IDAHO GEOLOGICAL SURVEY

Critical Minerals, National Security and Energy/Technology Transition:

The Idaho Opportunity

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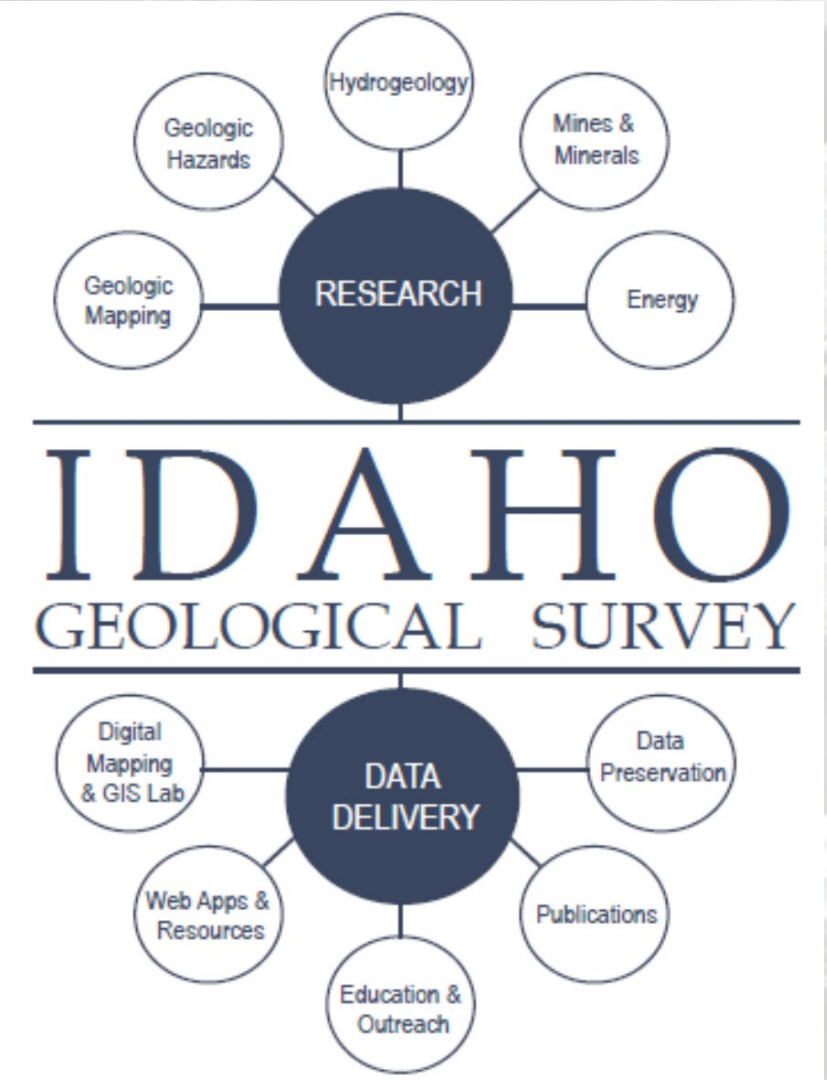
THE IDAHO GEOLOGICAL SURVEY (IGS)

"The survey shall be the **lead state agency** for the collection, interpretation, and dissemination of geologic and mineral data for Idaho".



IGS's Statutory Authority is found in **Title 47, Chapter 2** of the Idaho State Statute, to be administered as a special program at the University of Idaho.

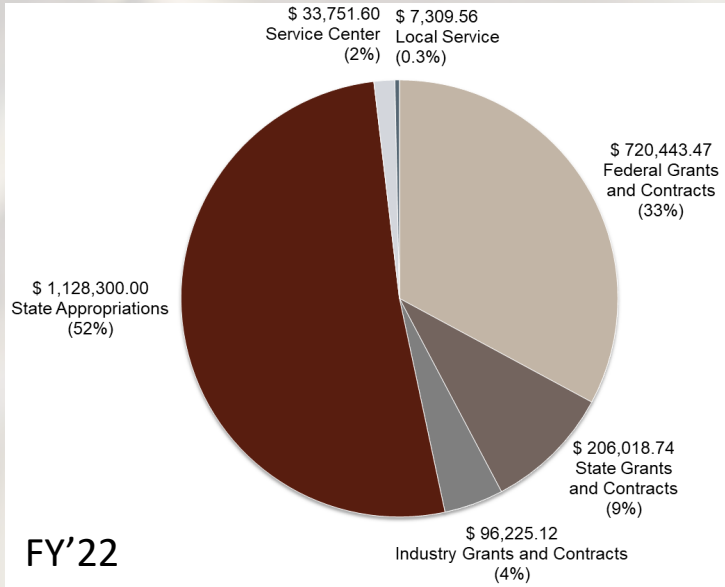
OUR MISSION:

Non-regulatory.

Members of the IGS fulfill this mission through applied geologic research and strong collaborations with federal and state agencies, academia, and the private sector.

IGS research focuses on geologic mapping, geologic hazards, hydrogeology, geothermal energy, oil and gas, and metallic and industrial minerals.

The IGS is also engaged in the dissemination of historic mining records, community service, and earth science education.

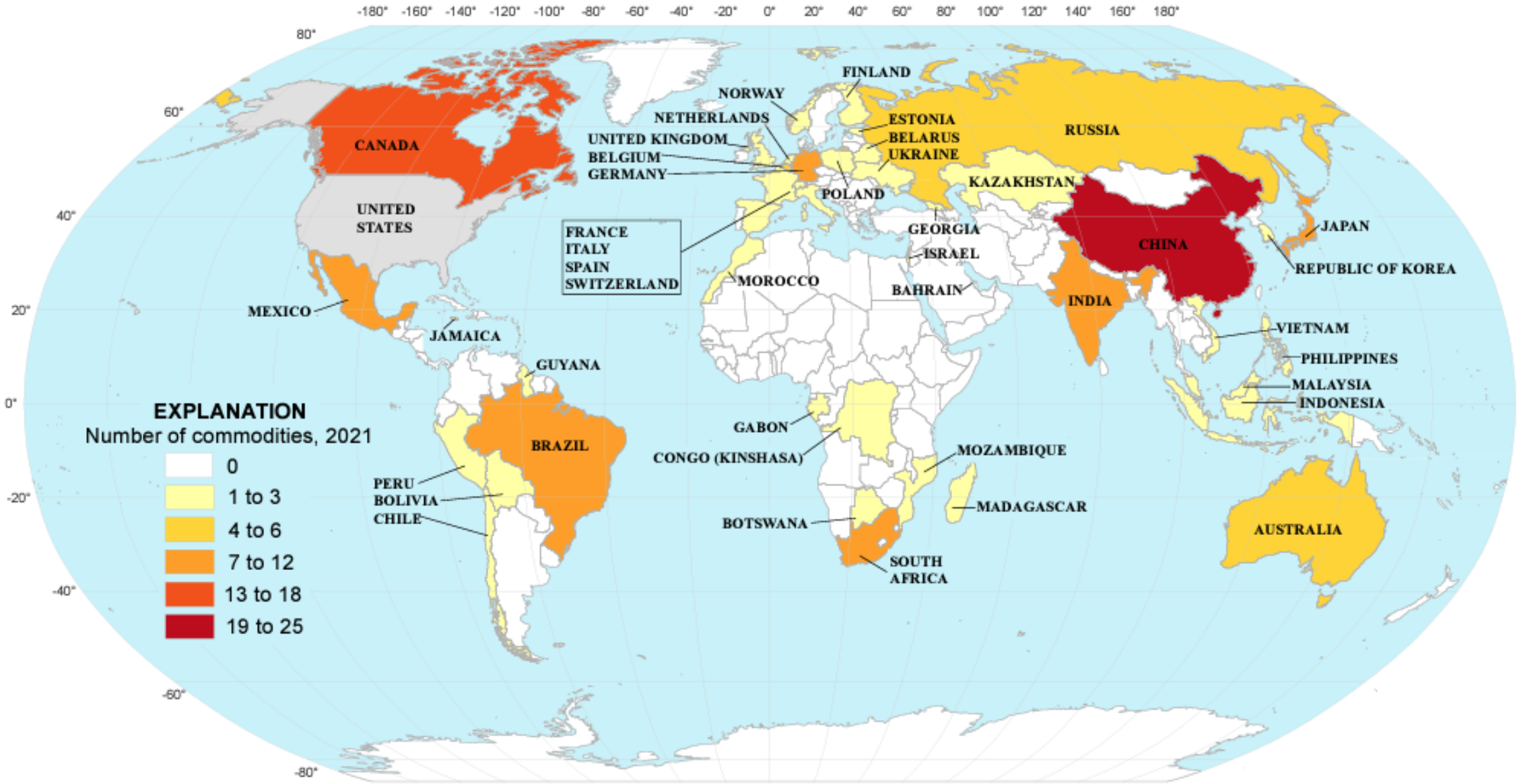


The Energy Act of 2020 defines a “critical mineral” as a **non-fuel** mineral or mineral material **essential** to the economy or national security of the U.S. and which has a **supply chain vulnerable to disruption**. Critical minerals are also characterized as serving an essential function (strategic)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

aluminium	antimony	arsenic	barite	beryllium
bismuth	cerium	cesium	chromium	cobalt
dysprosium	erbium	europium	fluorspar	gadolinium
gallium	germanium	graphite	hafnium	holmium
indium	iridium	lanthanum	lithium	lutetium
magnesium	manganese	neodymium	nickel	niobium
palladium	platinum	praseodymium	rhodium	rubidium
ruthenium	samarium	scandium	tantalum	tellurium
terbium	thulium	tin	titanium	tungsten
vanadium	ytterbium	yttrium	zinc	zirconium

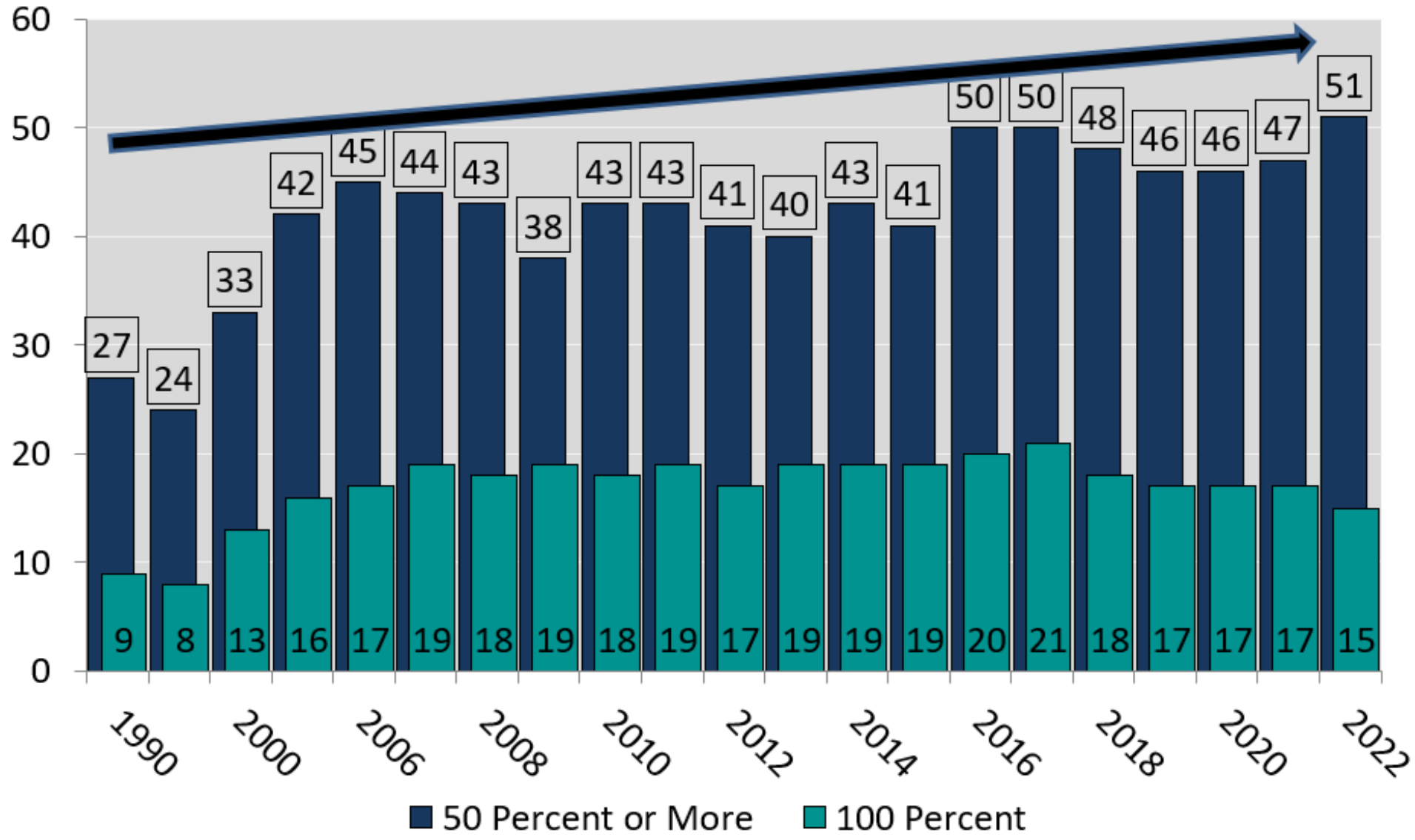
2022 list of critical minerals

Major Import Sources of Nonfuel Mineral Commodities for Which the United States was Greater Than 50% Net Import Reliant in 2021



Source: U.S. Geological Survey

U.S. Mineral Import Reliance



Source: USGS Mineral Commodity Summaries 1990-2023 editions

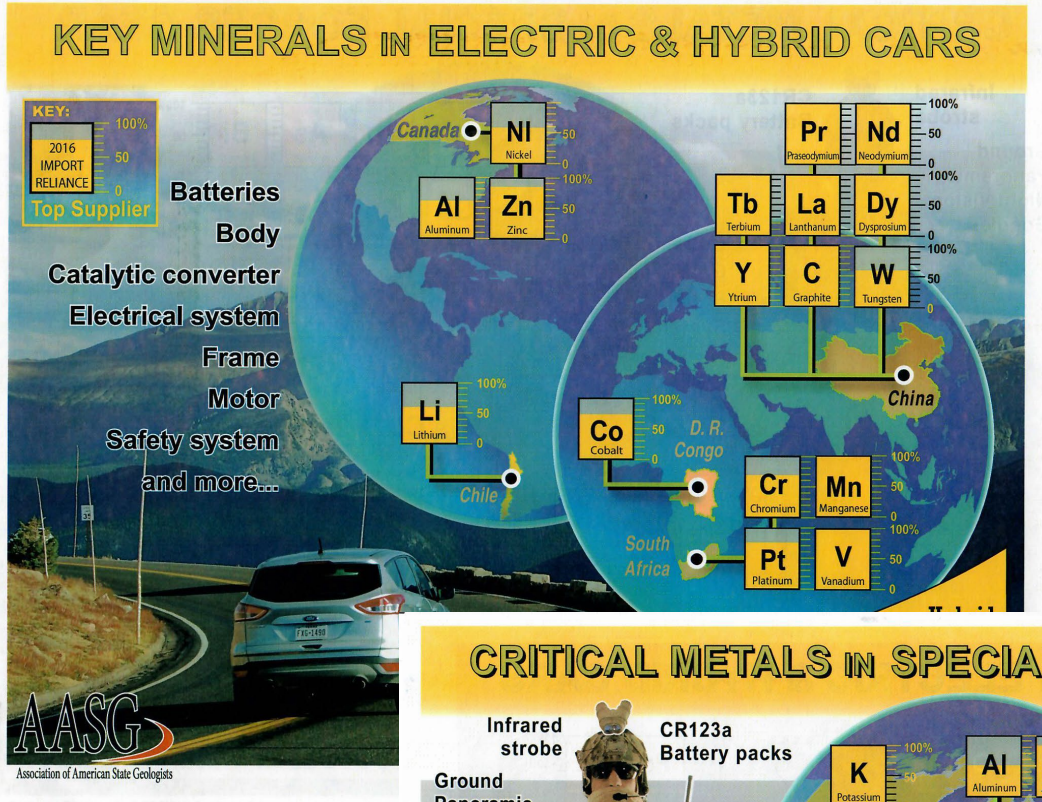
NMA National Mining Association

Uses of Critical Minerals

~ 2,000lbs of Rare Earth Elements

~ 1,000lbs of Rare Earth Elements

~ 20lbs of Cobalt
400lbs of minerals



AIR&SPACE FORCES MAGAZINE

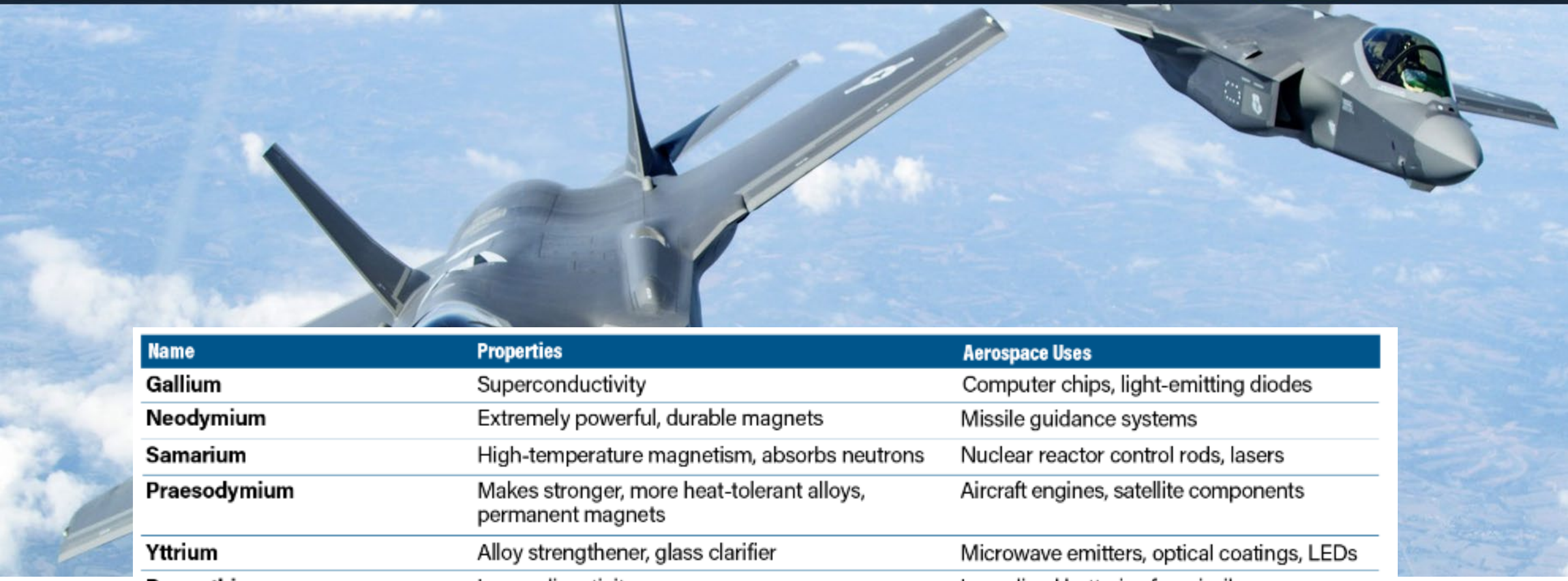
Each F-35 contains more than 900 pounds of rare earth elements, which are crucial to targeting, communications, and other systems. China has sought to dominate markets for mining and refining these materials. Here, two F-35 Lightning IIs bank over the U.S. Midwest on Sept. 19, 2019. Master Sgt. Ben Mota

Photo Caption & Credits

Rare Elements of Security

By Alyk Russell Kenlan | Nov. 1, 2020

Each F-35 contains about 1000 pounds of rare earth elements!



Name	Properties	Aerospace Uses
Gallium	Superconductivity	Computer chips, light-emitting diodes
Neodymium	Extremely powerful, durable magnets	Missile guidance systems
Samarium	High-temperature magnetism, absorbs neutrons	Nuclear reactor control rods, lasers
Praesodymium	Makes stronger, more heat-tolerant alloys, permanent magnets	Aircraft engines, satellite components
Yttrium	Alloy strengthener, glass clarifier	Microwave emitters, optical coatings, LEDs
Promethium	Low radioactivity	Long-lived batteries for missiles
Lanthanum	Glass clarifier, reacts with hydrogen	Optics and lenses, night-vision goggles, fuel cells
Europium	Phosphorescence	LEDs, plasma displays

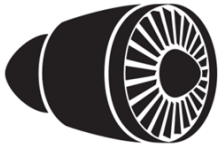
How important are minerals to our national defense?

750k tons

The DoD uses up to 750,000 tons of minerals annually in the manufacture of military gear, weapon systems and other defense applications.

GIVING AIRMEN & AIRWOMEN FLIGHT:
Aircraft and Fighter Jets

SILVER is a key resource for military aircraft like the Air Force's C17 and the Army's Apache Helicopter because it is malleable and ductile while also being one of the strongest of the known elements.



RARE EARTH MINERALS are used in the manufacturing of jet engines.

BERYLLIUM'S lightweight properties make fighter jets faster.

80% of aircraft, including fighter jets like the F-16, are made of **ALUMINUM** because it is lightweight and improves fuel efficiency.

HELPING SOLDIERS SEE IN THE DARK:
Night-Vision Goggles and Surveillance

RARE EARTH MINERALS like lanthanum are used to make night-vision goggles.

21% of BERYLLIUM is used in defense applications, like the technologies used to help detect potential threats.

RARE EARTH MINERALS

RARE EARTHS are used to make infrared absorbing glass.

They are added to camera lenses to improve image clarity.

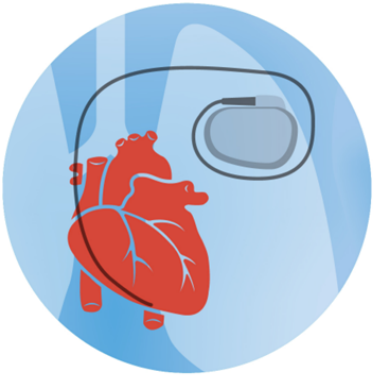
BERYLLIUM

BERYLLIUM'S thermal conductivity improves surveillance capabilities.

It helps produce real-time imagery and targeting for surveillance and makes reconnaissance flights performed by unmanned aerial systems possible.

ENSURING OUR TROOPS ARE HEALTHY:
Medical Technologies

Metals like **TITANIUM** and **MOLYBDENUM** are used to make life-saving surgical implants like stentrodes and prosthetic limbs.



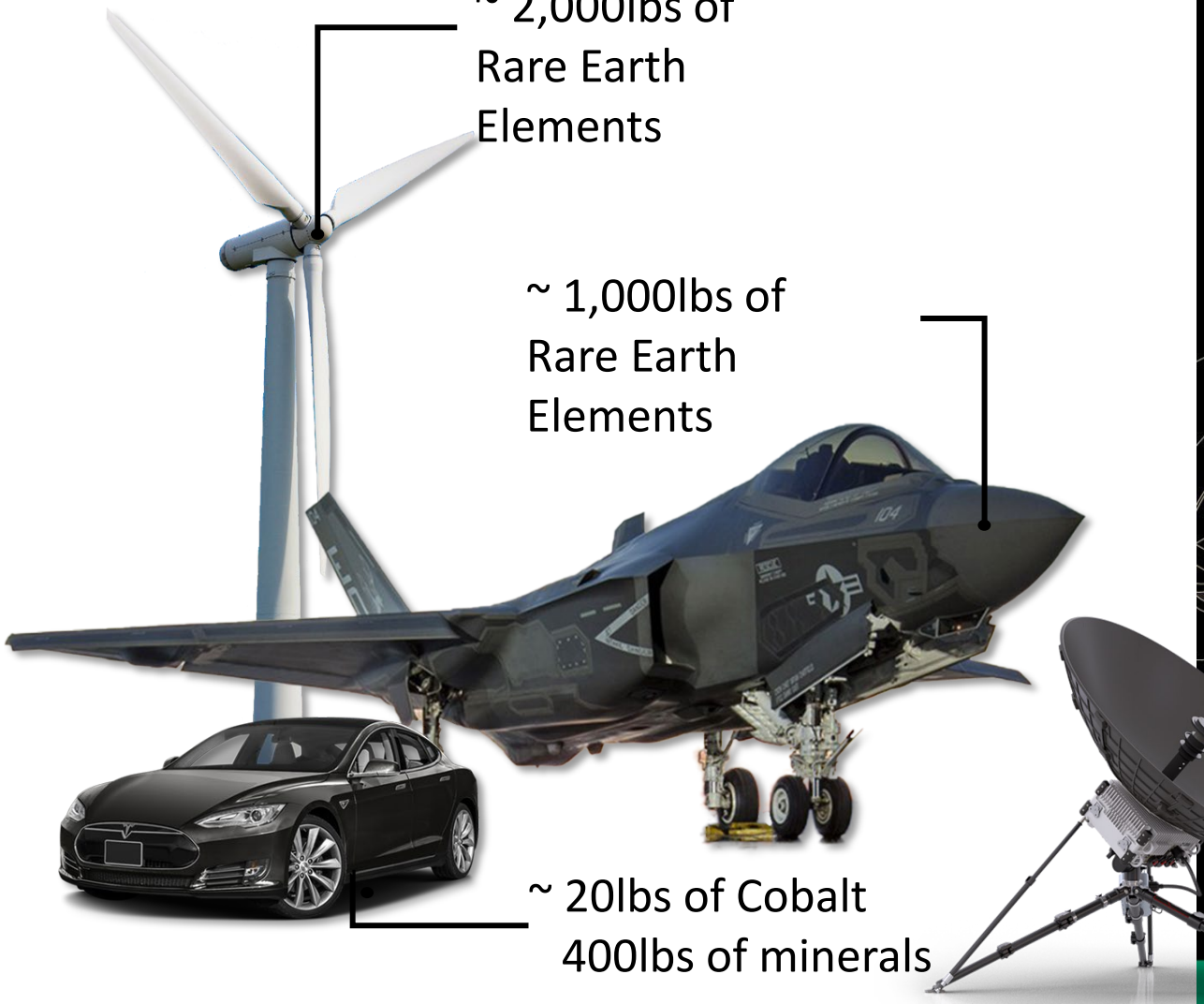
Because of their resistance to corrosion, **PLATINUM GROUP METALS** are frequently found in pacemakers, implantable defibrillators, catheters, stents and neuromodulation devices.

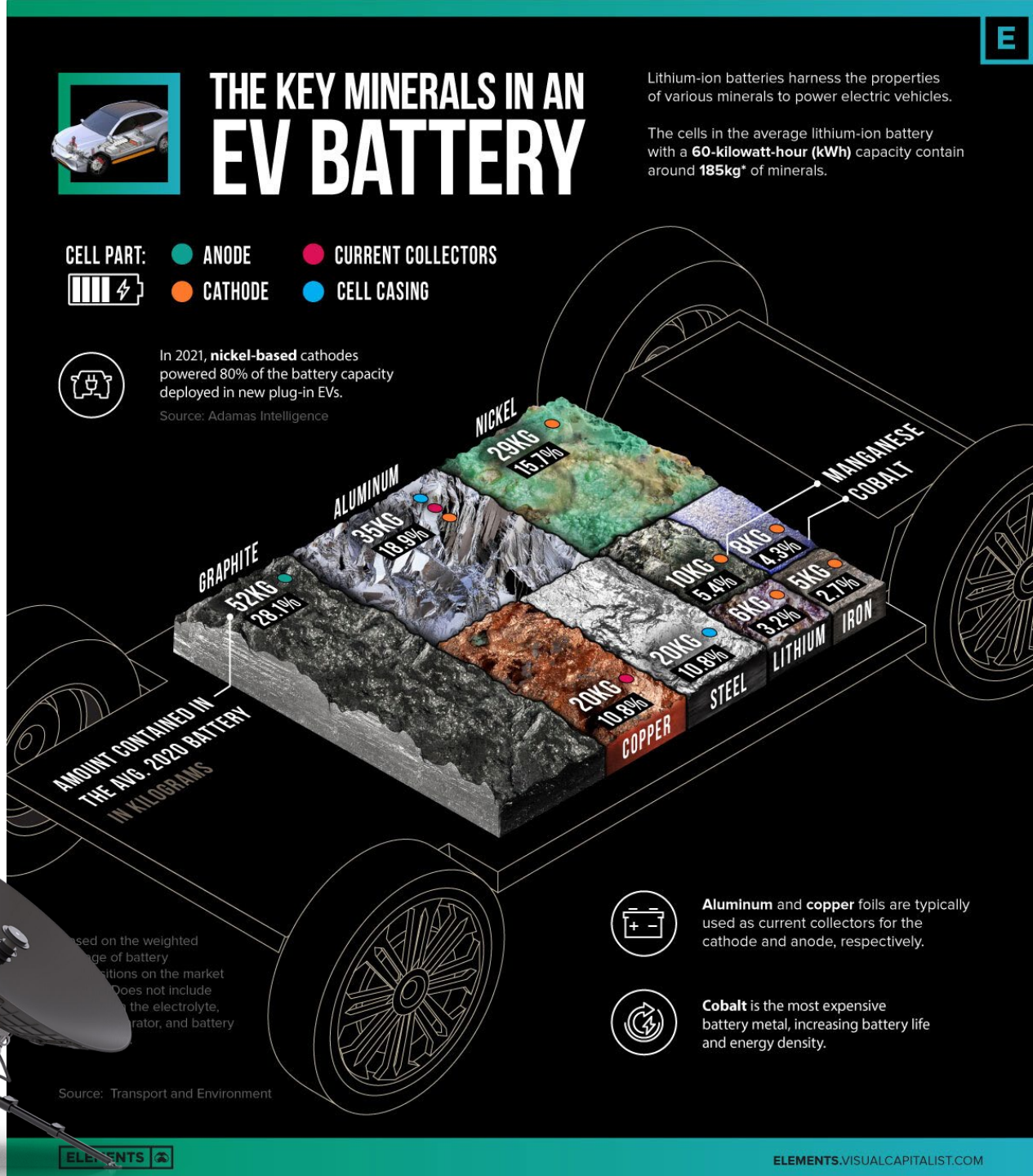
KEEPING OUR TROOPS SAFE:
Body Armor

NICKEL resists corrosion and oxidation and prevents degeneration.

NICKEL'S toughness makes it ideal for body armor because it can withstand harsh impacts.

Uses of Critical Minerals





The Growth of Lithium Consumption

2010-2021

Global consumption of lithium **increased by 283%** between 2010 and 2021.

How has lithium demand changed over the last decade?

2010 23,500t (tonnes)

- Ceramics and glass 7,285t
- Batteries 5,405t
- Lubricating greases 2,350t
- Air treatment 1,175t
- Continuous casting 940t
- Other 6,345t

2021 93,000t

- Batteries 68,820t
- Ceramics and glass 13,020t
- Lubricating greases 2,790t
- Continuous casting 1,860t
- Air treatment 930t
- Other 5,580t

Batteries accounted for 74% of lithium consumption in 2021, up from 23% in 2010.

Lithium-based lubricant greases represent over 70% of global grease production for technical uses.

Source: Albemarle

Glass-ceramic cooktops use lithium to reduce thermal expansion and increase mold strength.

Source: USGS Mineral Commodity Summaries (2022), Minerals Yearbook (2010)

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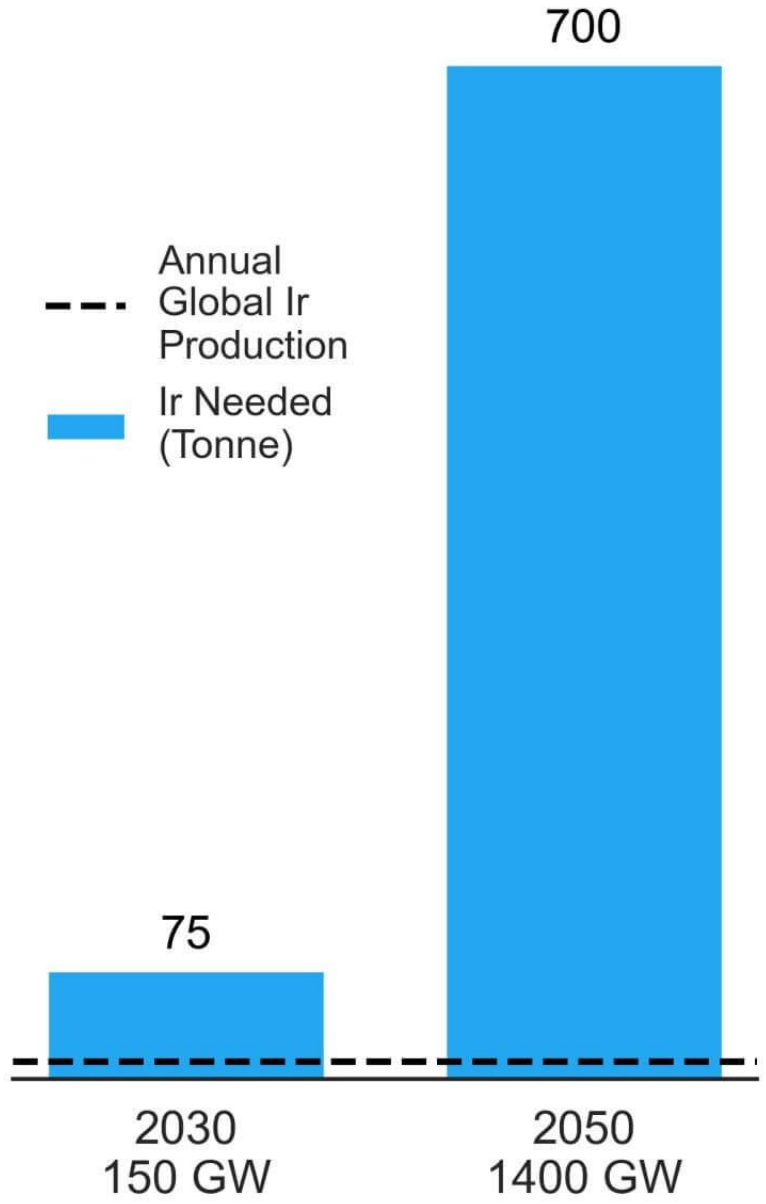
ELEMENTS

ELEMENTS.VISUALCAPITALIST.COM

Iridium needs for Hydrogen Cells electric production



ALL THE METALS WE MINED
IN 2021

The world produced roughly **2.8 billion tonnes** of metals in 2021.
Here are all the metals we mined, visualized on the same scale.

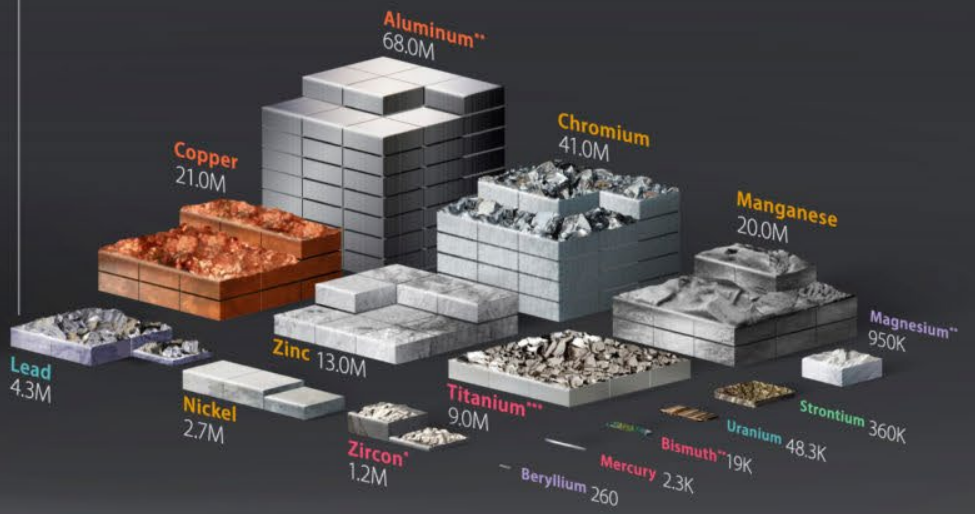
IRON ORE
2,600,000,000 tonnes*

= 1,000,000 tonnes

LARGEST END-USE

- Steelmaking
- Construction
- Chemicals
- Alloying Agents
- Energy/Batteries
- Magnets
- Electronics
- Other

INDUSTRIAL METALS
181,579,892 tonnes



TECHNOLOGY AND PRECIOUS METALS
1,474,889 tonnes

ELEMENTS

Source: *USGS Mineral Commodity Summaries (2022)*

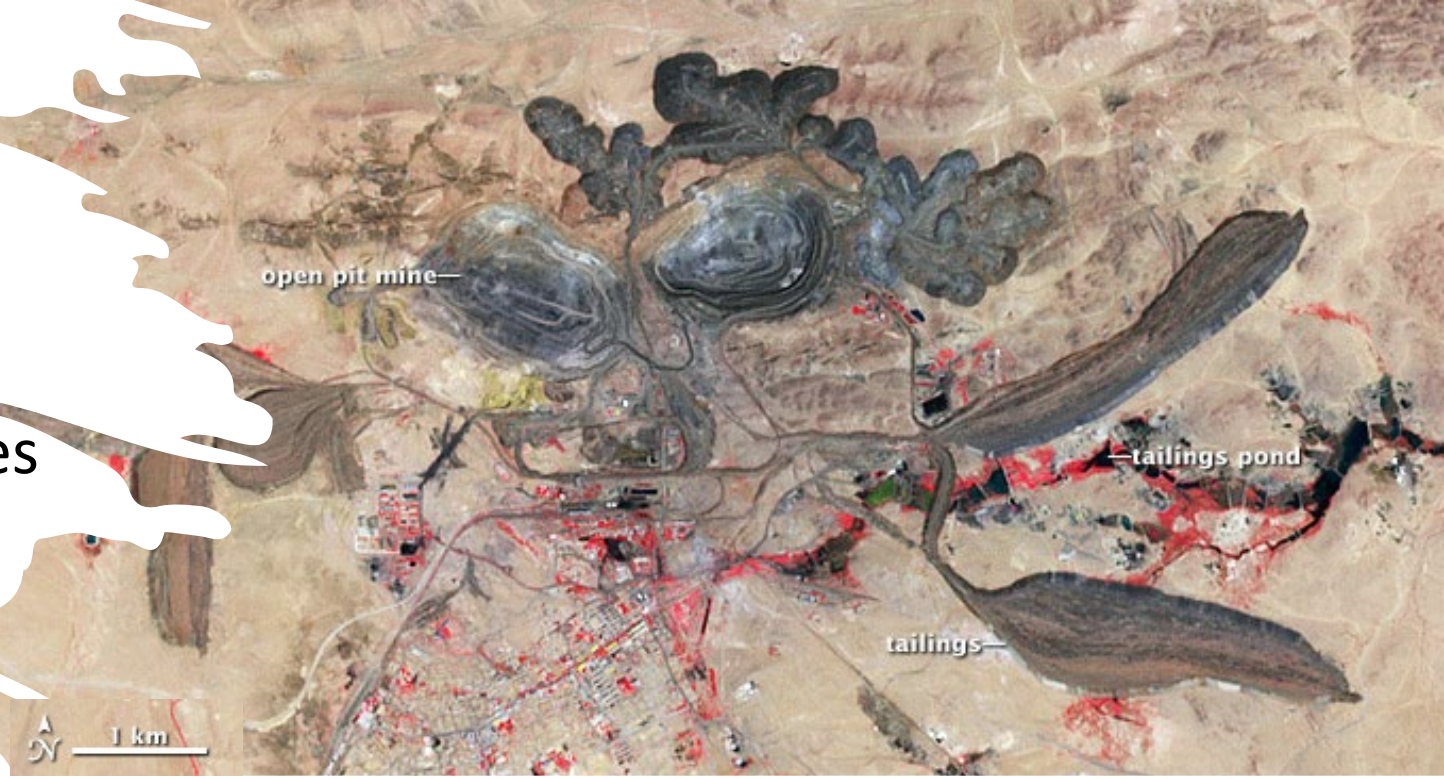
**Ore production does not reflect actual metal production as metals only make up a certain portion of ores.*

***Smelter/refinery production.*

****Represents titanium mineral concentrate production.*

ELEMENTS.VISUALCAPITALIST.COM

The Bayan Obo mine located in the Inner Mongolia region of China is the world's biggest rare earth element (REE) mine both by recoverable reserves and production.

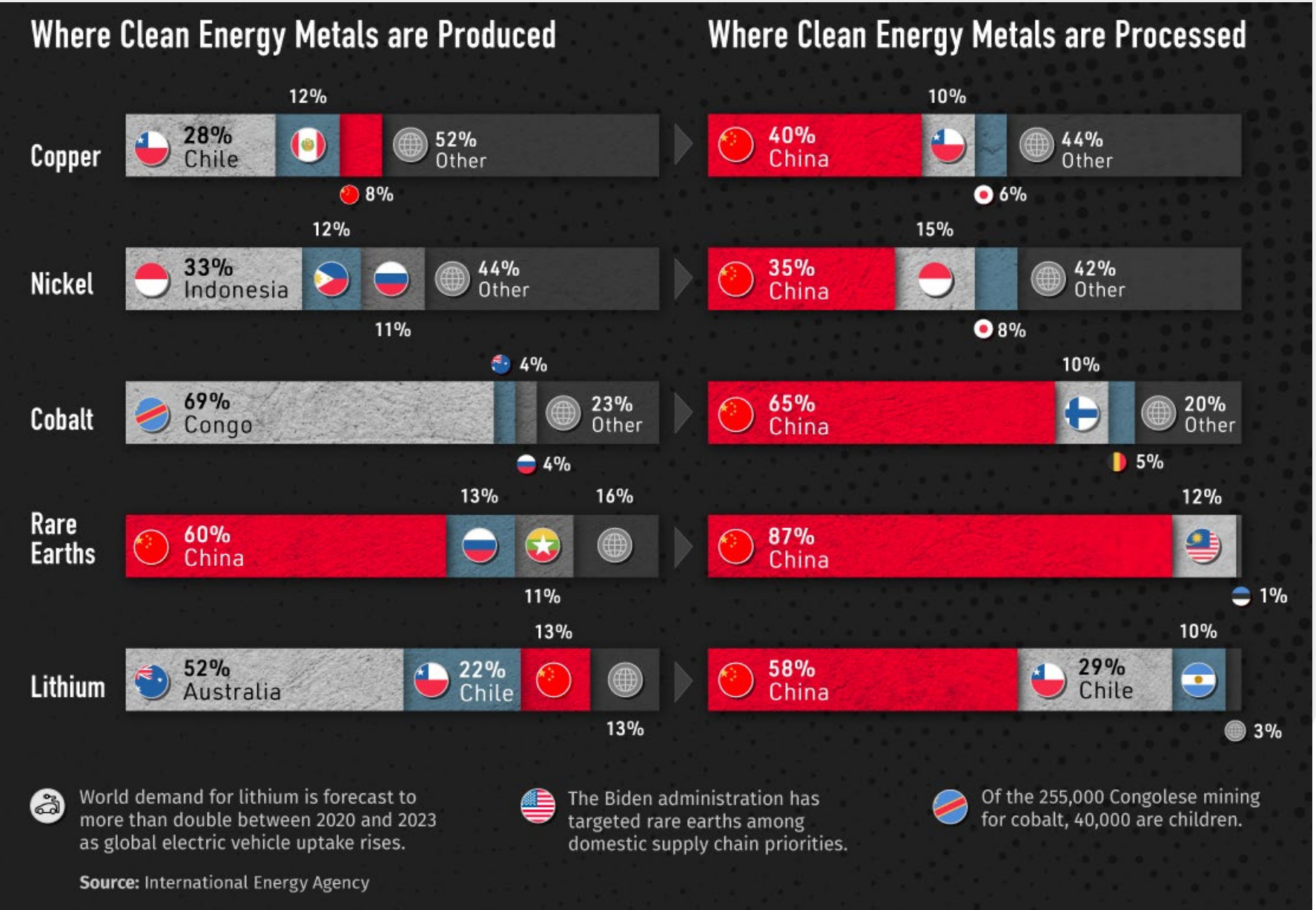


But… it is was originally (and to these days) a polymetallic operation!

Discovered in 1927 as an Iron deposit.

Most (all?) critical minerals are accessory to precious minerals or other commodities, which are “needed” to support CM extraction.

The “down stream issue”



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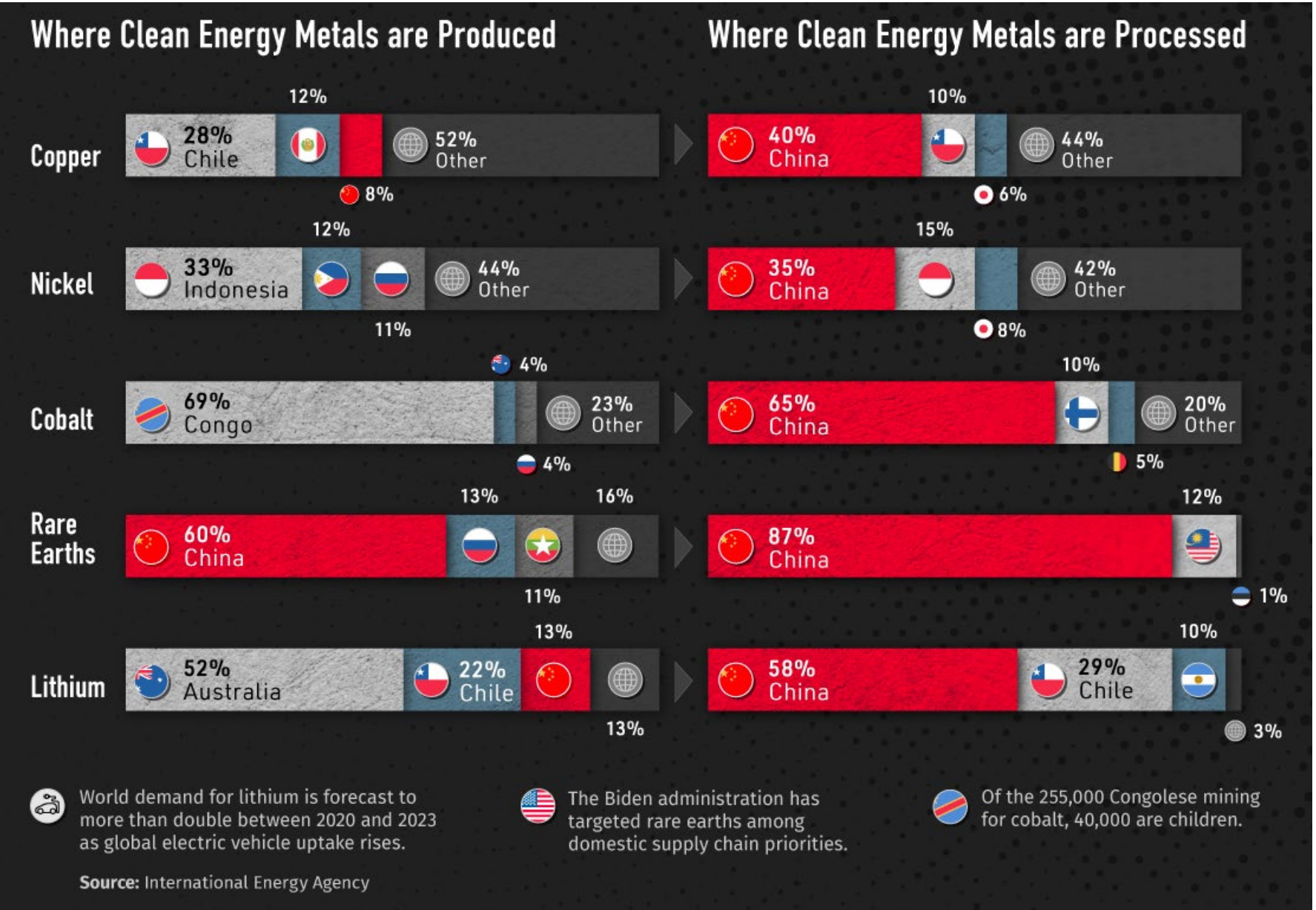
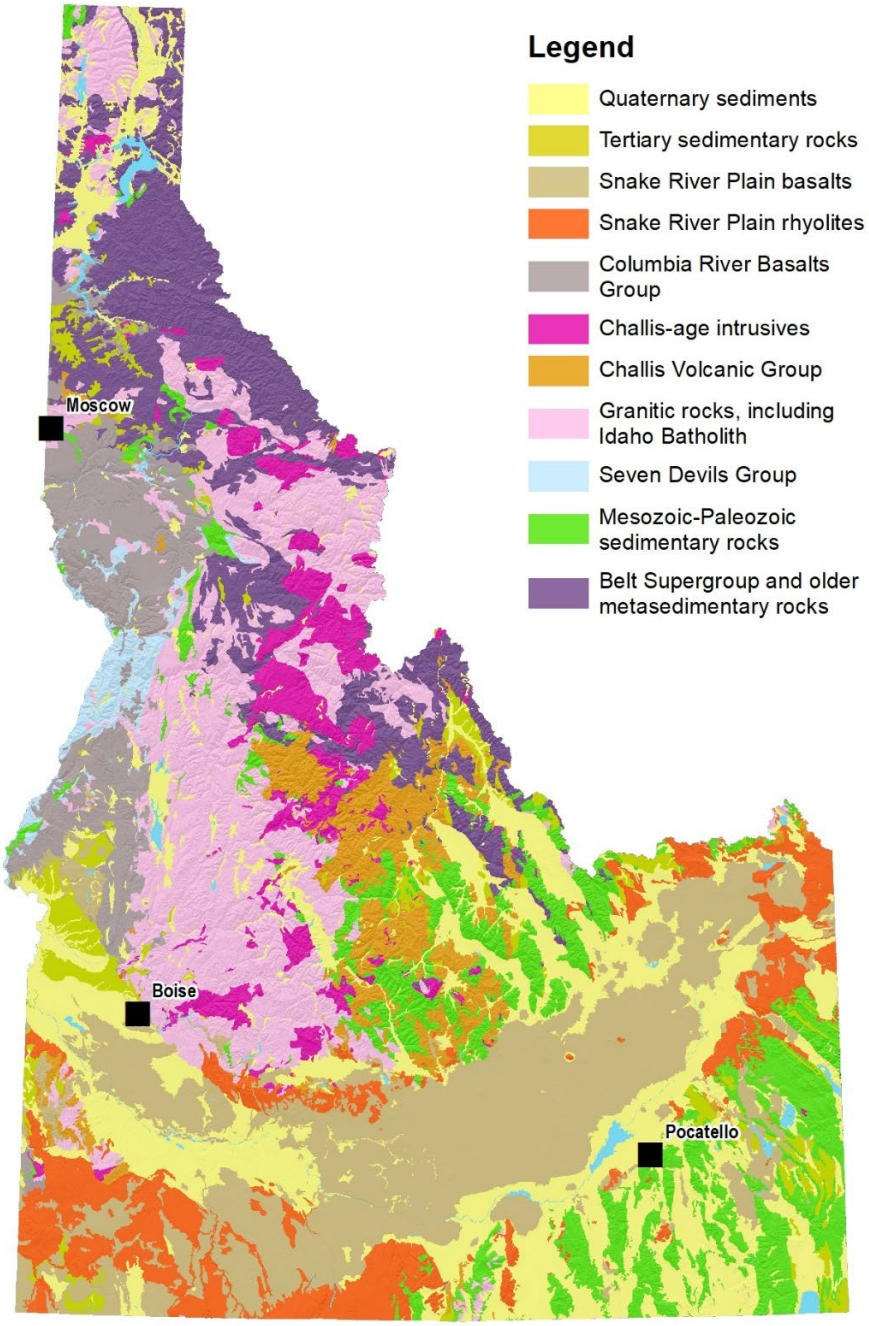
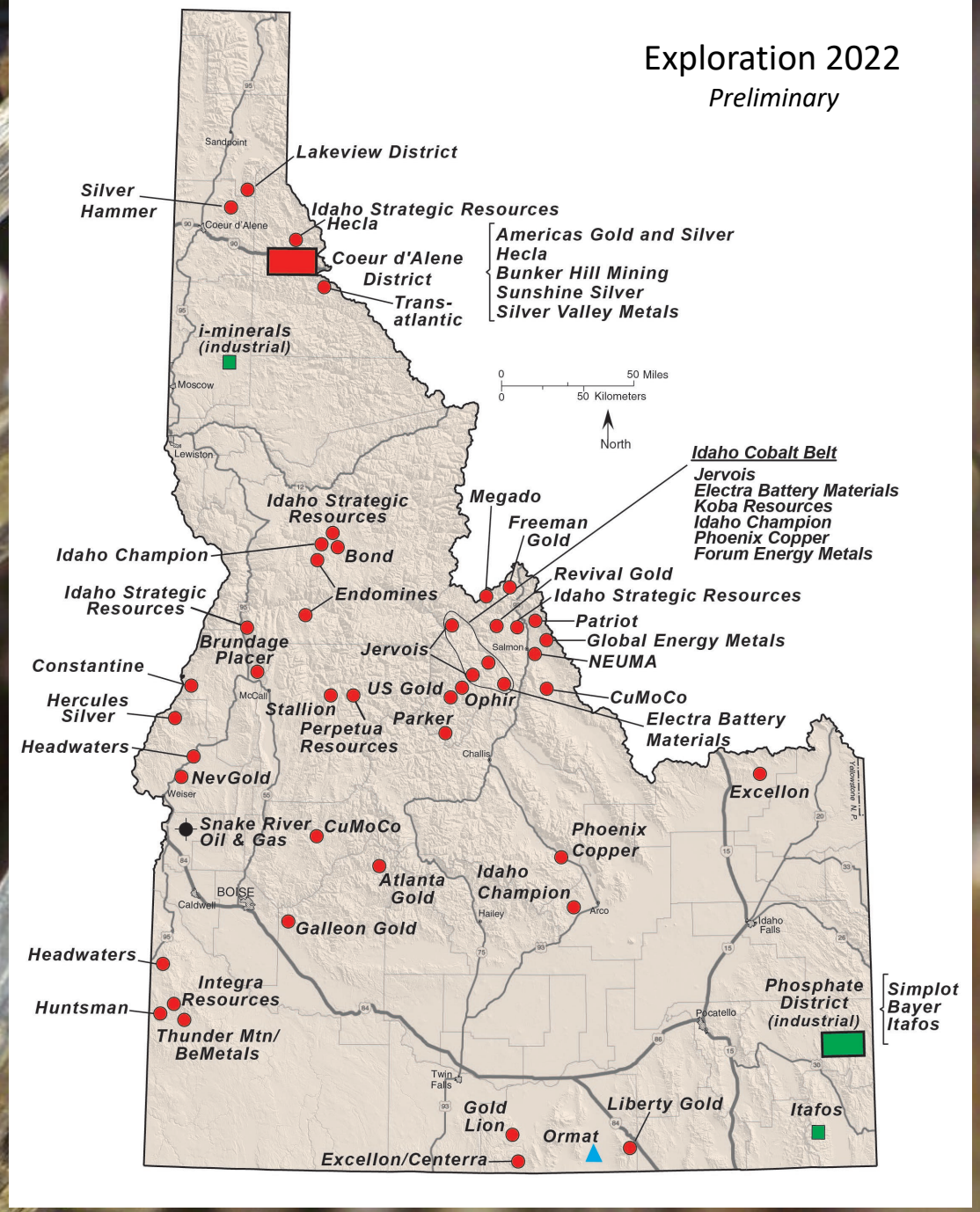



Legend
Quaternary sediments
Tertiary sedimentary rocks
Snake River Plain basalts
Snake River Plain rhyolites
Columbia River Basalts Group
Challis-age intrusives
Challis Volcanic Group
Granitic rocks, including Idaho Batholith
Seven Devils Group
Mesozoic-Paleozoic sedimentary rocks
Belt Supergroup and older metasedimentary rocks
Moscow
Boise
Pocatello


Exploration 2022
Preliminary
Lakeview District
Silver Hammer
Idaho Strategic Resources
Hecla
Coeur d'Alene District
Trans-atlantic
Americas Gold and Silver
Hecla
Bunker Hill Mining
Sunshine Silver
Silver Valley Metals
i-minerals (industrial)
0 50 Miles
0 50 Kilometers
North
Idaho Cobalt Belt
Jervois
Electra Battery Materials
Koba Resources
Idaho Champion
Phoenix Copper
Forum Energy Metals
Megado
Freeman Gold
Idaho Strategic Resources
Bond
Idaho Champion
Endomines
Idaho Strategic Resources
Revival Gold
Idaho Strategic Resources
Patriot
Global Energy Metals
NEUMA
Brundage Placer
Jervois
Constantine
Hercules Silver
Stallion
US Gold
Ophir
CuMoCo
Electra Battery Materials
Perpetua Resources
Parker
Headwaters
NevGold
Excellon
Snake River Oil & Gas
CuMoCo
Phoenix Copper
Atlanta Gold
Idaho Champion
Galleon Gold
Headwaters
Integra Resources
Huntsman
Thunder Mtn/ BeMetals
Phosphate District (industrial)
Simplot
Bayer
Itafos
Gold Lion
Liberty Gold
Ormat
Itafos
Excellon/Centerra

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dysprosium	**erbium**	**europium**	**fluorspar**	**gadolinium**
gallium	**germanium**	graphite	hafnium	**holmium**
indium	iridium	**lanthanum**	lithium	**lutetium**
magnesium	manganese	**neodymium**	nickel	**niobium**
palladium	platinum	**praseodymium**	rhodium	rubidium
ruthenium	**samarium**	scandium	**tantalum**	tellurium
terbium	**thulium**	tin	titanium	**tungsten**
vanadium	**ytterbium**	**yttrium**	**zinc**	**zirconium**

2022 list of critical minerals

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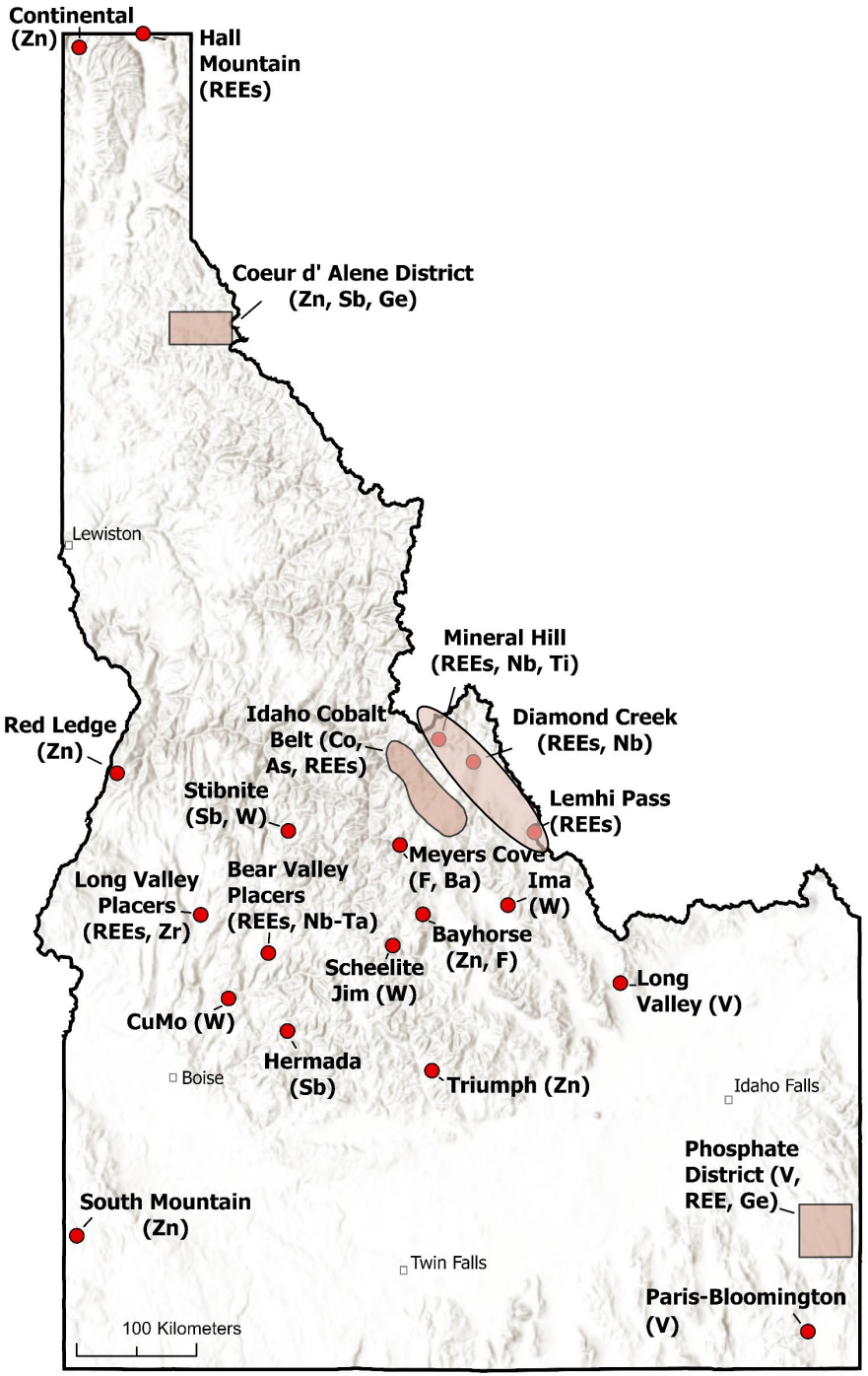
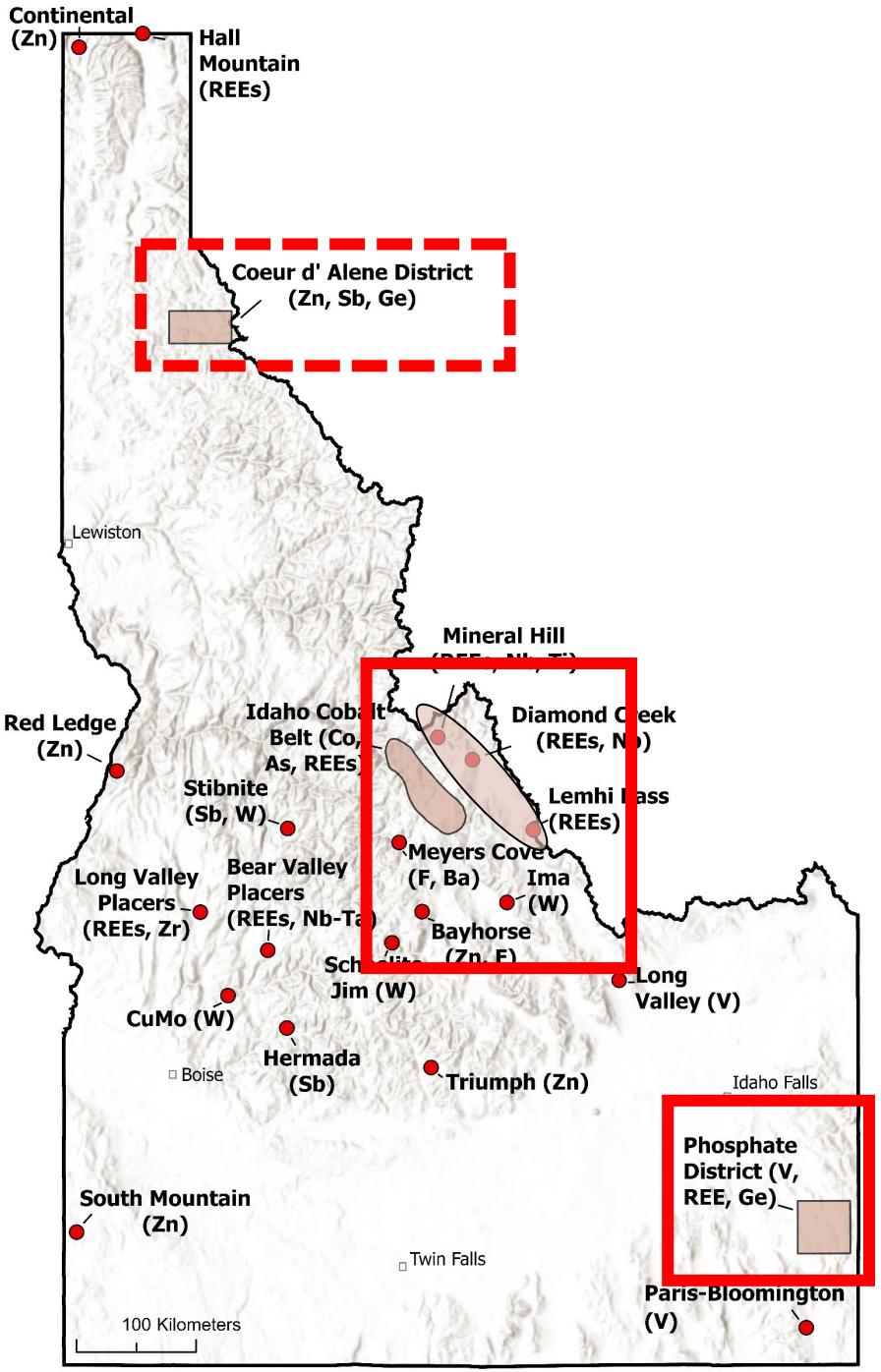


Critical mineral production potential

High
Medium
Low
Very low

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



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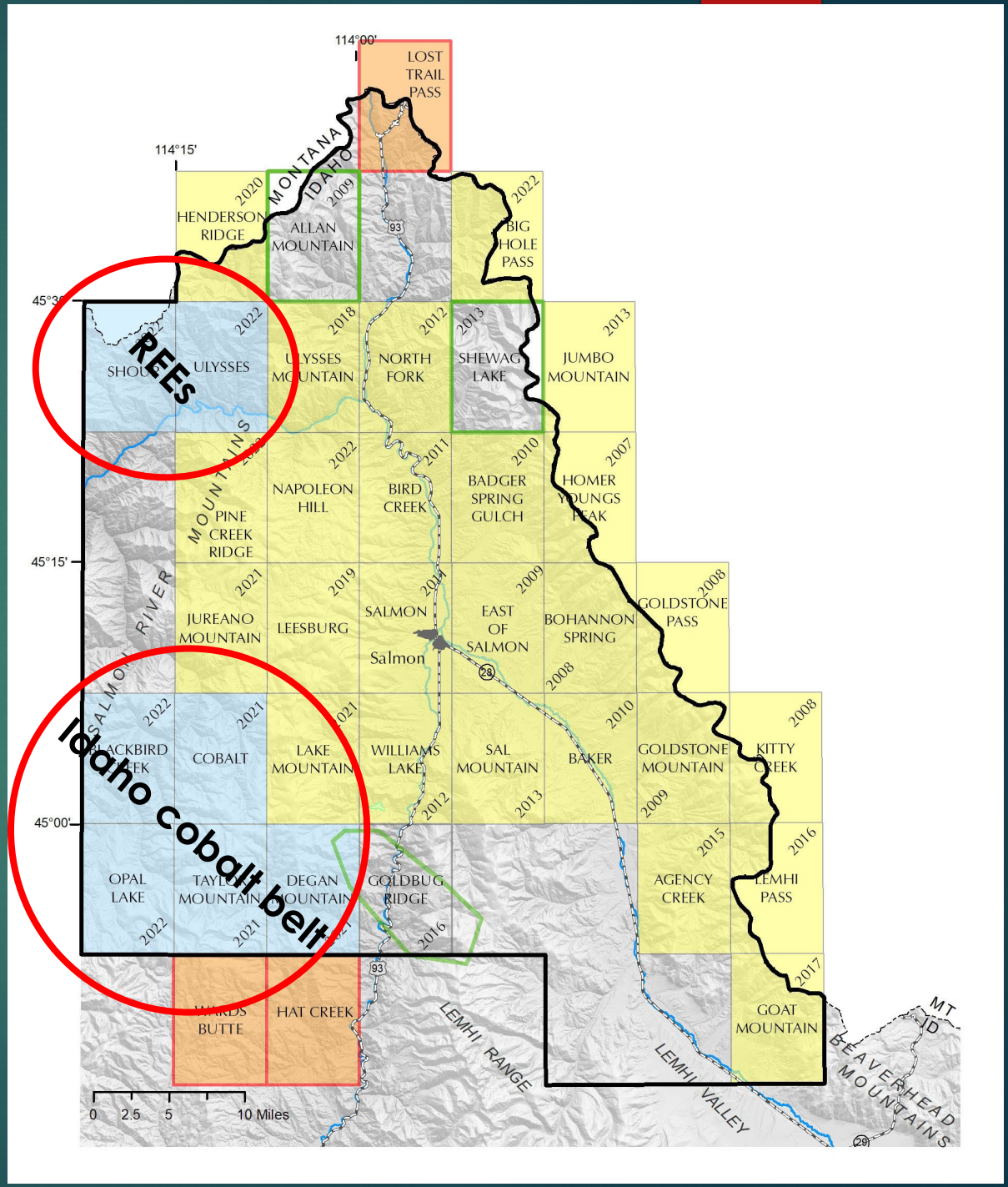
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Earth MRI

- USGS-funded critical minerals work
- Completed mapping Cobalt, Taylor Mountain, and Degan Mountain quadrangles
- 2-year mapping project in Blackbird Creek and Opal Lake quadrangles in progress ($100k project)
- Newly funded for Sheep Creek-Mineral Hill REE-Nb district
- Geochemical and geophysical characterization
- Liaison with industry, local economy, academia



Salmon Area Critical Mineral Projects

Sheep Creek – Mineral Hill REE Belt

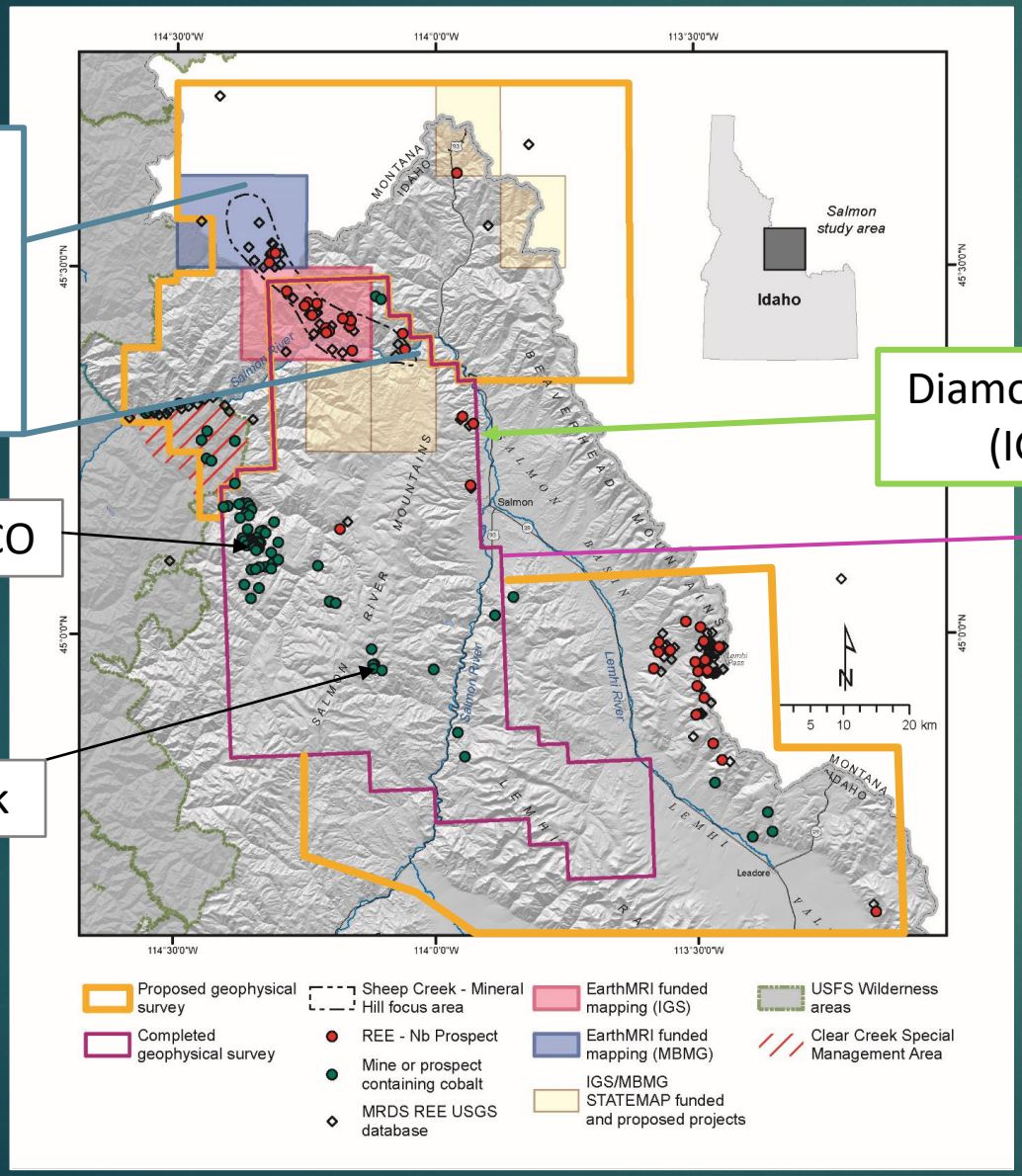
ICO

Cobalt Belt (green dots)

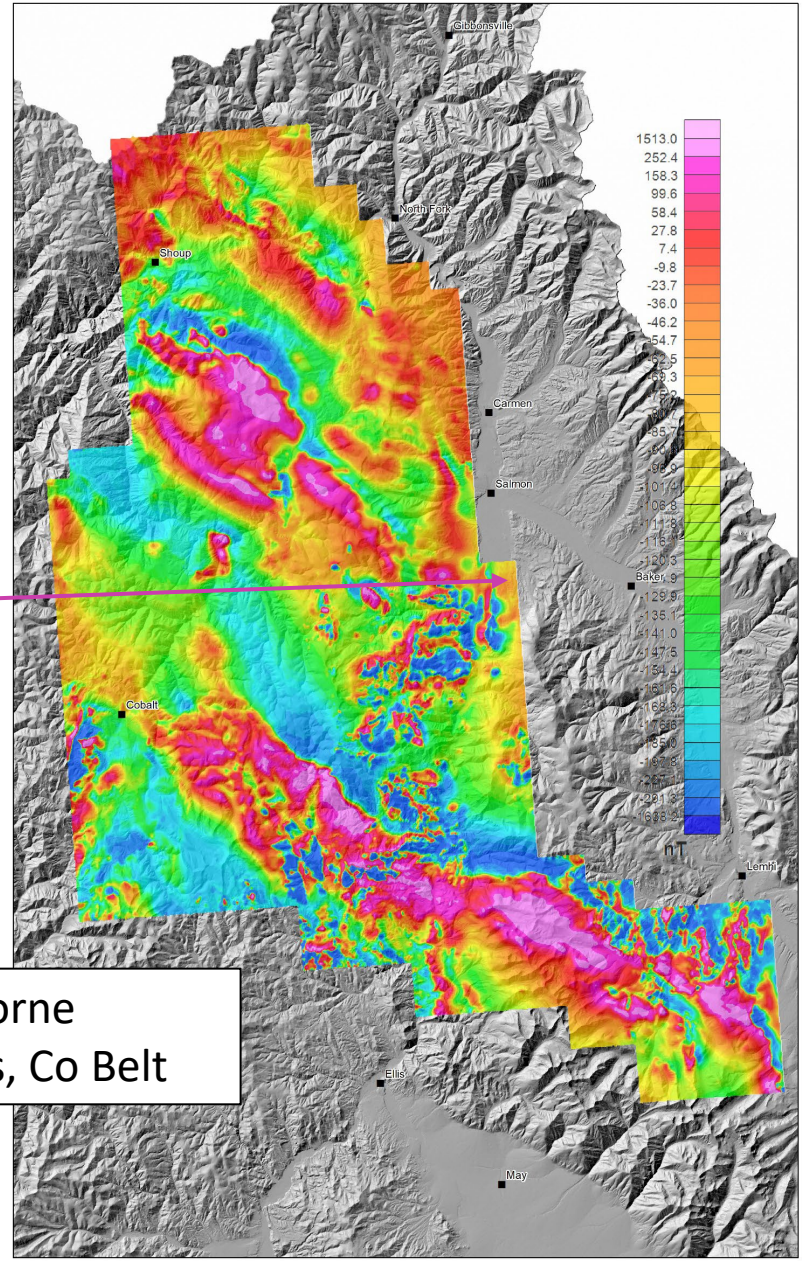
Iron Creek

REEs (red dots)

Diamond Creek (IGEM)

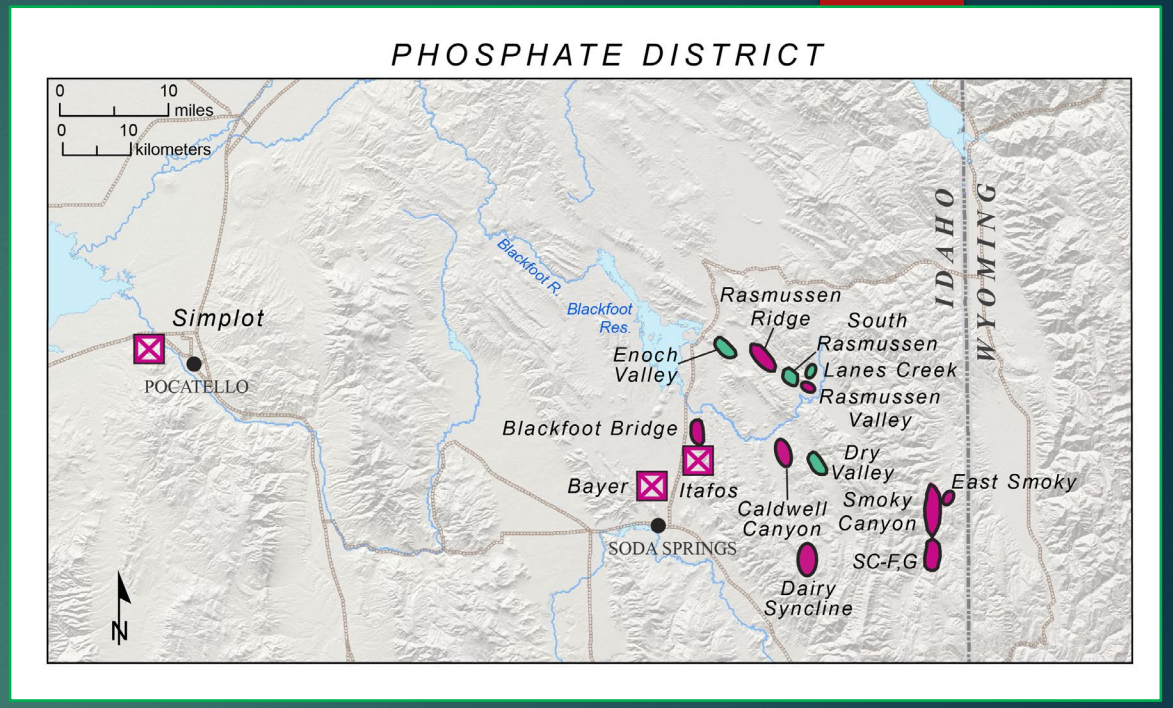


New Airborne Magnetics, Co Belt



Western Phosphate Basin

~ Basin and Range: exposed faulted and folded Paleozoics



Phosphoria Formation: Permian Age (265 Ma) black phosphatic shale of regional extent. Ore is approximately 25% P_2O_5 and various strata are enriched in trace elements including V, REEs, Se, U, etc. Mine 4 – 5 million tons/year.

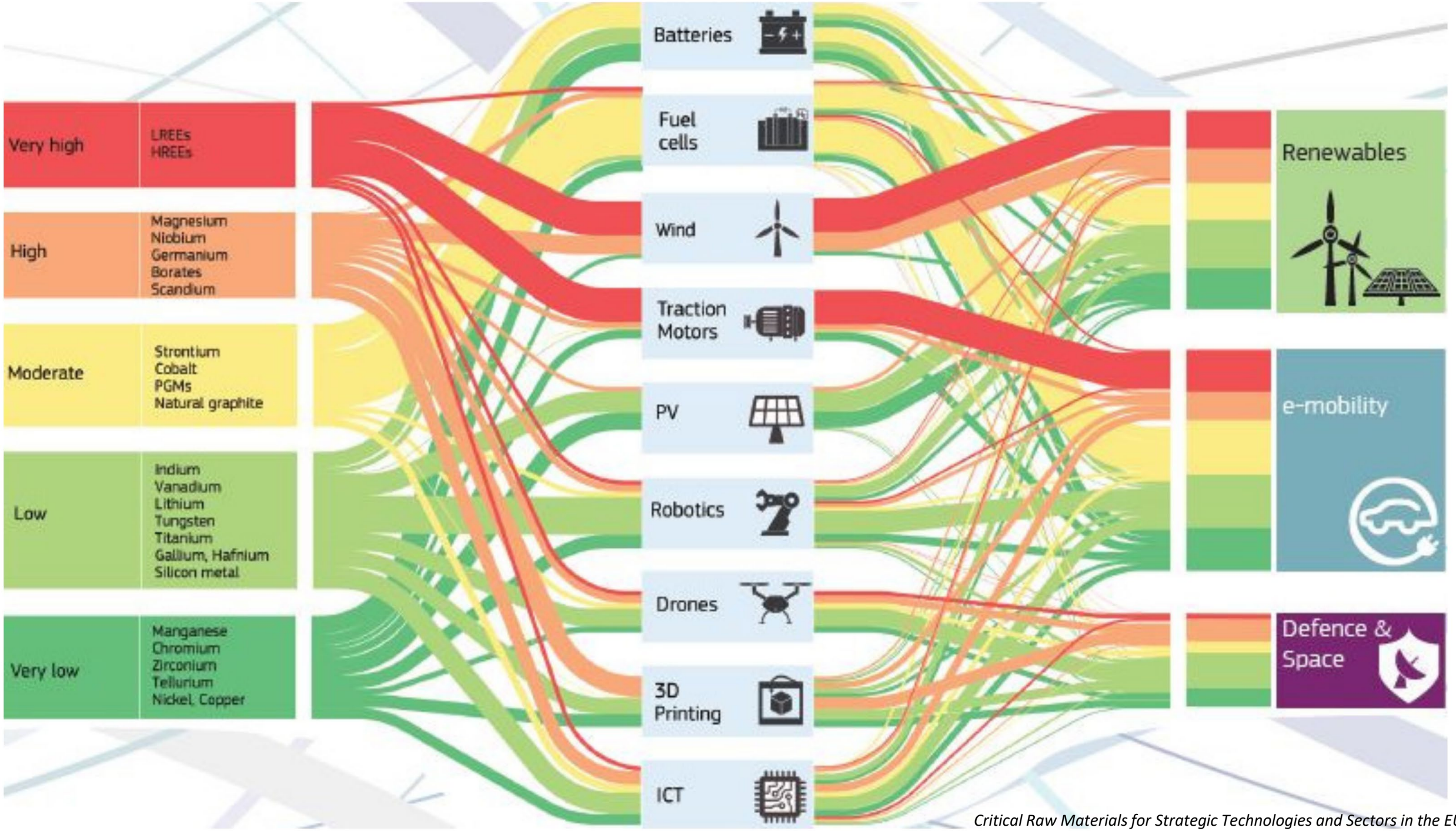
2021 – Phosphate is largest segment of the mining industry. 3 large processing plants, 3 large open pit mines, new mines in construction, southeastern Idaho. Approx. 4-5 million tons/year.

Products:

Phosphoric Acid Fertilizer
Elemental Phosphorus

How to maximize this opportunity?

- Basic and applied research
- Provide incentives to junior companies
- Enhance attractiveness by investing in data acquisition!
- Collect and preserve exploration data and samples
- Baseline data (for both exploration and conservation)



Critical Raw Materials for Strategic Technologies and Sectors in the EU

In 2022…

Idaho dropped out of the top 10 most attractive jurisdictions in which to invest this year.

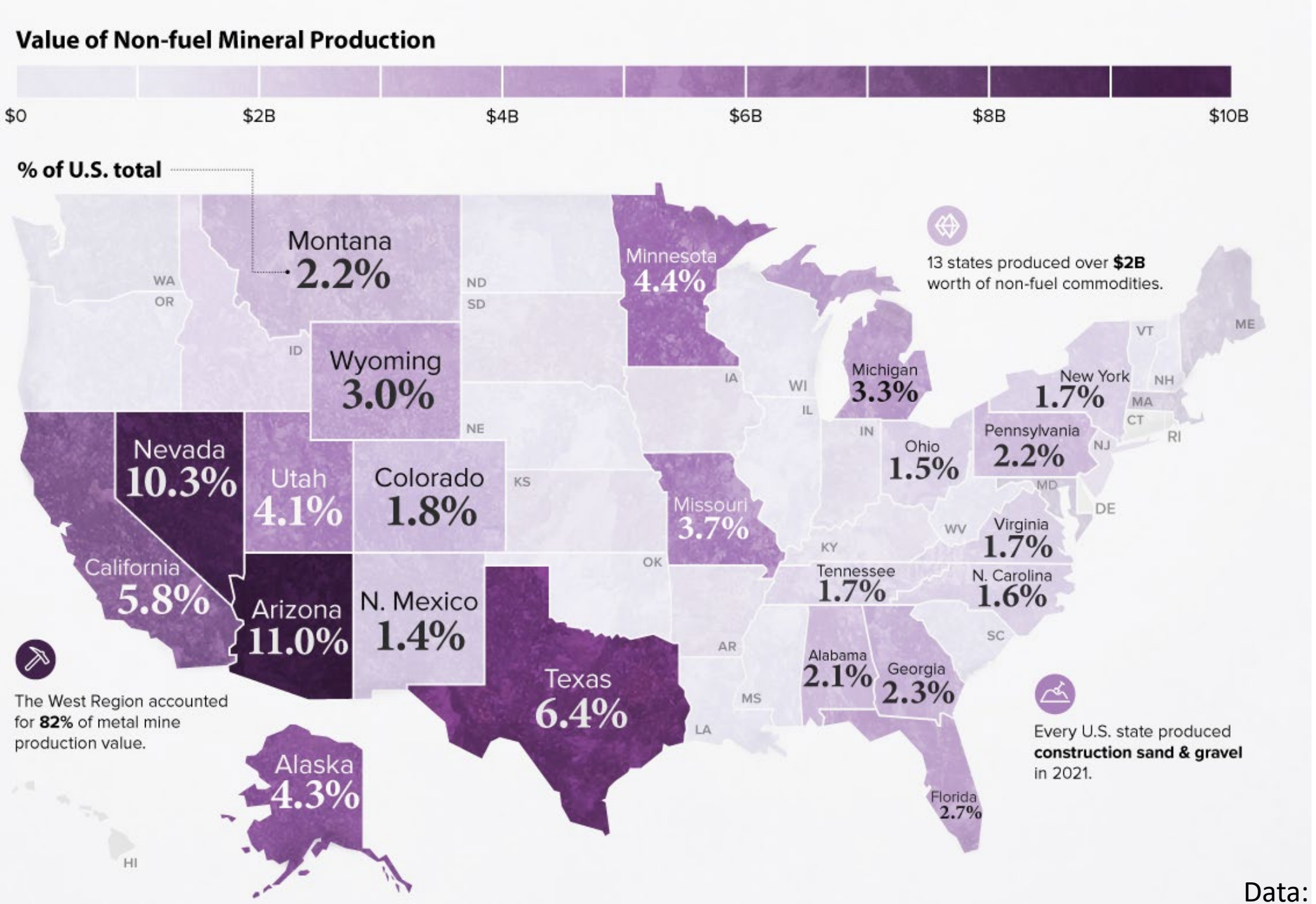
The state, which **in 2021 ranked 7th** (out of 84) due to its attractiveness for investment, this year **dropped to the 28th spot** (out of 62).

When **considering policy alone, Idaho increased its PPI score** by over 3 points and ranked 11th out of 62.

Respondents expressed increased concerns over the availability of skilled labor (+18 points), infrastructure (+15 points), and uncertainty concerning protected areas (+ 9 points).

FRASER INSTITUTE 2023


E
HOW MUCH OF EACH METAL YOU CAN BUY WITH
$1,000
When it comes to metals markets and trade, dollar figures cited are often in the millions if not billions.
If you only had $1,000 to spend, how much of each metal would you be able to buy?
OSMIUM
0.3 CM
0.1 INCHES
RHODIUM
0.6 CM
0.2 INCHES
PLATINUM
1.2 CM
0.5 INCHES
GOLD
1.0 CM
0.4 INCHES
IRIDIUM
0.7 CM
0.3 INCHES
PALLADIUM
1.1 CM
0.4 INCHES
RUTHENIUM
1.7 CM
0.7 INCHES
SILVER
SIDE LENGTHS
5.4 CM
2.1 INCHES
COBALT
12.9 CM
5.1 INCHES
COPPER
24.6 CM
9.7 INCHES
NICKEL
17.3 CM
6.8 INCHES
ALUMINUM
55.1 CM
21.7 INCHES
STEEL
62.5 CM
24.6 INCHES
LEAD
35.2 CM
13.9 INCHES
ELEMENTS
Source: TradingEconomics
ELEMENTS.VISUALCAPITALIST.COM


Value of Non-fuel Mineral Production
$0
$2B
$4B
$6B
$8B
$10B
% of U.S. total
Montana 2.2%
Wyoming 3.0%
Nevada 10.3%
Utah 4.1%
Colorado 1.8%
California 5.8%
Arizona 11.0%
N. Mexico 1.4%
Texas 6.4%
Alaska 4.3%
Minnesota 4.4%
Missouri 3.7%
Michigan 3.3%
Ohio 1.5%
Pennsylvania 2.2%
New York 1.7%
Virginia 1.7%
Tennessee 1.7%
N. Carolina 1.6%
Alabama 2.1%
Georgia 2.3%
Florida 2.7%
WA
OR
ID
ND
SD
NE
KS
OK
IA
WI
IL
IN
KY
WV
MD
DE
NJ
CT
RI
MA
VT
NH
ME
AR
MS
LA
SC
HI
13 states produced over $2B worth of non-fuel commodities.
The West Region accounted for 82% of metal mine production value.
Every U.S. state produced construction sand & gravel in 2021.

Data: 2021

IGS: Critical Minerals Projects

- **iGEM (Idaho Dept. of Commerce)**
  - **Industry Partner:** Idaho Strategic Resources, Inc.
  - Lead PI: UI at Idaho Falls + CAES, IGS, Idaho Strategic Res., INL
    - 2022 Drilling, Characterization, Processing and Separation: REEs at Diamond Creek Project, Lemhi Co.
    - IGS co-PIs: C. Berti, V. Gillerman

- **Petrochemistry of Magnetite, Iron Creek deposit, Lemhi Co.**
  - **Industry Partner:** Electra Battery Materials
  - Petrography, Chemistry
  - PI: V. Gillerman

- **Geologic Mapping: Idaho Cobalt Belt**
  - **Partners: USGS-IGS**
  - Airborne Magnetics and Radiometrics (USGS)
  - Field Mapping, Geochemistry (IGS)
  - Lead PI: R. Lewis

- **Geochemical Characterization of Idaho Phosphate**
  - **Partners: USGS-IGS**
    - **lead role**

Ages:
Lemhi Pass REE-Th veins are Mississippian/Devonian; North Fork area carbonatites are ??

Mining Cycle – simplified: Mine Startup in US: 5 to 25 years

Exploration to Discovery

- Target Concept
- Exploration – recon
- Property Acquisition
- Drilling - Exploration
- Discovery to Delineation Drilling
- Fund-raising
- Metallurgical Tests, Economic Analysis
- Public Relations/Community ESG
- Permitting: Federal NEPA, State
  - Appeals of ROD by NGOs

Mining to Closure

- Mine Financing
- Engineering Studies, Economic Studies, Mine Plan Optimization and Environmental Modelling
  - Global Market Conditions for 20+ year projections
- Mining and Processing:
  - Mill- Ore Grinding/separation to Concentrate
  - Concentrate to Smelter or Refinery
  - Refinery to Intermediate Product
  - To End User
- Mine Reclamation and Closure
  - Required by State and Federal Regulations/Banks