

Potential Sources of Critical Mineral Commodities in Montana



Montana State Legislature
 Environmental Quality Council

September 28, 2023

John Metesh, Director & State Geologist
 Montana Bureau of Mines and Geology

KEY MINERALS IN ELECTRIC & HYBRID CARS



Batteries

Body

Catalytic converter

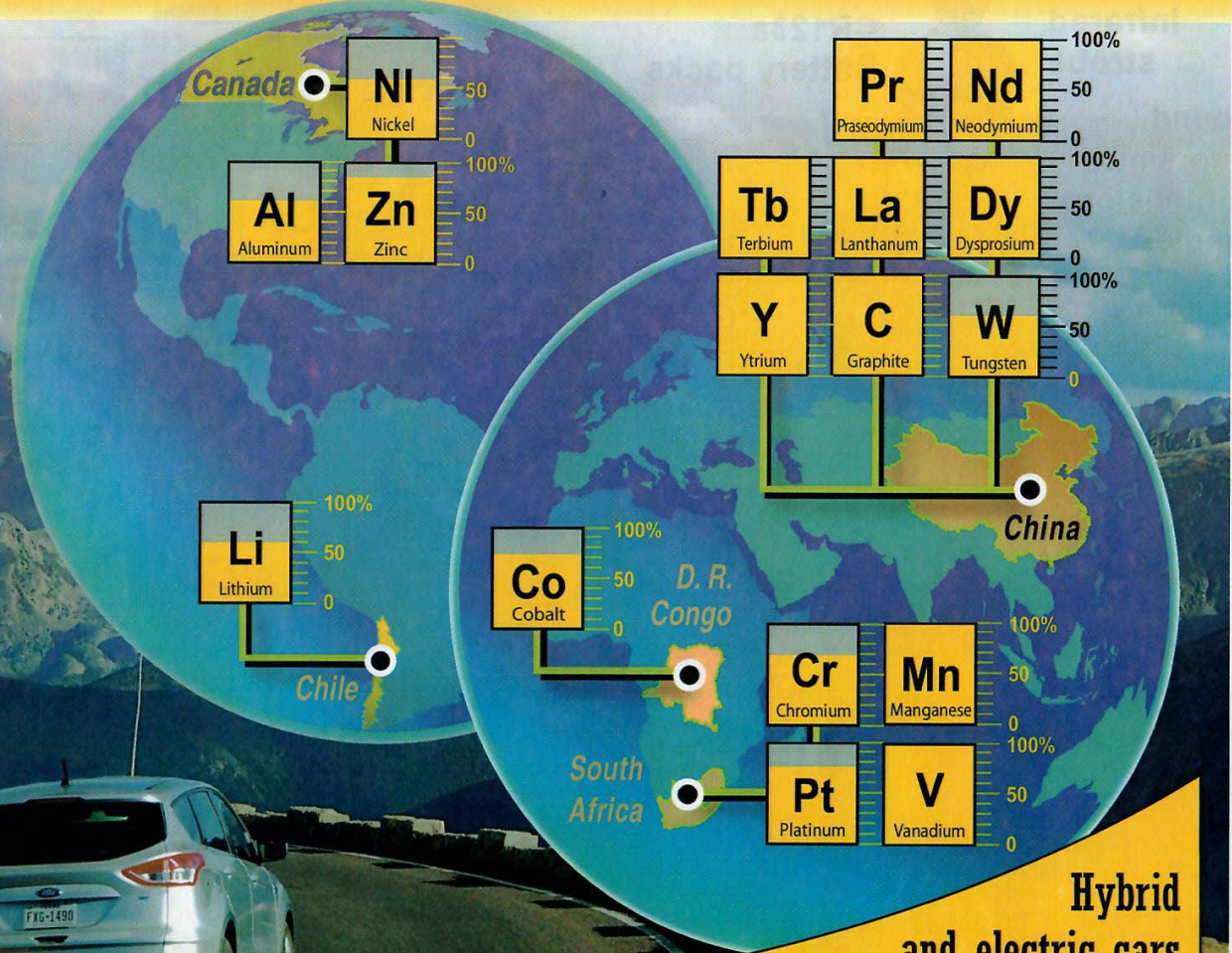
Electrical system

Frame

Motor

Safety system

and more...



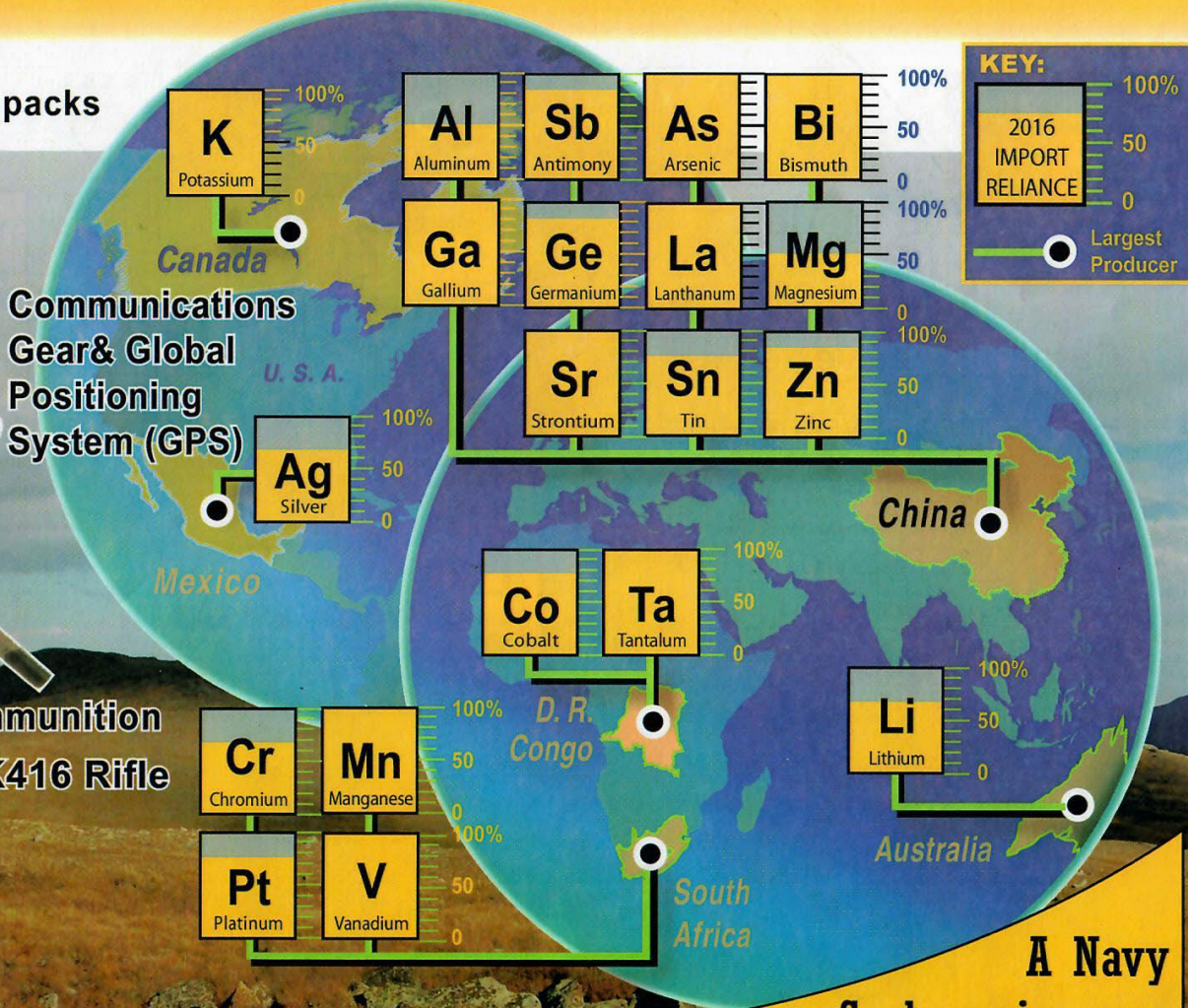
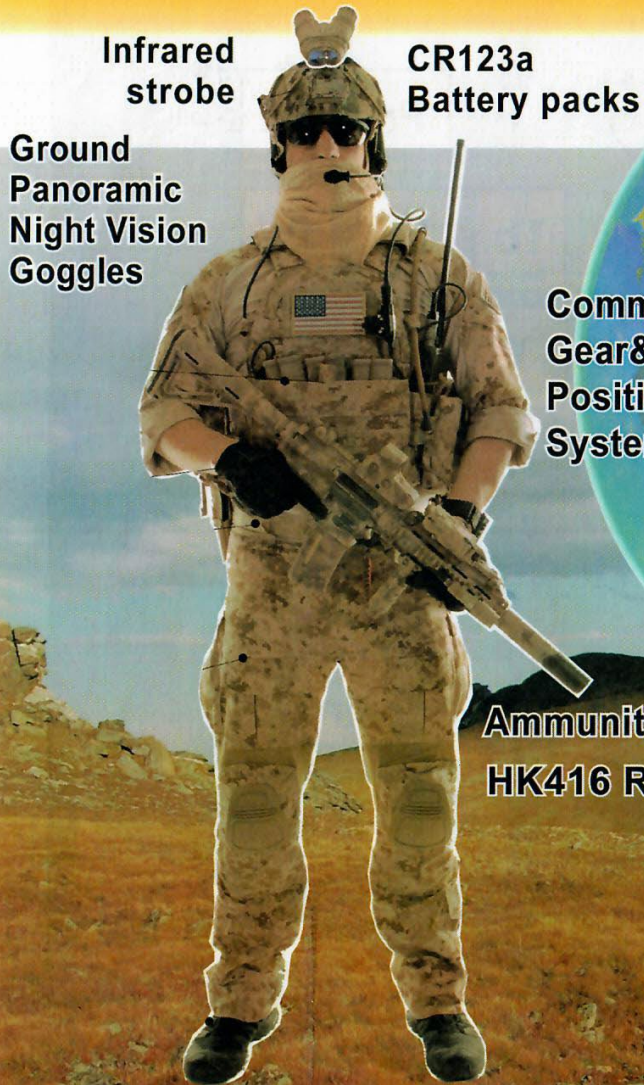
Hybrid and electric cars contain minerals for which the **USA is >50% IMPORT RELIANT**



Association of American State Geologists

Information from USGS Professional Paper 1802

CRITICAL METALS IN SPECIAL FORCES GEAR

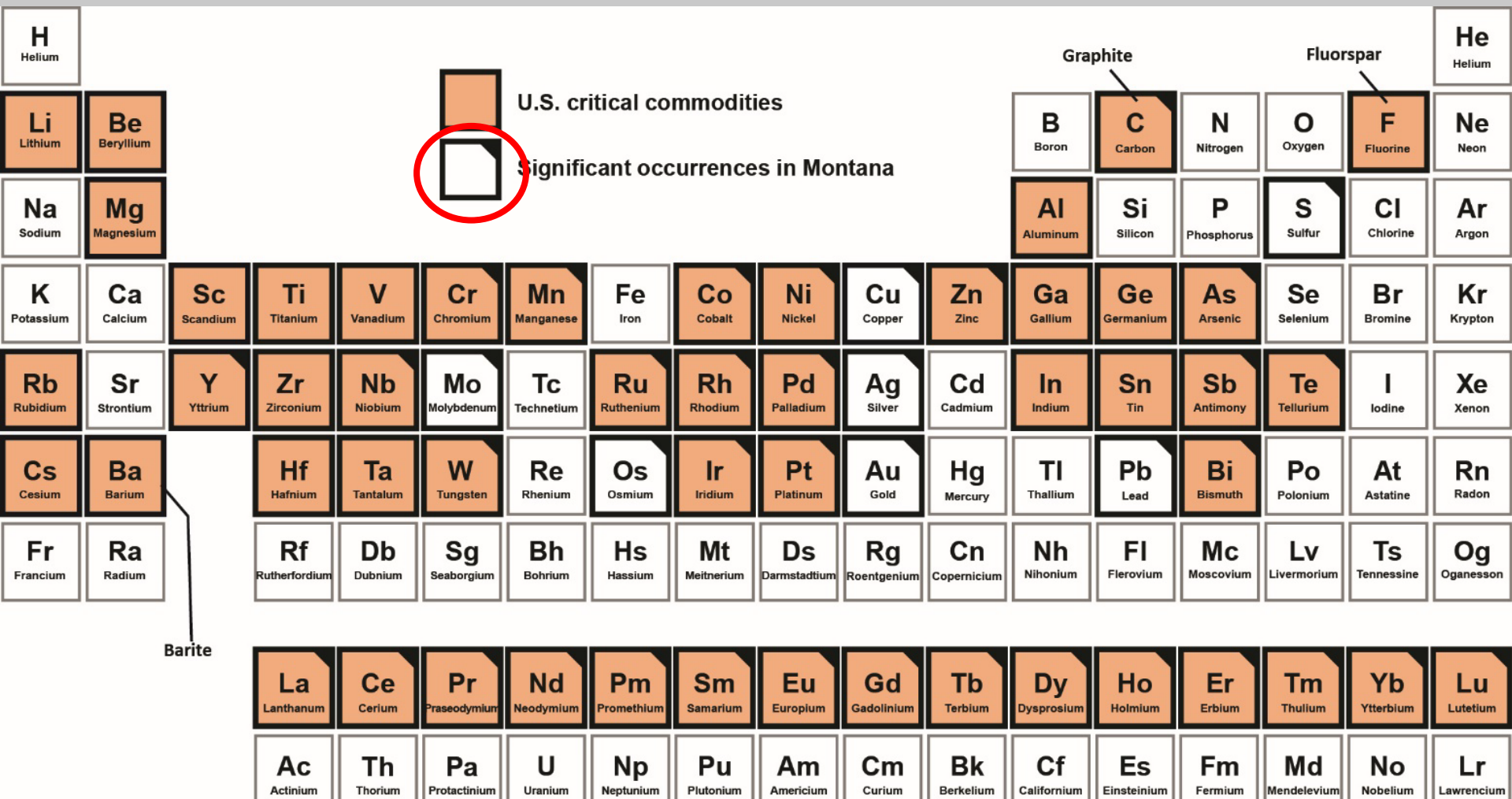


A Navy Seal carries gear containing at least 20 METALS for which the USA is >50% IMPORT RELIANT

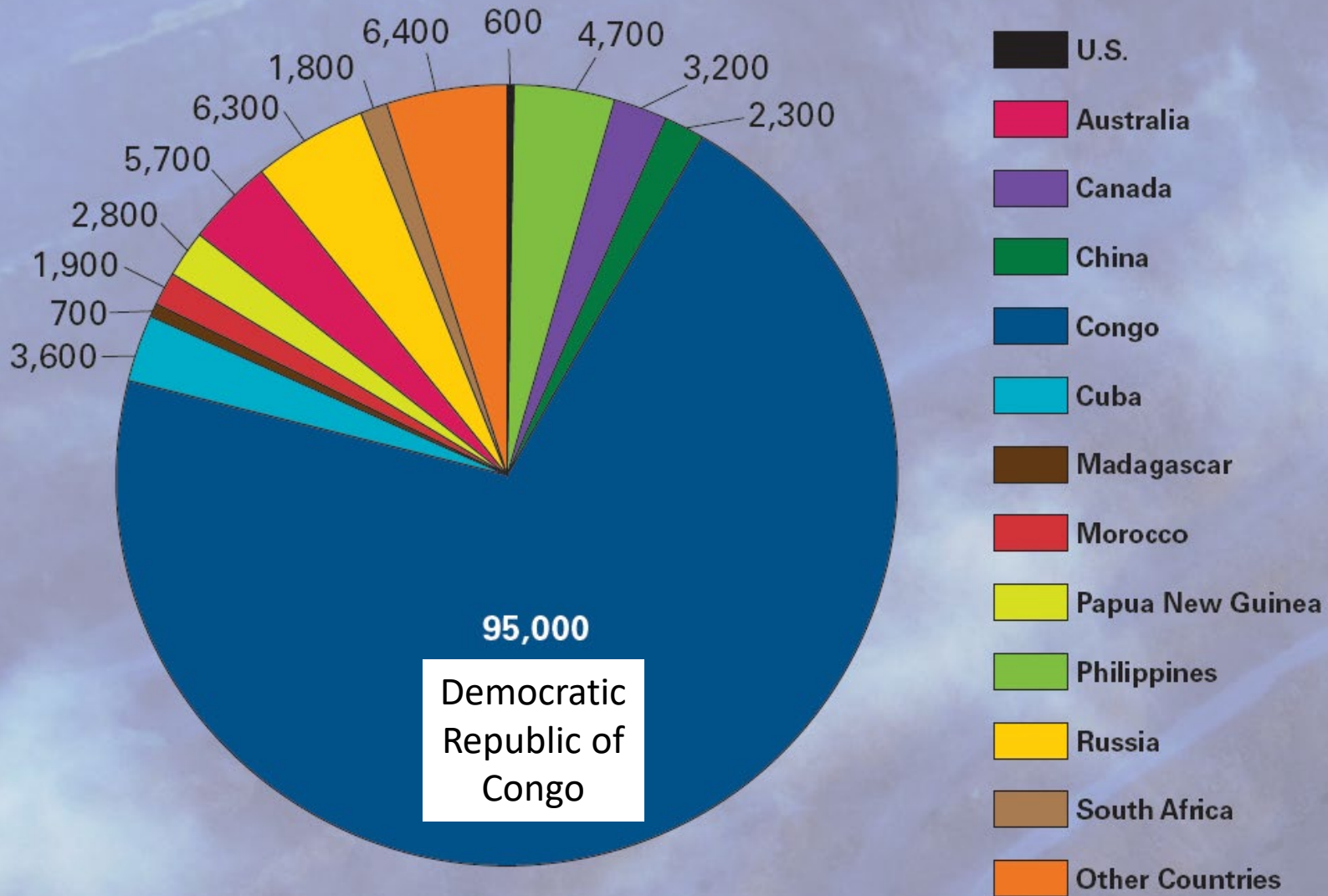
Critical Commodities in US and Montana

Critical mineral commodities are "critical" because

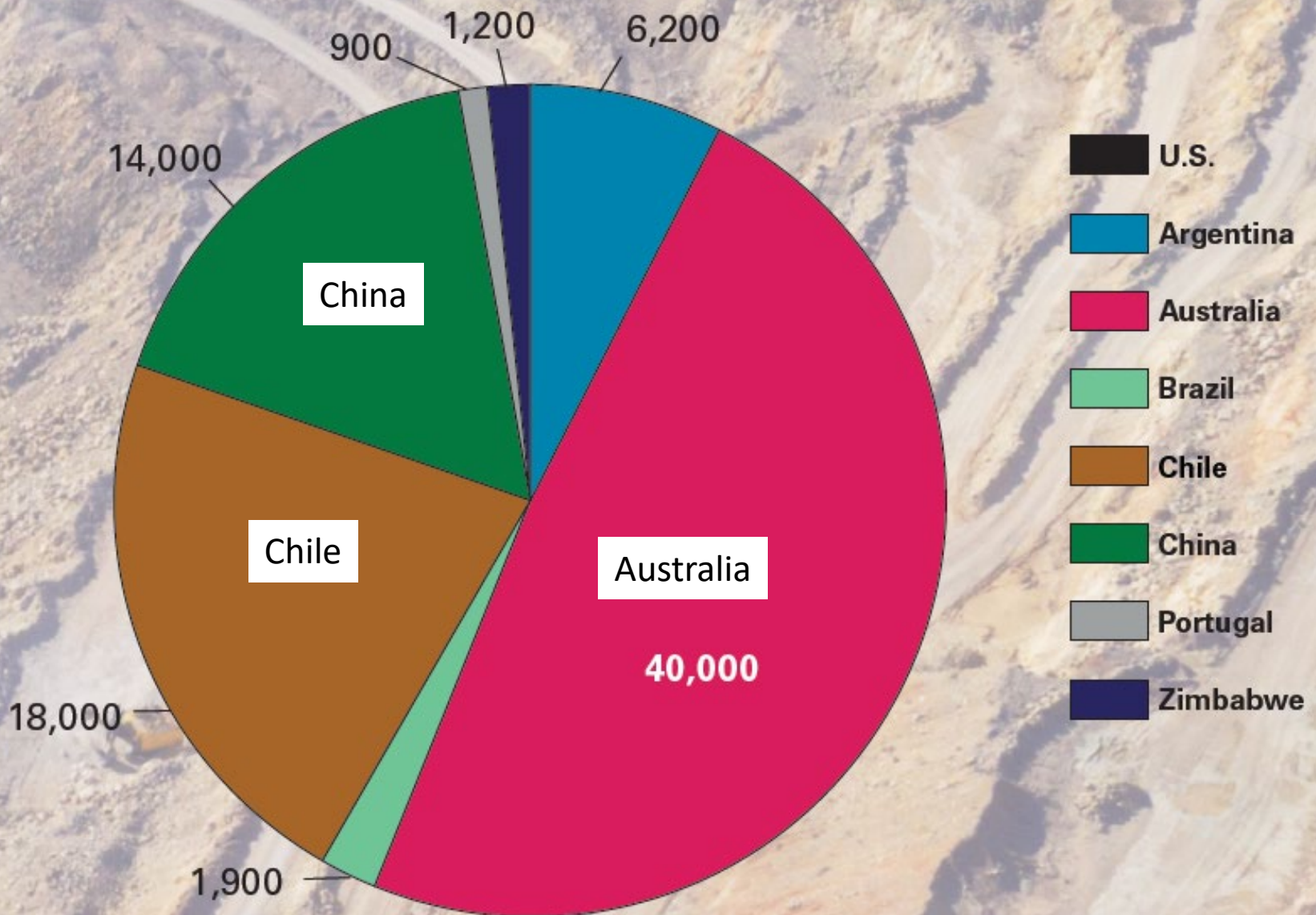
- 1) their ready supply (reserves) is limited in the U.S., and
- 2) foreign supply is threatened by geopolitical complications.



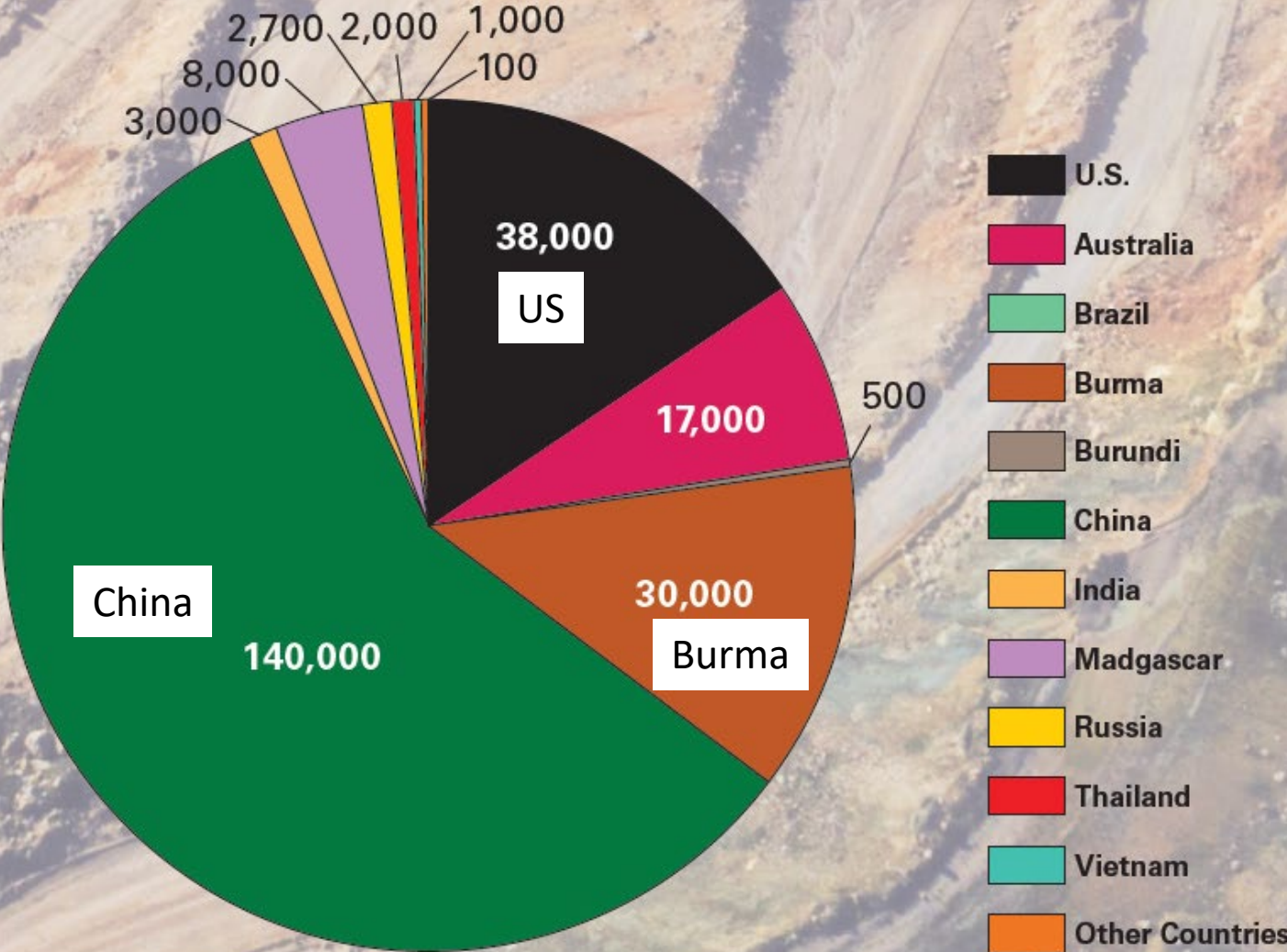
COBALT MINING PRODUCTION (data in metric tons)



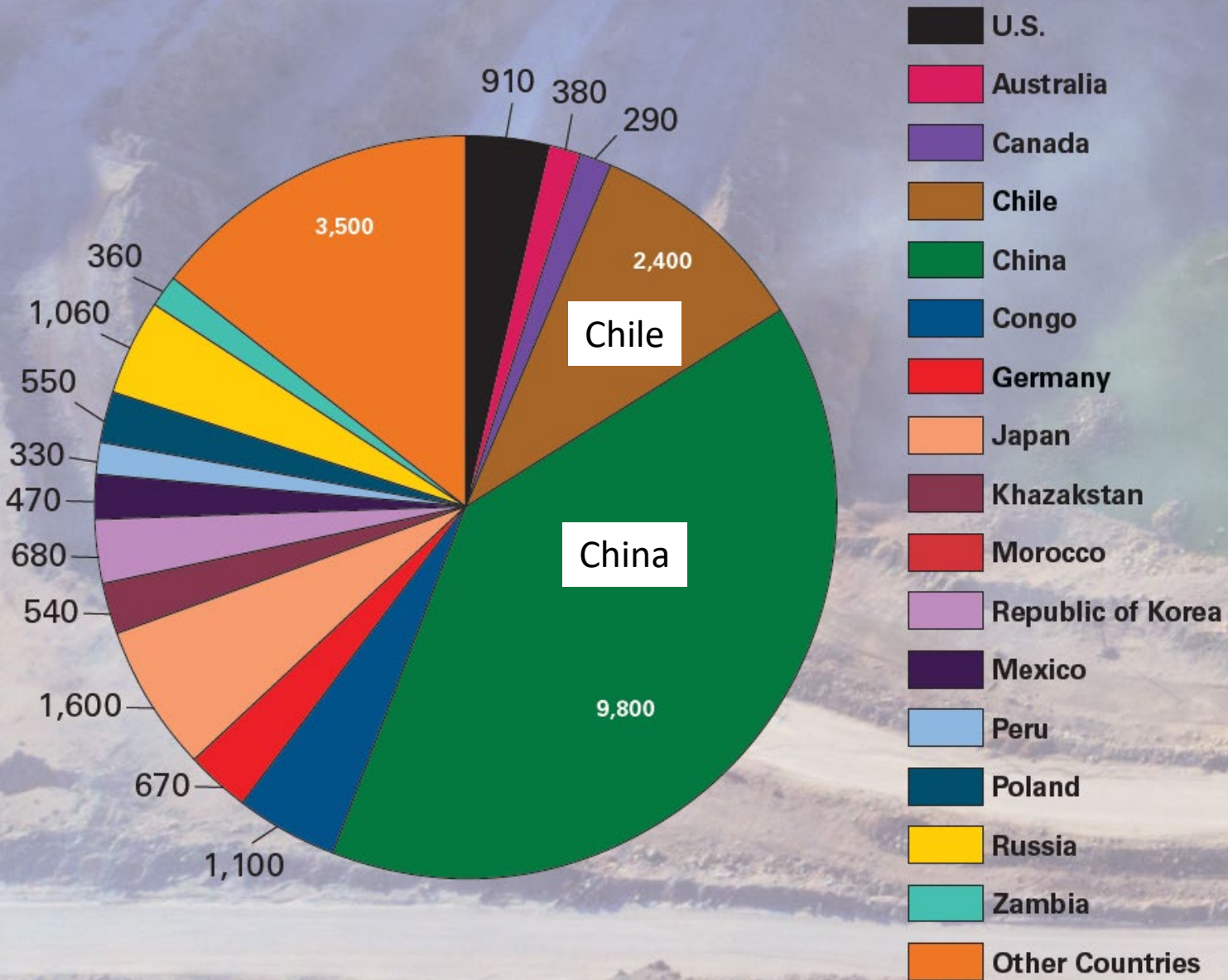
LITHIUM MINING PRODUCTION (data in metric tons)



RARE EARTH MINING PRODUCTION (data in metric tons)



COPPER REFINERY PRODUCTION (data in thousand metric tons)

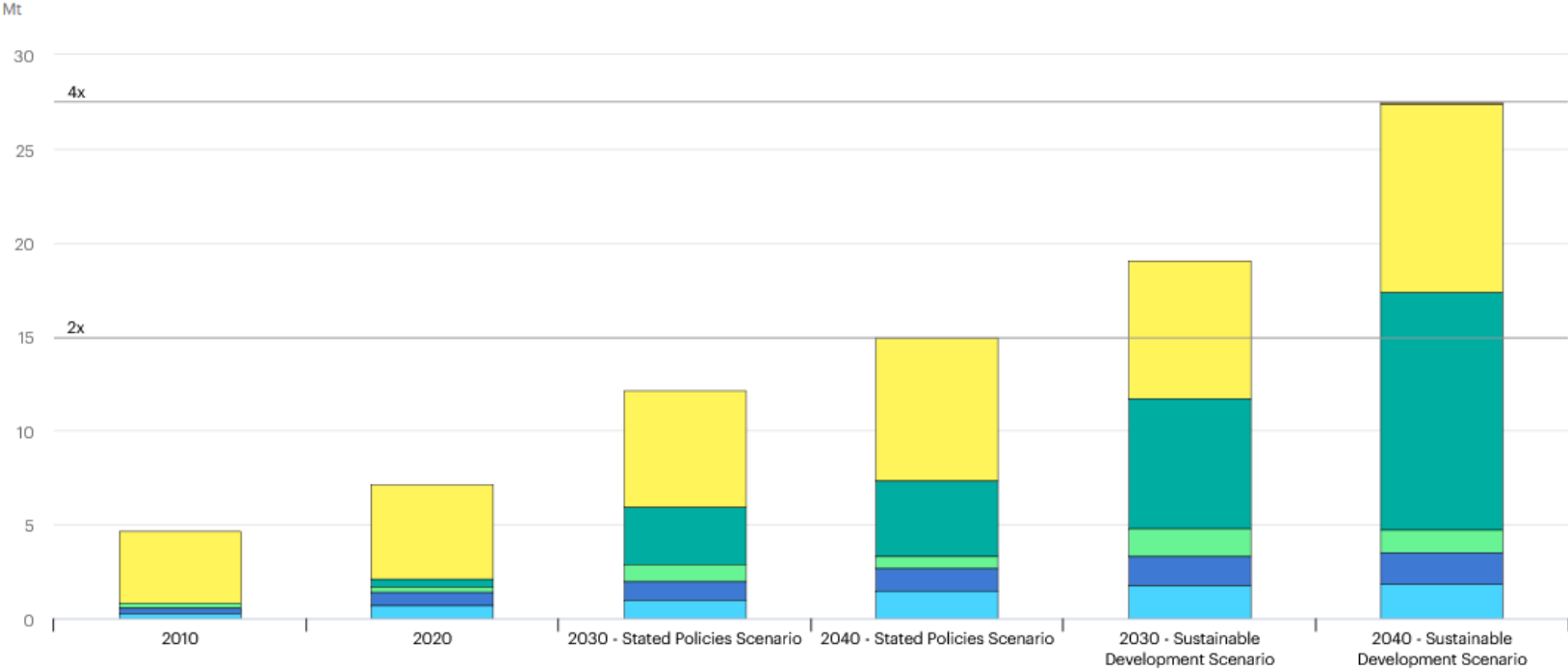


Oil security vs mineral security

“peak oil” again?
peak supply vs peak demand

Total mineral demand for clean energy technologies by scenario, 2010-2040

Open ↗

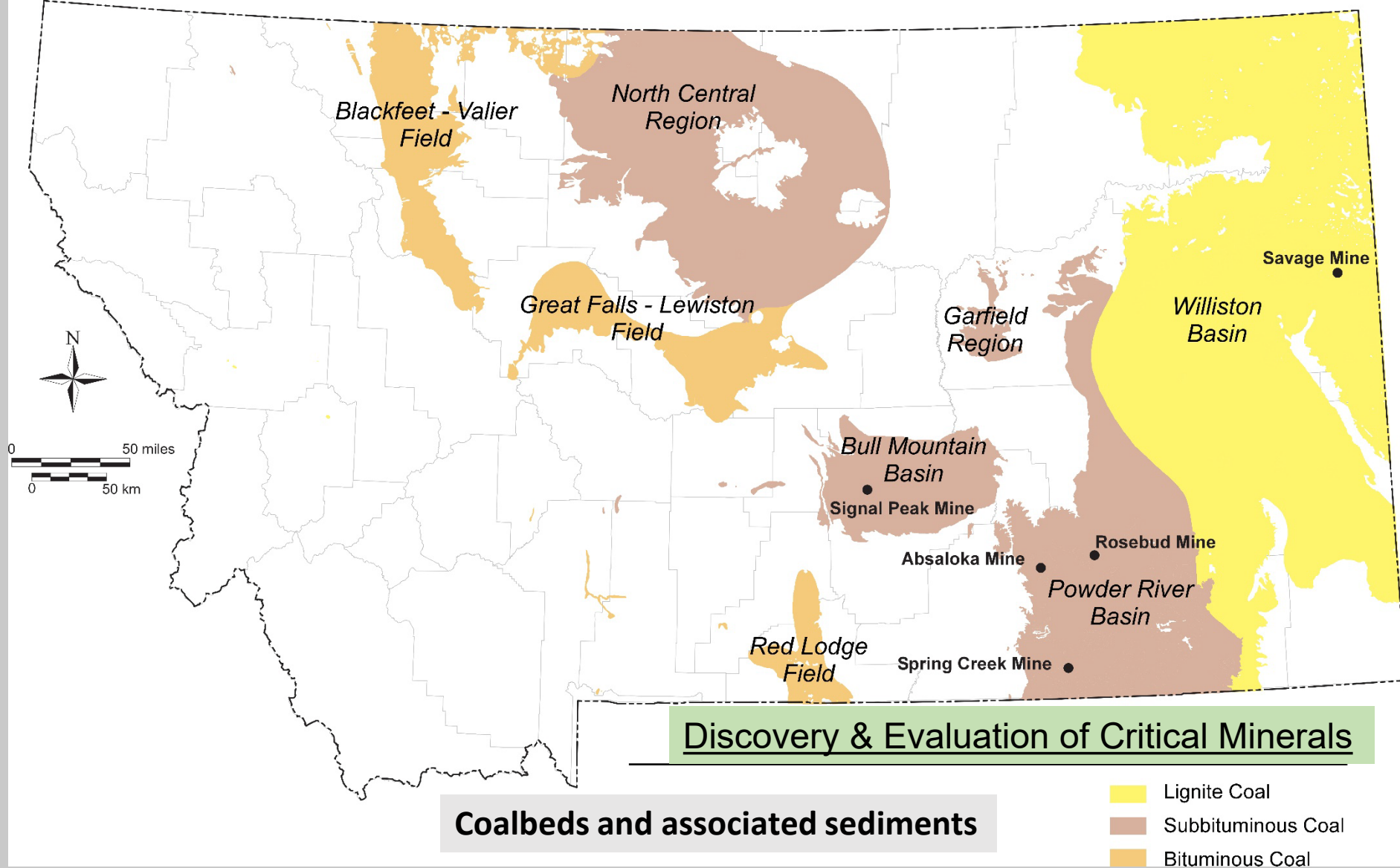


IEA. Licence: CC BY 4.0

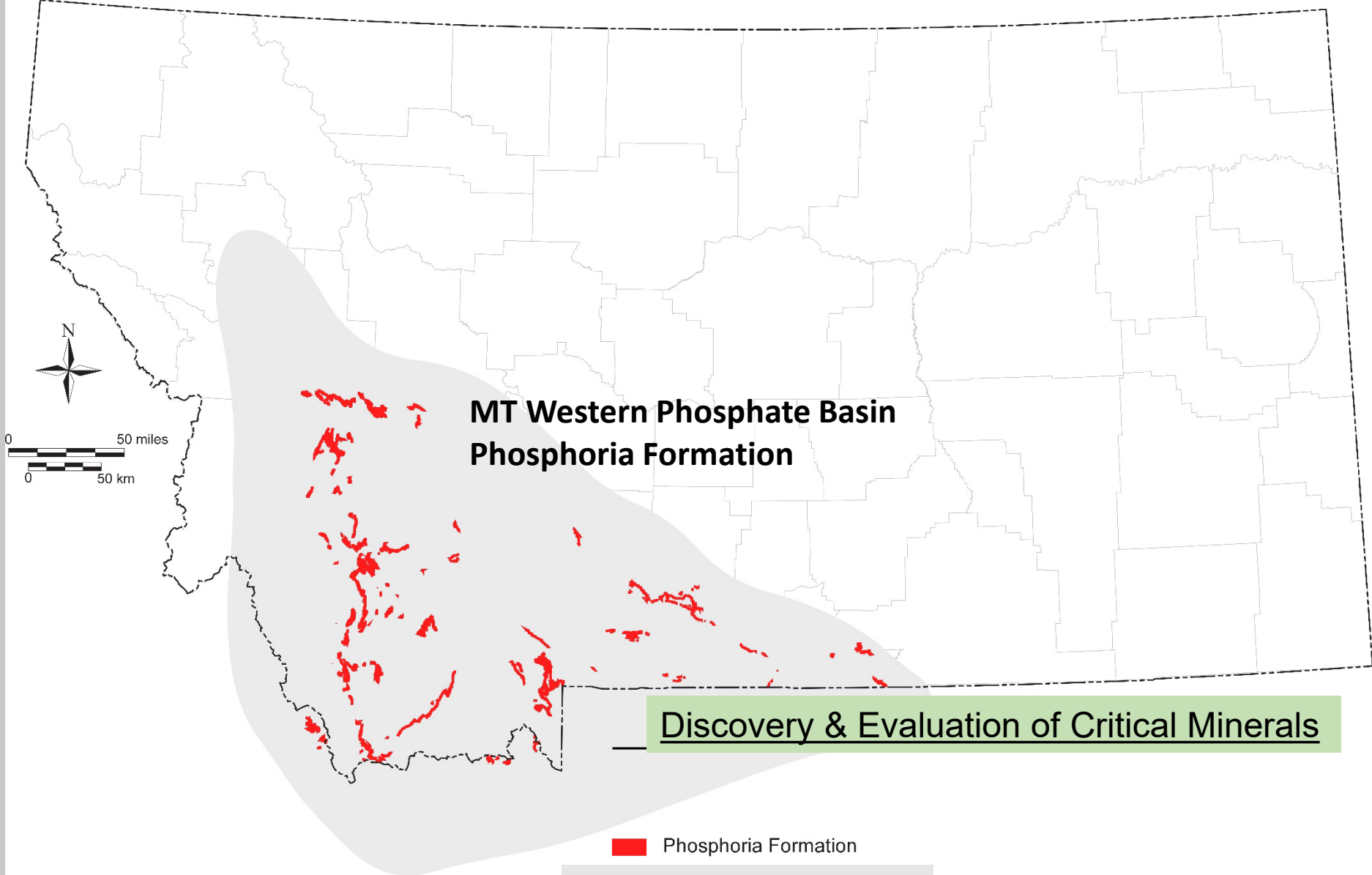
- Solar PV
- Wind
- Other low-carbon power generation
- EVs and battery storage
- Electricity networks
- Hydrogen

Potential Sources of Critical
Mineral Commodities
in Montana

by resource



lignite coal and mudstones contain up to 2570 ppm total REEs (300 ppm considered economic). Enriched concentrations of critical minerals including cobalt, gallium, germanium, and lithium were also present in these samples.

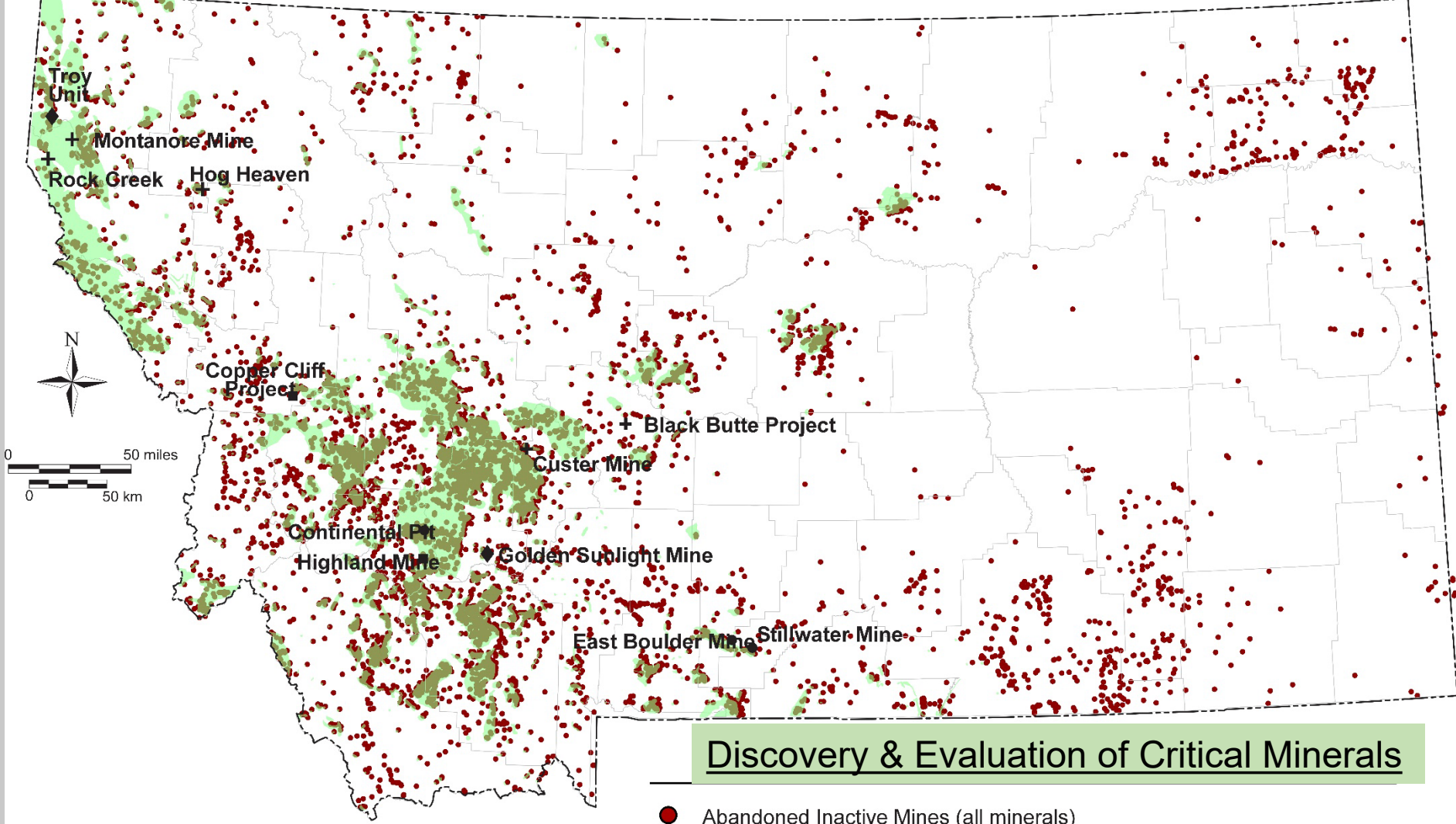


**MT Western Phosphate Basin
Phosphoria Formation**

Discovery & Evaluation of Critical Minerals

■ Phosphoria Formation

Phosphoria Formation



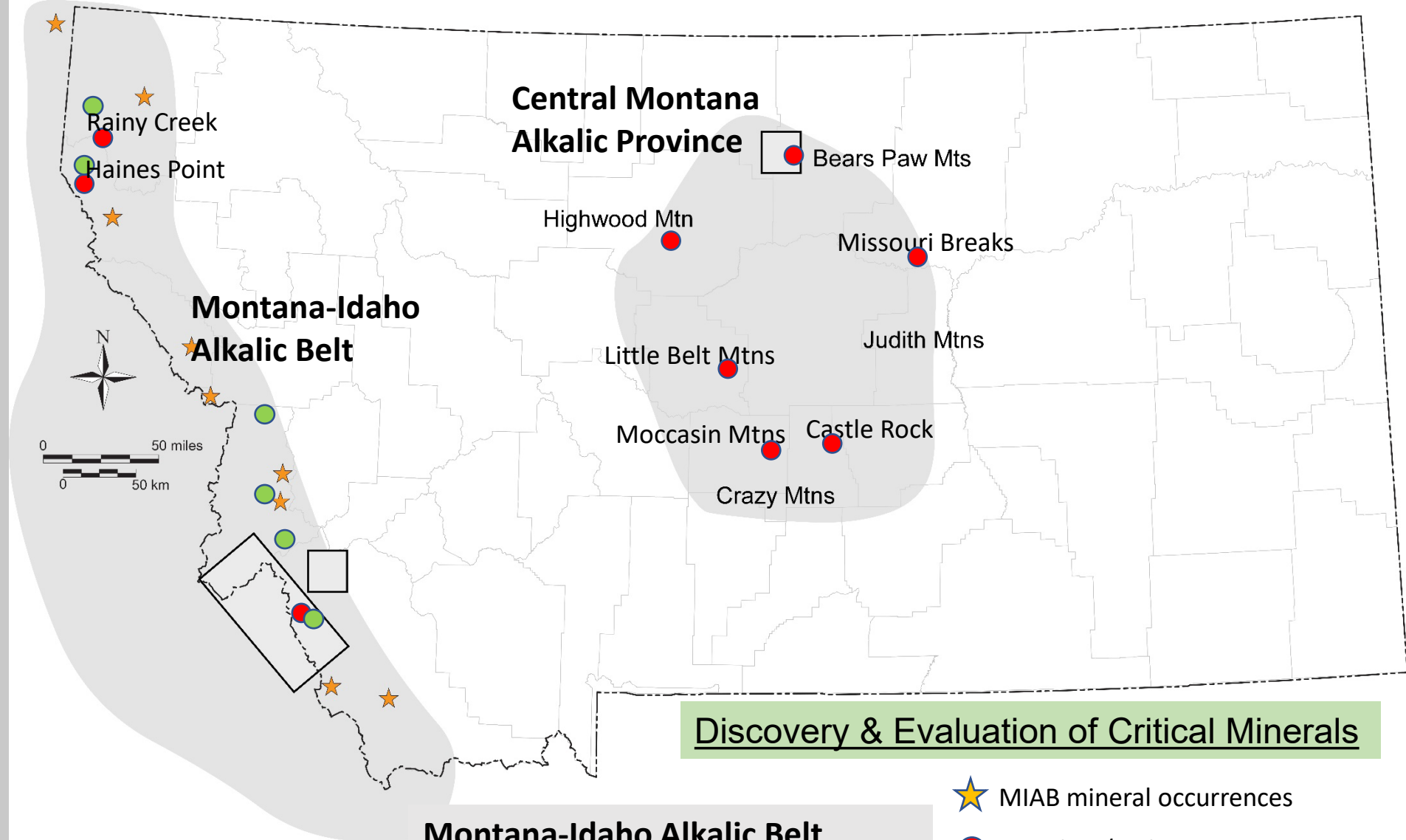
Discovery & Evaluation of Critical Minerals

Active Mines (2020)

- Production
- Standby
- + Permitting
- ◆ Reclamation

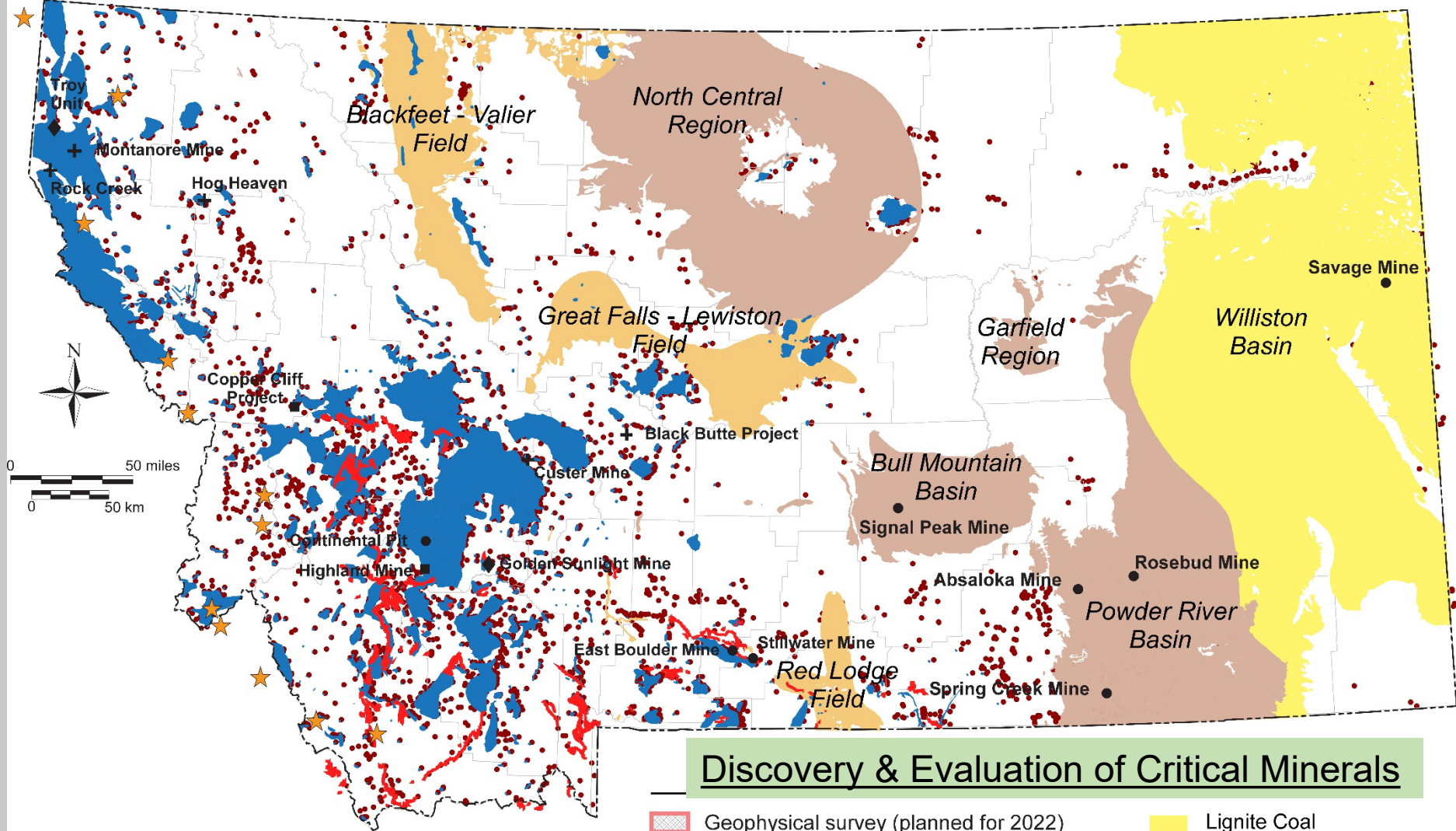
- Abandoned Inactive Mines (all minerals)
- High/Moderate Mineral Potential (all minerals)

Abandoned Mine Lands and areas of moderate to high mineral potential



Montana-Idaho Alkalic Belt
Central Montana Alkalic Province

- ★ MIAB mineral occurrences
- Tantalum/niobium occurrences
- Thorium/titanium occurrences



Discovery & Evaluation of Critical Minerals

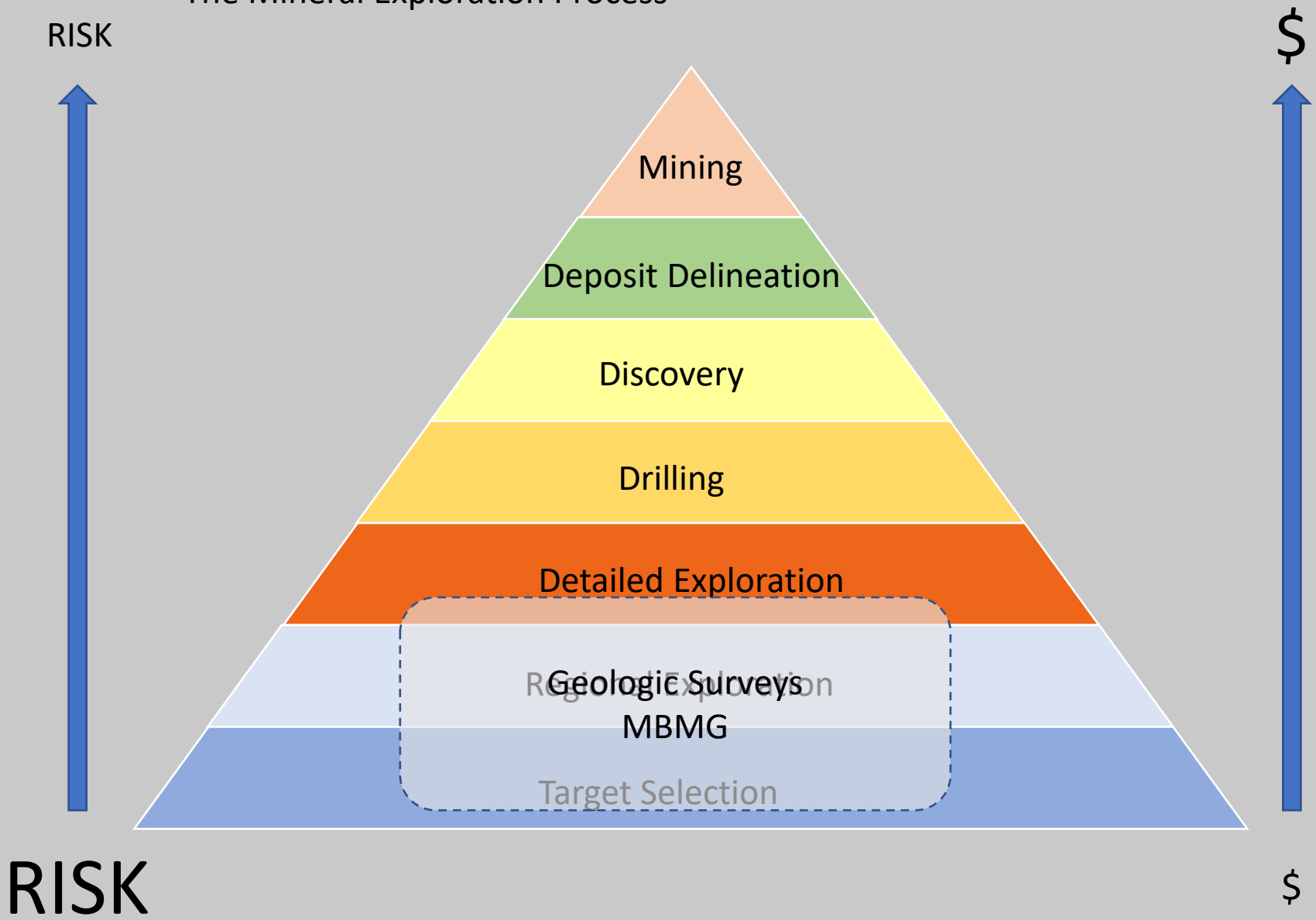
Active Mines (2020)

- Production
- Standby
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- ◆ Reclamation

- Geophysical survey (planned for 2022)
- High/Moderate Mineral Potential (all minerals)
- Phosphoria Formation
- MT-ID Alkalic Belt (MIAB) mineral deposits
- Lignite Coal
- Subbituminous Coal
- Bituminous Coal

**Large-scale mine waste
waste rock, tailings, ash...**

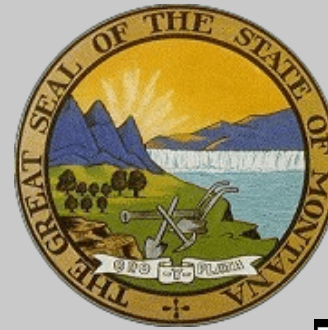
The Mineral Exploration Process



Projects

• USGS Earth Mapping Resources Initiative

- Data preservation
 - Historic collections (paper, core, samples...)
- Geologic mapping (regional and detailed)
 - Radersburg
 - Sheep Creek
 - Elkhorn (complete)
- Geophysical surveys (regional)
 - Boulder Batholith (complete)
 - Boulder Batholith extension (June 2023)
- Abandoned Inactive Mines (detailed)
 - characterization of mine waste



• Army Research Laboratory (REEs)

- 5 projects: coal, waste, AIM, Phosphoria, alkalic deposits (CAMP)
- Berkeley Pit Butte, MT (WVU)



• DOE Core CM (in coal)

- Wyoming Energy Center (UW)
- Energy & Environmental Research Center (UND)



Tabular data...national database

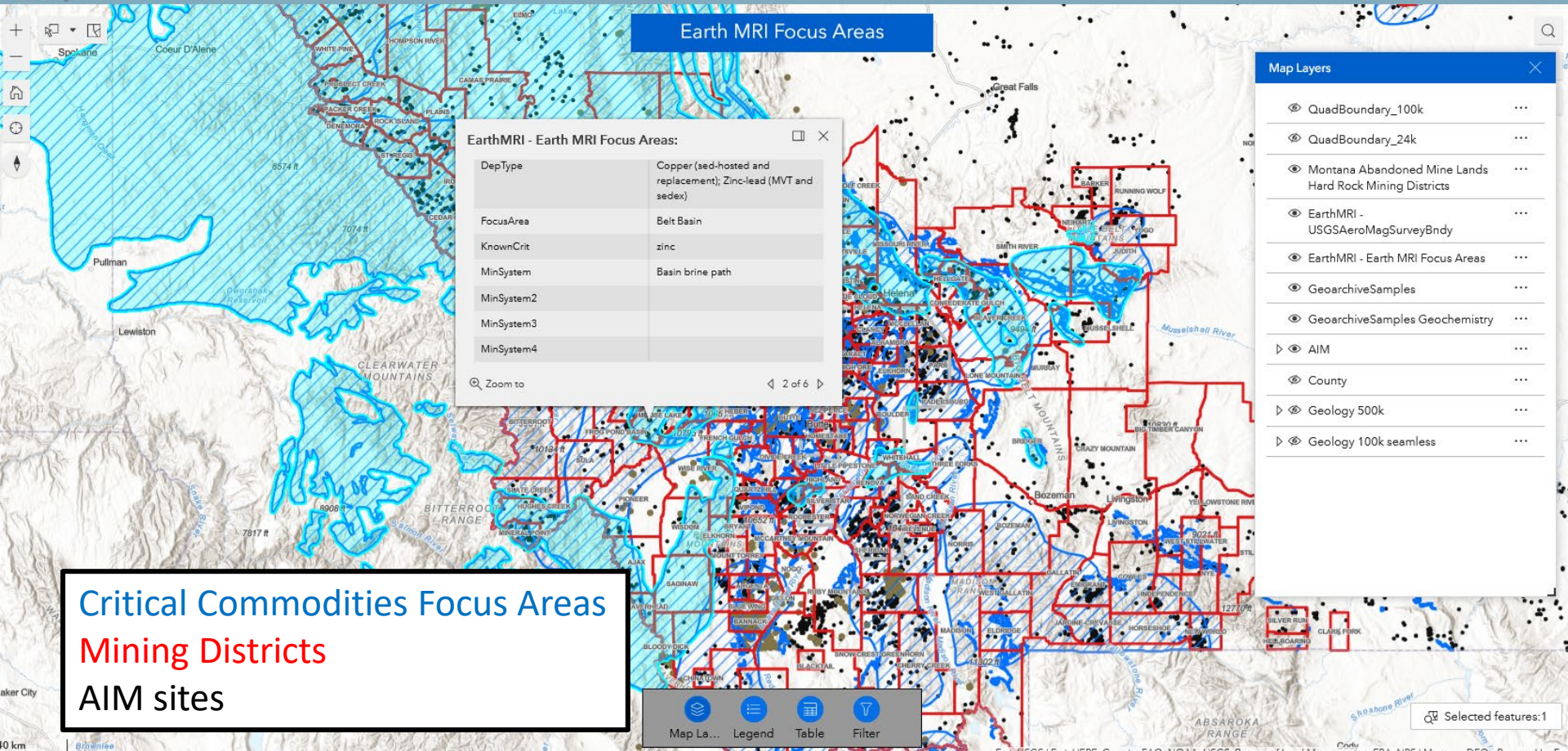
Area	State(s)	Mineral System	Deposit Types	Commodities
Central Montana alkalic province	Montana; Wyoming	Magmatic REE; Alkalic porphyry	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites; Carbonatite; Porphyry/skarn copper-gold	copper; antimony; niobium ; tantalum ; titanium; tellurium; REE; tungsten; vanadium; gold; lead; zinc; sapphire
Highwood Mountains	Montana	Magmatic REE	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites	REE; niobium ; tantalum ; tellurium
Little Belt Mountains	Montana	Magmatic REE; Alkalic porphyry	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites; Polymetallic sulfide S-R-V-IS	REE; niobium ; tantalum ; tungsten; gold; silver; lead; copper; zinc; tellurium
Castle stock	Montana	Magmatic REE; Alkalic porphyry	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites; Polymetallic sulfide S-R-V-IS	REE; niobium ; tantalum ; tungsten; silver; lead; zinc; gold; copper; manganese
Bearpaw Mountains plutons	Montana	Magmatic REE; Alkalic porphyry	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites; Polymetallic sulfide S-R-V-IS	REE; niobium ; tantalum ; tellurium; gold; silver
Missouri Breaks diatremes	Montana	Magmatic REE	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites	REE; niobium ; tantalum ; titanium
Mocassin Mountains plutons	Montana	Magmatic REE; Alkalic porphyry	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites; Polymetallic sulfide S-R-V-IS	REE; niobium ; tantalum ; tellurium; gold; silver
Judith Mountains	Montana	Magmatic REE; Alkalic porphyry	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites; Polymetallic sulfide S-R-V-IS	gold; silver; tellurium; REE; niobium ; tantalum ; vanadium
Idaho-Montana REE province	Idaho; Montana	Magmatic REE	Carbonatite	REE; thorium; titanium; niobium ; fluorspar; scandium
Sheep Creek-Mineral Hill	Idaho; Montana	Magmatic REE	Carbonatite	REE; titanium; niobium
Haines Point	Montana	Magmatic REE	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites	REE; titanium; niobium
Rainy Creek	Montana	Magmatic REE	Peralkaline syenite/granite/rhyolite/alaskite/pegmatites	REE; titanium; niobium ; copper; lead; zinc; vanadium; fluorspar; vermiculite; feldspar

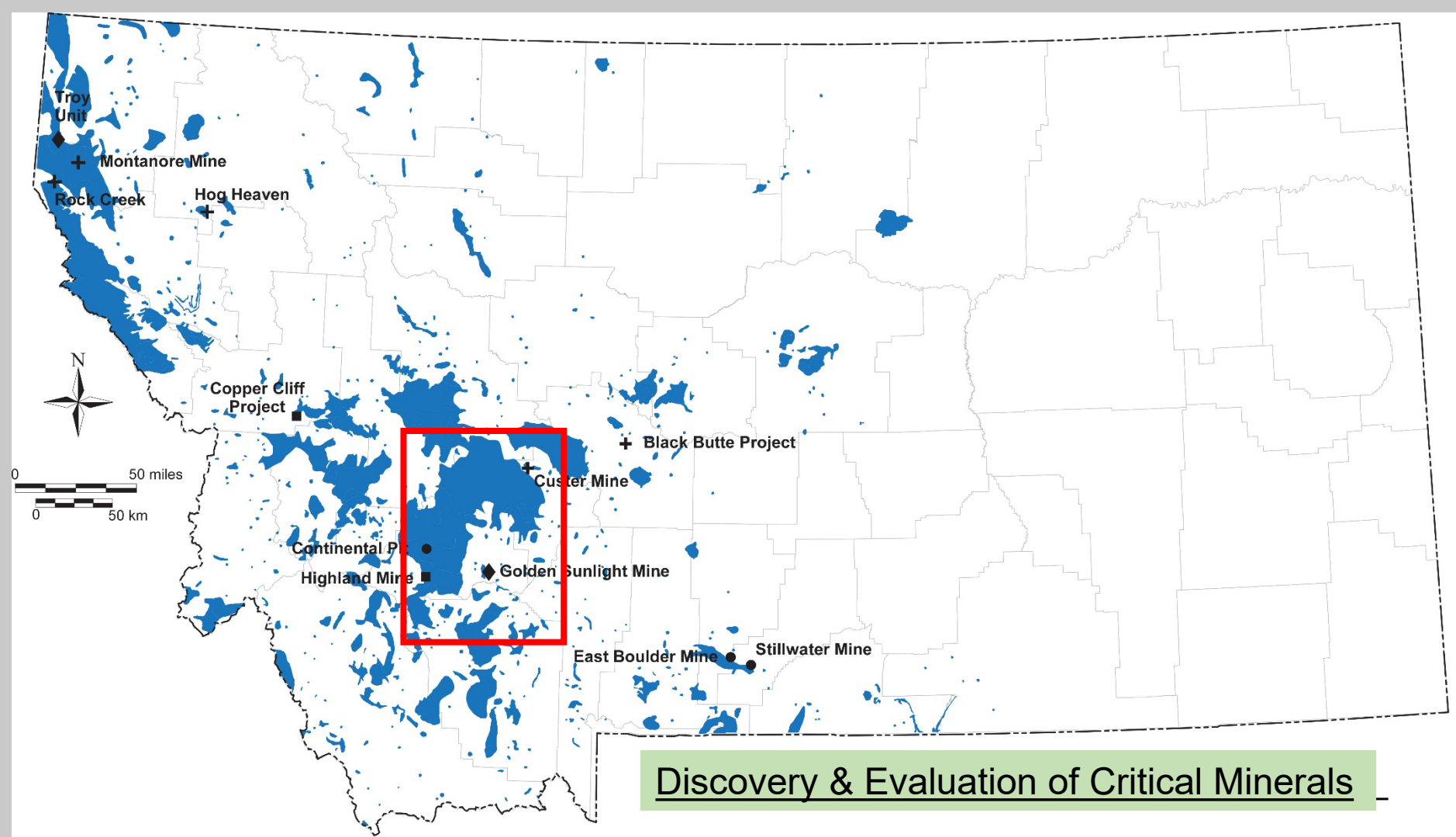
Tabular data...national database

Information leading to the delineation of this focus area

Basis for focus area	The central Montana alkalic province consists of a variety of intrusive plutons exposed in isolated mountain ranges. Pluton compositions are variable and are represented by syenite porphyries, trachyte dikes, lamprophyres, shonkinite, monzonite, rhyolite porphyries, granite, carbonatite, latite, phonolite diatremes, tinguaitite, alkali gabbro, kimberlite, peridotites, and alnoite. It is proposed most of the mafic alkalic magmas originated from an underlying Precambrian age lithospheric mantle and there is evidence for contributions from underlying asthenosphere with granitic assimilation originating from the base of the crust. Magmatic related mineral deposits associated with alkaline/peralkaline plutons and carbonatites. Deposit types vary throughout the alkalic province consisting of hydrothermal breccias, epithermal veins, contact metasomatic skarns, replacements, placers, breccia fillings, strata-bound mantos in carbonates, disseminations in intrusions and carbonates, karst breccias, and lamprophyre dikes.
Identified resources	gold, tellurium, copper, lead, zinc, sapphire
Production	Past gold production was from telluride minerals. Historical production was for gold, silver, lead, zinc, and sapphires.
Status	No current mining or exploration for critical elements but some intrusions were drilled for gold resources.
Estimated resources	No estimated resources for critical elements
Geologic maps	State-scale compilation (Horton, 2017) covers the broad parent area; See National Geologic Map Database for local maps.
Geophysical data	Adequate Rank 1 magnetic and aeroradiometric data available over southeast Missouri (McCafferty and others, 2019).
Authors	Stanley L. Korzeb
Bibliographic references	Baker, D.W., and Berg, R.B., eds., 1991, Guidebook of the Central Montana Alkalic Province—Geology, Ore Deposits, and Origin: Montana Bureau of Mines and Geology Special Publication 100, 201 p.

Spatial data...



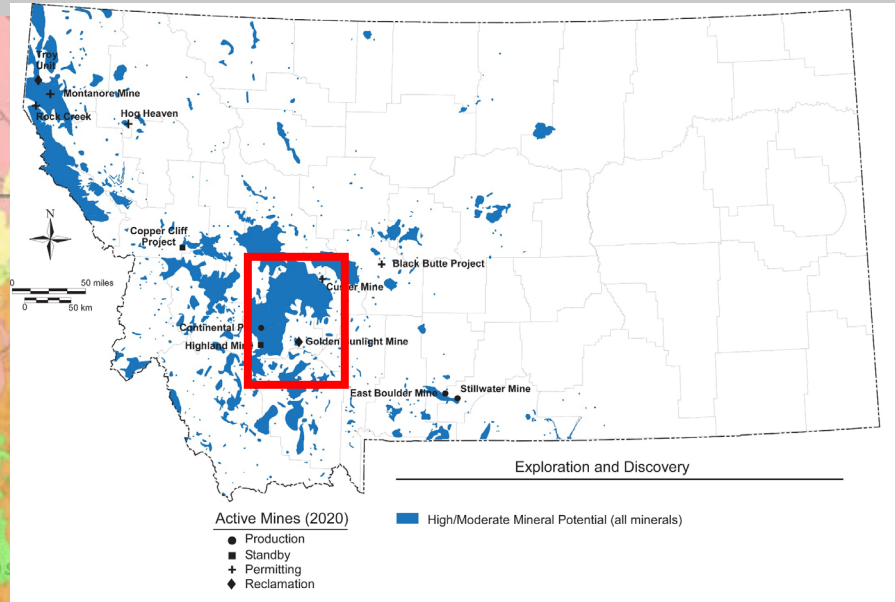
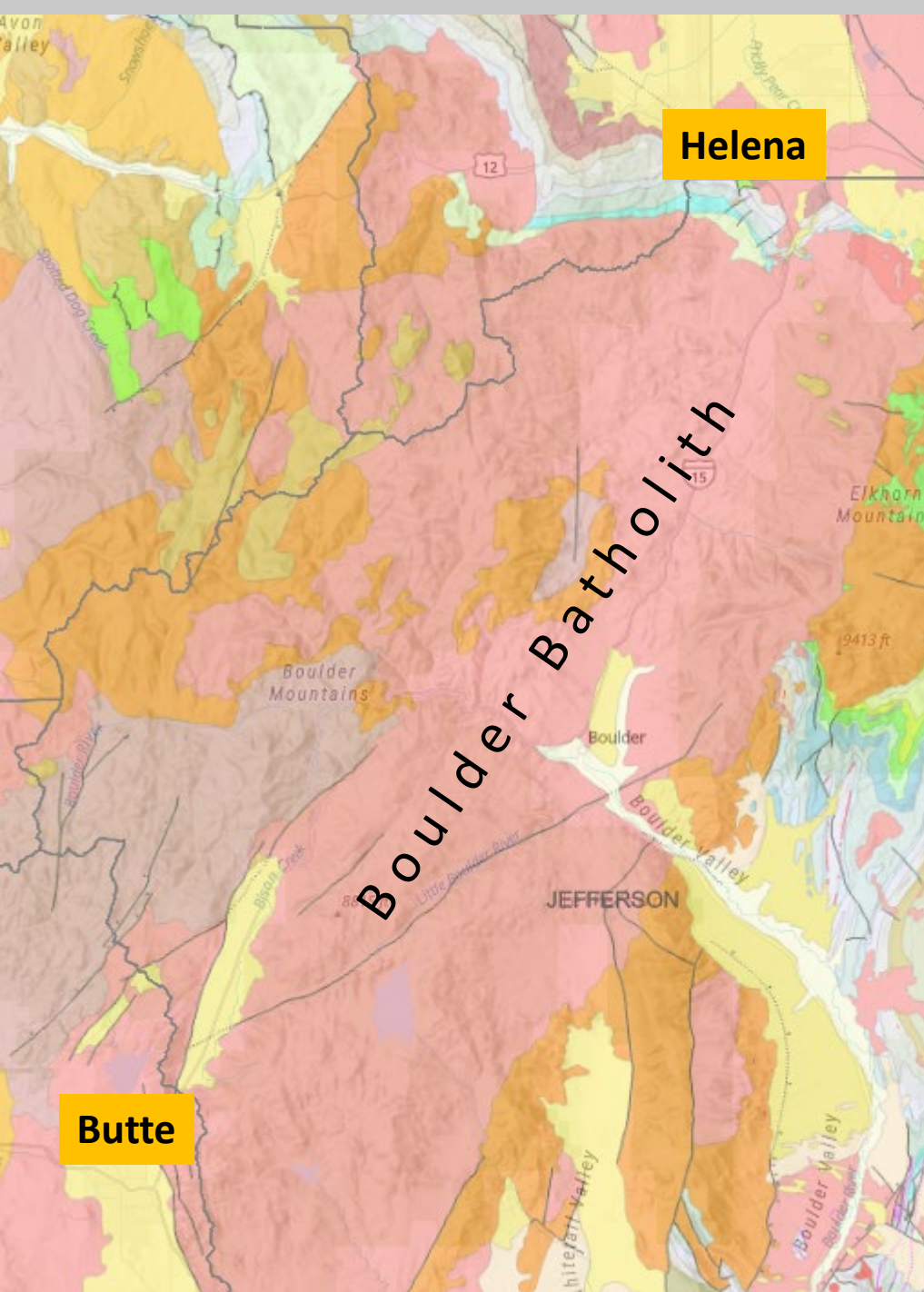


Discovery & Evaluation of Critical Minerals

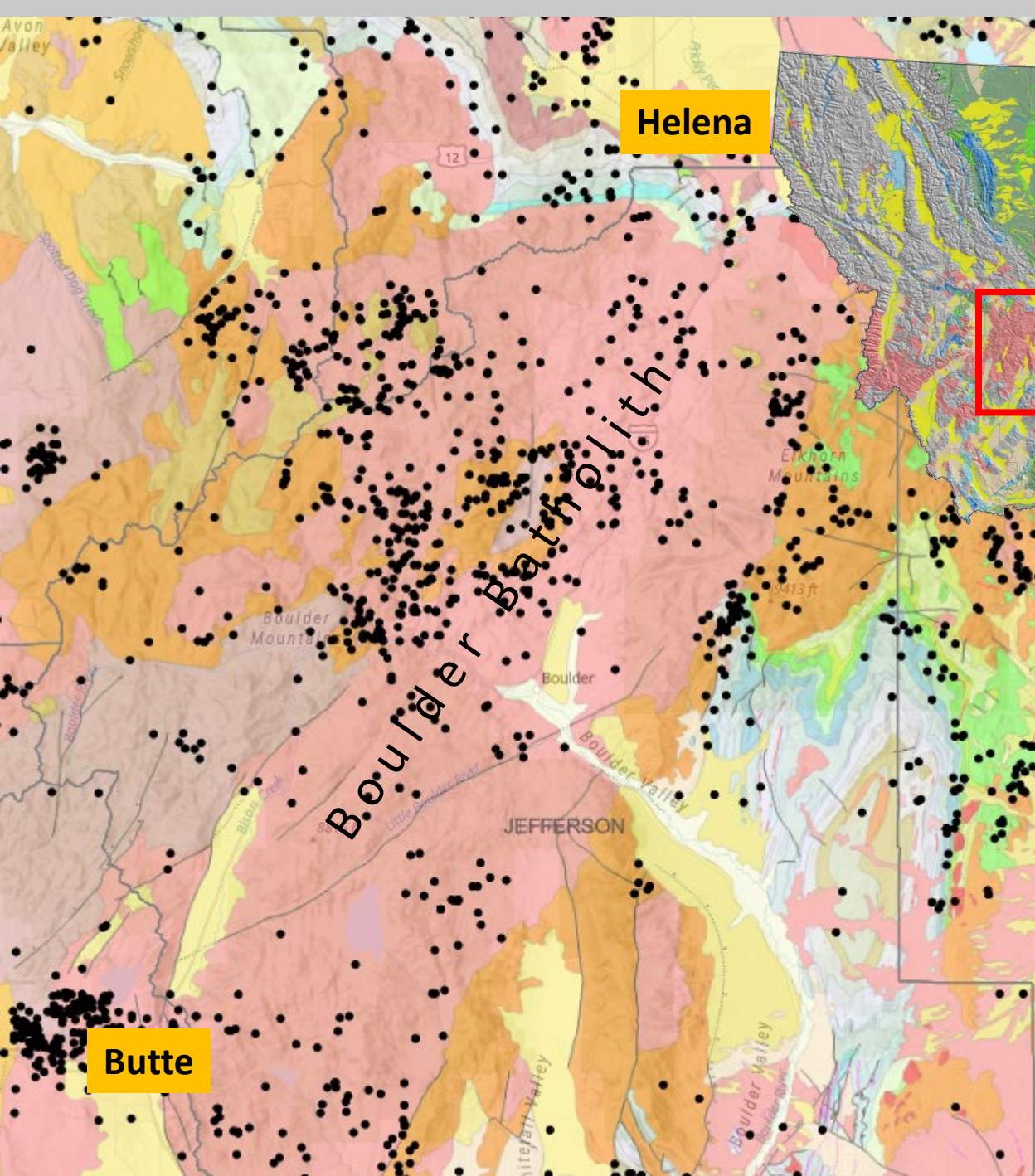
Active Mines (2020)

- Production
- Standby
- + Permitting
- ◆ Reclamation

■ High/Moderate Mineral Potential (all minerals)

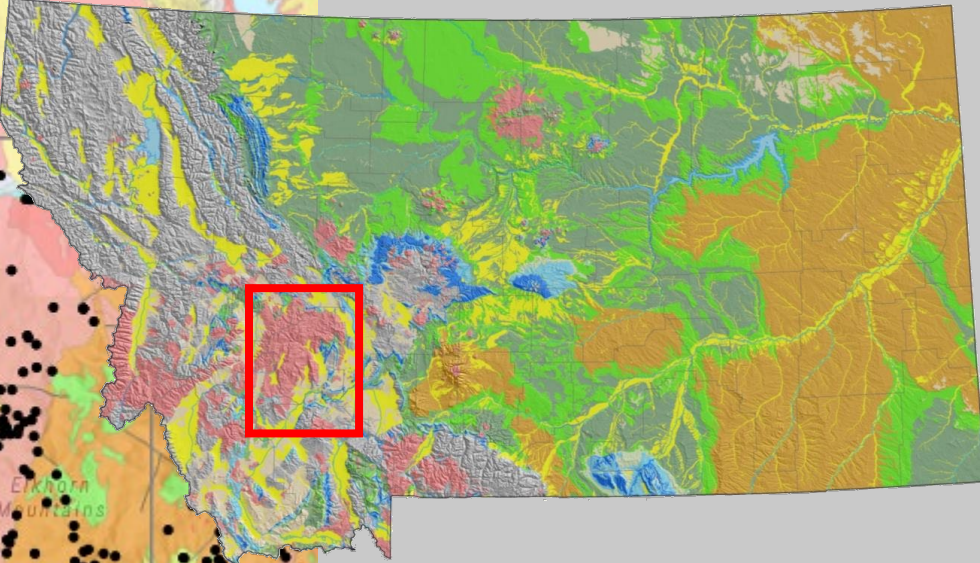


Geologic setting

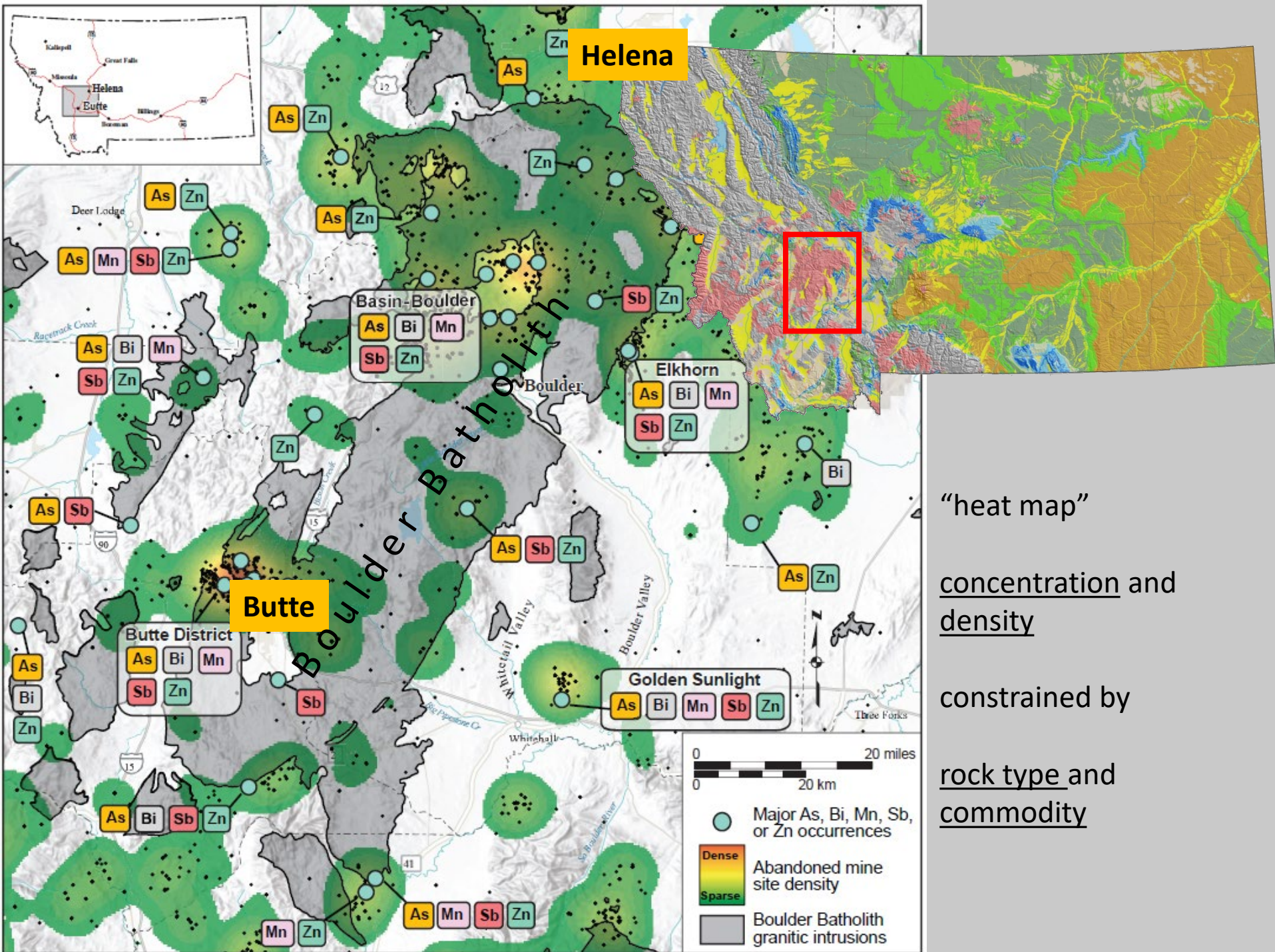


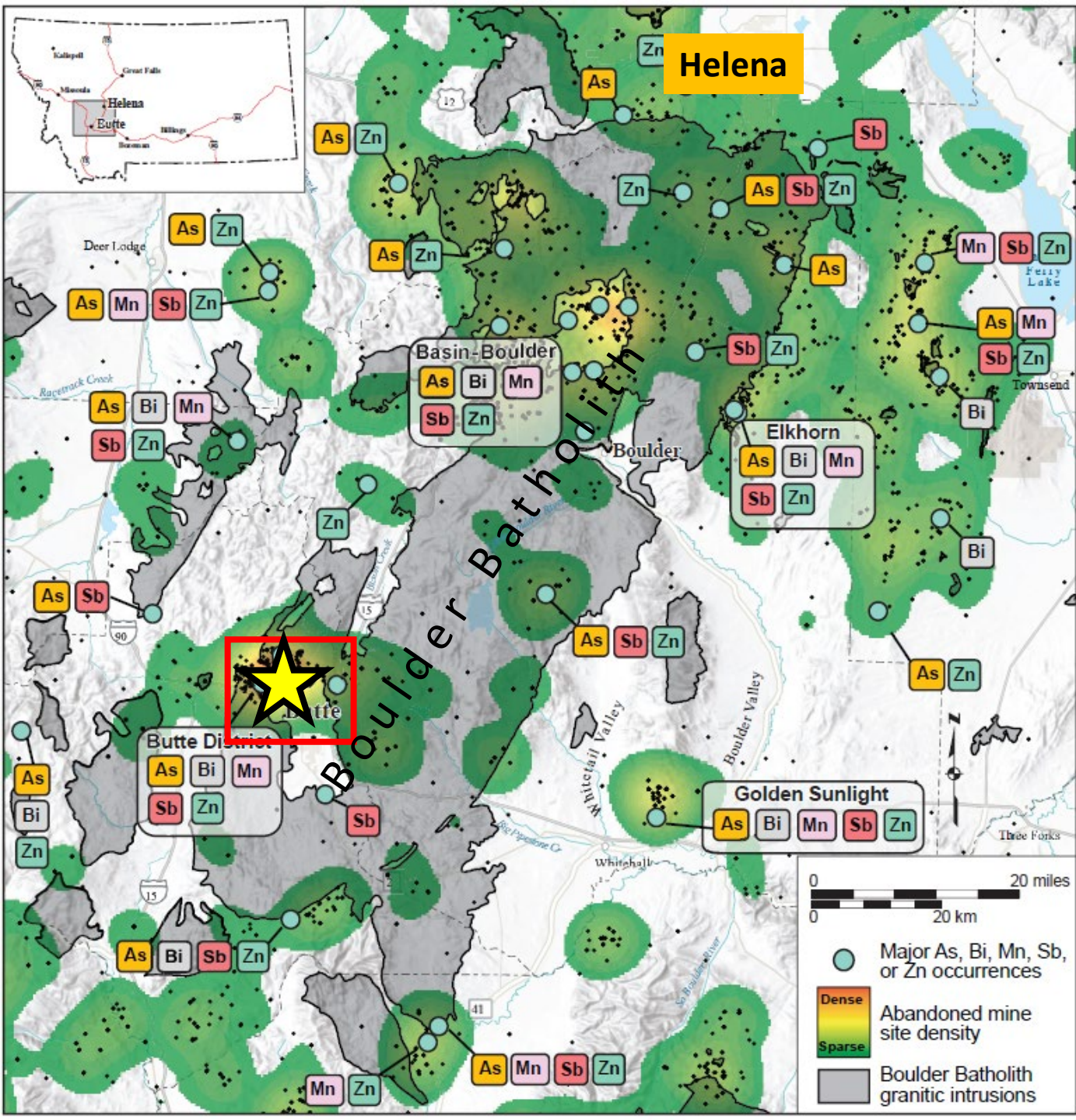
Helena

Butte

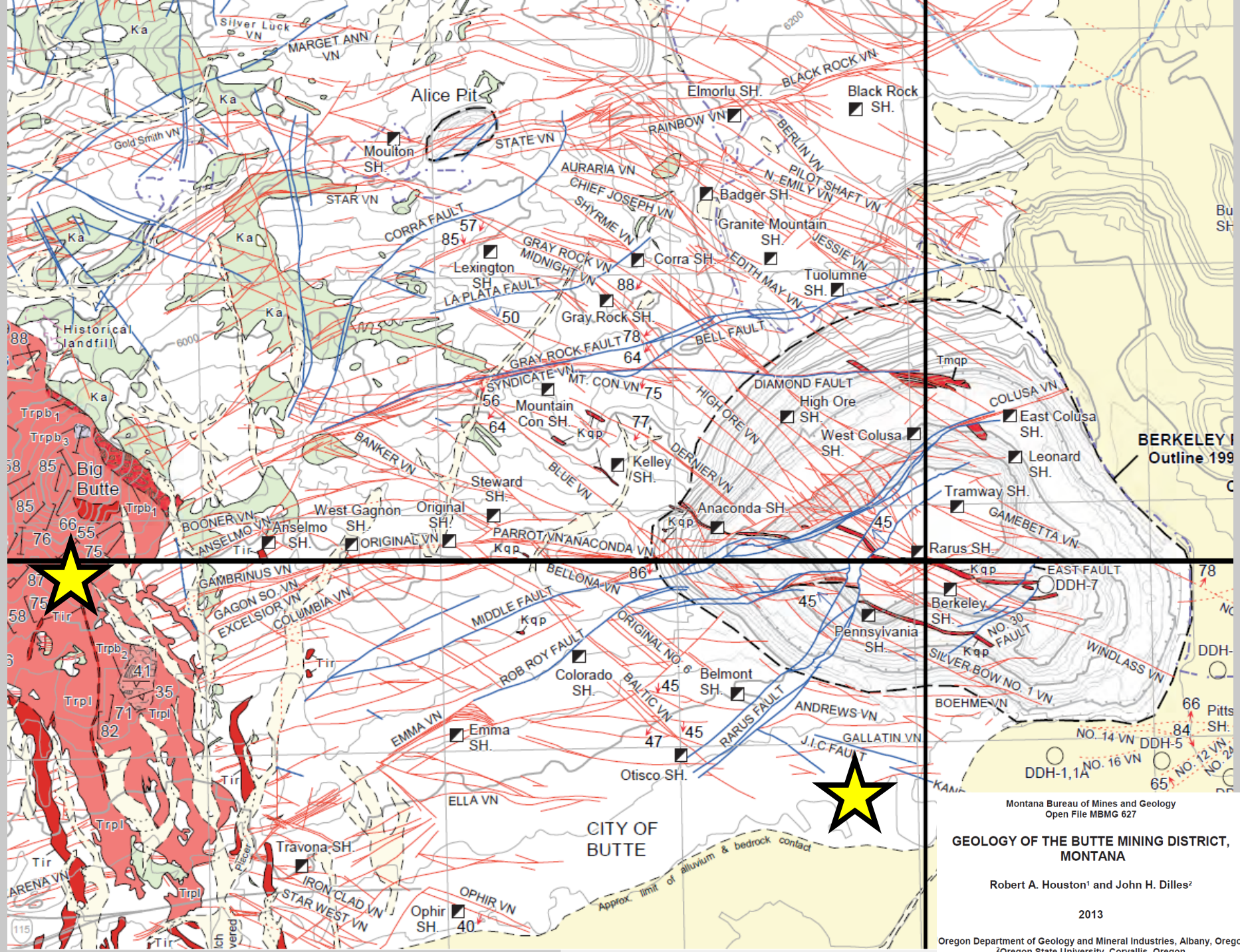


Commodities and production from past mining









Montana Bureau of Mines and Geology
Open File MBMG 627

**GEOLOGY OF THE BUTTE MINING DISTRICT,
MONTANA**

Robert A. Houston¹ and John H. Dilles²

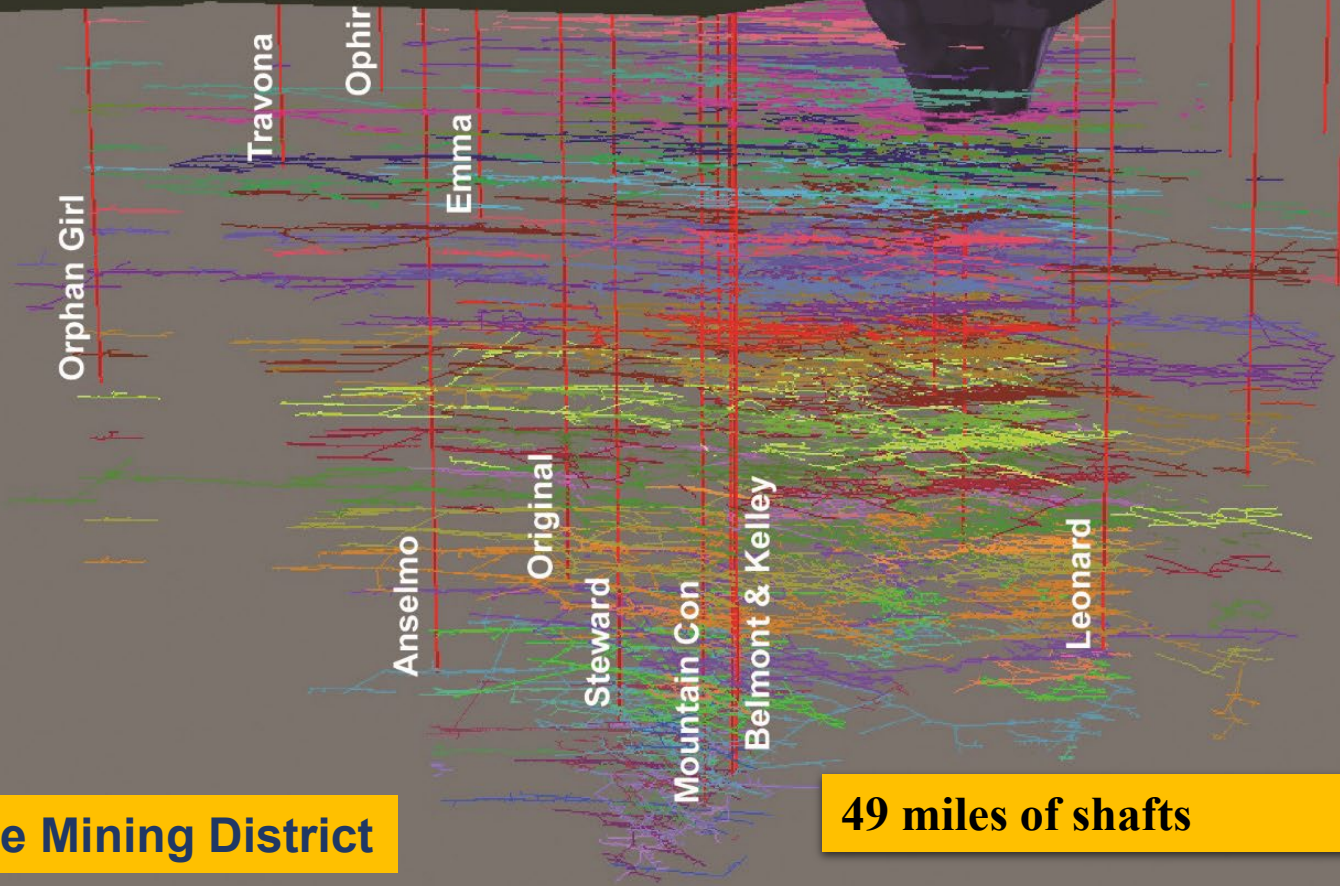
2013

¹Oregon Department of Geology and Mineral Industries, Albany, Oregon
²Oregon State University, Corvallis, Oregon

7 square miles



5,600 miles of workings



Butte Mining District

49 miles of shafts

Critical commodities produced (1880-1972)

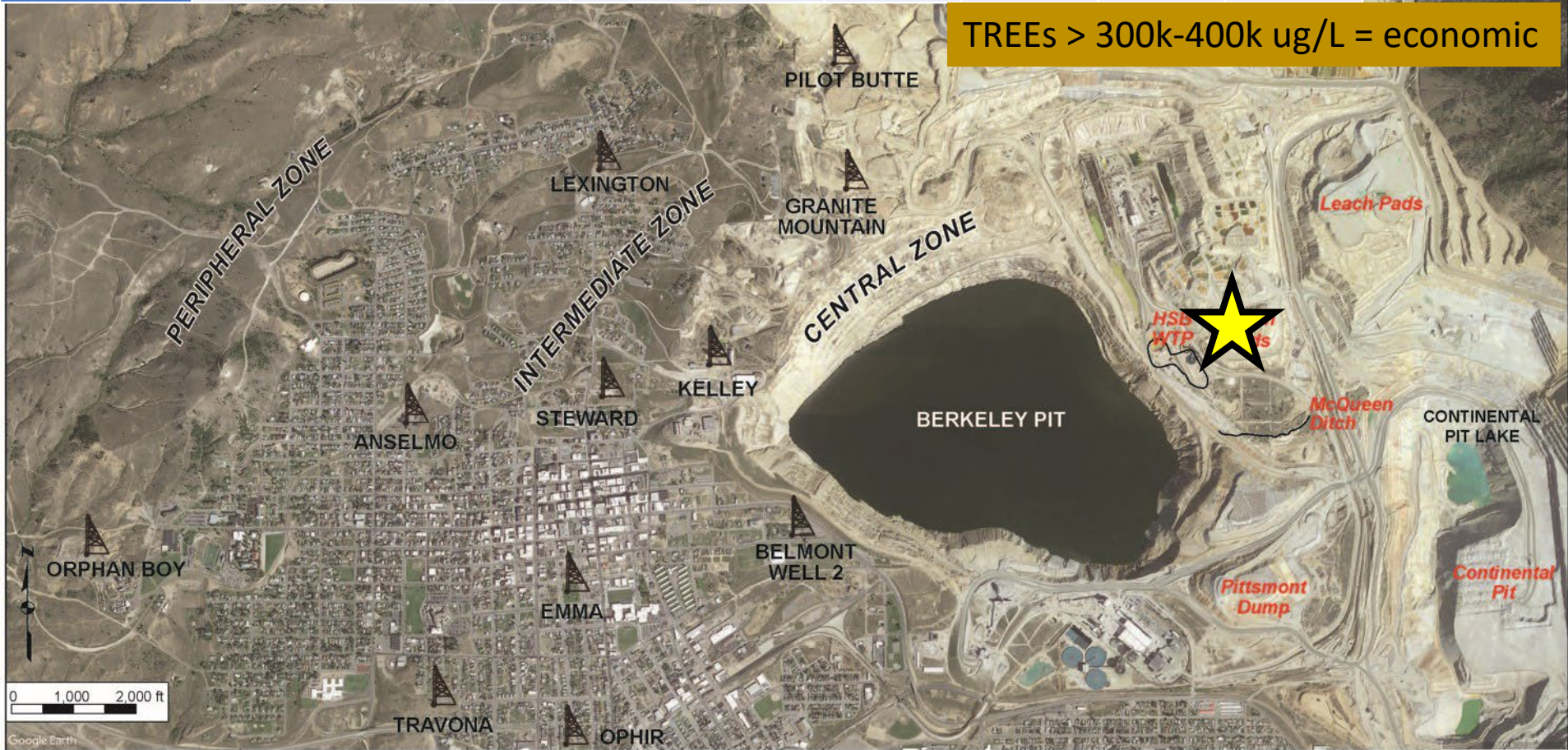
Bismuth	4.0 million pounds
Manganese	3.7 billion pounds
Tellurium	0.2 million pounds
Zinc	4.9 billion pounds



Critical commodities reported, no production

- Antimony in tetrahedrite
- Germanium in sphalerite and enargite
- Indium in sphalerite
- Tungsten in scheelite
- Vanadium in colusite

Site/Analyte	Nd	Eu	Tb	Dy	Er	Y	Ce	La	TREE*
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Berkeley Pit	629	39	38	250	155	1,411	1,303	330	4,950
MR Leach Pad Water	411	21	19	122	72	NA	674	150	1,890
HsB Sludge**	50,000	3,200	3,100	21,000	13,000	113,000	102,000	26,000	397,820



*TREE-total rare earth element concentration for all REE analyzed. NA-not analyzed.

**HsB Sludge-concentrations of REE from water treatment plant stage 1 sludge.

MBMG Fact Sheets (so far...)

- Potential Sources of Critical Mineral Commodities in Montana
- Critical Commodity Research in Western Montana
- Mineral Deposits of Beaverhead County, Montana
- Critical Commodity Potential of the Boulder Batholith Region, Southwest Montana
- Critical Mineral Commodity Potential in the Butte Mining District
- Critical Mineral: Germanium
- Critical Mineral: Tantalum
- Critical Mineral: Graphite (in review)
- Critical Mineral: Zinc
- Critical Mineral: Gallium
- Critical Mineral: Ytterbium