# CRITICAL METALS AND THEIR ROLE IN THE GREEN ENERGY, TRANSPORTATION AND AI DRIVEN FUTURE

By Rick Van Nieuwenhuyse

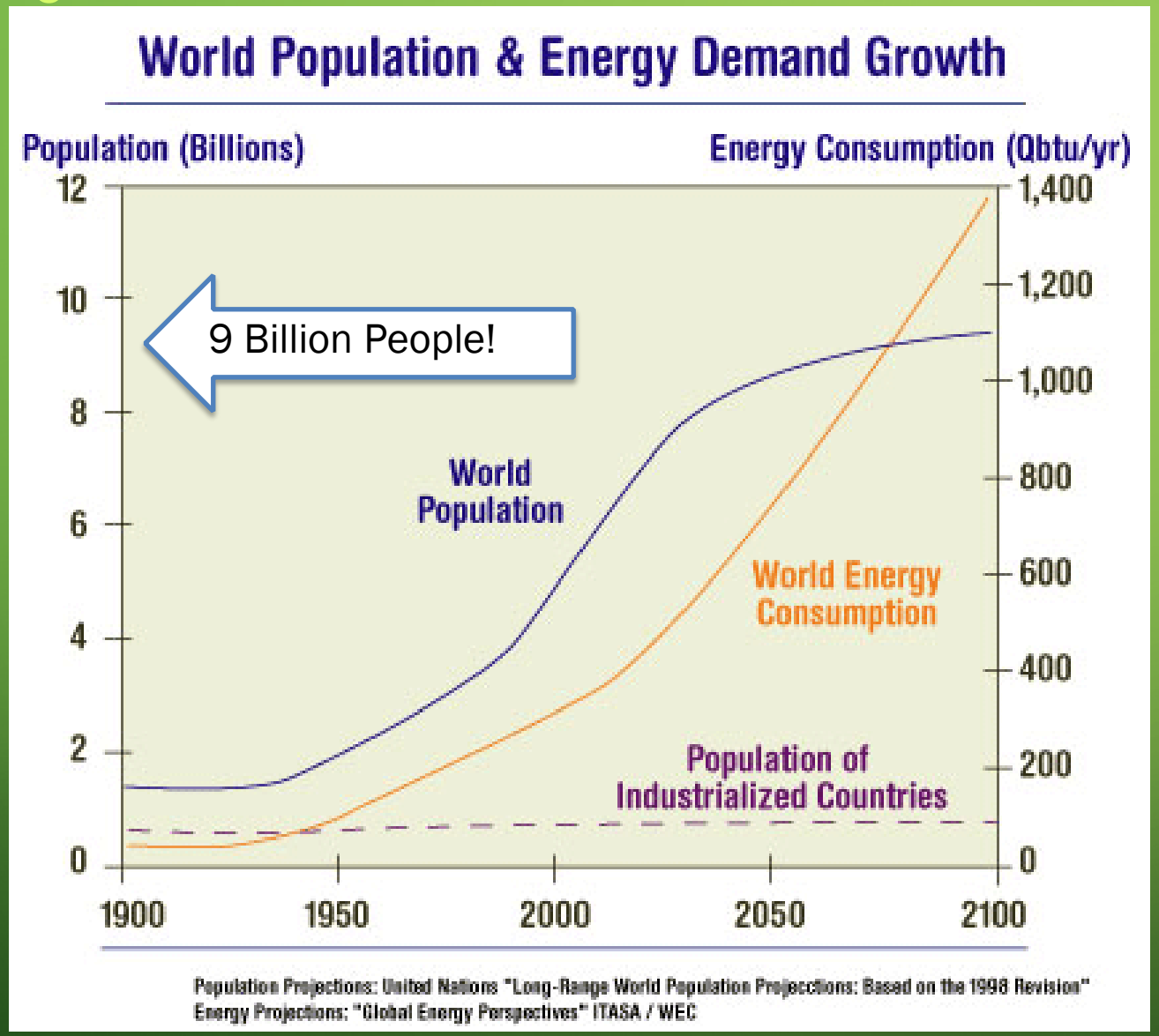
NET ZERO BY 2050

YOU CAN'T GET THERE WITHOUT MINING… LOTS OF MINING!

# "YOU CAN AVOID REALITY BUT YOU CAN'T AVOID THE CONSEQUENCES OF AVOIDING REALITY"

AYN RAND

# ENERGY CONSUMPTION KEEPS GOING UP




# ENERGY CONSUMPTION KEEPS GOING UP

## Global primary energy consumption by source

Primary energy is based on the substitution method and measured in terawatt-hours.

Our World in Data

Table | Chart | Settings

ExaJoules = $10^{18}$ Joules

180,000 TWh
160,000 TWh
140,000 TWh
120,000 TWh
100,000 TWh
80,000 TWh
60,000 TWh
40,000 TWh
20,000 TWh
0 TWh

1800 1850 1900 1950 2000 2023

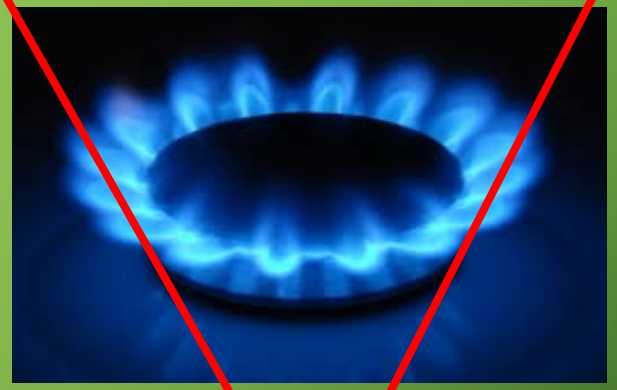
Other renewables
Modern biofuels
Solar
Wind
Hydropower
Nuclear
Natural gas
Oil
Coal
Traditional biomass

1800 2023

**Data source:** Energy Institute - Statistical Review of World Energy (2024); Smil (2017) – Learn more about this data

**Note:** In the absence of more recent data, traditional biomass is assumed constant since 2015.

OurWorldinData.org/energy | CC BY




Source: theOilDrum.com

# TYPES OF NON-CARBON TO AUGMENT ENERGY GENERATION

- Solar
- Wind
- Geothermal
- Hydro
- Hydrogen
- Nuclear

# COPPER AS ENERGY

You can't produce or transfer electricity without copper and none of the other metals work without copper!

## COPPER USAGE INTENSITY (PER MW CREATED)

Conventional


Wind & Solar


Off-shore Wind


**NONE-CARBON ENERGY = *MORE COPPER***

# THE HYBRID & ELECTRIC VEHICLES

## REQUIRE MORE COPPER, COBALT, GRAPHITE, LITHIUM

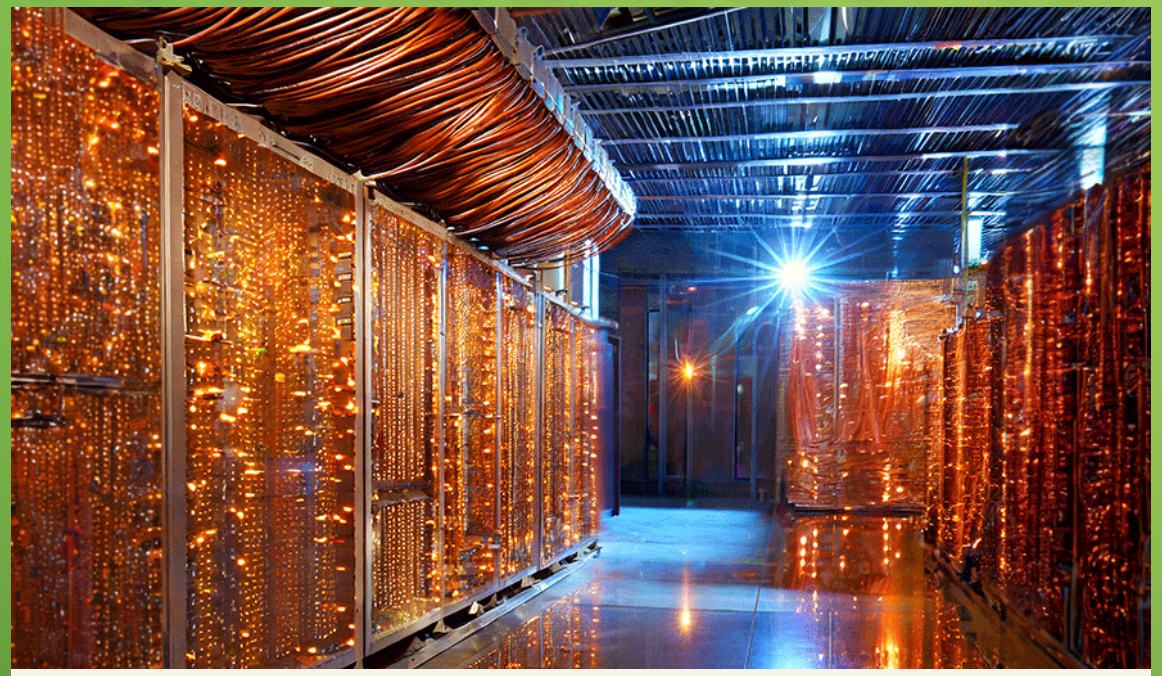
20 Kg of Copper

**Canada's Suncor CEO sees electric vehicles disrupting oil demand as much as coronavirus, June 2, 2020**
The shift to electric vehicles and other low-carbon technologies could disrupt crude oil demand on a similar scale to the coronavirus pandemic, Suncor Energy's chief executive said.

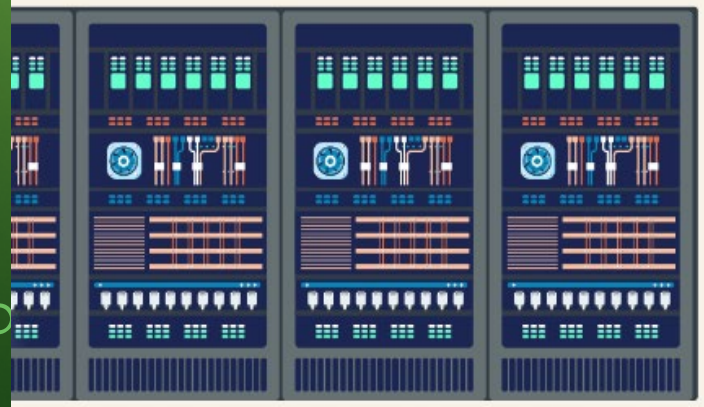
.....and more energy....another 20kg ➔5X !

80 Kg of Copper

# THE CRITICAL ROLE OF COPPER IN AI DATA CENTERS



## Copper Content
of Data Centers



= **27 tonnes**
*per MW of applied power*

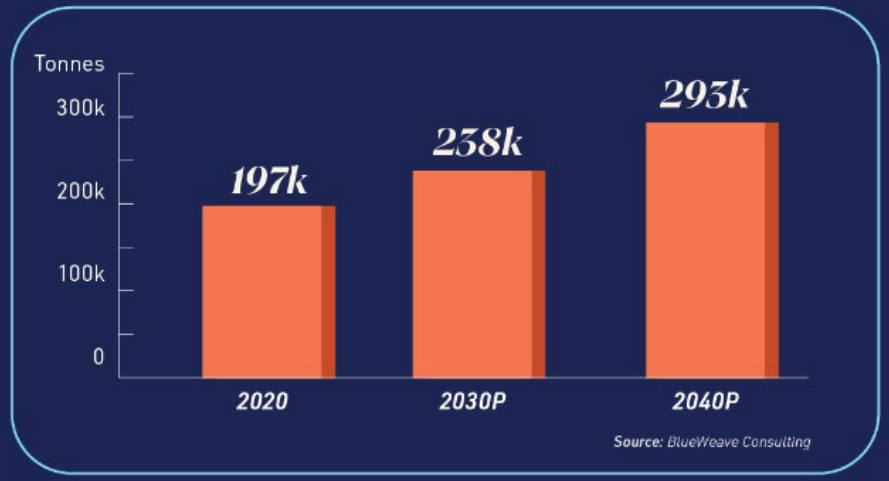
Microsoft's $500 million data center in Chicago required 2,177 tonnes of copper for its construction.

*Source: Data Center Knowledge and CNET*

## North American Data Center Infrastructure Size 2020–2040P


*Source: BlueWeave Consulting*

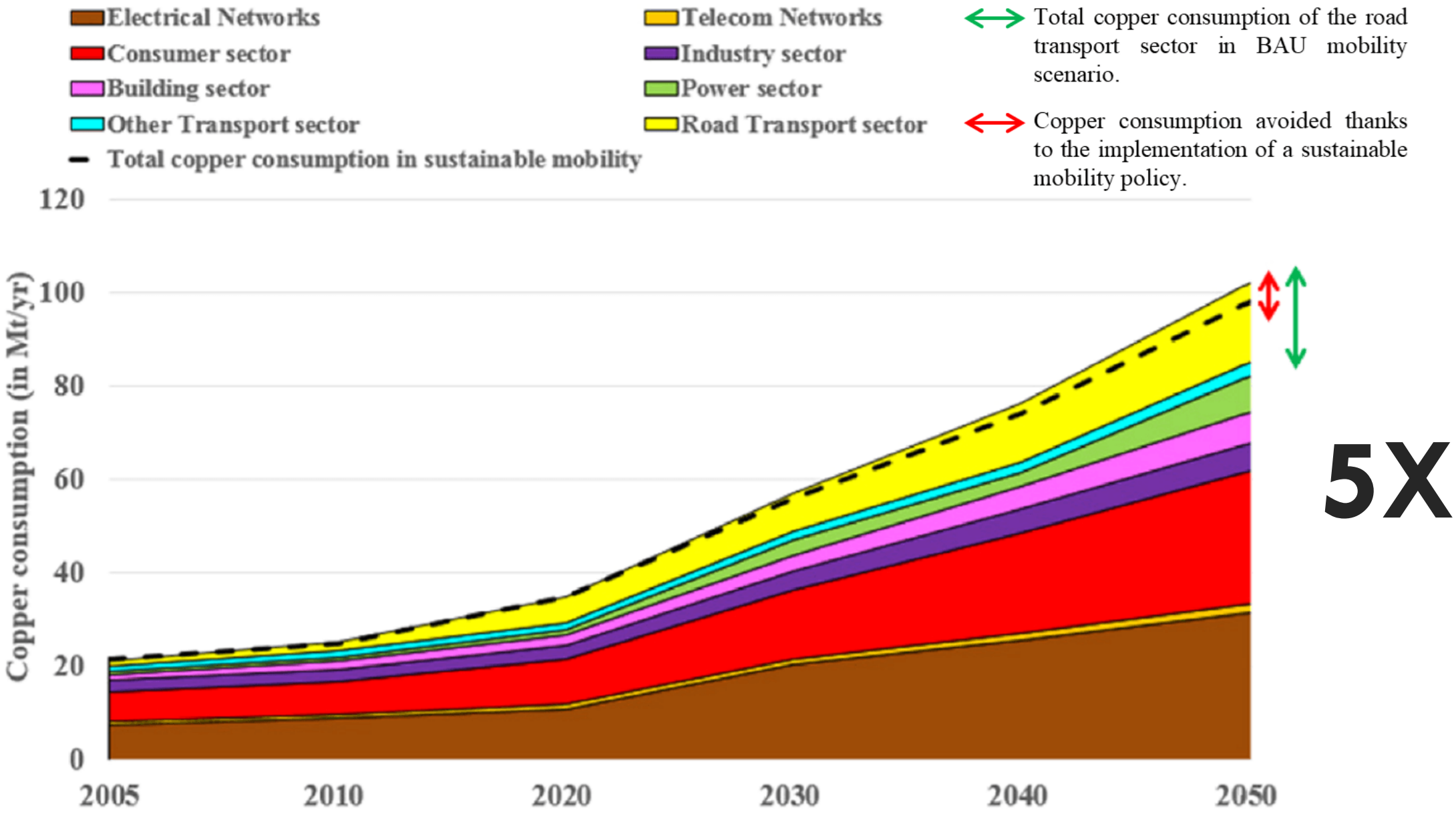
## Copper Consumption in North American Data Centers 2020–2040P




*Source: BlueWeave Consulting*

**Copper's ability to maximize the efficiency and reliability of data centers makes it an indispensable material in the modern digital age.**

# EVOLUTION OF COPPER CONSUMPTION IN A 2°C SCENARIO: IMPACT OF THE TRANSPORT MOBILITY SHIFT



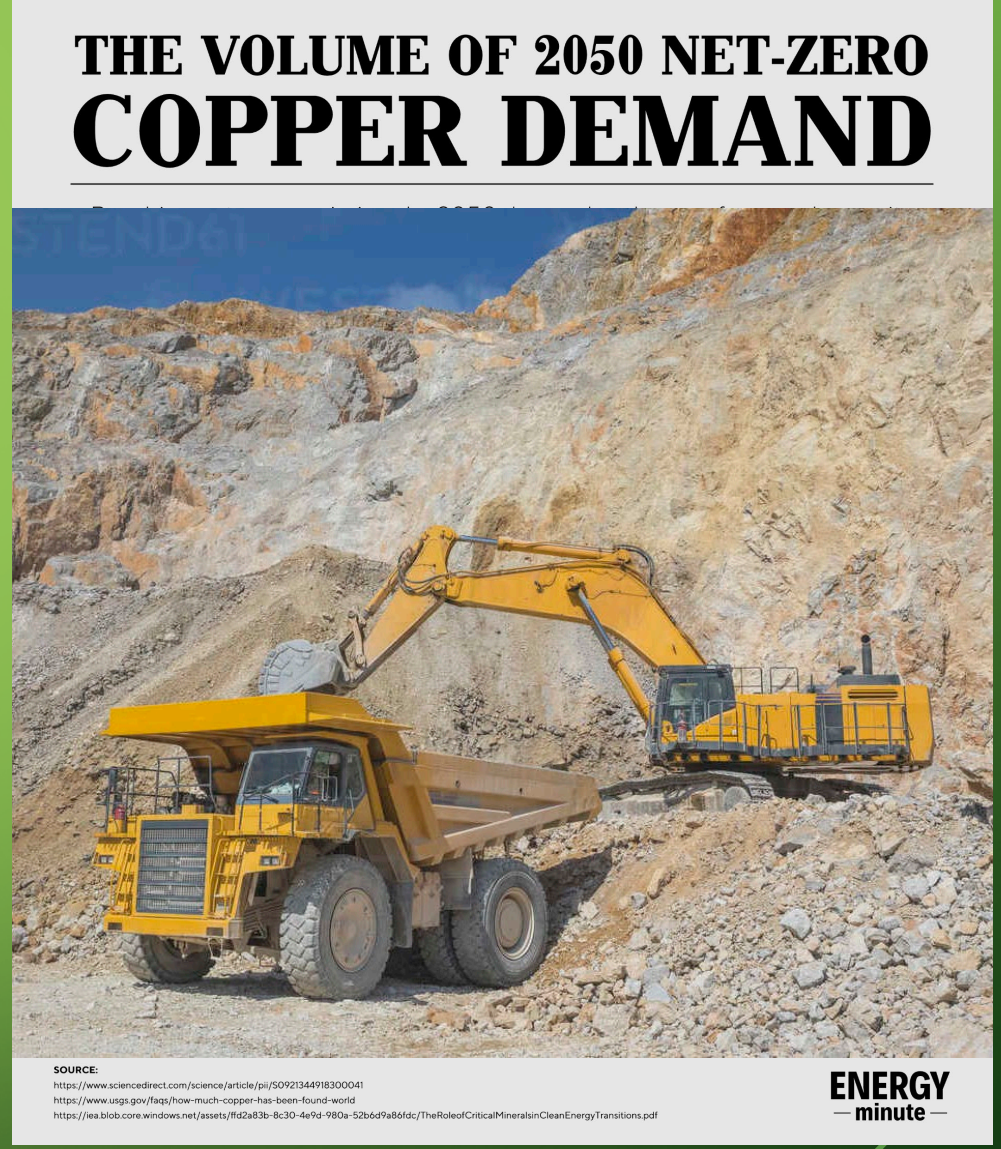
# TRANSITION TO ELECTRIC VEHICLES REQUIRES MINING…. A LOT OF MINING!

- To make a single 1000 lbs (1/2 ton) EV battery requires around 500,000 lbs (250 tons) of mined materials

You don't get there without mining

…a lot of mining

- To transition just the ICE vehicle fleet to electric in North America (400 Million vehicles) over the next 30 years will require 200,000,000,000,000 Pounds in mined materials (100 Billion tons) +….Europe…China…..India……and then there's the Green Energy & AI……way more than we have mined in human history!….



# CAN RECYCLING GET US THERE?

# NO!

# THE COPPER EXAMPLE

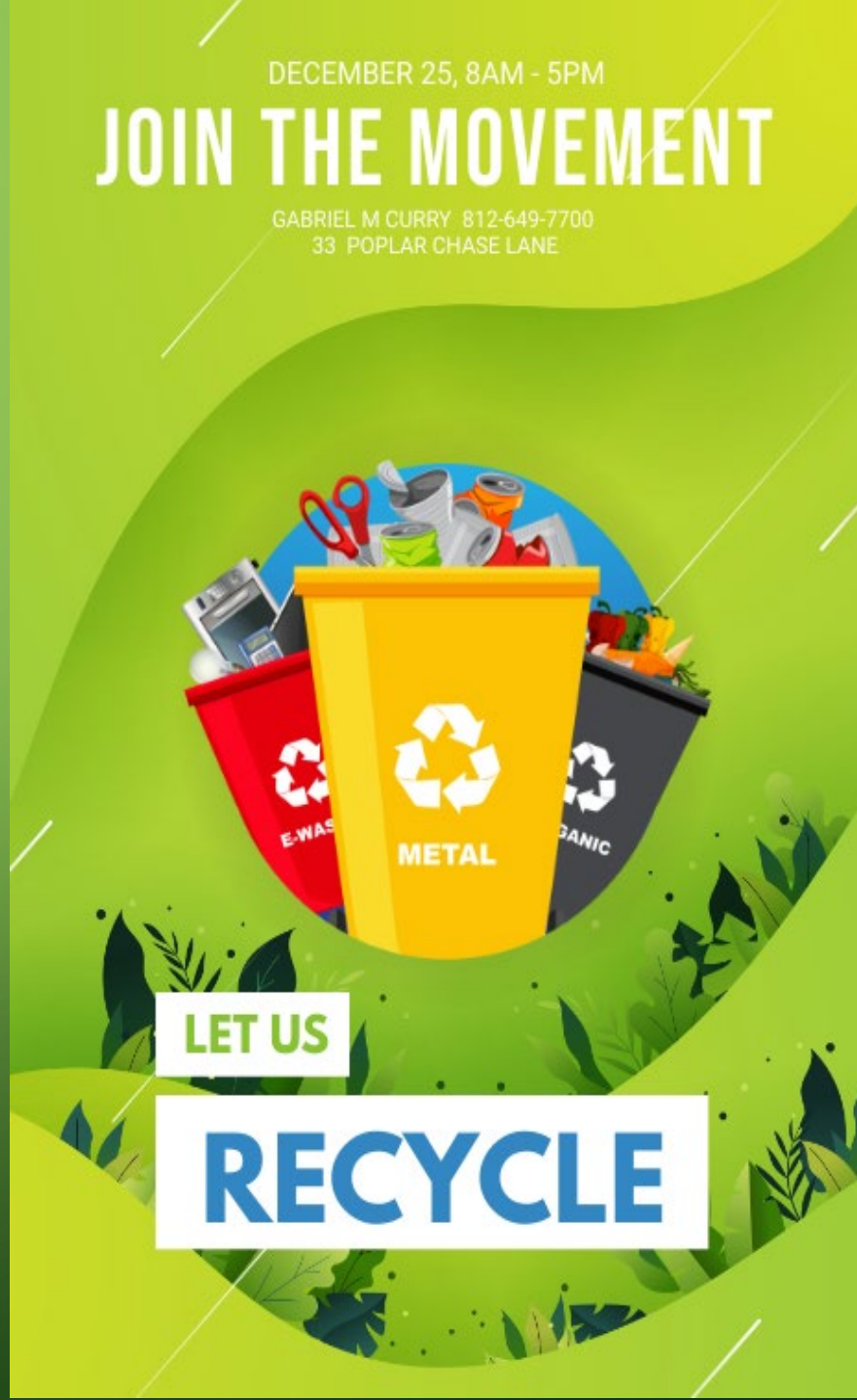
- We consume 28 Mt of copper annually (NOW)
- About 32% of that is Recycled Annually (~8.7 Mt/year)
- Copper has a 5 to 30 year product life use

➔ We already re-cycle about 80% of the copper in use

**NOT A SOLUTION!**

➔ We should recycle more….incentives and research

**NOT BY 2050!**

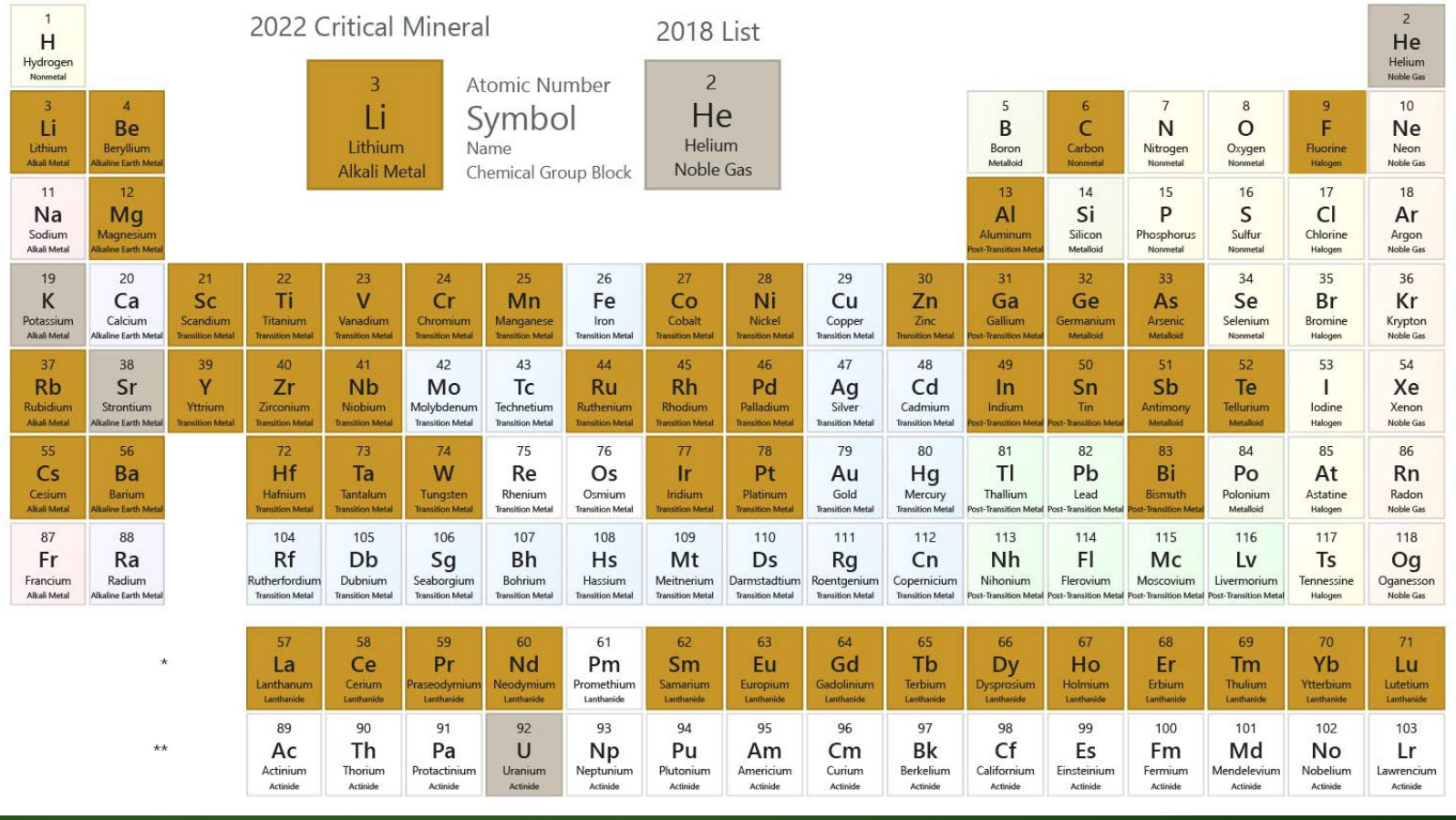


# CRITICAL METALS: WHAT ARE THEY AND WHY ARE THEY CRITICAL?

The Energy Act of 2020 defines a “critical mineral” as a non-fuel mineral or mineral material essential to the economic or national security of the U.S. and which has a supply chain vulnerable to disruption. Critical minerals are also characterized as serving an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economy or national security.

# 50

## Periodic table of elements highlighting the “critical minerals”



The 2022 US list of critical minerals

| | | | |
|---|---|---|---|
| Aluminum | used in almost all sectors of the economy | Magnesium | used as an alloy and for reducing metals |
| Antimony | used in lead-acid batteries and flame retardants | Manganese | used in steelmaking and batteries |
| Arsenic | used in semi-conductors | Neodymium | used in permanent magnets, rubber catalysts, and in medical and industrial lasers |
| Barite | used in hydrocarbon production | Nickel | used to make stainless steel, superalloys, and rechargeable batteries |
| Beryllium | used as an alloying agent in aerospace and defense industri | Niobium | used mostly in steel and superalloys |
| Bismuth | used in medical and atomic research | Palladium | used in catalytic converters and as a catalyst agent |
| Cerium | used in catalytic converters, ceramics, glass, metallurgy, and polishing compounds | Platinum | used in catalytic converters |
| Cesium | used in research and development | Praseodymium | used in permanent magnets, batteries, aerospace alloys, ceramics, and colorants |
| Chromium | used primarily in stainless steel and other alloys | Rhodium | used in catalytic converters, electrical components, and as a catalyst |
| Cobalt | used in rechargeable batteries and superalloys | Rubidium | used for research and development in electronics |
| Dysprosium | used in permanent magnets, data storage devices, and lase | Ruthenium | used as catalysts, as well as electrical contacts and chip resistors in computers |
| Erbium | used in fiber optics, optical amplifiers, lasers, and glass colorants | Samarium | used in permanent magnets, as an absorber in nuclear reactors, and in cancer treatments |
| Europium | used in phosphors and nuclear control rods | Scandium | used for alloys, ceramics, and fuel cells |
| Fluorspar | used in the manufacture of aluminum, cement, steel, gasolin and fluorine chemicals | Tantalum | used in electronic components, mostly capacitors and in superalloys |
| Gadolinium | used in medical imaging, permanent magnets, and steelmaking | Tellurium | used in solar cells, thermoelectric devices, and as alloying additive |
| Gallium | used for integrated circuits and optical devices like LEDs | Terbium | used in permanent magnets, fiber optics, lasers, and solid-state devices |
| Germanium | used for fiber optics and night vision applications | Thulium | used in various metal alloys and in lasers |
| Graphite | used for lubricants, batteries, and fuel cells | Tin | used as protective coatings and alloys for steel |
| Hafnium | used for nuclear control rods, alloys, and high-temperature ceramics | Titanium | used as a white pigment or metal alloys |
| Holmium | used in permanent magnets, nuclear control rods, and lasers | Tungsten | primarily used to make wear-resistant metals |
| Indium | used in liquid crystal display screens | Vanadium | primarily used as alloying agent for iron and steel |
| Iridium | used as coating of anodes for electrochemical processes and a chemical catalyst | Ytterbium | used for catalysts, scintillometers, lasers, and metallurgy |
| Lanthanum | used to produce catalysts, ceramics, glass, polishing compounds, metallurgy, and batteries | Yttrium | used for ceramic, catalysts, lasers, metallurgy, and phosphors |
| Lithium | used for rechargeable batteries | Zinc | primarily used in metallurgy to produce galvanized steel |
| Lutetium | used in scintillators for medical imaging, electronics, and sor cancer therapies | Zirconium | used in the high-temperature ceramics and corrosion-resistant alloys |

Source: United States Geological Survey.



# USGS OFFICIAL CRITICAL METALS LIST

## WHAT'S MISSING?

**COPPER AND SILVER** – TWO OF THE MOST CRITICAL METALS …SILVER KEY FOR SOLAR PANELS AND NONE OF THE OTHER METALS WORK WITHOUT COPPER!

- Mined for Primary Metal
- Mined as By-Product Metal
- Mined as Co-Product Metal
- Mined as Co-Product - Platinum Group Metals
- Rare Earth Metals

➔ Many Critical metals are mined as By/Co-Products

➔ We need Smelters/Hydrometallurgical facilities!

➔ Mining & Refining + Research for new technologies

# WHAT MAKES THEM "CRITICAL"?


How did they become critical?

- ➔ Clean Air Act - 1970
- ➔ Clean Water Act - 1972
- ➔ 50 years of Anti-mining movement
- ➔ Permitting Challenges

What's changed recently?

Why the rush now?

What's all the fuss about?

# GLOBAL POLITICS….THESE GUYS!

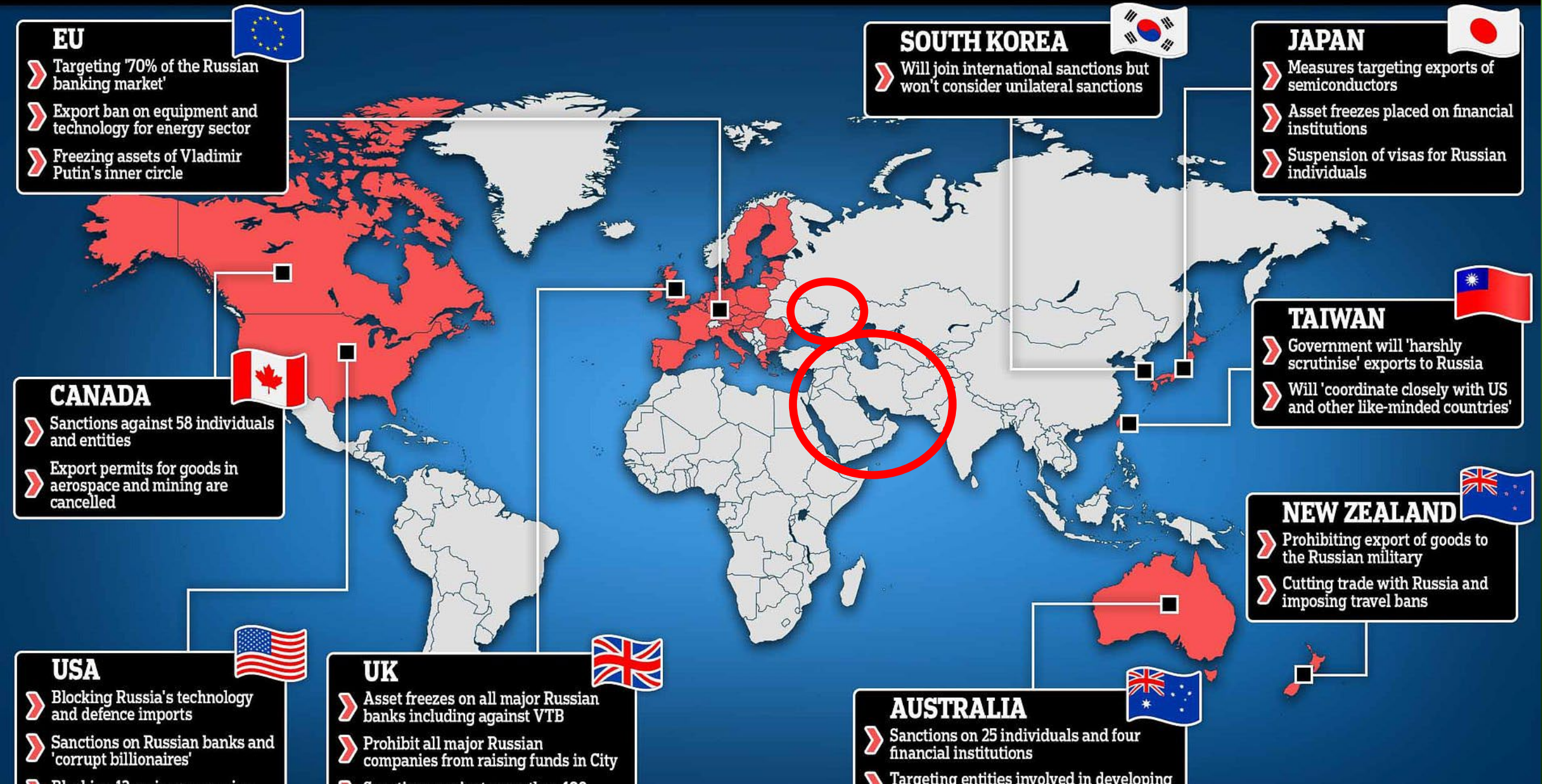
July 9, 2009 in Yekaterinsburg, Russia

# BRICS

Established to challenge the dollar as an exchange currency and eventually as a reserve currency…..consequences?


**Meeting in Kazan, Russia last week**

# SANCTIONS PLACED ON RUSSIA BY GOVERNMENTS AROUND THE WORLD





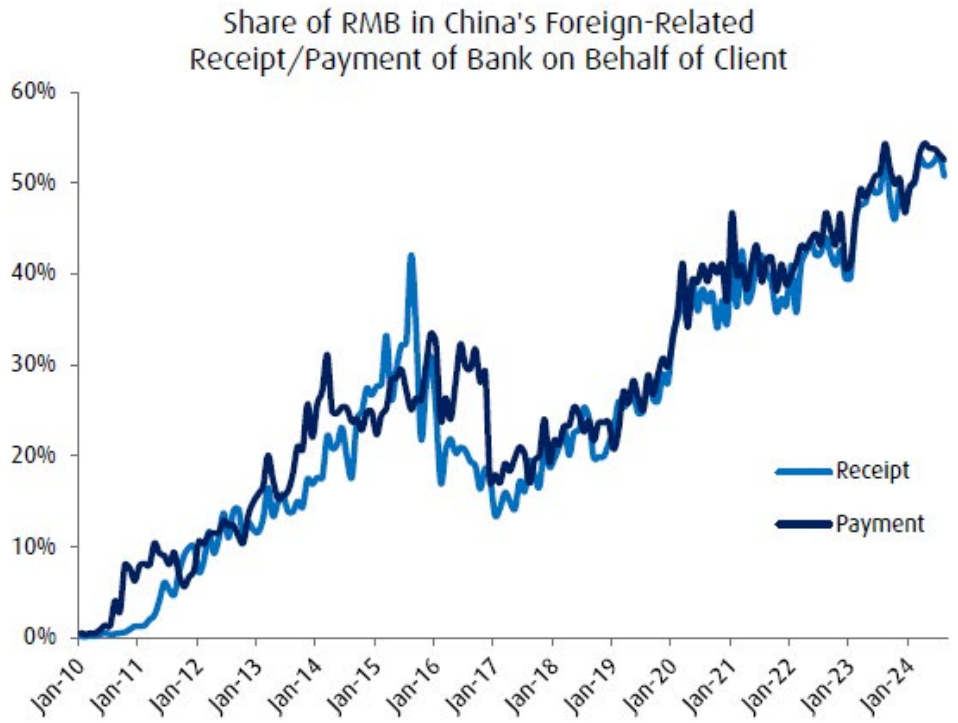
Brazil-Russia-India-China-South Africa

BRICS 2024
RUSSIA

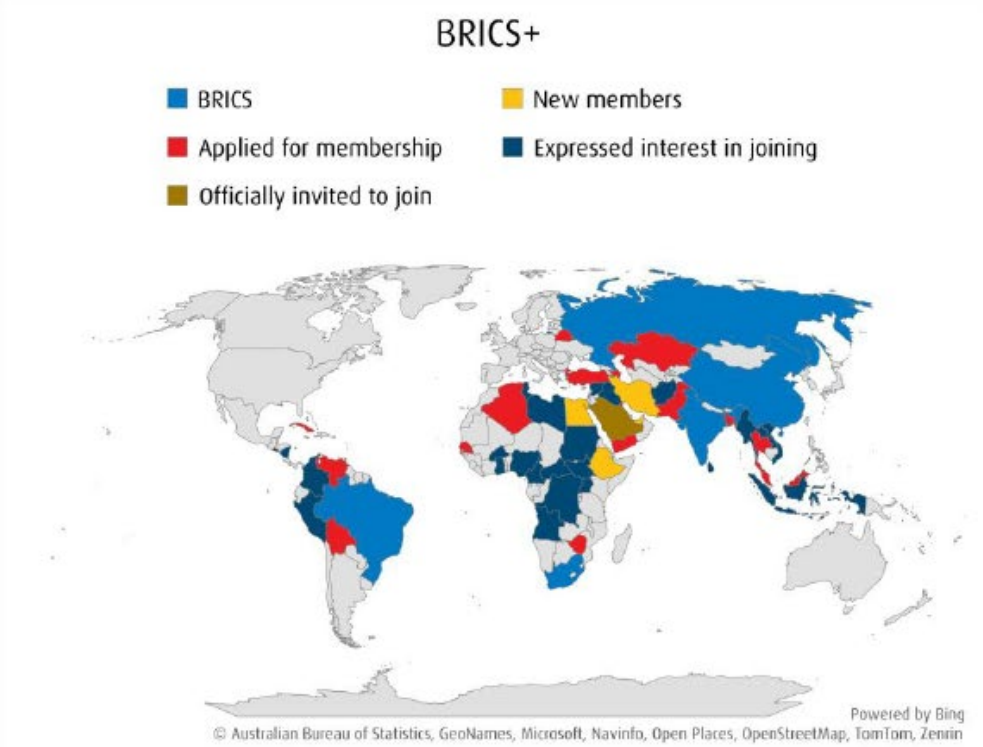
In 2024, the member countries have expanded to 10 countries.
The five new countries that have joined are Egypt, Ethiopia, Iran, Saudi Arabia and the United Arab Emirates.

Over 40 countries, including Iran, Saudi Arabia, United Arab Emirates, Turkey, Argentina, Algeria, Bolivia, Indonesia, Egypt, Ethiopia, Cuba, Democratic Republic of Congo, Comoros, Gabon, and Kazakhstan have expressed interest in joining the forum, according to 2023 summit chair in South Africa.

# We See the Dedollarisation of Global Trade as an Underappreciated Dynamic, and an Accelerating One




China's trade pivot to emerging markets has been accompanied by increased use of the RMB for trading

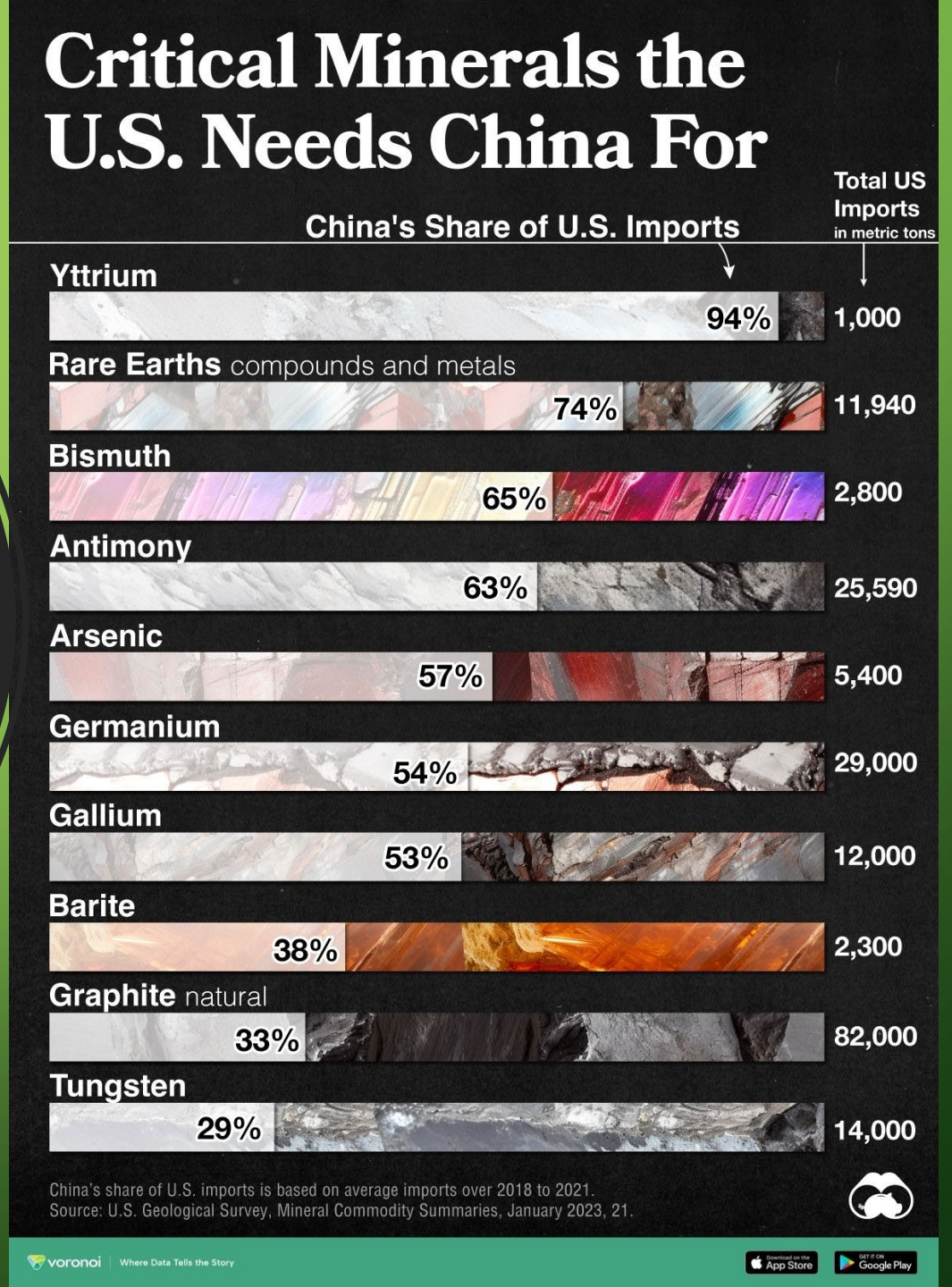


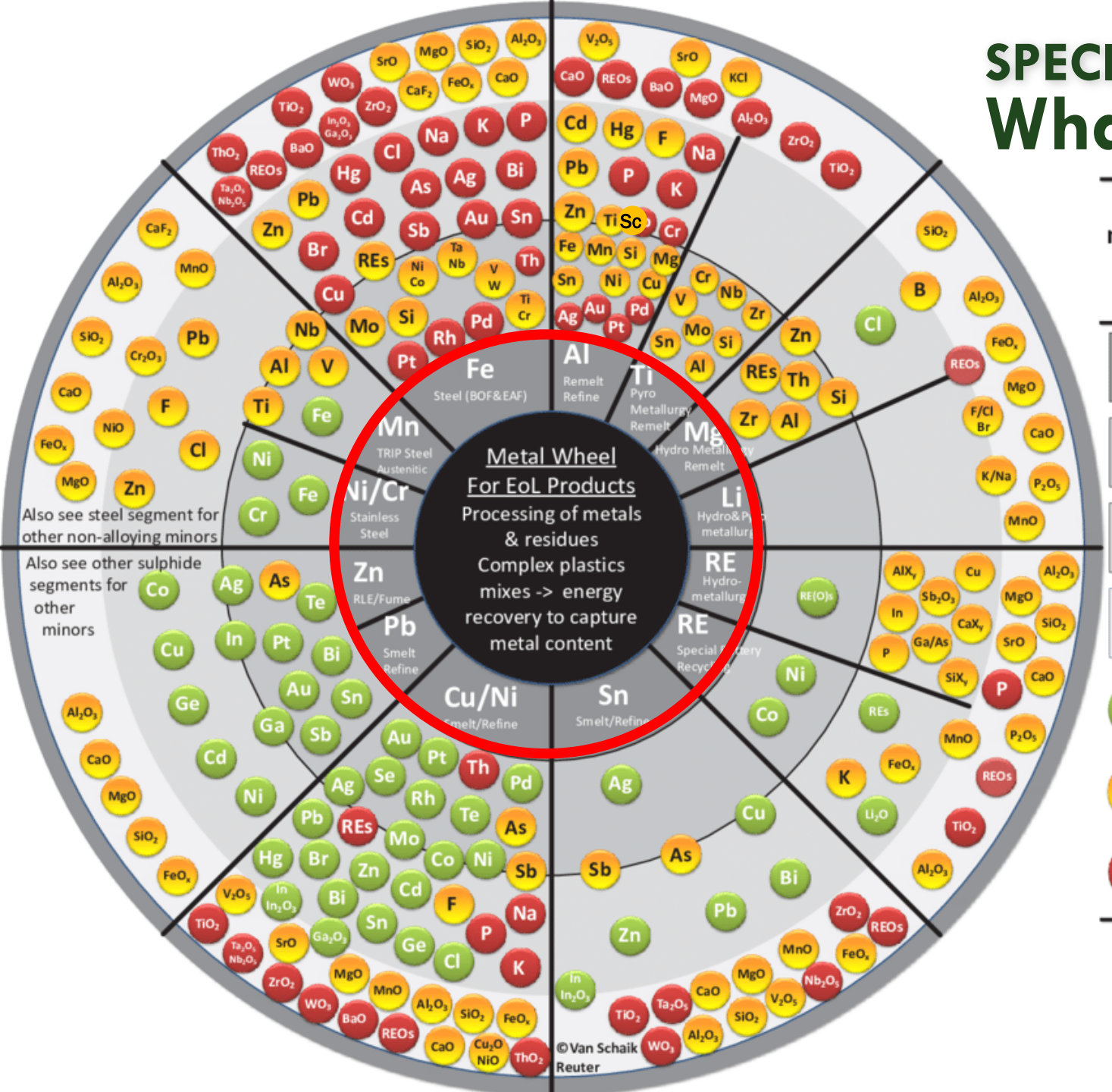

The mBridge ledger system has been proposed as the trade settlement platform for an expanded BRICs bloc

BMO Capital Markets

Source: SAFE, PBoC, CEIC, BMO Capital Markets

# WHAT ARE WE DOING ABOUT IT?






# SPECIALTY/CRITICAL = BY-PRODUCTS

# What metals do we mine?

**Economically viable destinations of complex EoL designed functional material combinations, scrap, residues etc. to metallurgical processing infrastructure (each segment) to produce refined metal, compounds and alloys in best available technology**

**Circular Economy's carrier metals processing infrastructure**
Extractive Metallurgy's Backbone, the enablers of a Circular Economy (CE) as it also recovers technology elements used e.g. in renewable energy infrastructure, IoT, eMobility etc.

**Dissolves mainly in carrier metal if metallic (mainly pyrometallurgy)**
Valuable elements recovered from these or (dissipative) lost (metallic, speiss, compounds, alloy in EoL also determines destination as also the metallurgical conditions in flowsheet).

**Compounds mainly to dust, slime, speiss (mainly hydrometallurgy)**
Collector of valuable minor elements as oxides/sulphates/chlorides etc. and mainly recovered in appropriate metallurgical infrastructure if economical.

**Mainly to benign lower value building material products**
Relatively lower value but inevitable part of society and materials processing. A sink for metals and loss from the CE system as oxides/ compounds. Dissipative losses.

**A** **Mainly recovered element**
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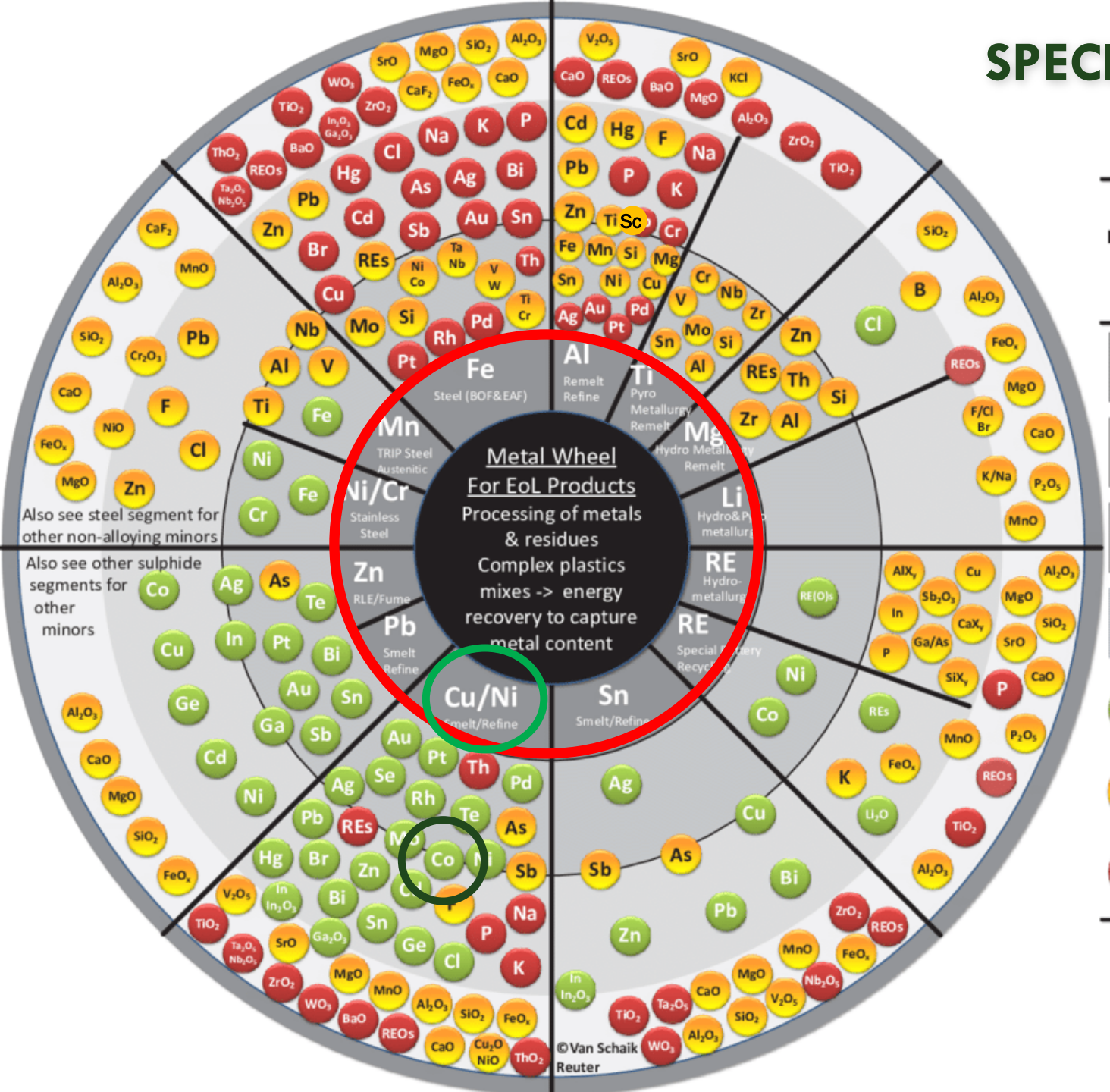
**C** **Mainly element lost, not always compatible with carrier metal or product**
Detrimental to properties and cannot be economically recovered e.g. Au dissolved in steel or aluminium will be lost.

# Why no Uranium?

# SPECIALTY/CRITICAL = BY-PRODUCTS

# Cobalt

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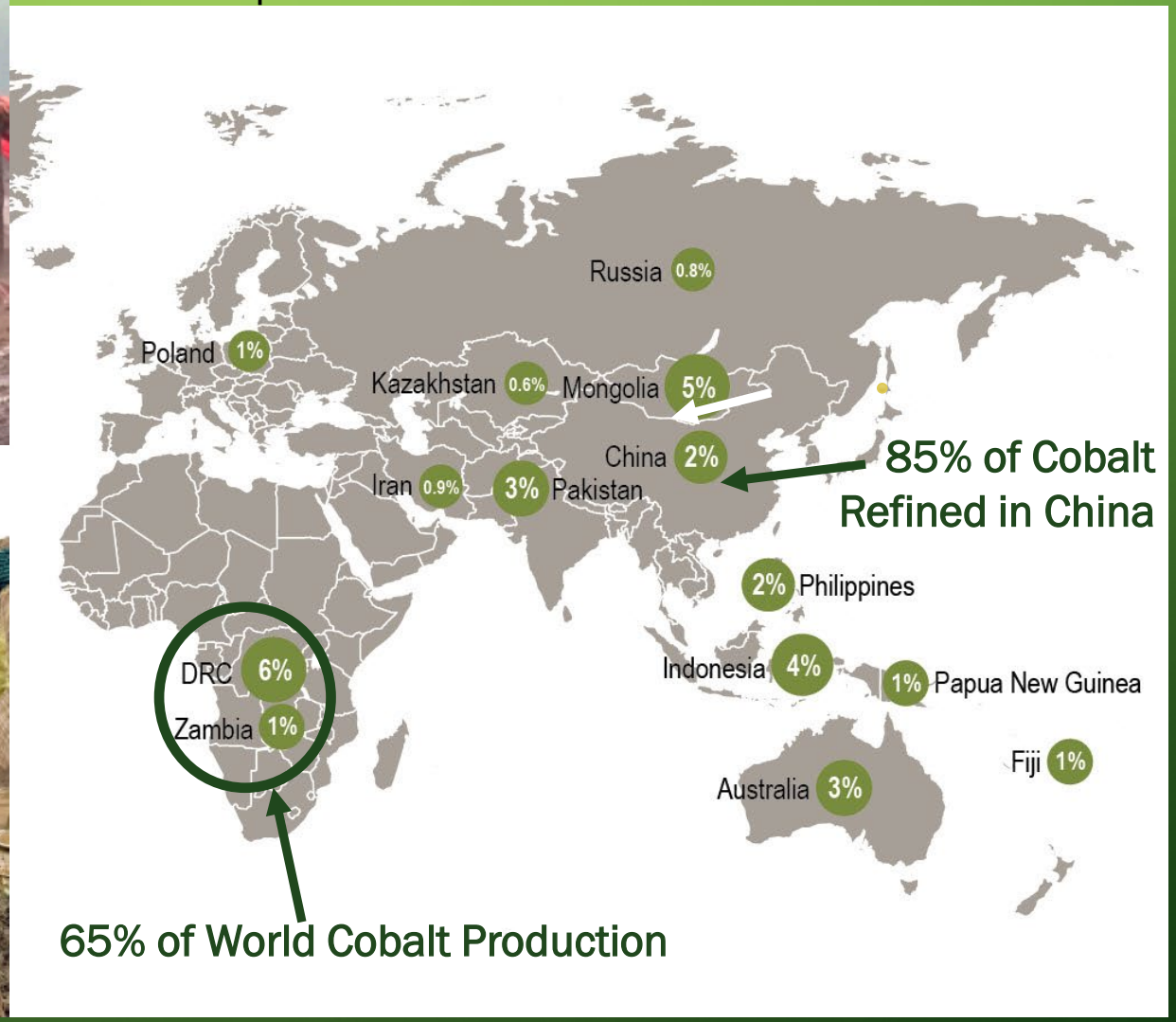
# WORLD COPPER AND COBALT SUPPLY

65% of World Supply of Cobalt is mined in the DRC and 85% in processed in China



# BMW – ETHICAL SOURCING OF COBALT

- BMW signed a five-year cobalt supply deal on July 10, 2020 with Moroccan miner Managem worth US$112 million. Managem owns Bou-Azzer in the Anti Atlas mountains, the only primary cobalt mine in the world and in operation since 1930.
- BMW says the offtake agreement, covers one-fifth of its requirements for the NCM (nickel-cobalt-manganese) cathodes in its batteries, which together with Tesla's NCA (nickel-cobalt-aluminum) represents more than 90% of the market.
- The other 80% of the cobalt it needs comes from the Murrin Murrin mine in Australia, a Glencore(LSE: GLEN) owned operation, which makes BMW the only carmaker with a direct to mine raw material sourcing approach.
- Roskill, a metals, minerals and chemical industry research company, estimates approximately 19.6 kt cobalt will be required and provided for by the two sole suppliers, between 2020 and 2025.
- Annual cobalt production worldwide is only around 130,000 tonnes, mostly as a byproduct of nickel and copper mining.
- More than 80% of the chemical processing and refining capacity of cobalt is located in China, which after Glencore, is also the largest cobalt miner inside the DRC.
- Roskil says a core driver of BMW's direct to mine strategy has been to minimise exposure to DRC cobalt production and also to increase control, transparency and auditability of its cobalt supply.

Another reason BMW is looking outside central Africa is that much of the DRC's cobalt is already tied up by China.

https://www.mining.com/cobalt-price-bmw-avoids-the-congo-conundrum-for-now/

Responsible Cobalt Initiative

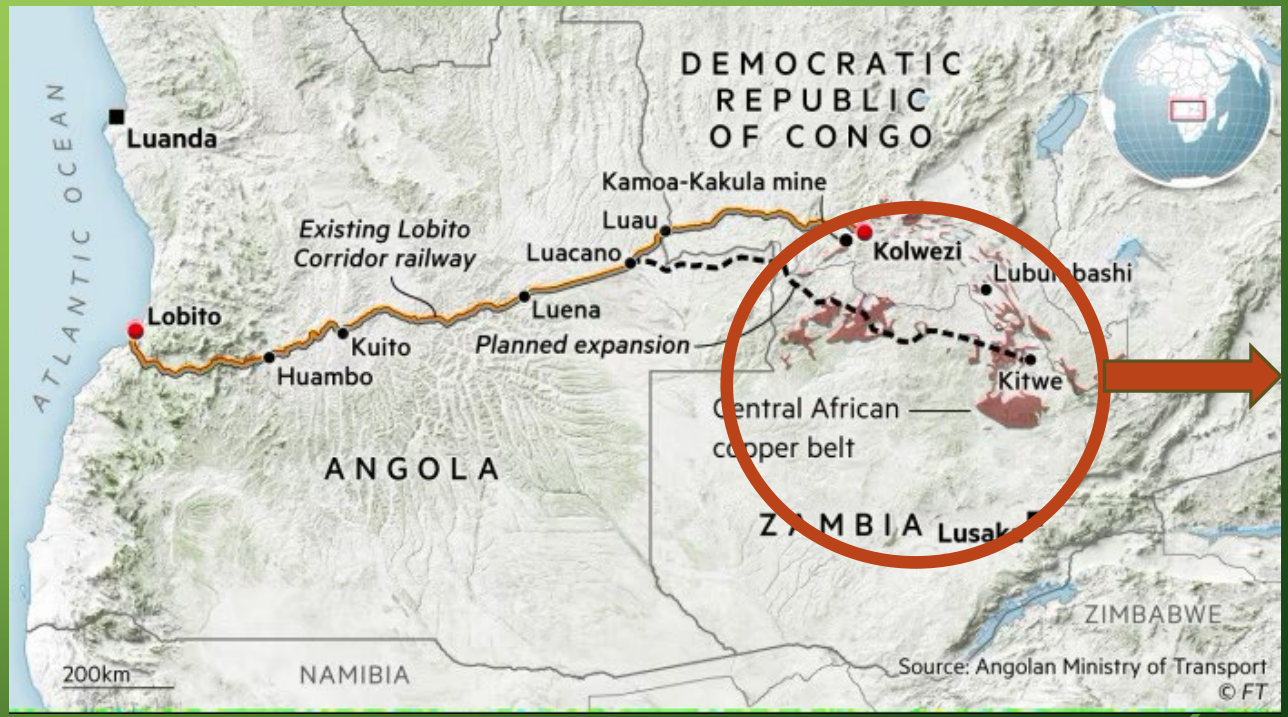
Fair Cobalt Alliance

TESLA

# US GOVERNMENT COMMITS TO $100 BILLION INVESTMENT IN INFRASTRUCTURE IN SOUTHERN AFRICA ALONGSIDE OF EUROPE AND SAUDIA ARABIA

## Accelerating US-African Partnership – 2022 African Leaders Summit

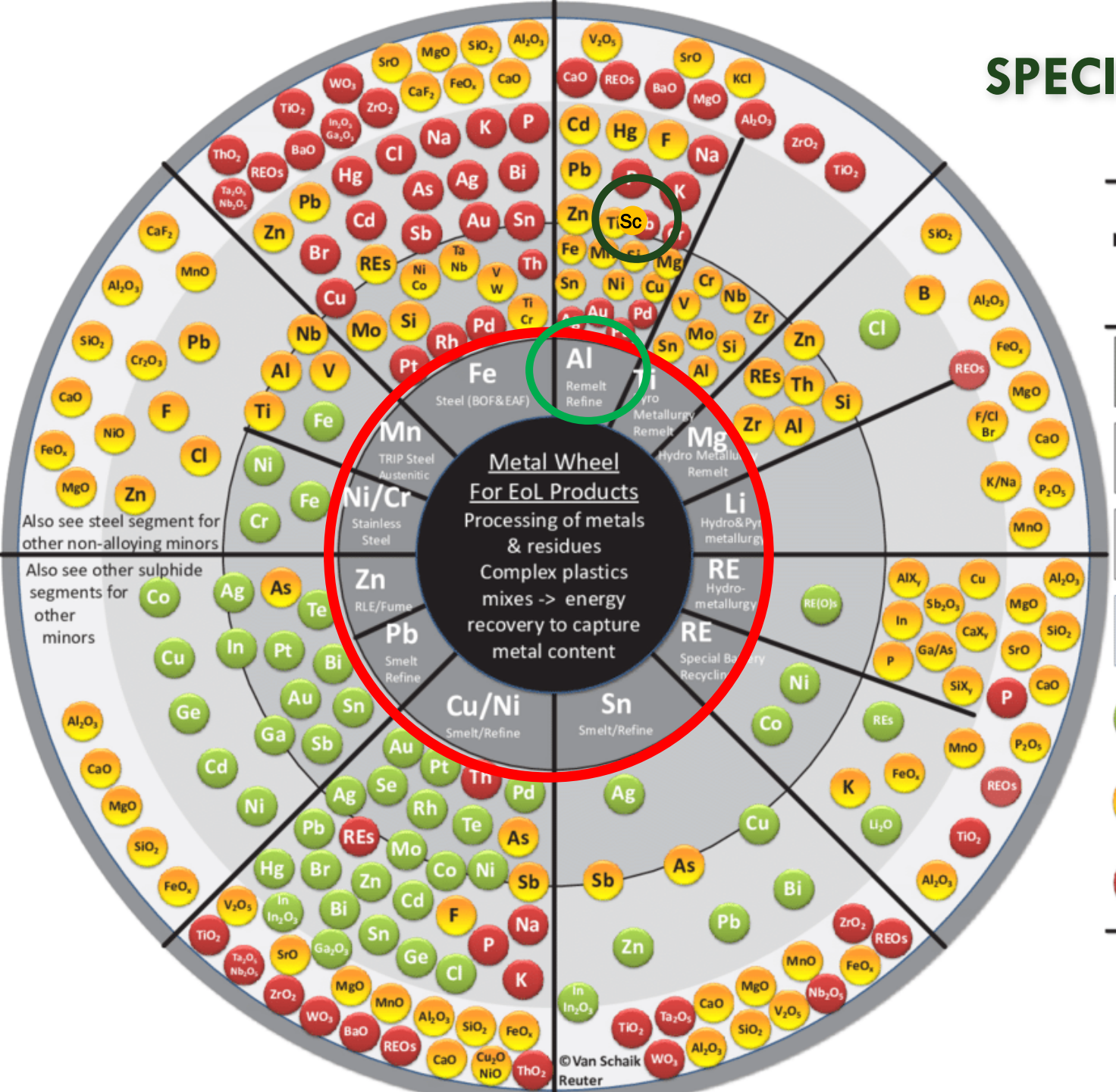
- The Biden-Harris Administration is over-delivering on our commitment to invest $55 billion in Africa over three years.
- In May 2023, President Biden chose Africa for the first and flagship economic corridor under his signature $600 billion Partnership for Global Infrastructure and Investment (PGI) initiative to address the global infrastructure gap. Since December, PGI announced U.S. investments totaling more than $1.5 billion in the Lobito Corridor for transportation, digital access, agricultural and clean energy infrastructure projects…




**Where are the ESG Principles for investing?**

**Where will the copper and cobalt concentrates be processed (smelted) into Cu&Co metal?**

https://www.whitehouse.gov/briefing-room/statements-releases/2023/12/13/fact-sheet-accelerating-the-u-s-africa-partnership-after-the-2022-u-s-africa-leaders-summit/




# SPECIALTY/CRITICAL = BY-PRODUCTS

# Scandium

**Economically viable destinations of complex EoL designed functional material combinations, scrap, residues etc. to metallurgical processing infrastructure (each segment) to produce refined metal, compounds and alloys in best available technology**

**Circular Economy's carrier metals processing infrastructure**
Extractive Metallurgy's Backbone, the enablers of a Circular Economy (CE) as it also recovers technology elements used e.g. in renewable energy infrastructure, IoT, eMobility etc.

**Dissolves mainly in carrier metal if metallic (mainly pyrometallurgy)**
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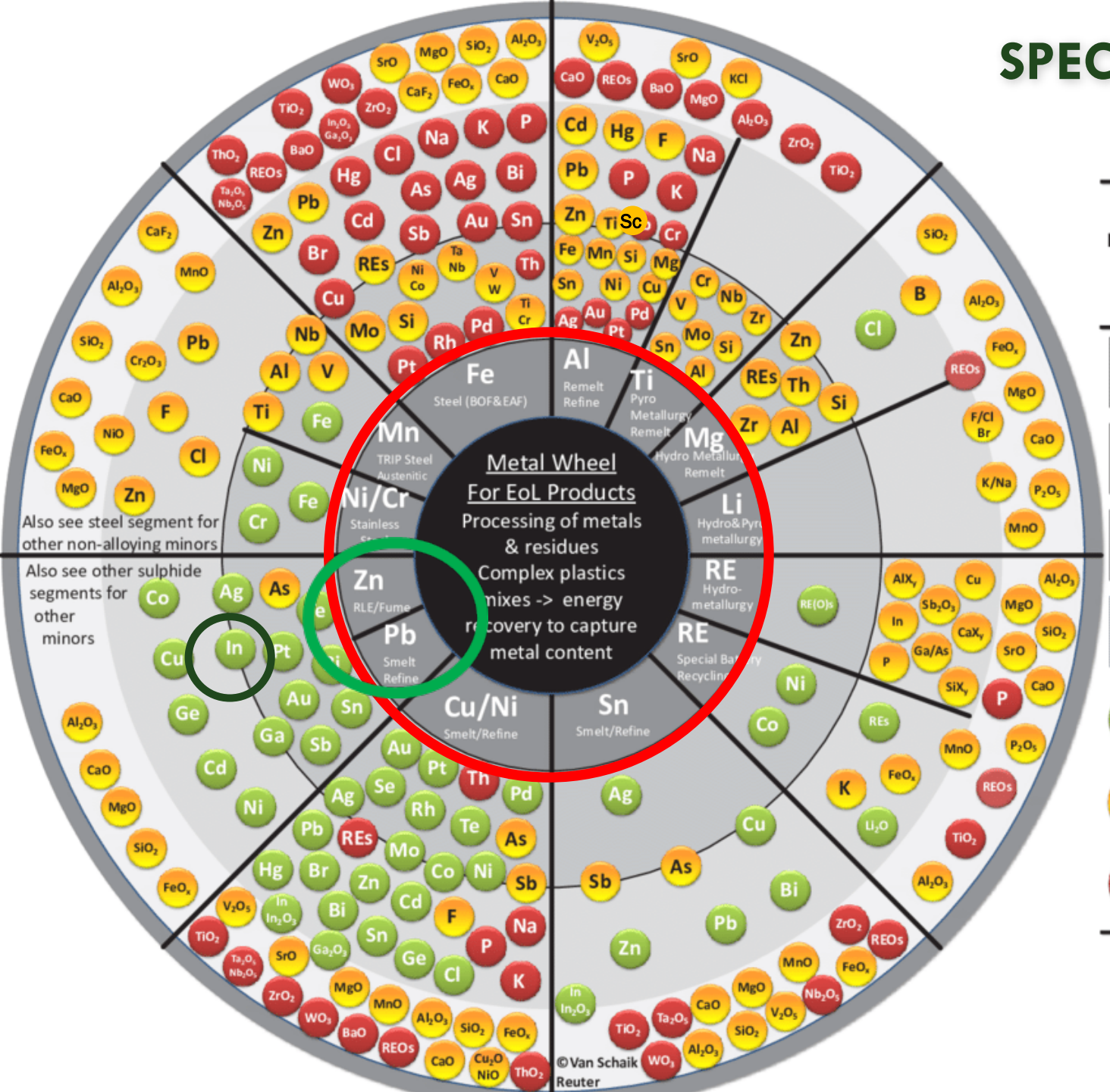
# Red Mud

# RECOVERING SCANDIUM FROM WASTE PRODUCT

- **Scandium occurs in the waste product of aluminum processing – referred to as Red Muds**
- **A new source of the Scandium-Aluminum alloy will create a market's "Pull Demand" and grow the appetite for the product.** However, the scandium that Rio Tinto is planning to produce is only a fraction of the market's demand, as their waste streams only contain **15 - 20 ppm** scandium, and it will likely be used by their internal aluminum division to produce high-value scandium-aluminum alloys. Therefore, it is opening up opportunities for our Crater Lake Scandium Project, also located in the heart of the aluminum production area of Quebec.
- **This development will stimulate new product and R&D activities related to scandium in the province**, providing it with global leadership in the space.
- **The Rio Tinto's announcement is an important sign of support and recognition** of the importance of scandium as a next-generation aluminum alloy additive, while the Canada-US Collaborative Agreement on Critical Metal Development will provide incentives to the Governments to support the development of the sector.
- **Scandium Oxide** is priced at ~$5000/kg. Red Muds have already been mined and milled so just the extraction costs apply to produce scandium oxide.
- **However, need Low-cost energy**

# SPECIALTY/CRITICAL = BY-PRODUCTS

# Indium

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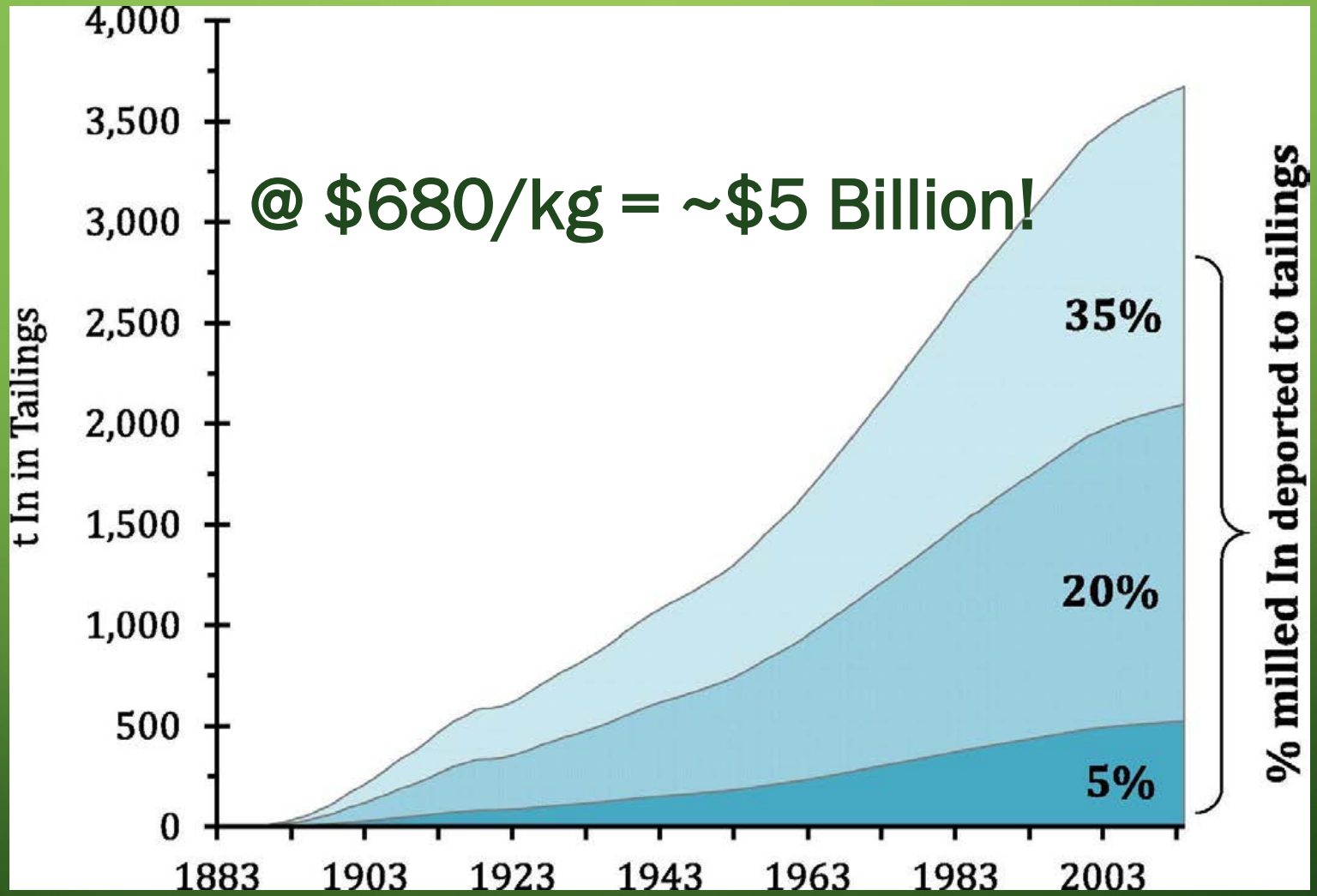
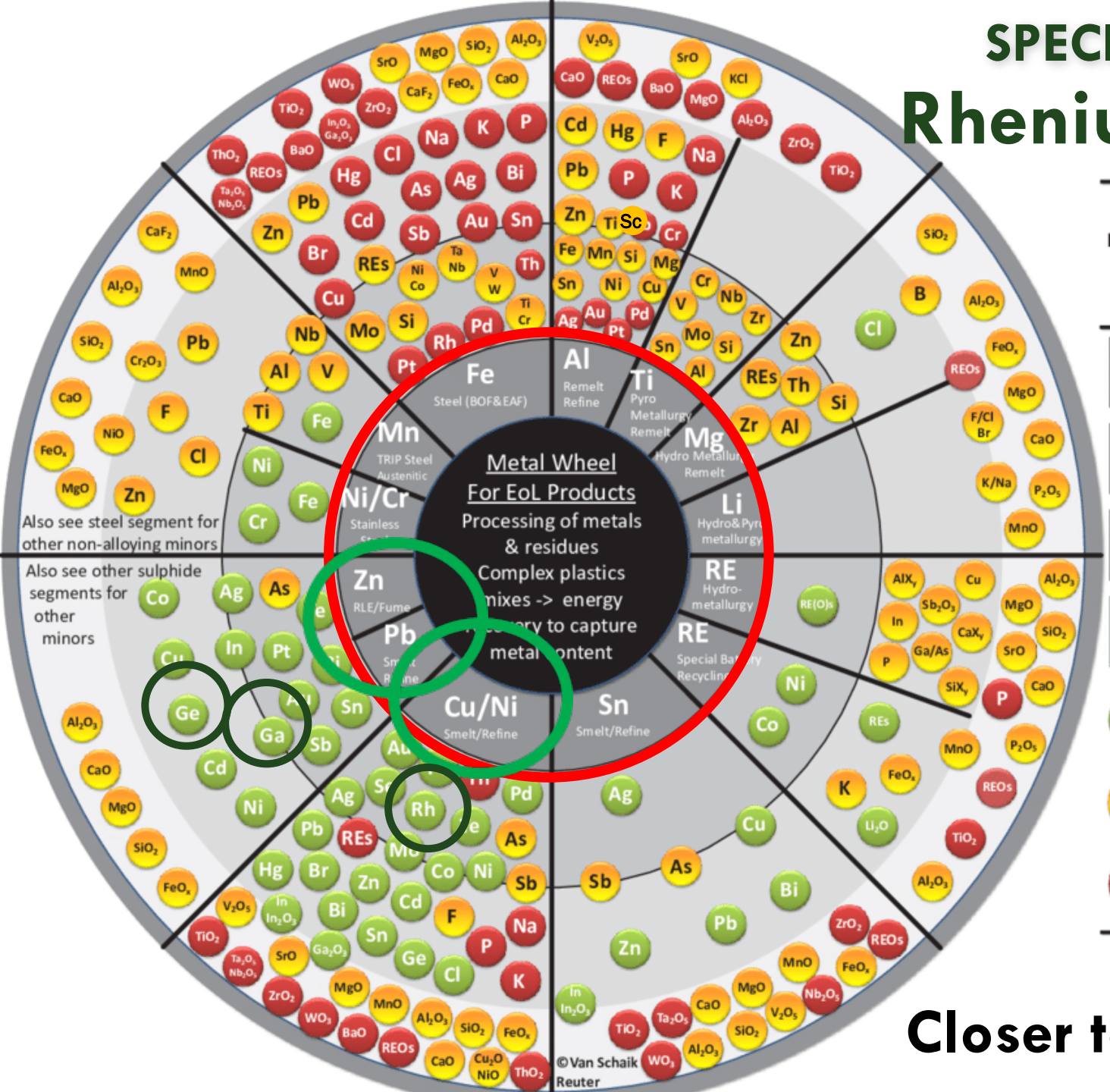
# Research Opportunity

# ESTIMATES OF AMOUNT OF INDIUM DEPORTING TO TAILINGS FROM LEAD-ZINC PROCESSING IN AUSTRALIA



## SPECIALTY/CRITICAL = BY-PRODUCTS

# Rhenium-Germanium-Gallium

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**Circular Economy's carrier metals processing infrastructure**
Extractive Metallurgy's Backbone, the enablers of a Circular Economy (CE) as it also recovers technology elements used e.g. in renewable energy infrastructure, IoT, eMobility etc.

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## Closer to home in Alaska and the US

# GERMANIUM, RHENIUM, AND GALLIUM AS BY-PRODUCT METALS


- Extraction may or may not take place at smelters/refineries

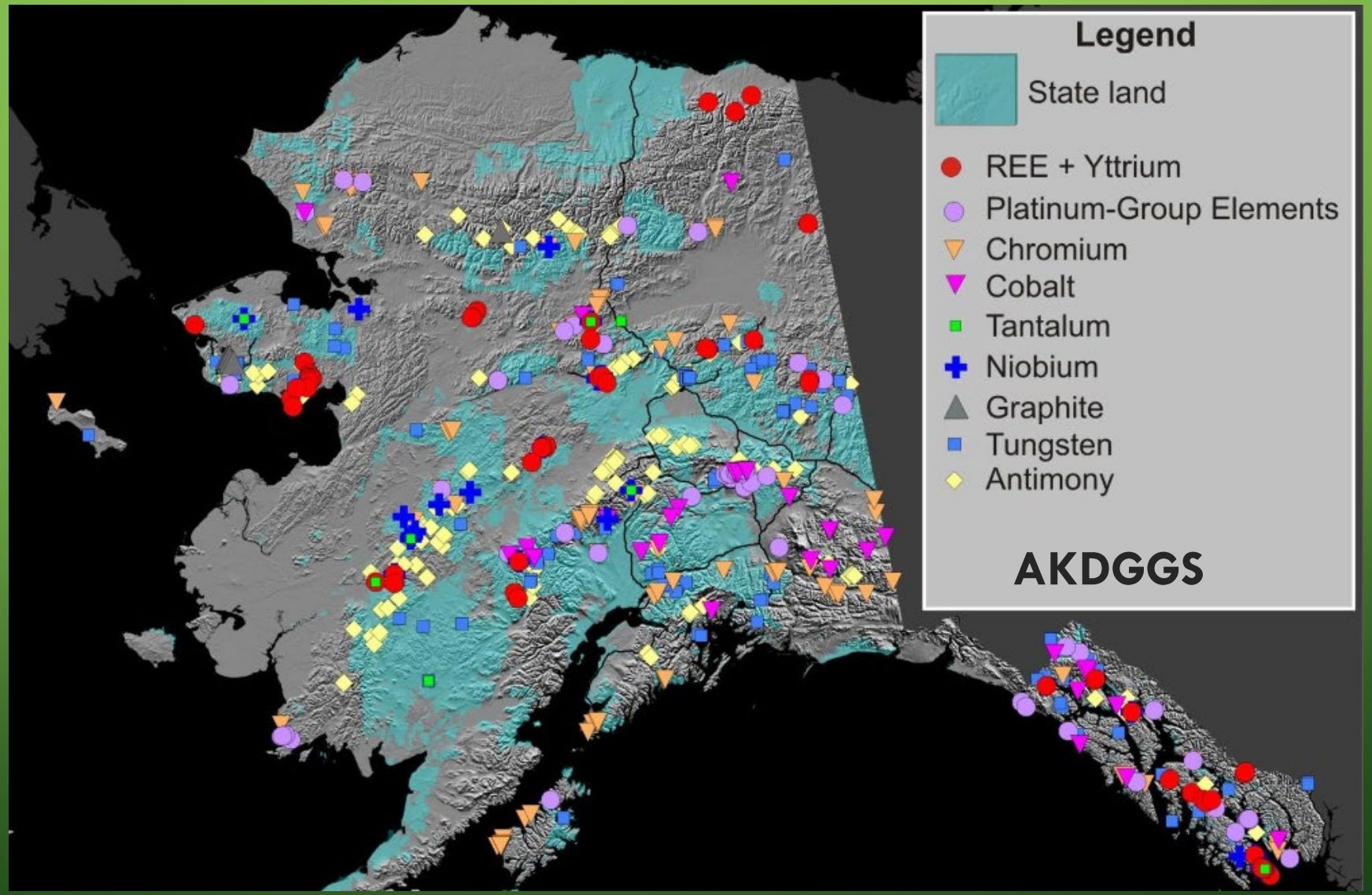
➔ Red Dog Pb-Zn mine in NW Alaska produces Germanium (US$2,200/kg) as a by product

➔the US produces no Gallium – China 90% Potentially could be extracted from Zinc ores, Bauxite and Coal…Gallium @ US$7500/kg and consumption of Ga is expected to grow 10X by 2032 ➔ Let's figure it out!

- Don't have a good handle on reserves/resource

➔ Sierrita Copper mine in Arizona produces Rhenium but does not report either a resource or reserve for Rhenium (US$2,844/kg)

# BRINGING IT BACK HOME TO ALASKA




https://dggs.alaska.gov/energy/download/core-cm/05-masterman-core-cm-objectives-and-overview.pdf

# US GOVT POLICY CONUNDRUM

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## BLM Alaska Mining and Minerals

https://www.blm.gov/programs/energy-and-minerals/mining-and-minerals/about/alaska

## Biden administration makes final decision rejecting Ambler Access Project in Alaska

A BLM record of decision made formal the rejection announced in April, and the agency also backs continued ban on development for 28 million acres

BY: **YERETH ROSEN** - JUNE 28, 2024 1:14 PM

# MINERALS ARE CRITICAL TO A RENEWABLE FUTURE

*Alaska holds untapped resources*

Renewable energy, next-gen battery and fuel cells, and ultra-strong, ultralight materials all depend on mineral resources.

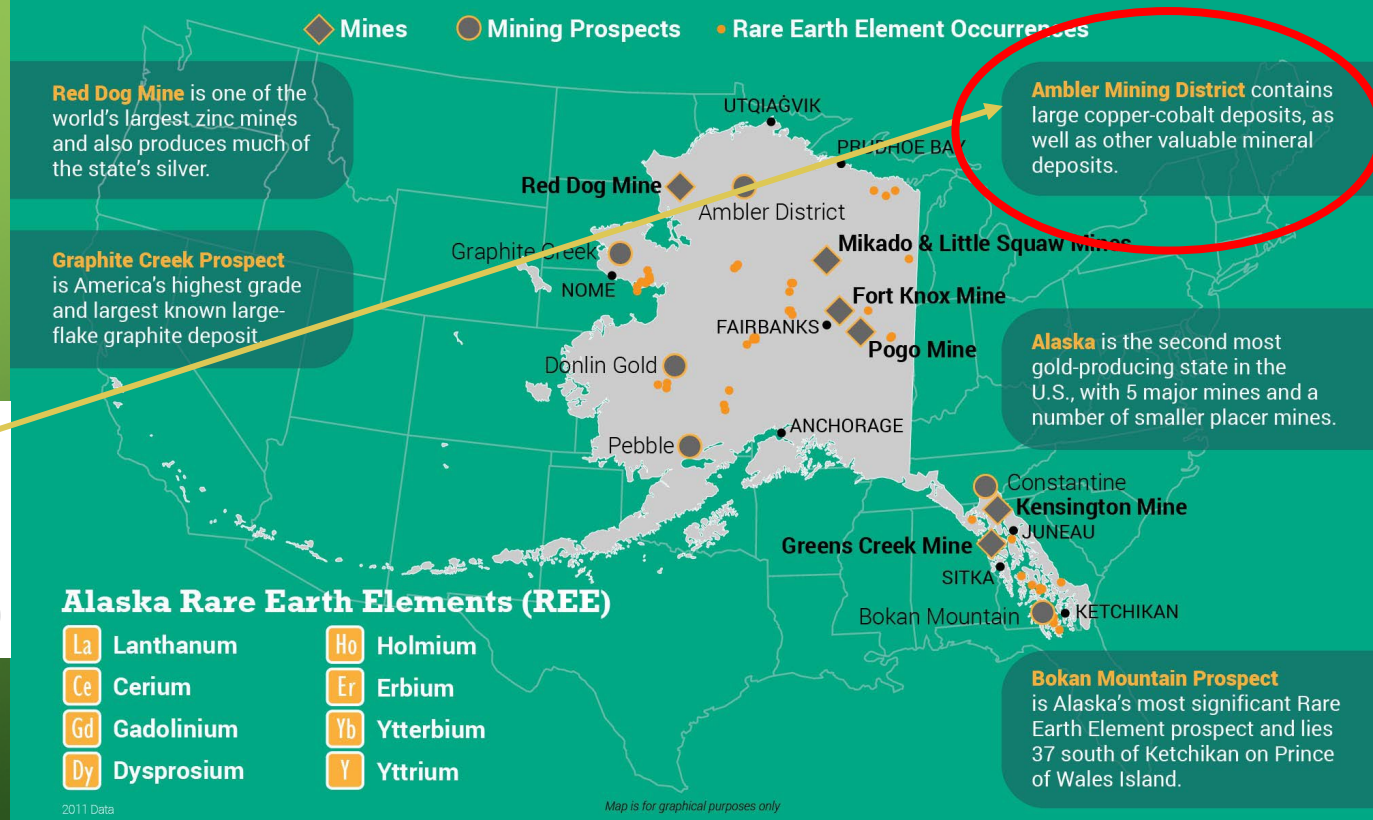
Determining what the nation has and the feasibility of responsibly extracting it are starting points for securing the minerals we need now to build a renewable future.

Alaska's vast mineral resources may help decrease national reliance on imports while protecting the Earth under some of the most stringent environmental laws in the world.

### Even green tech generates waste

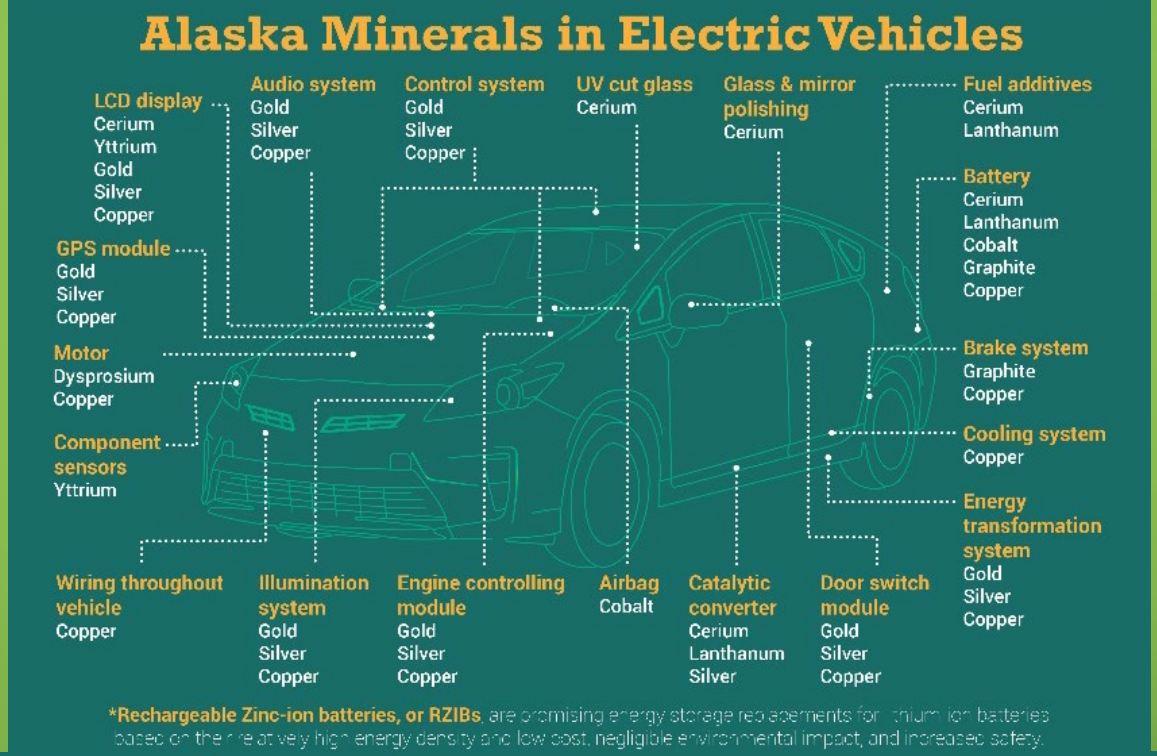
Considering that fewer than 5% of lithium-ion batteries were recycled worldwide in 2019, for example, we can all do better at recycling the critical minerals already mined to reduce e-waste. Thinking "Recycling before re-mining" is a good place to start.

## Alaska Critical Mineral Locations

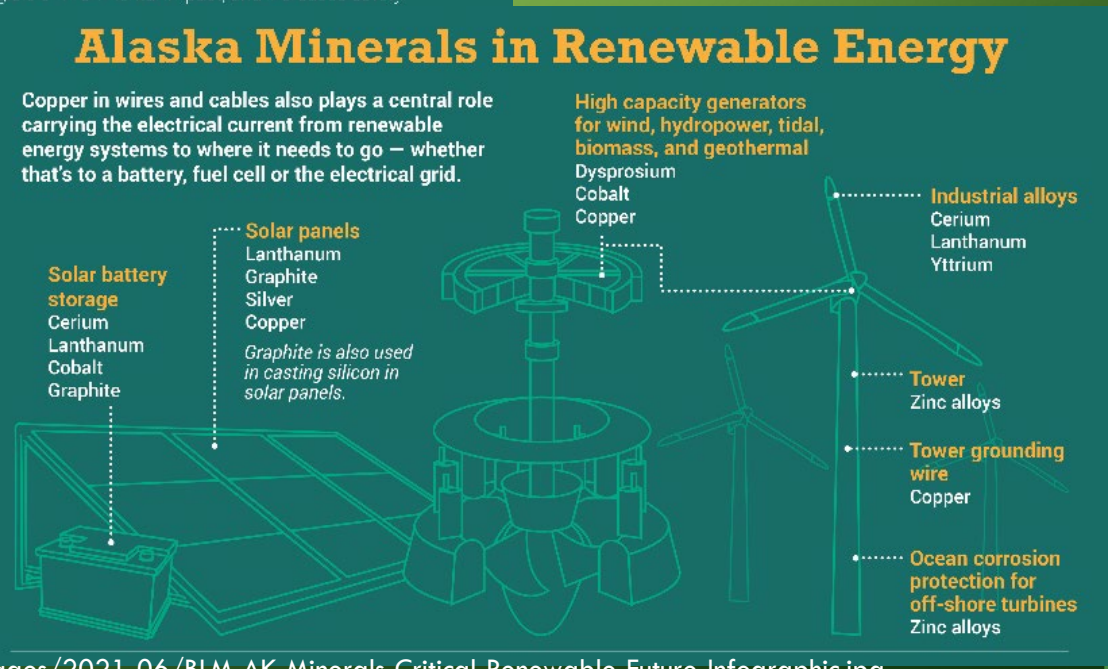


WOW!

WT…?





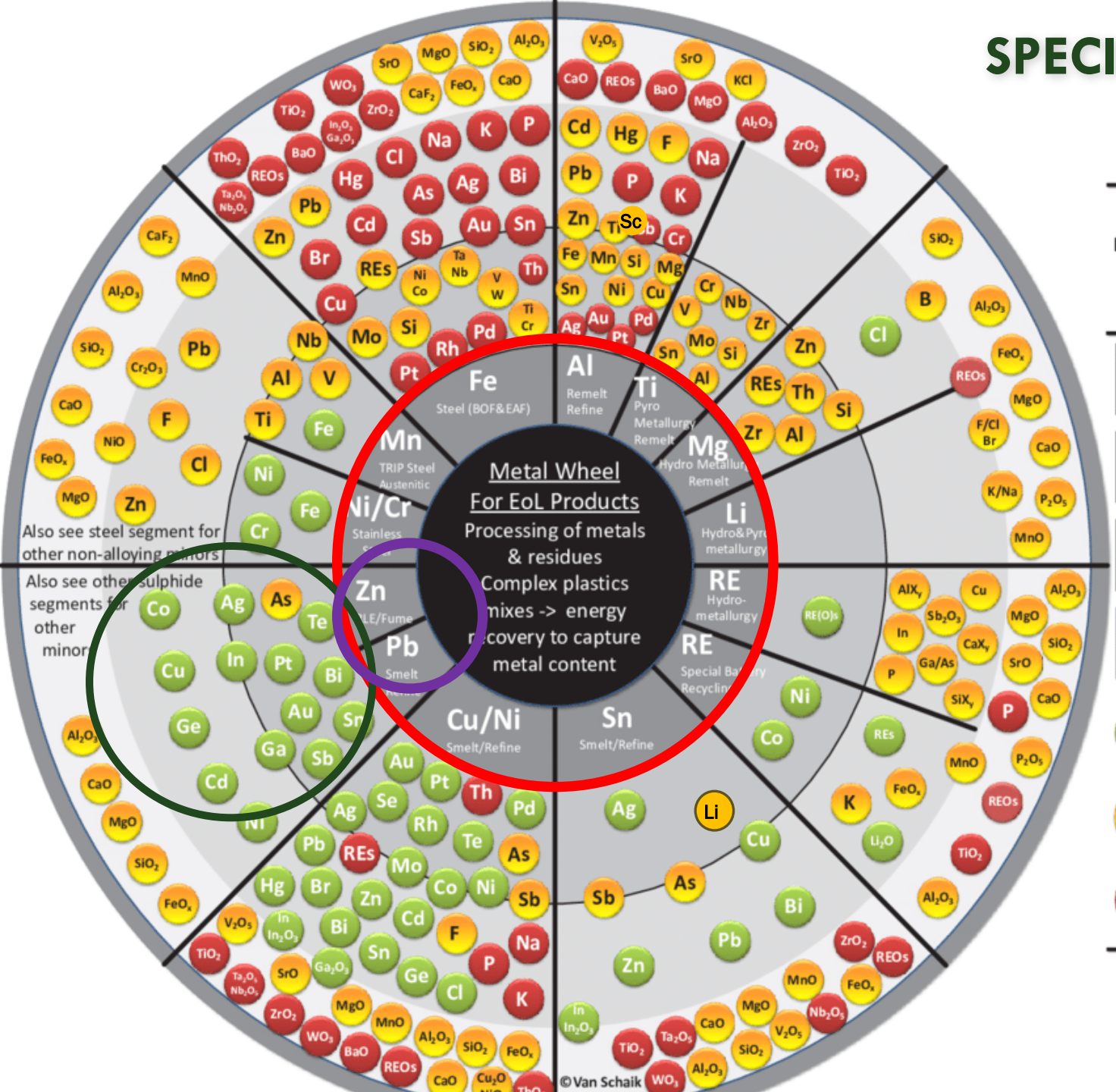



www.blm.gov/alaska/minerals

https://www.blm.gov/sites/default/files/images/2021-06/BLM-AK-Minerals-Critical-Renewable-Future-Infographic.jpg

# SPECIALTY/CRITICAL = BY-PRODUCTS

# Lead-Zinc

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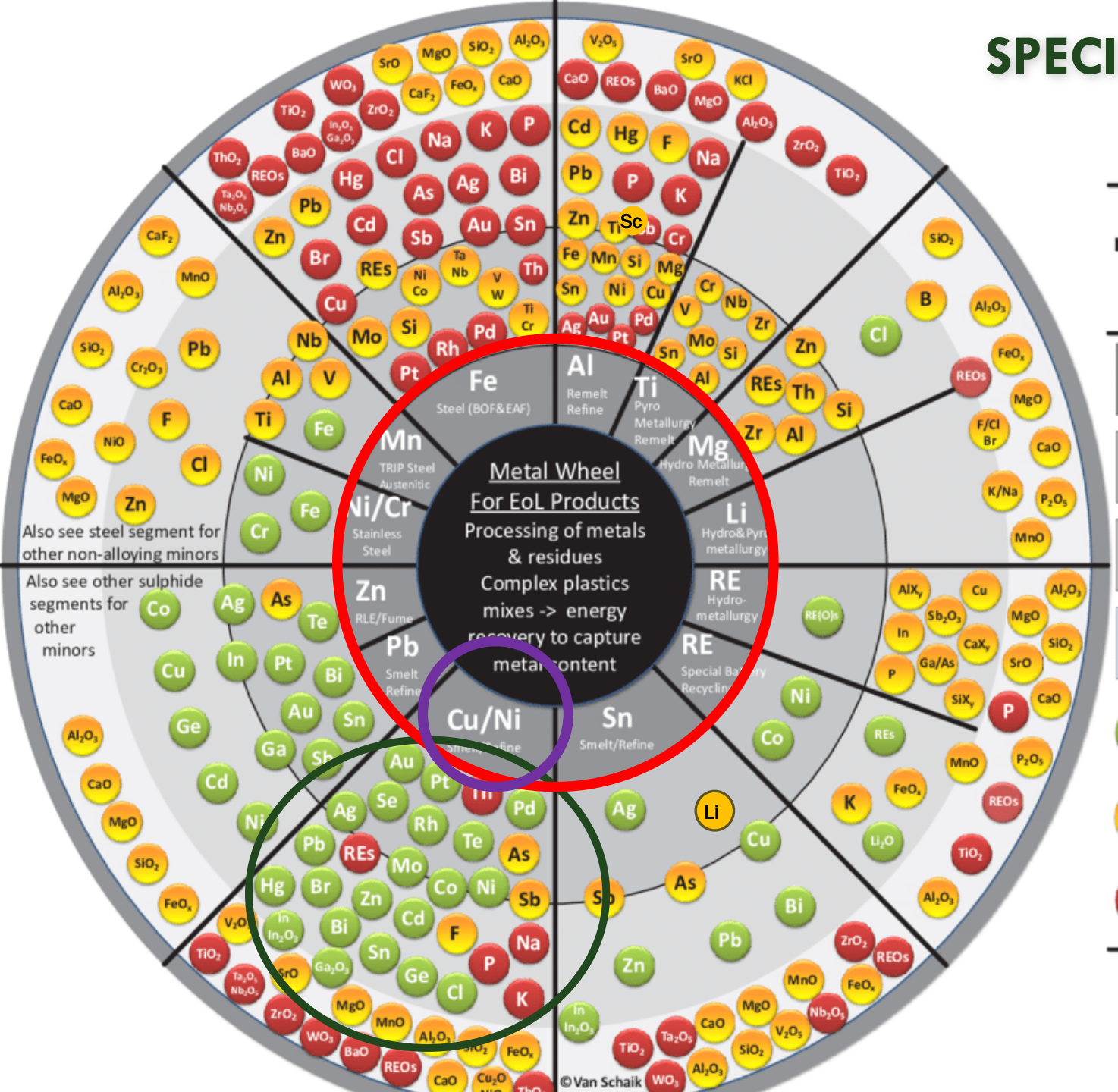
# Copper-Nickel

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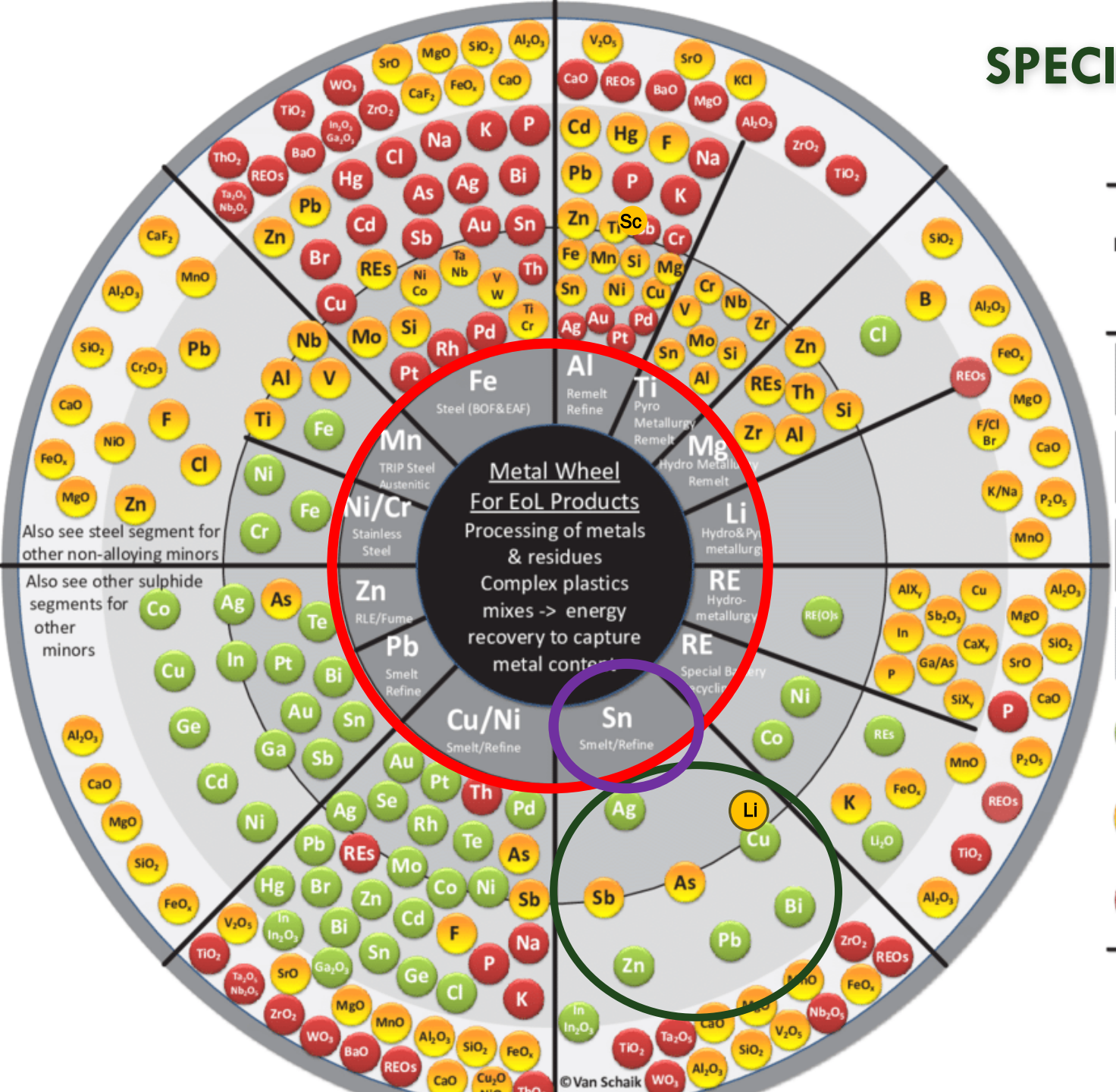
# Tin-Tungsten

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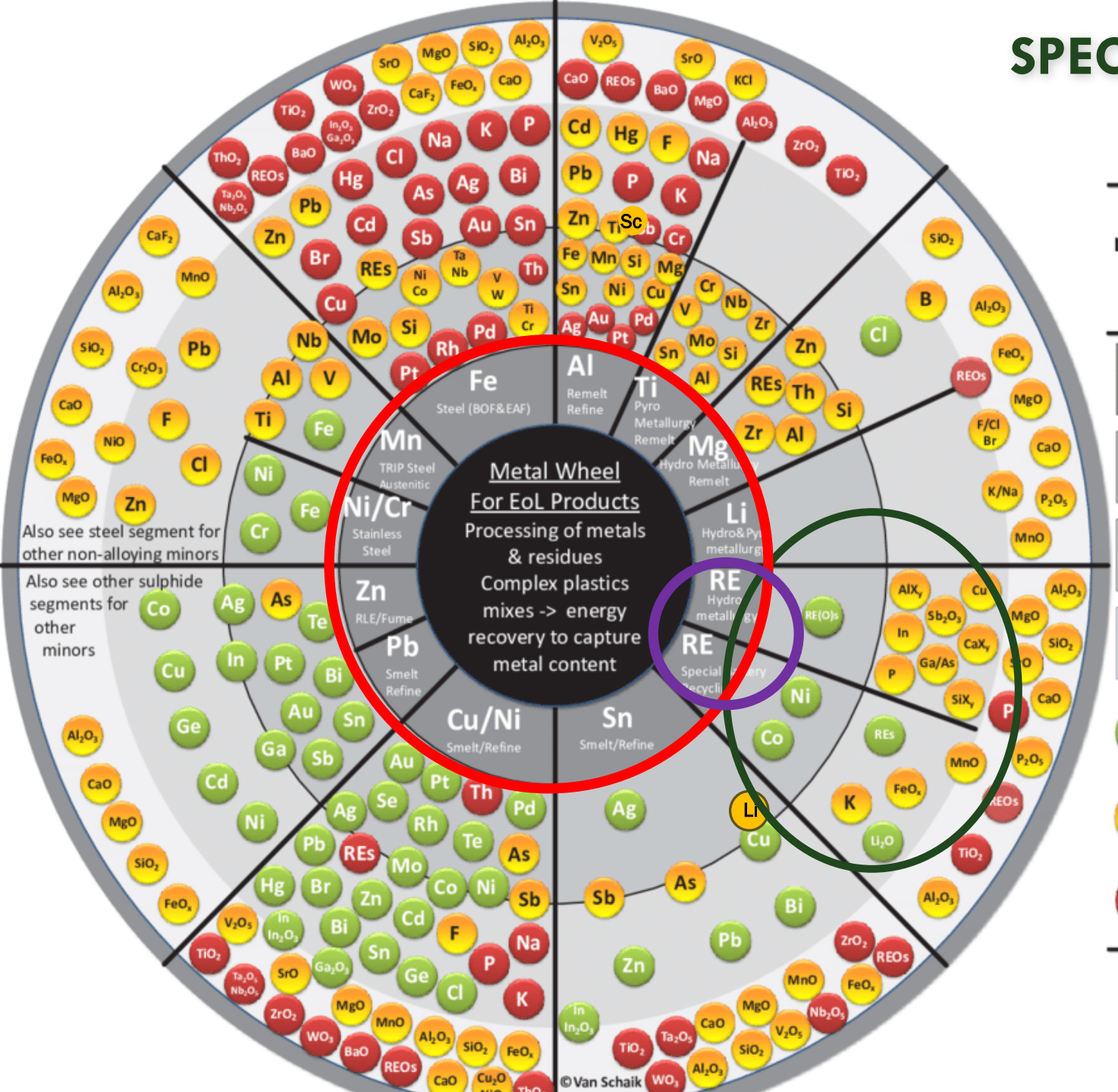
# Uranium-REE

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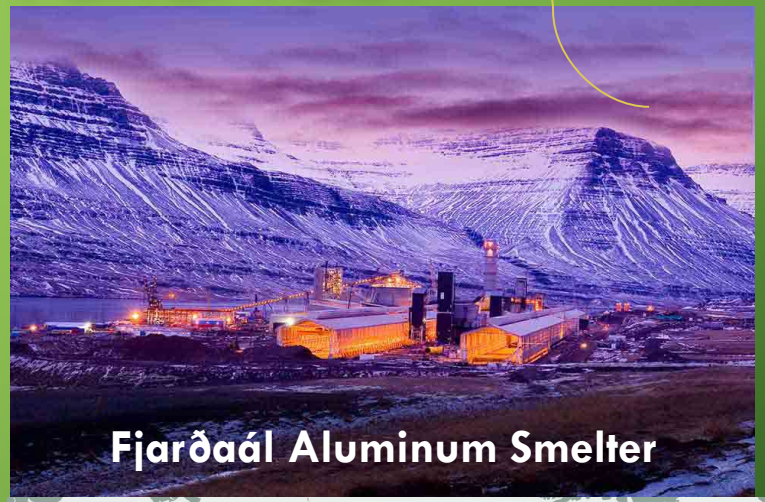
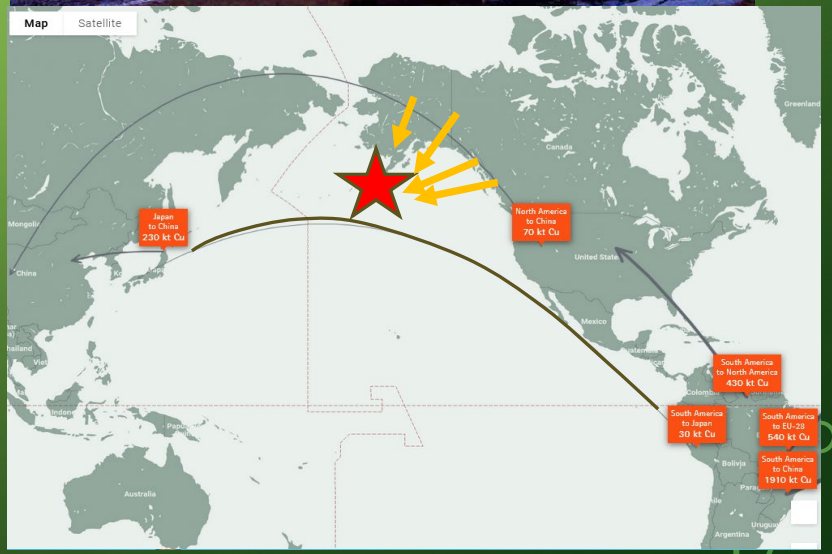
# CRITICAL METALS: HOW CAN ALASKA MAKE A DIFFERENCE?

- Be like Iceland!
  - Iceland is one of the highest ESG-rated countries in the world
  - Iceland is a major producer of Aluminum and yet they possess no Aluminum ore (Bauxite) – sourced from South America and Africa
  - How? ➔ Low-cost Power – Hydro/Geothermal
- Be part of the **Solution!!!**
- Build a Hydro/Geothermal or Coal with Carbon Capture technology to power hydrometallurgical facility in the Aleutians or elsewhere in Alaska!
  ➔ Clean Cheap Power
  - Cheap Power is key to be competitive processing raw materials
  - Results in good quality jobs
  - Cheap Power could also result in better quality food sourced locally
  - Yields a better quality of life
- Alaska could mine the raw materials and add value by producing/processing metals in Alaska – especially Critical Metals!




**WOULDN'T GOOD JOBS, CHEAP POWER, AND A BETTER FUTURE BE WHAT WE WANT FOR OUR FUTURE GENERATIONS?**


QUESTIONS?
THANK YOU

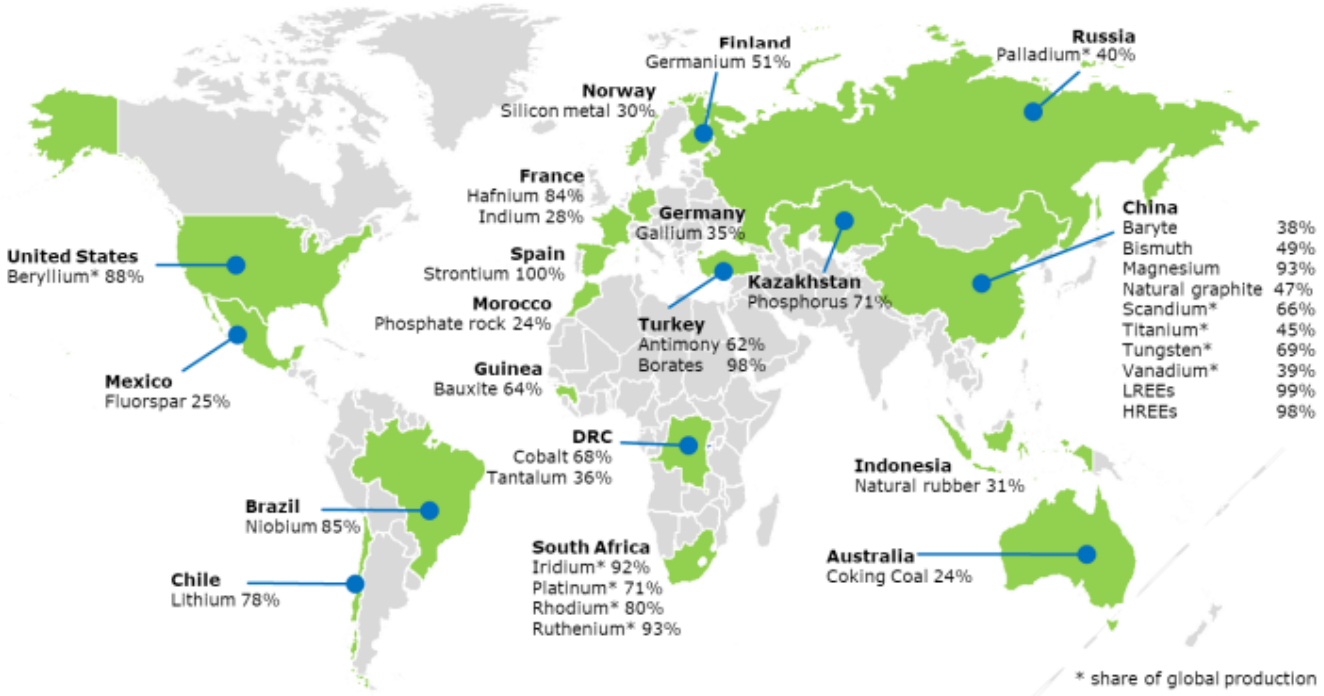
# APPENDIX SLIDES - HIDE

# EUROPEAN UNION LIST OF CRITICAL RAW MATERIALS (CRMS)

**List of EU Critical Minerals**
**Why isn't Copper on this list….since none of the other metals work without Copper!?**

**Poland has huge copper reserves…….right next to Russia**

| 2020 Critical Raw Materials (new as compared to 2017 in bold) | | |
|---|---|---|
| Antimony | Hafnium | Phosphorus |
| Baryte | Heavy Rare Earth Elements | Scandium |
| Beryllium | Light Rare Earth Elements | Silicon metal |
| Bismuth | Indium | Tantalum |
| Borate | Magnesium | Tungsten |
| Cobalt | Natural Graphite | Vanadium |
| Coking Coal | Natural Rubber | **Bauxite** |
| Fluorspar | Niobium | **Lithium** |
| Gallium | Platinum Group Metals | **Titanium** |
| Germanium | Phosphate rock | **Strontium** |




## EU Formula for Determining Criticality

Economic importance (EI) $EI = \sum (As\ s * Qs) * SIE$

Substitution index (SIEI) $SIEI = \sum\sum SCPi,a\ a * Subsharei,a * Share$

Supply risk (SR)
$SR = [(HHIWGI,t)\ GS \cdot IR\ 2 + (HHIWGI,t)\ EUsourcing\ (1 - IR\ 2\ )] \cdot (1 - EoLRIR) \cdot SIS$

Importance Reliance
$Import\ Reliance\ (IR) = Import — Export\ Domestic\ production + Import — Expor$