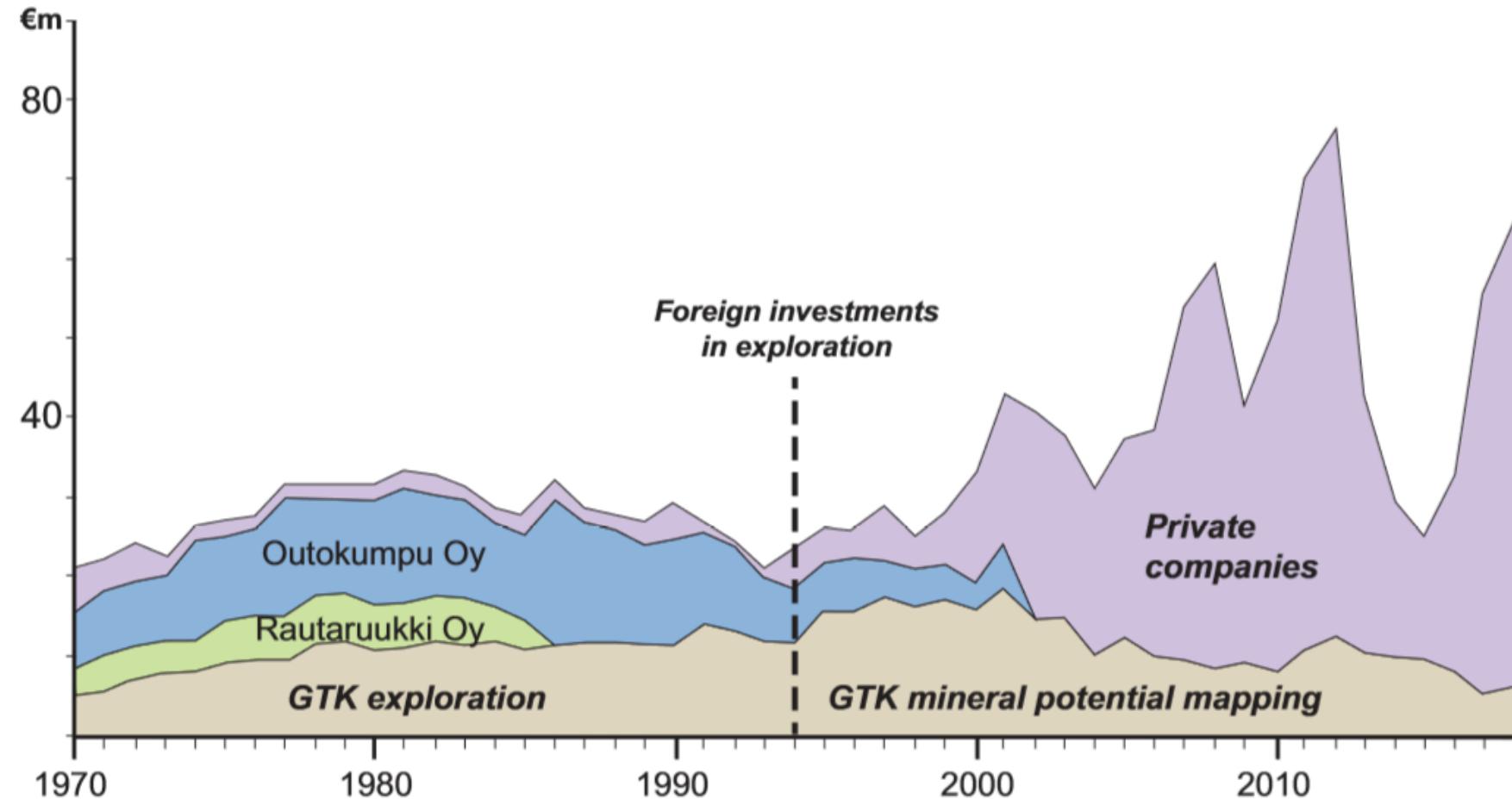
World uses **~15 billion tons**  
**coal+oil+gas\*\* every year**



\* The Beyond 2 Degrees Scenario (B2DS): Aims to limit with a 50% chance global temperature rise to 1.75°C. above pre-industrial levels. (Hund, K., La Porta, D., Fabregas, T.P., Laing, T. & Drexhage, J. 2020.)

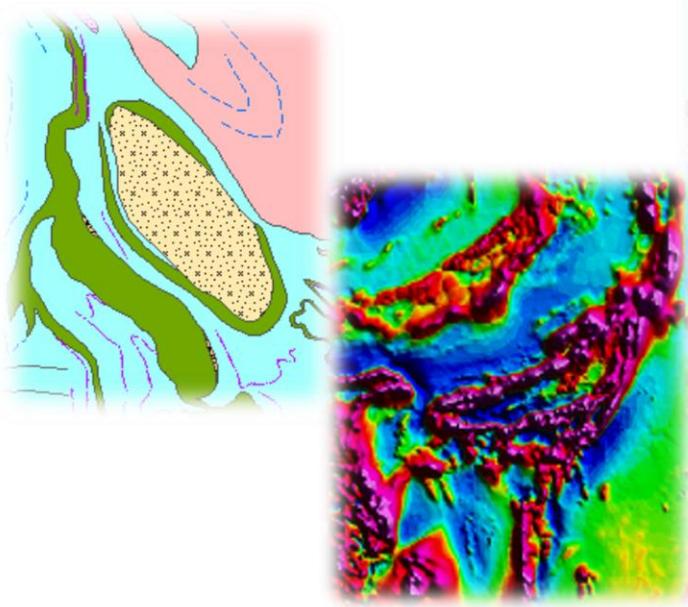
\*\* gas counted as tonne oil equivalent

# Mineral exploration expenditure in Finland from 1970 to 2018



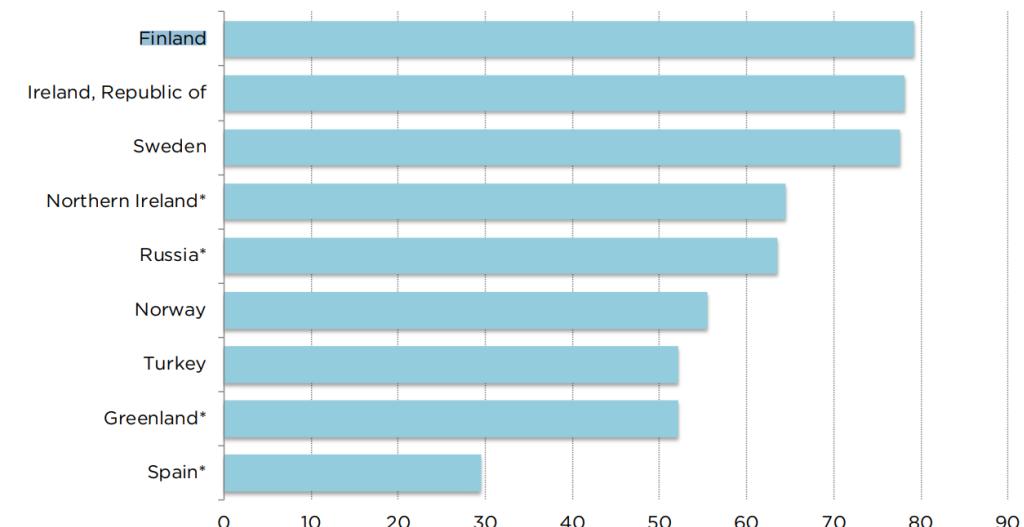
# Value of geological data

- Availability and the quality of **digital geodata** attracts investments and increases discovery potential
- Along with robust and transparent legislation and good infrastructure and political stability
- Value of gathered geological data in Finland 1300 M€



Aleksi Salo/GTK-Georgia 19.4.2022

**Figure 12: Investment Attractiveness Index—Europe**



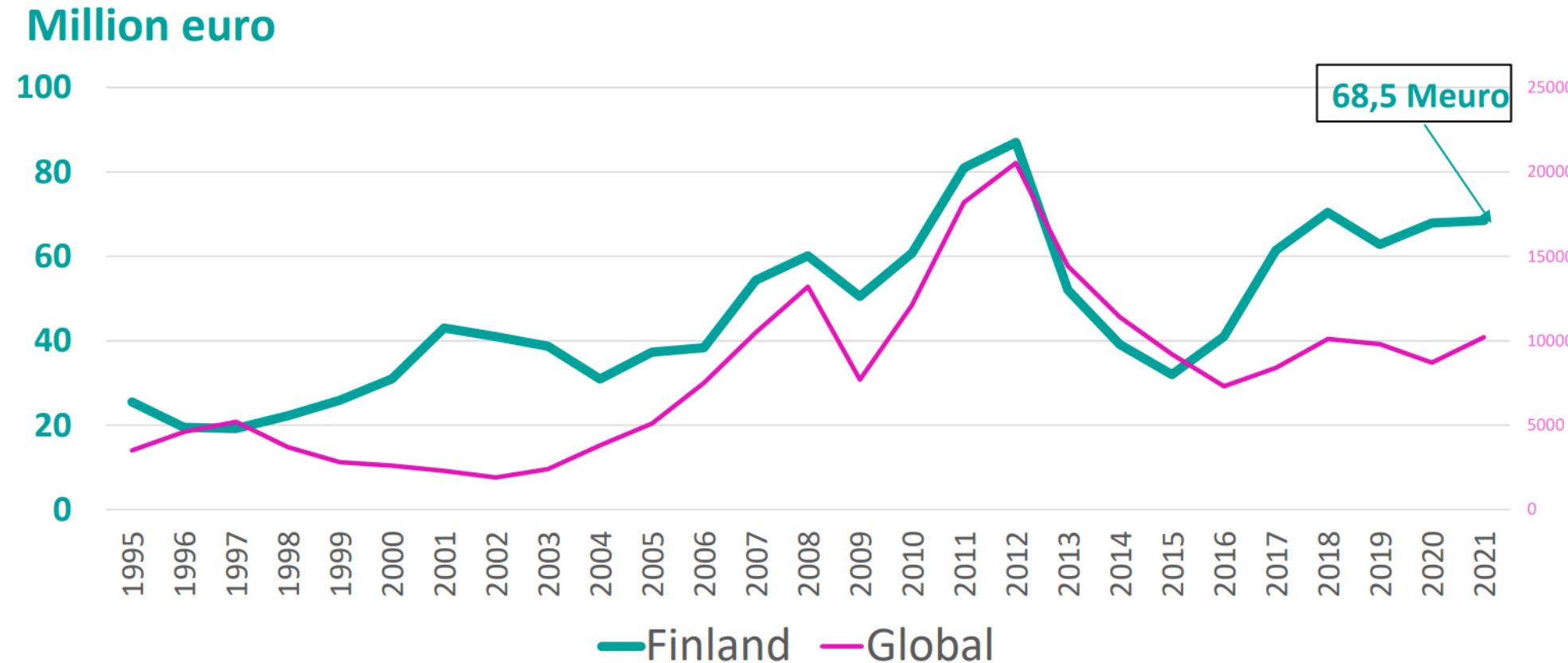
Yunis, Jairo, and Elmira Aliakbari (2022). Fraser Institute Annual Survey of Mining Companies 2021. Fraser Institute. .

## National drill core archive

- 3 600 km of drillcore
- 9600 pallets
- Other samples 2 500 000 pcs
- Initial spot for an exploration company
- Provides income to GTK
- New data collection continues with new methods



# Mineral exploration expenditure



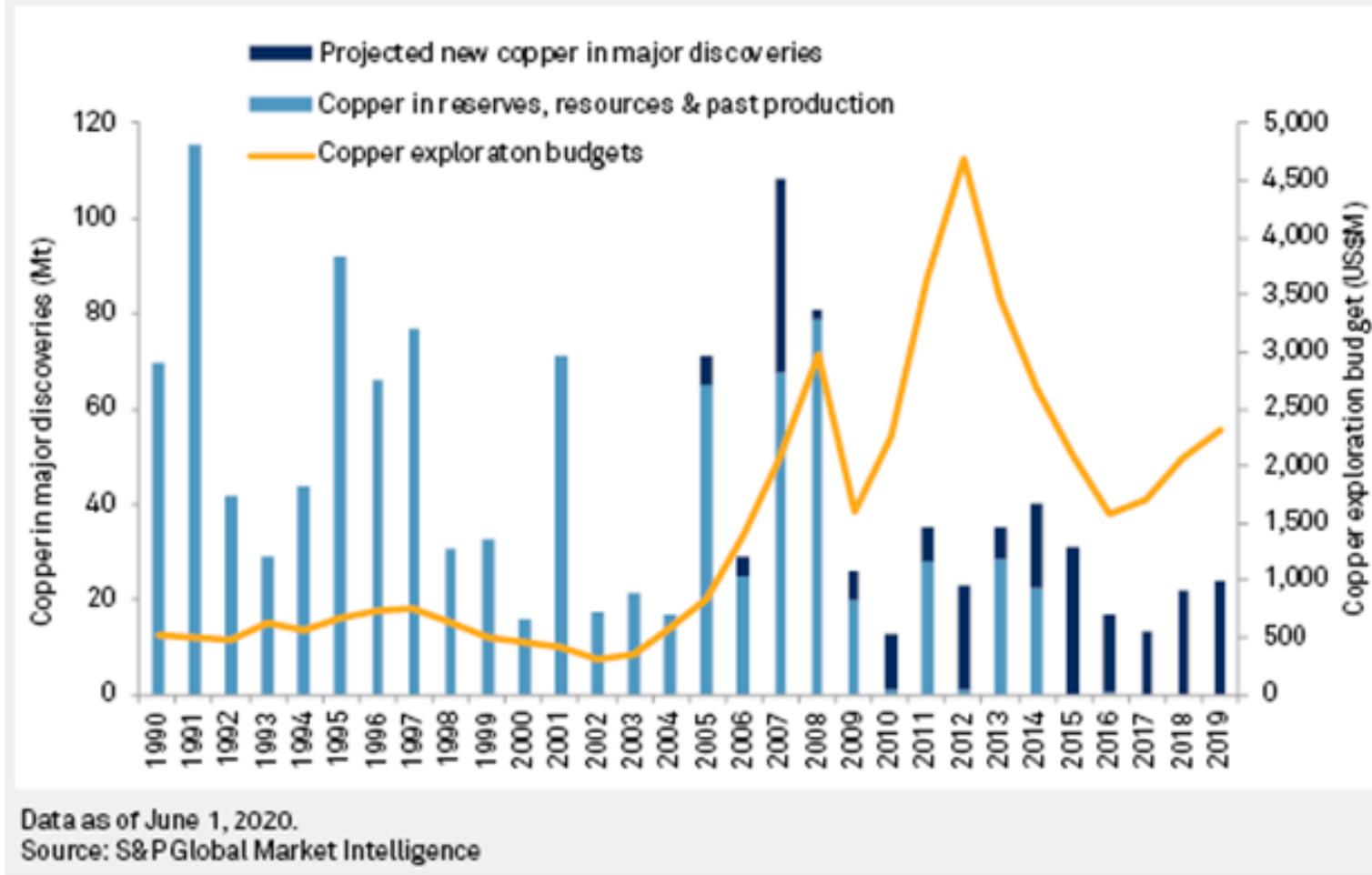
# Significance of exploration

- ONLY exploration will provide new mineral resources and deposits
- Geological data derived from exploration (even failed projects) can be used again
- Several constraints in exploration
  - *Time & Money*
  - *Drilling capacity*
  - *Sample handling capacity*
- Only 0.1% of project are successful



# Copper deposits found 1990-2015

Less than 1 Mt discovered since 2015

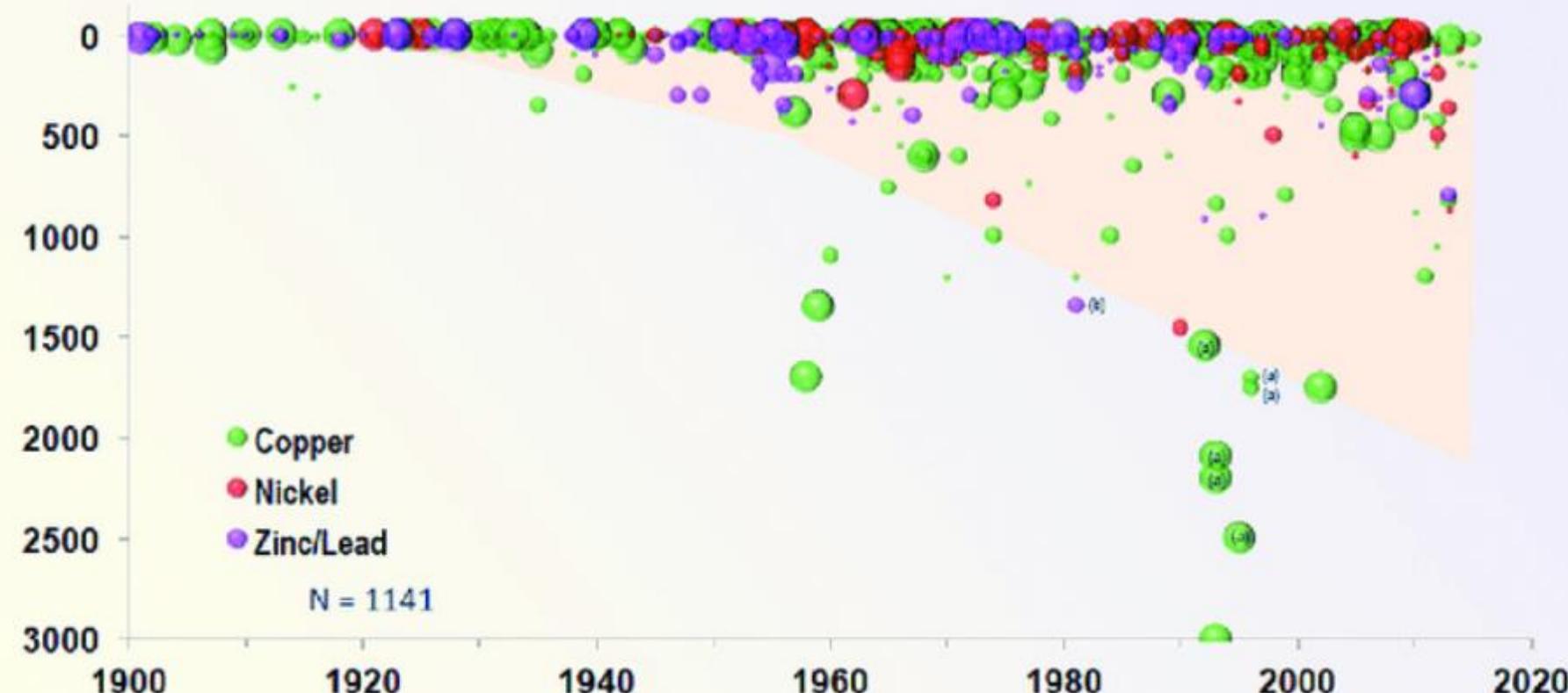


(Source: S&P Global Market Intelligence)

# Good deposits are hard to find

Base Metal Deposits Found in the World Between 1900 and 2015

Depth of Cover (Metres)



Note: Size of bubble refers to "Moderate", "Major" and "Giant"-sized Cu, Ni, Pb and Zn deposits.

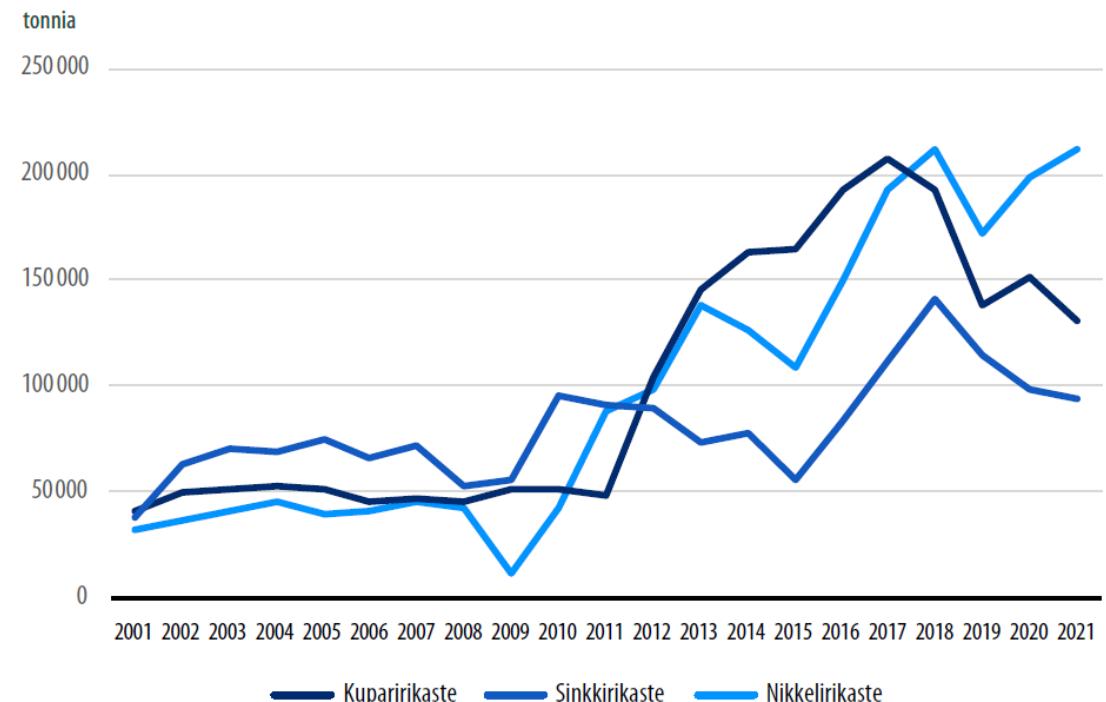
Excludes Nickel Laterite deposits and undersea deposits

(a) Stratabound copper deposits in Poland, found while drilling for oil

(b) Admiral Bay zinc deposit in Australia, found while drilling for oil

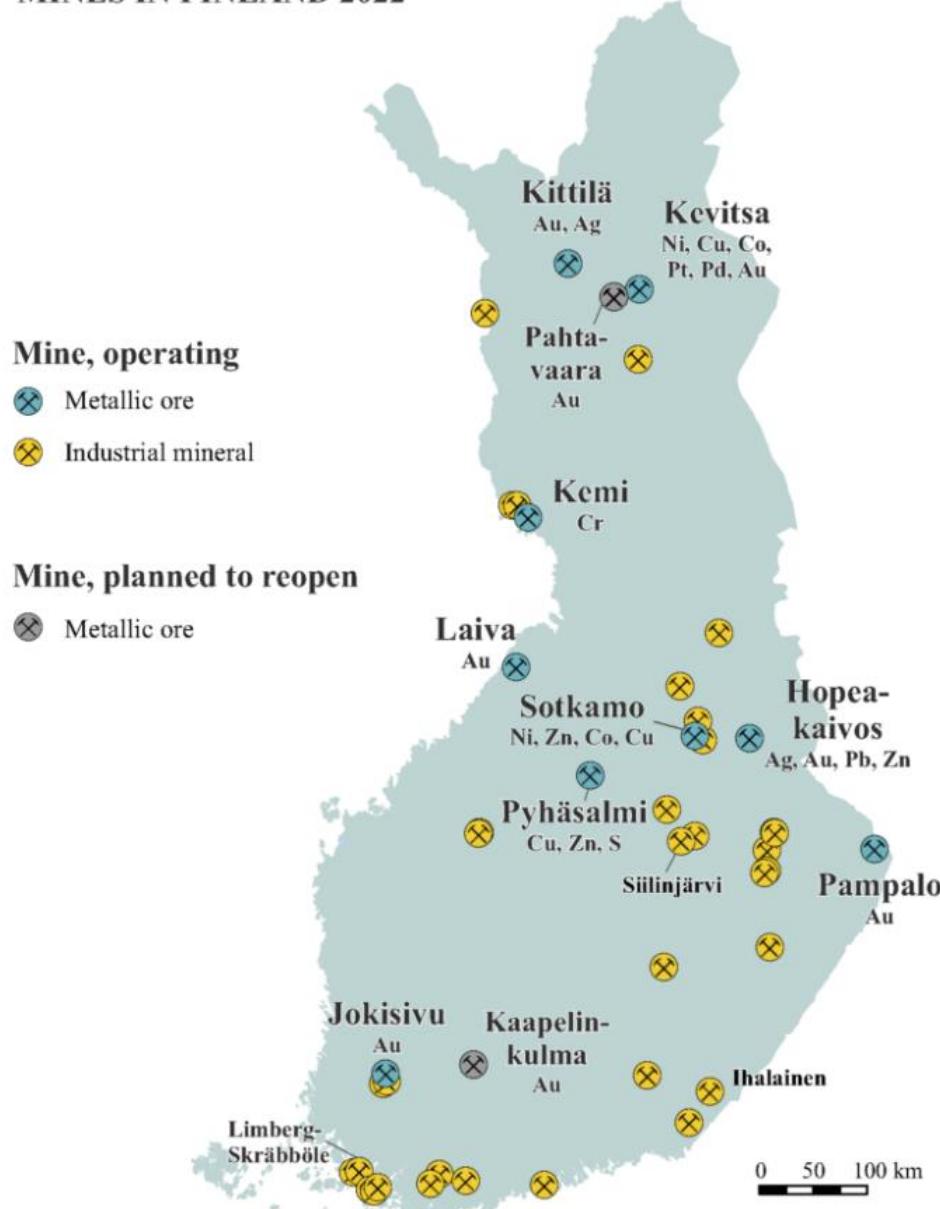
# Mining and mining sector in Finland

- Mineral strategy 2010 VISION 2050
  - *Finland is a global leader in the sustainable utilization of mineral resources and the minerals sector is one of the key foundations of the Finnish national economy.*
  - *Directing all research and funding efforts to support this long term vision*
  - *Driver was to multitude of mining projects in the pipeline at this time*



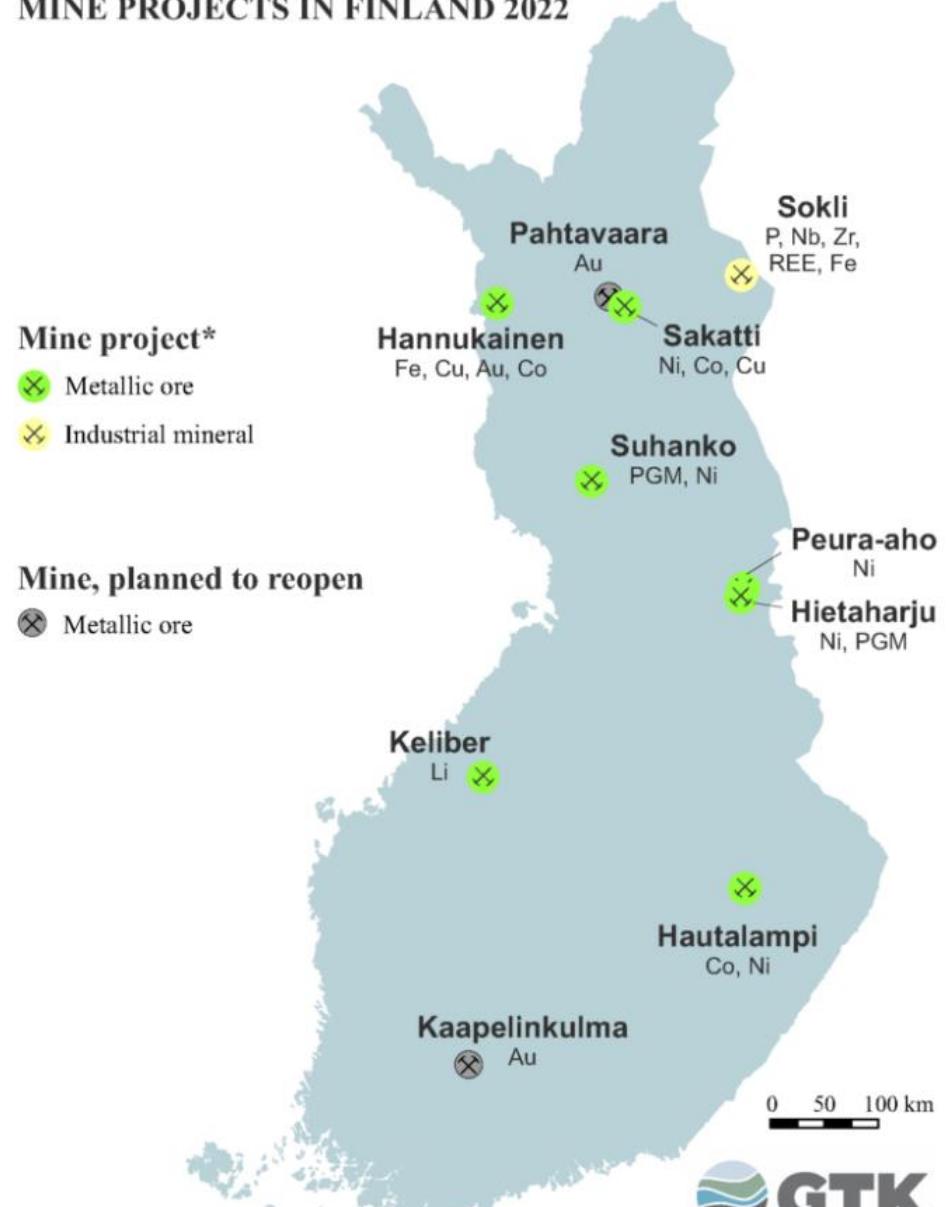
Lähde: 2001–2010 TEM, 2011–2021 Tukes.

## MINES IN FINLAND 2022



Basemap © The National Land Survey of Finland, 2020

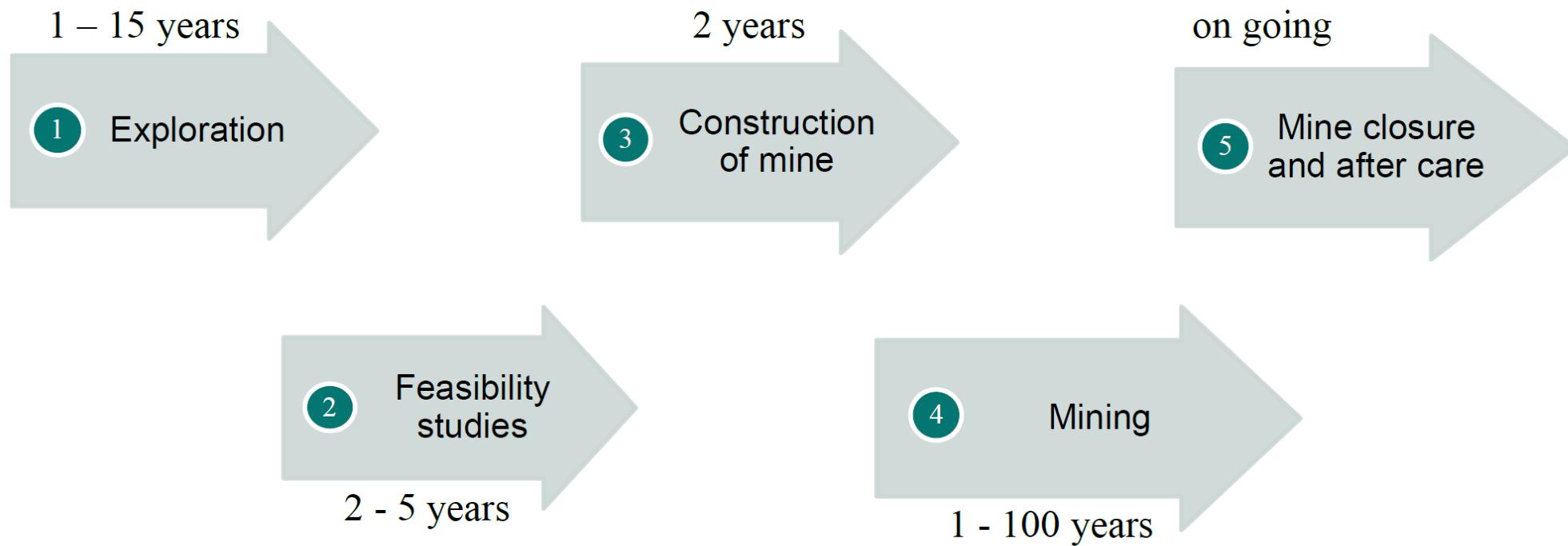
## MINE PROJECTS IN FINLAND 2022



\*'Mine project' refers here to a project which is actively developed towards the start-up of mine production and, as main rule, environmental impact assessment programme has been submitted to the contact authority.



# Mining project lifeline



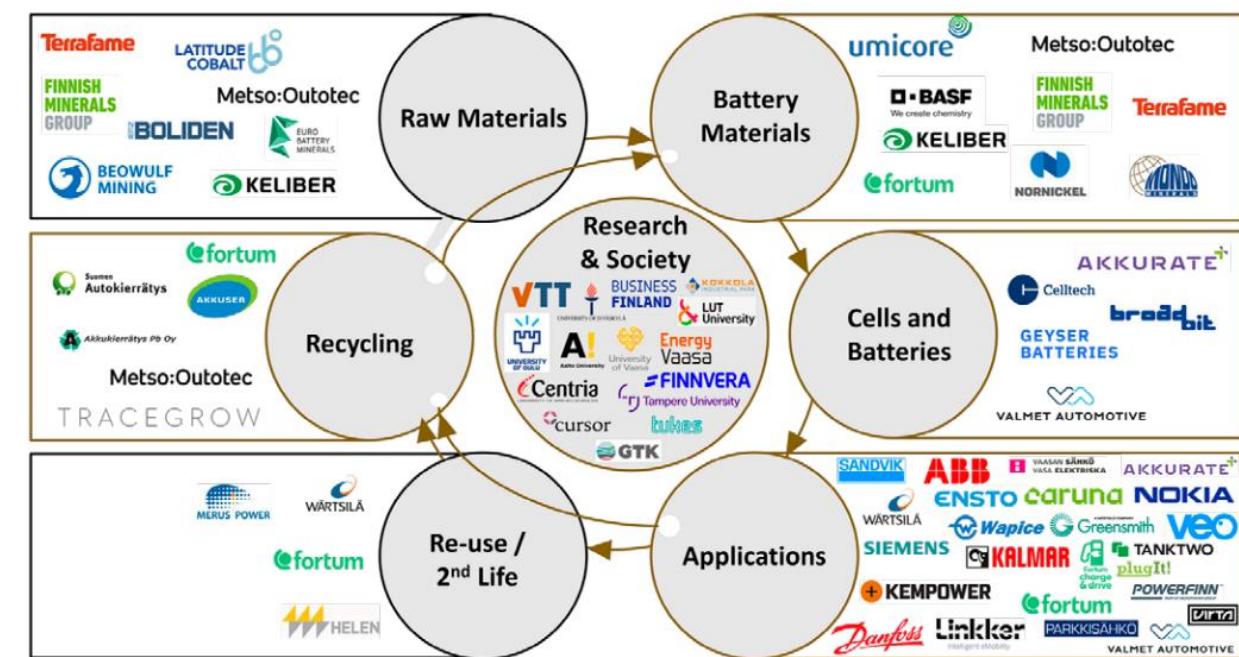
J.Hokka, GTK

# Battery strategy 2025

## VISION

In 2025, the Finnish Battery and Electrification sector will be a forerunner that provides skills, innovation, sustainable economic growth, well-being and new jobs for Finland.

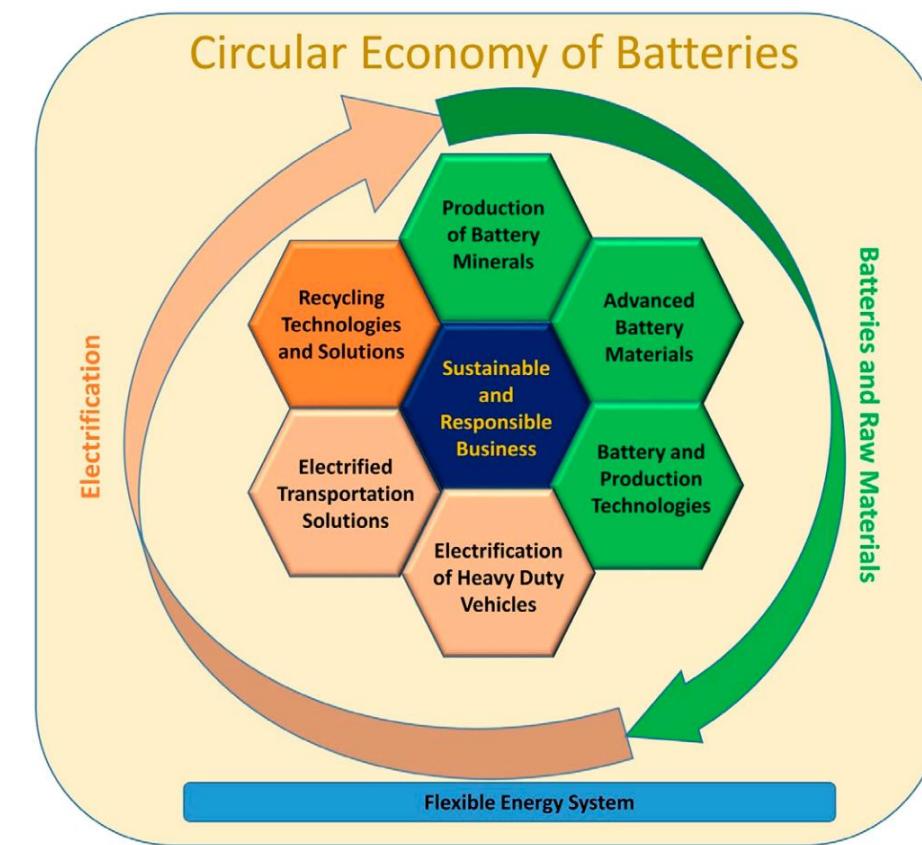
The ambitious strategy covers all fields of the battery value chain from education to battery manufacturing



# Battery value chain

The value chain consists of all fields including:

- Sustainability and responsibility
- Circular economy
- Education and social dimension
- Permitting and green energy



## BATTERY MINERAL MINES AND PROCESSING PLANTS

- ✖ Active mine
- ✖ Closed mine with options for Co-Ni refining from side streams
- ✖ Mine project
- ✖ Advanced exploration project

- ⚡ Battery factory (operating)
- ⌚ Battery factory (planned)

- ♻️ Battery recycling plant
- 🏭 Cobalt refinery

- 🏭 Copper and nickel smelter
- 🏭 Nickel products, nickel-cobalt sulphate

- ⚠️ Nickel-cobalt mixed hydroxide precipitate
- ⚠️ Nickel-cobalt sulphate

- Copper products
- ★ Mining technology

- ✚ Company headquarters
- Energy technology hub

Plant under construction

● pCAM

Plant in feasibility

△ Lithium hydroxide

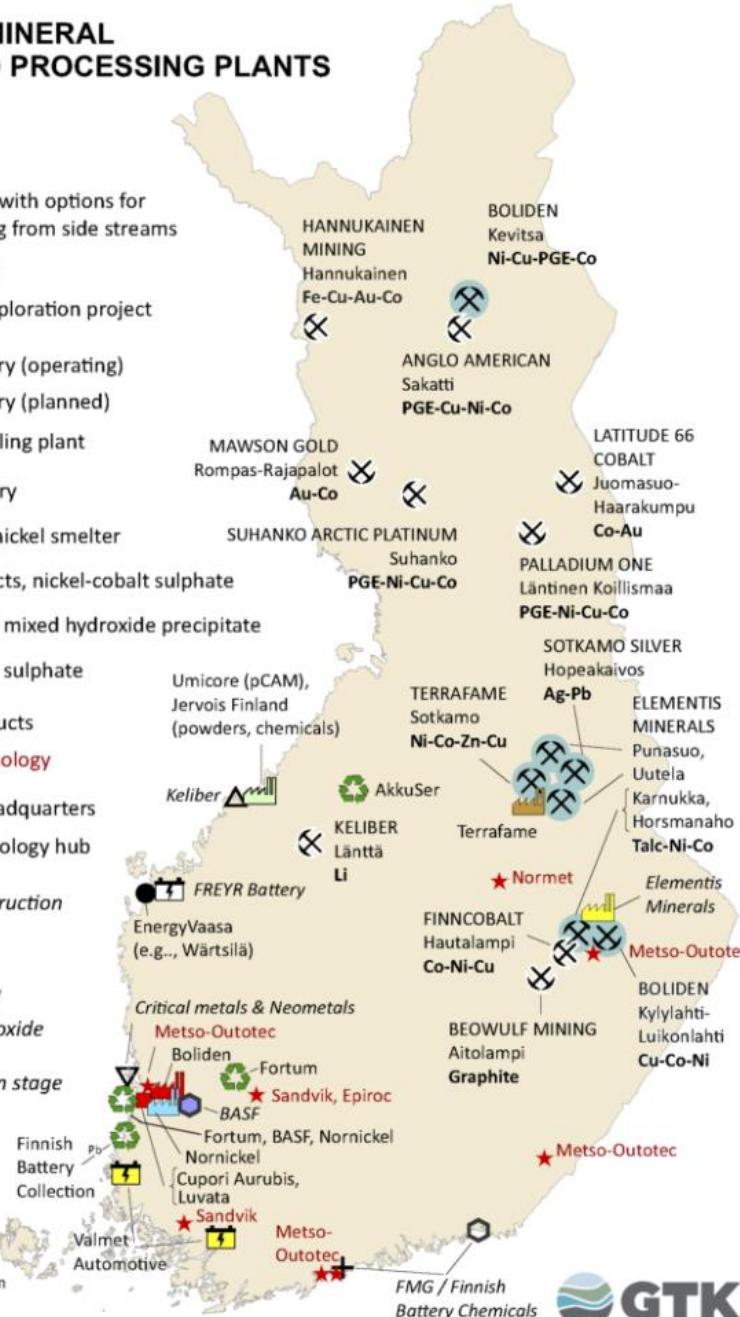
Plant at the design stage

▼ Vanadium

○ pCAM

Finnish Battery Collection

0 50 100 km

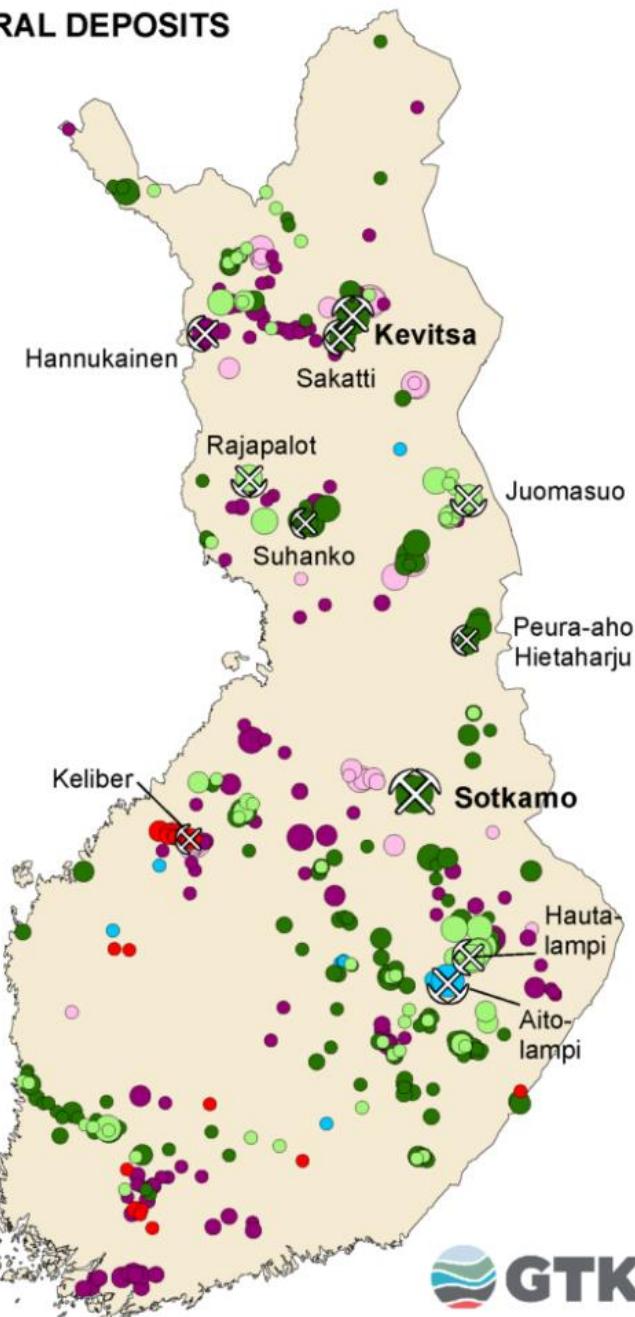


## BATTERY MINERAL DEPOSITS

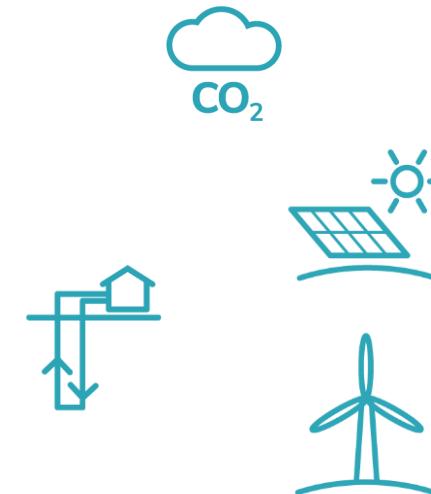
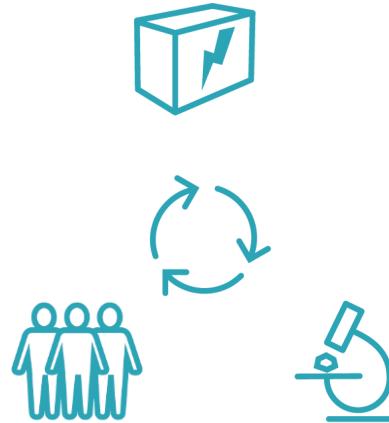
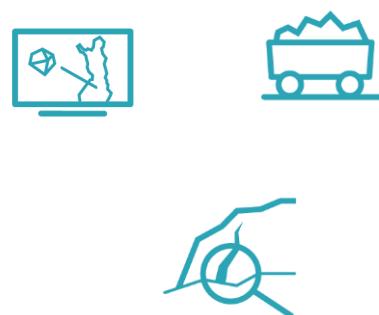
- Cobalt
- Lithium
- Graphite
- Nickel
- Copper
- Vanadium

- ✖ Active mine
- ✖ Mine project
- ✖ Advanced exploration project

0 50 100 km



# Industry point of view

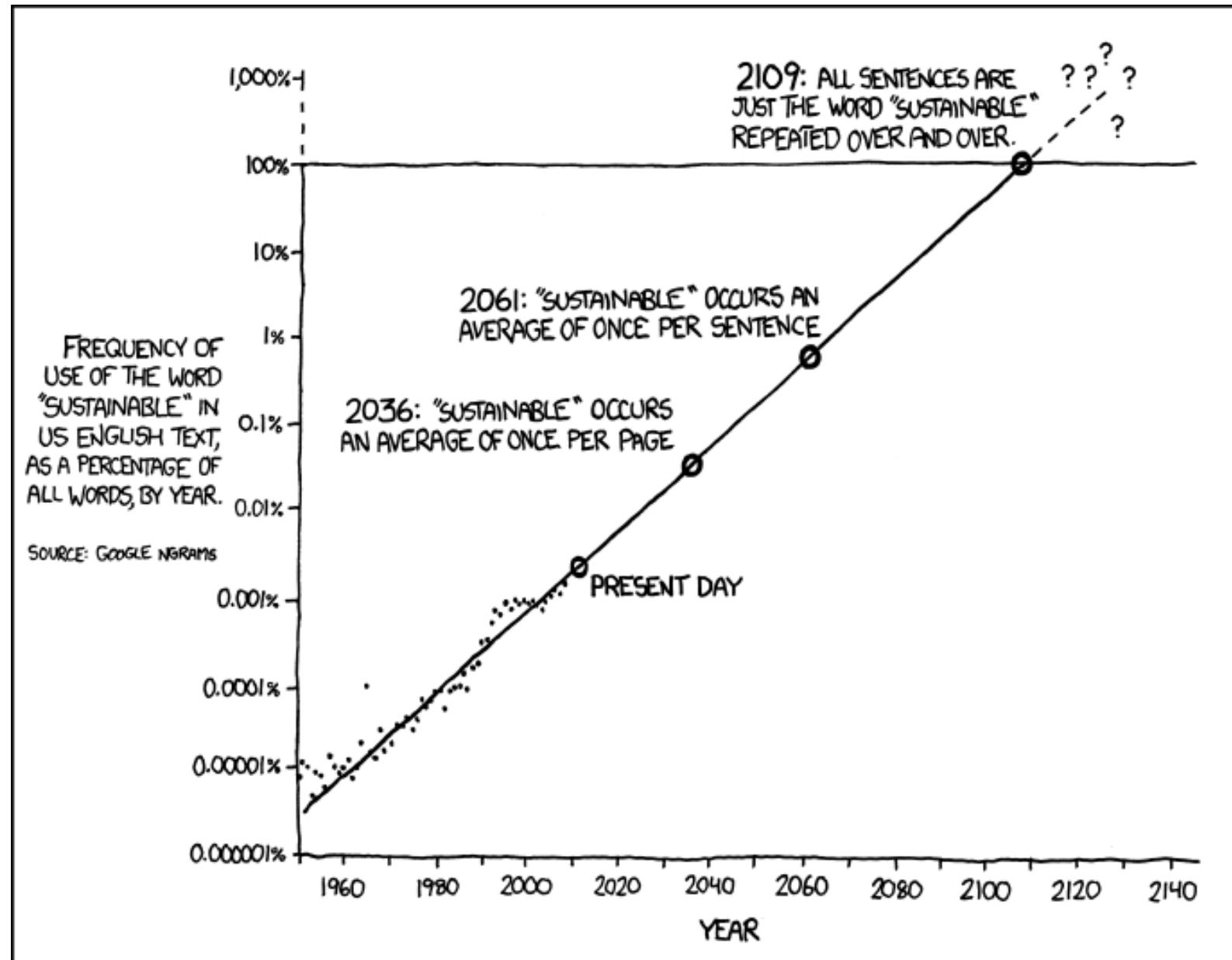


The Nordic industry highlight seven pivotal necessities for growth

1. The need for **access to raw materials** entails stability of available market volume and price
2. **Secured supply chains** of materials, machinery cells, and packs needs to be regional
3. Electrification and the new battery industry has generated a disruptive need for **competence**
4. Fundamental movements within value chains has created need for **strategic partnerships**
5. This new industry needs **public framework** to enable trade, scale, and levelled playing field
6. To support charging and ease fast establishments and **enabling infrastructure** is important
7. An increased supply of **green energy**, stable grids, and affordable prices is fundamental

## The Nordic Battery Value Chain

- Market drivers, the Nordic value proposition, and decisive market necessities Report from Innovation Norway, Business Finland, Business Sweden, and the Swedish Energy Agency Conducted by Business Sweden 2023



THE WORD "SUSTAINABLE" IS UNSUSTAINABLE.

# Sustainable value chain in the mining sector

- “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own **needs**”
- Minerals are actually renewable?
  - Nearly infinite circularity with circular end-product design
- Without mining there will be nothing to recycle and without exploration there is nothing to mine



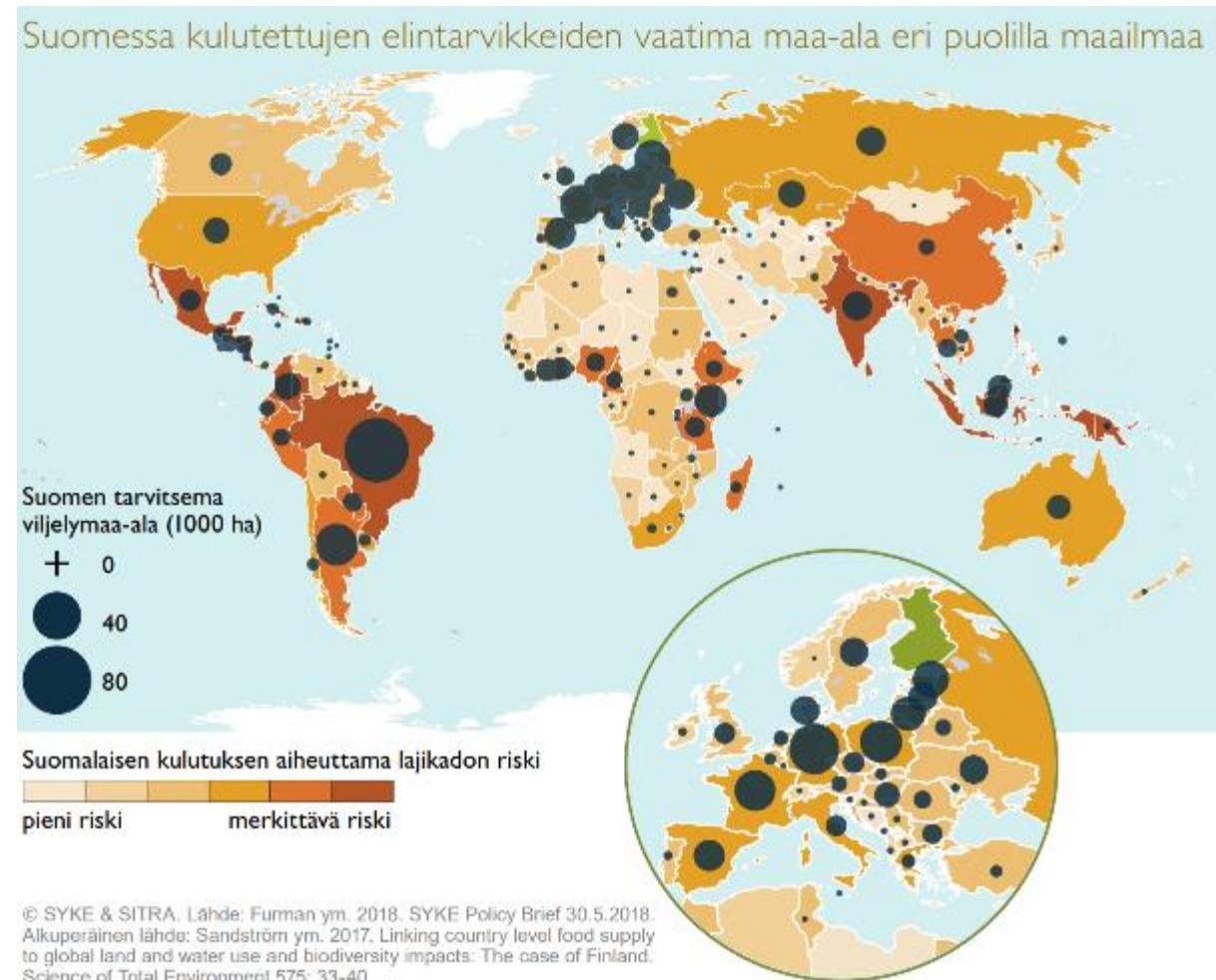
# Responsibility in value chains

Food production global footprint for Finland

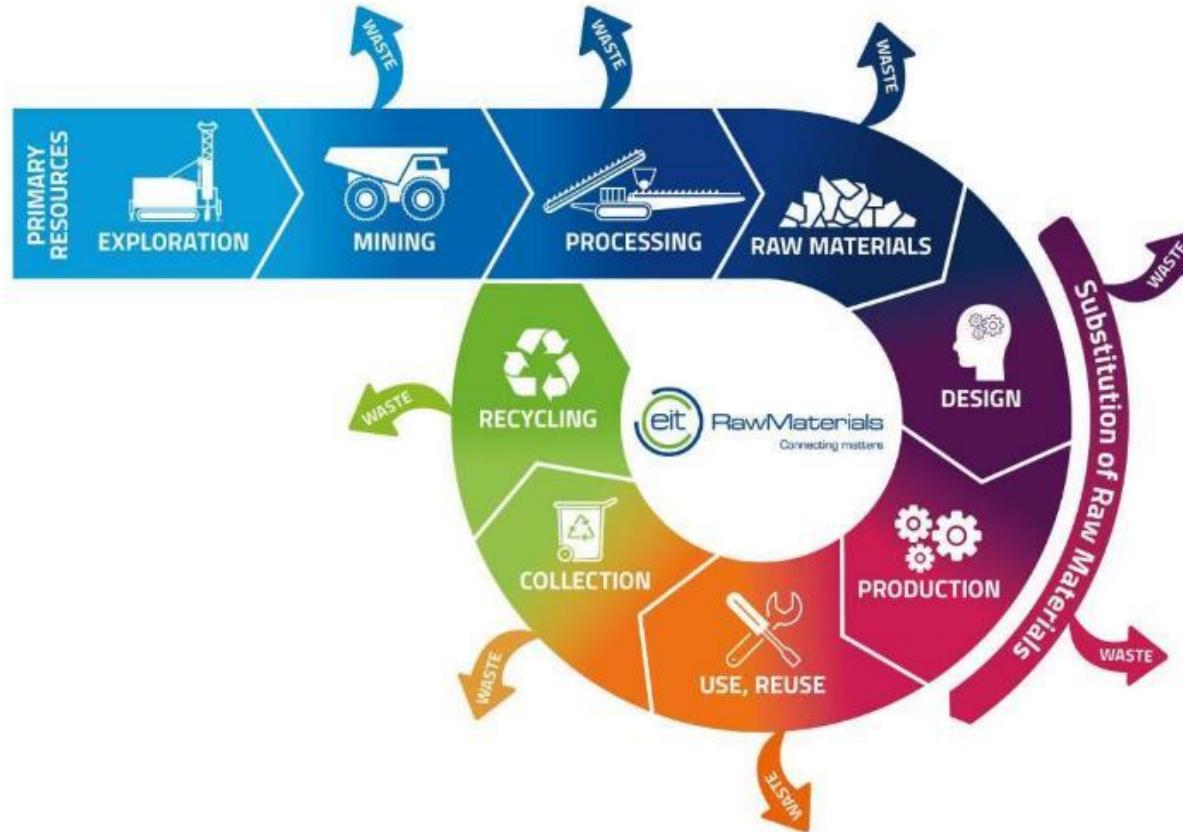
What would this look like for minerals?

End-user responsibility

Europe uses 20% of global mineral resources while producing only 3%



# Sustainable mining

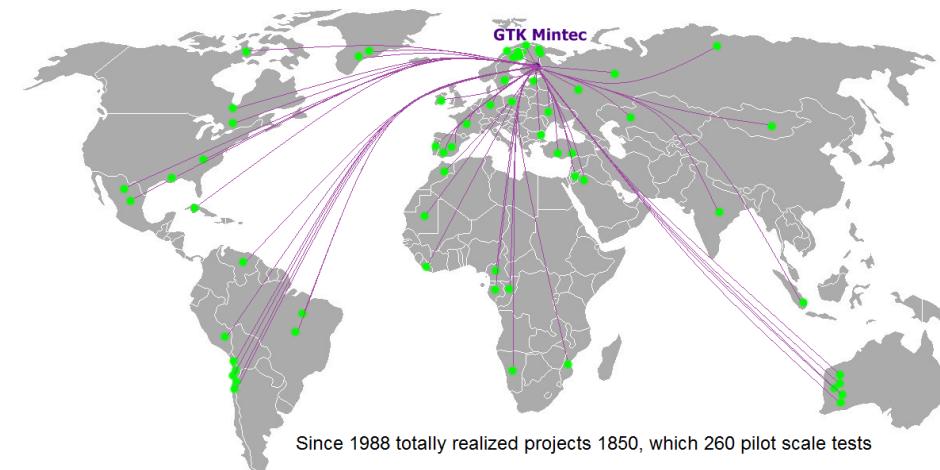


## Zero Waste design



# Process efficiency and side stream beneficiation

- GTK Mintec Pilot plant is world leading in mineral beneficiation testing facility
- Research of beneficiation of tailings, sidestreams
- Providing solutions to enhance process efficiency and reducing costs
- Focusing research on new raw material sources from industry side streams

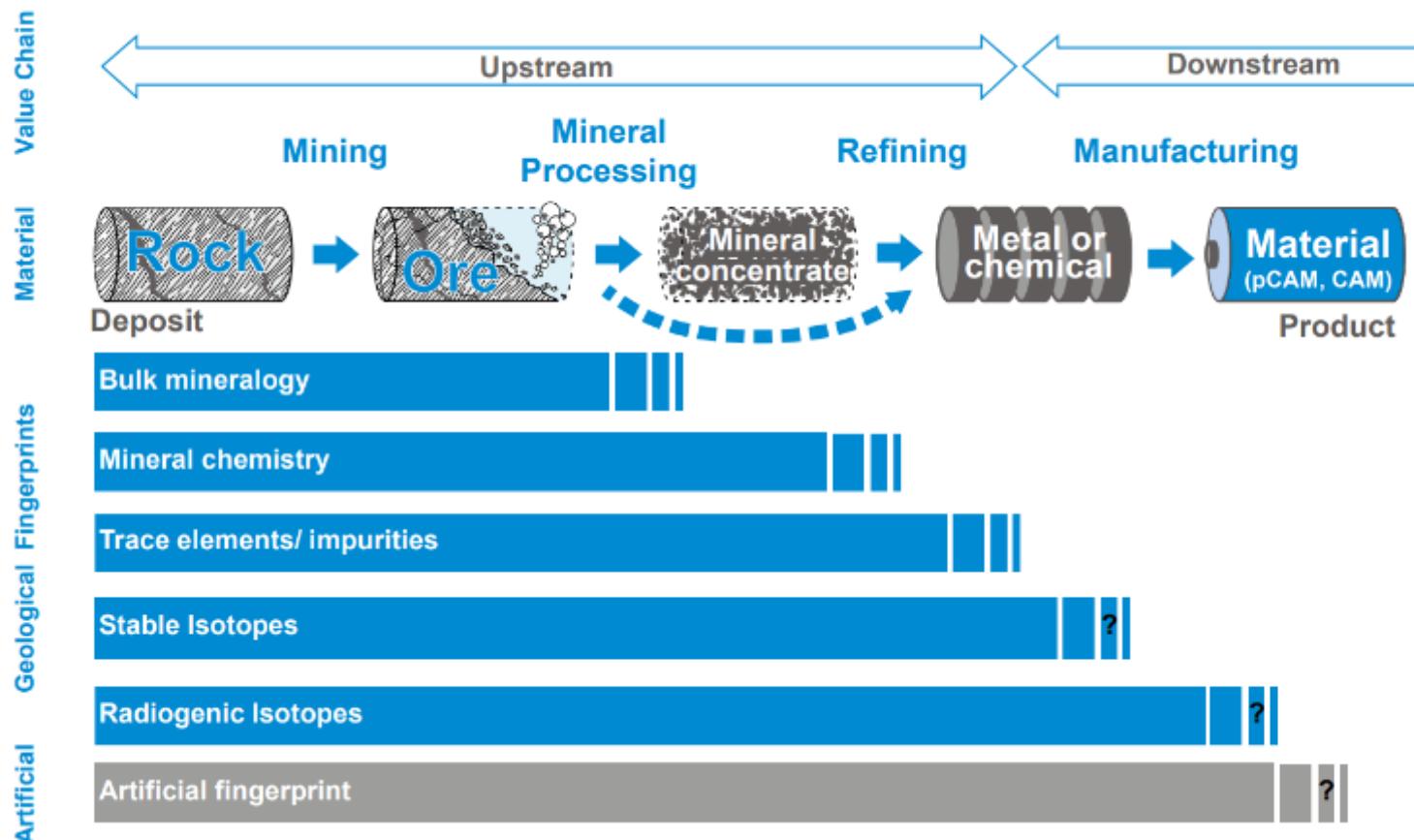


## Sustainable mineral system

- Circular design of a mining project – Zero waste mining
- Every ounce of material transport on site has an expense
  - *Diesel costs of hauling can be major cost (even >50%) for an open pit*
- Planning and end use on each material produced on site
- Careful planning of tailings and sidestream management from the start
- Primary and secondary resources form a combined system of material supply
- Case Forestry industry in FINLAND in 1990's



# Material traceability



Kaikkonen et al 2022. Traceability methods for cobalt, lithium, and graphite production in battery supply chains. Assessing geo-based fingerprinting as a method for battery raw materials' traceability. Geological Survey of Finland, Open File Research Report 20/2022, 49 pages, 1

## Value addition in battery chemicals

- Lithium concentrate 6% Li<sub>2</sub>O 3000 -3400 USD/t
- Lithium hydroxide or carbonate 27000-29000 USD/t
- Flake Graphite (depending on quality) 1000-2300 USD/t
- CSPG Graphite 8000-10000 USD/t
- Further value is added with battery cell production
- Each new beneficiation stage adds to the value of export and the final product
- Case Terrafame – From metal production to battery chemical production on site

# Constraints for value chain development

- The driver for green transition is ENERGY
- ENERGY is also required to produce high yield end products (battery chemicals and cells)
- CASE FINLAND
  - *CO2 free electricity production and independently within a joint Nordic network*
  - *Clean and abundant energy attracts investments to green steel and battery chemical plants*
- !Skilled experts!
  - *Europe has recognized a growing need of NEW expertise in the battery sector*
  - *Skills need to be upscaled from existing occupations and new lines of education is needed*

# Constraints for value chain development

- Permitting and availability of raw materials
- Friendly and supporting attitude towards different stages of value chain
  - *Policies need to be supportive and transparent on industry investments*
  - *World is changing fast → Fast and clear procedures are expected*
- Secured supply of battery grade concentrate and mineral material
  - *Disturbed global markets after a series of global and local crisis and disturbances in global market*

## FOR EARTH AND FOR US

The Geological Survey of Finland (GTK) produces impartial and objective research data and services in support of decision-making in industry, academia, and wider society to accelerate the transition to a sustainable, carbon-neutral world. GTK employs more than 400 experts specializing in the mineral economy, circular economy, solutions related to energy, water and the environment, as well as digital solutions. GTK is a research institution governed by the Finnish Ministry of Employment and the Economy, operating in Finland and globally.

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