OVERVIEW OF THE MINING INDUSTRY IN NEW MEXICO, WITH EMPHASIS ON CRITICAL MINERALS

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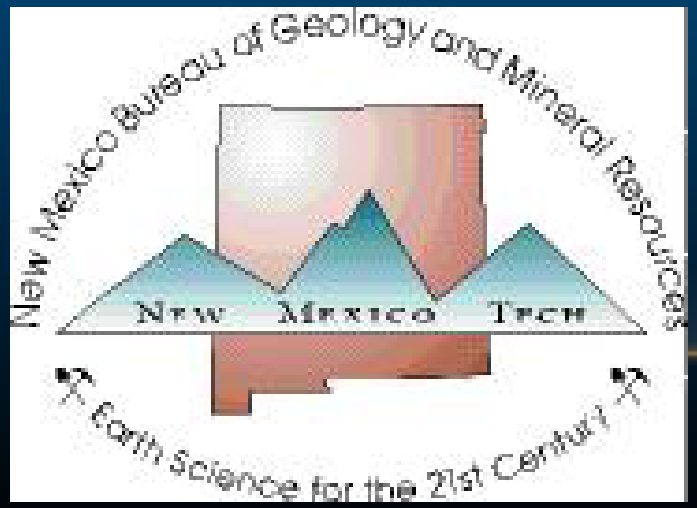

New Mexico Tech

ACKNOWLEDGEMENTS

- New Mexico Energy, Minerals and Natural Resource Department
- Company annual reports
- Personal visits to mines
- Historical production statistics from U.S. Bureau of Mines, U.S. Geological Survey, N.M. Energy, Minerals and Natural Resource Department (MMD), DOE, company annual reports
- Students at NM Tech, many part of the current Economic Geology Group

New Mexico Bureau of Geology and Mineral Resources

- A non-regulatory governmental agency (the state's geological survey) that conducts scientific investigations leading to responsible economic development of the state's mineral, water, and energy resources.
- We are a research division of New Mexico Tech.
- Founded in 1927 through state legislation.
- Currently 66 full and part time staff with a range of expertise. Active emeritus staff. Mentor and employ around 40 graduate and undergraduate students.


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OUTLINE

- What, where, and how much minerals are produced in New Mexico?
  - Where are potential future resources?
  - What are the minerals used for?
- What critical minerals are found in New Mexico?
  - Briefly describe some of the ongoing research
- What are the Mining Issues Facing New Mexico?
- Education outreach

WHAT, WHERE, AND HOW MUCH MINERALS ARE PRODUCED IN NEW MEXICO?

INTRODUCTION

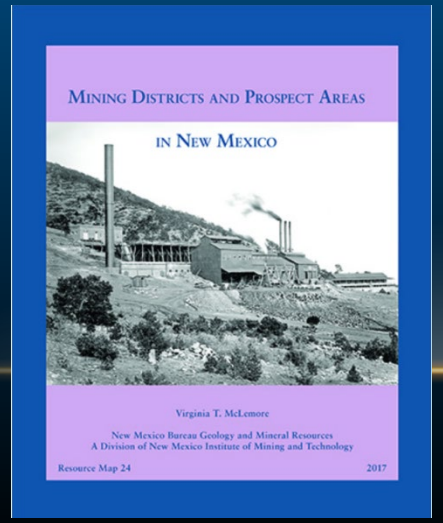
- NM has some of the oldest mining areas in the United States
- Native Americans mined turquoise from Cerrillos Hills district more than 500 yrs before the Spanish settled in the 1600s
- One of the earliest gold rushes in the West was in the Ortiz Mountains (Old Placers district) in 1828, 21 yrs before the California Gold Rush in 1849

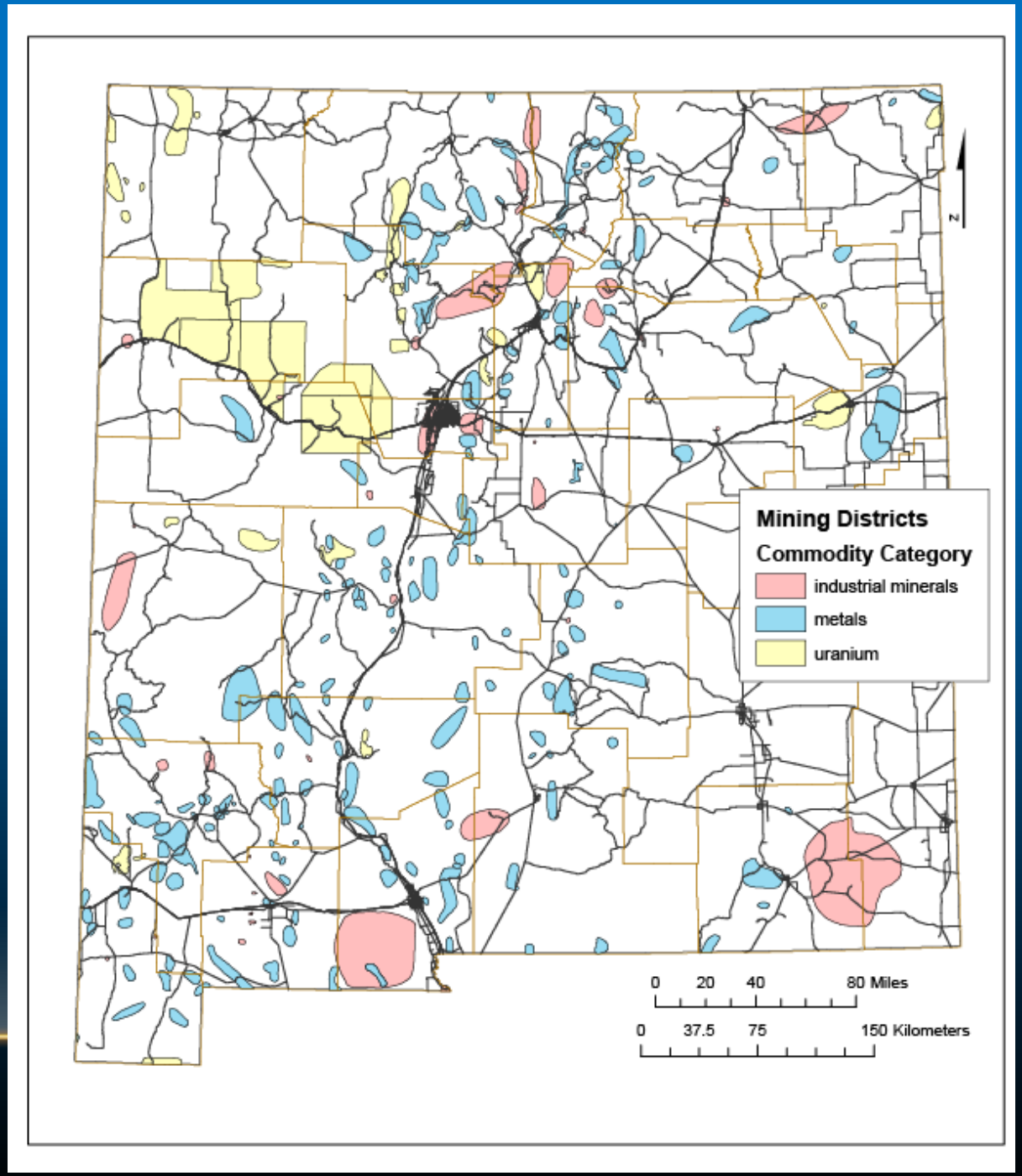
One of the turquoise mines in the Cerrillos Hills district

MINING DISTRICTS IN NEW MEXICO

274 mining districts and prospect areas

173 metals,
40 industrial minerals
33 uranium districts
28 coal fields





PRODUCTION SUMMARY—2021

- Value of mineral production in 2021 was $1.75 billion (up from 2020) (does not include oil and gas)—ranked 23rd in the US (18th in 2017)
- Employment in the mining industry is 3,757
- Exploration for garnet, gypsum, limestone, nepheline syenite, agate, specimen fluorite, gold, silver, iron, beryllium, uranium, copper, potash, rare earth elements, humate, clays, lithium
- ***MINERALS PRODUCTION IS DECREASING, ESPECIALLY COAL***

Value of mineral production in New Mexico 2000-2020

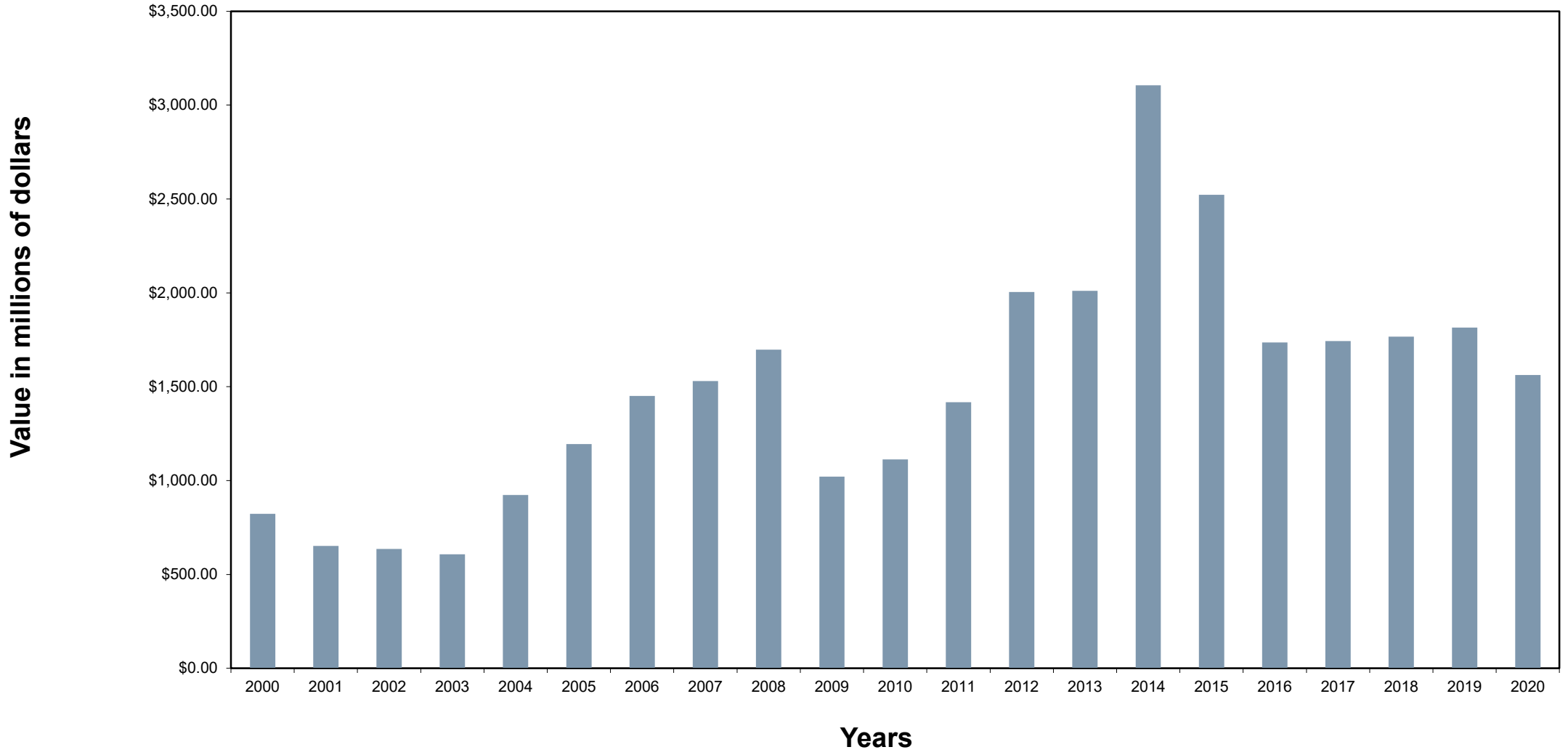
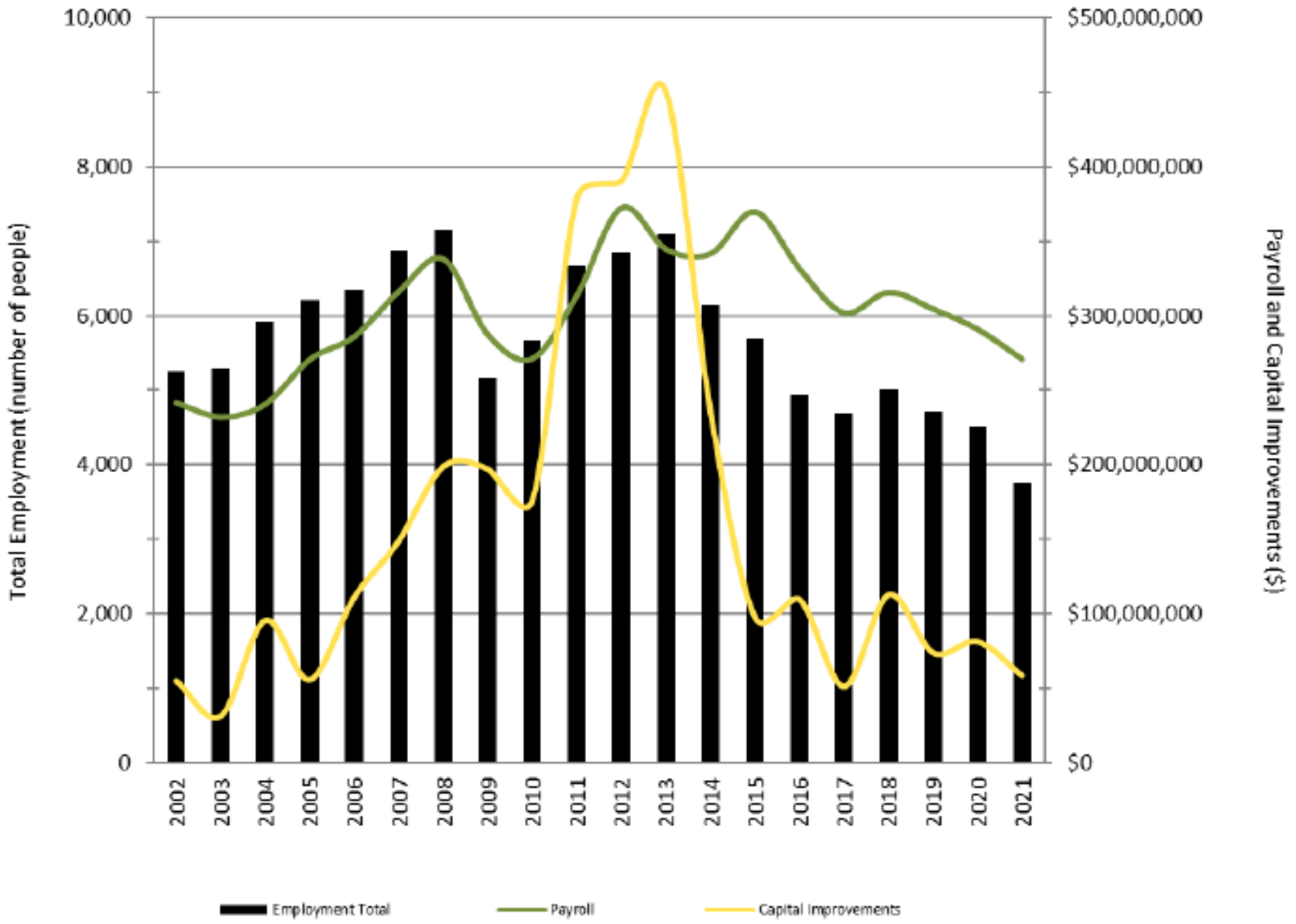


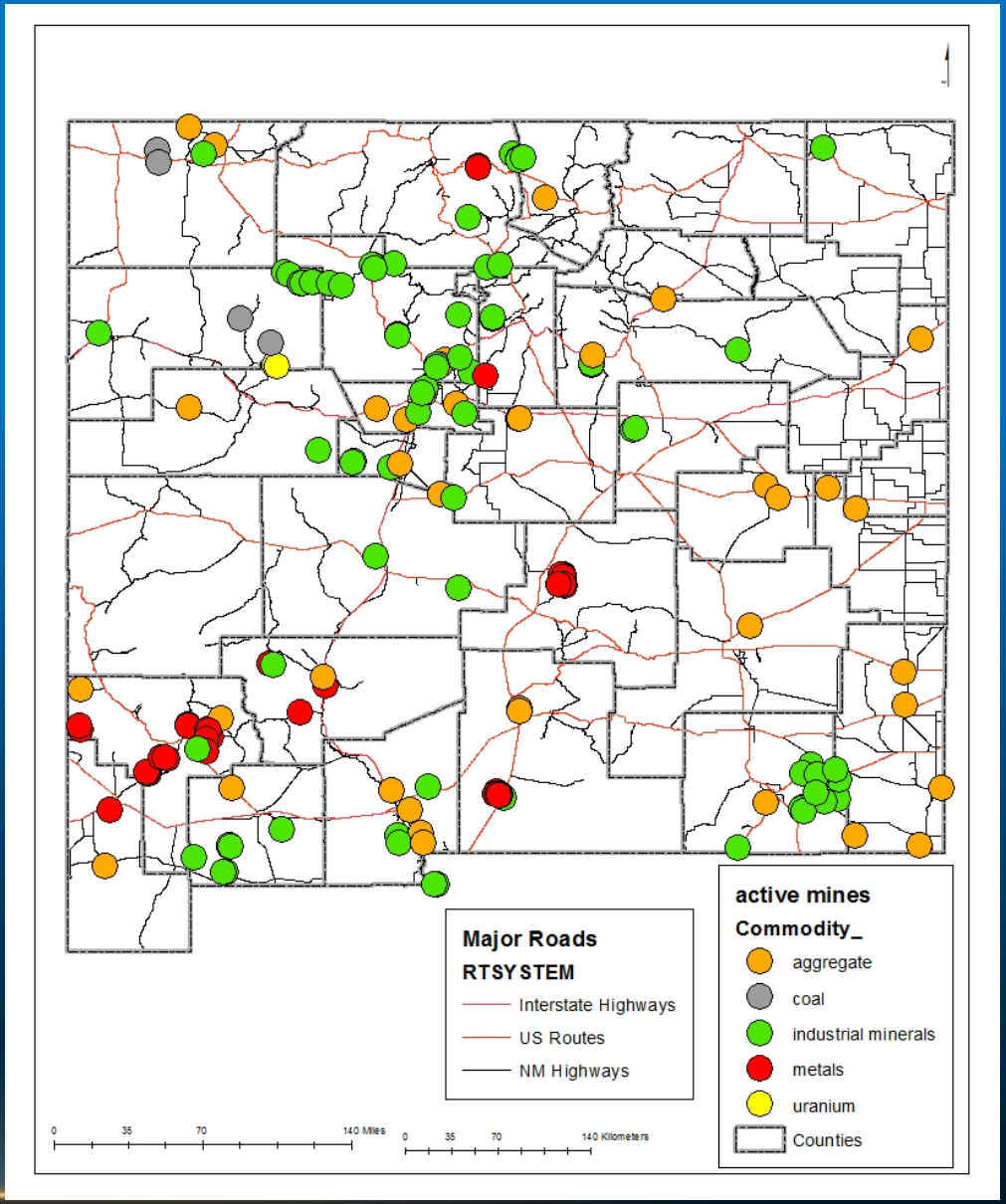
FIGURE 3 New Mexico Mineral Industry Employment, Payroll, and Capital Improvements: 2002-2021



EMNRD_AnnualReport_2022_final.pdf (nm.gov)

ACTIVE MINES 2023

- ~355 active registered mines (NMMMD)
- 2 coal, 1 electrical generating station
- 3 potash, 4 potash plants
- 2 copper open pits, 1 concentrator (mill), 2 solvent/electro-winning (SX-EW) plants
  - 1 additional mine in permitting stage
  - Several exploration projects
- 2 gold mines and 1 mill (active but not producing)
- 1 iron mine
- 31 industrial minerals mines, 18 mills
- ~302 aggregate/stone



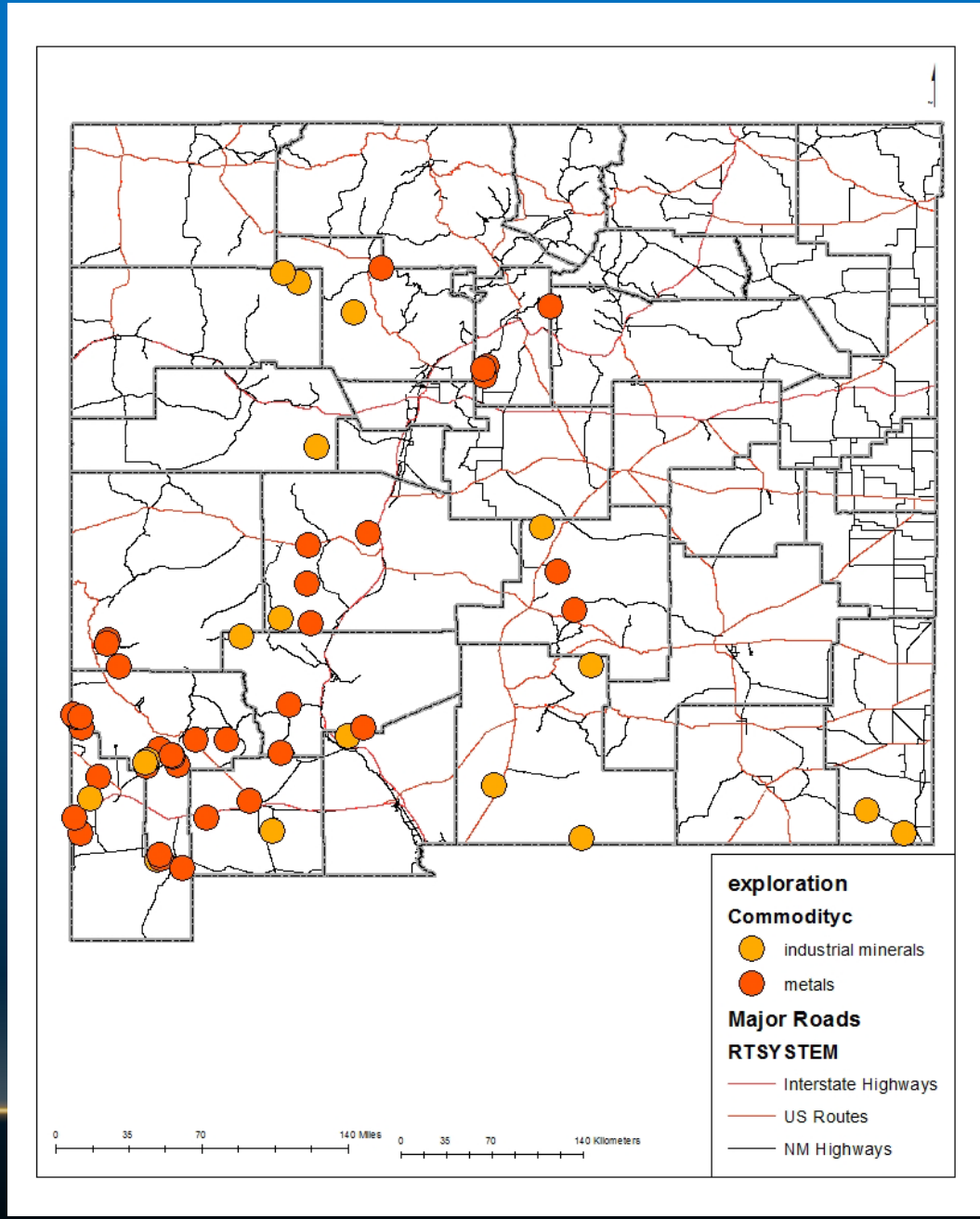
Not all aggregate mines are shown

From NM Mining and Minerals Div. database

SELECTED ACTIVE EXPLORATION SITES IN NEW MEXICO 2019-2023 (EXCLUDING U)

Most of these exploration sites have been known for >20 yrs

Industrial minerals deposits sometimes can be permitted within a few years but not metal mines

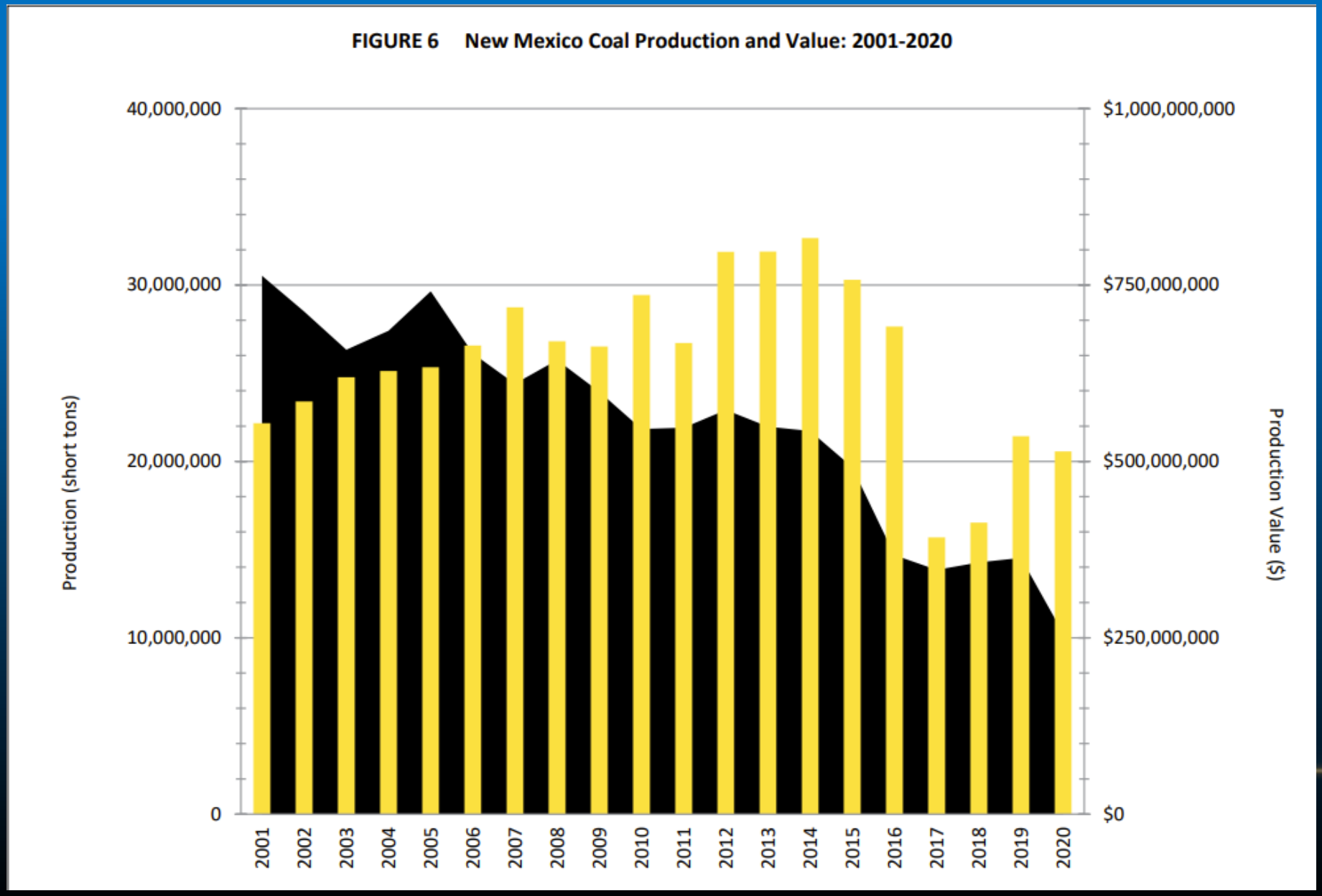


From NM Mining and Minerals Div. and NMBGMR databases, company web sites

COAL

- Fuels 1 electrical generating plant in NM and others in Az
  - Also used in chemical, metallurgical, and pharmaceutical industries
- 2 surface mines in San Juan Basin
- Resources at Raton, Carrizozo
- 12th in production in U.S. in 2021
  - 15th in estimated reserves
  - 65 million short tons of recoverable reserves
- San Juan generating station in the Farmington closed in 2022
- ***Coal production is expected to continue to decrease in the near future***

COAL PRODUCTION IN NEW MEXICO 2000-2020



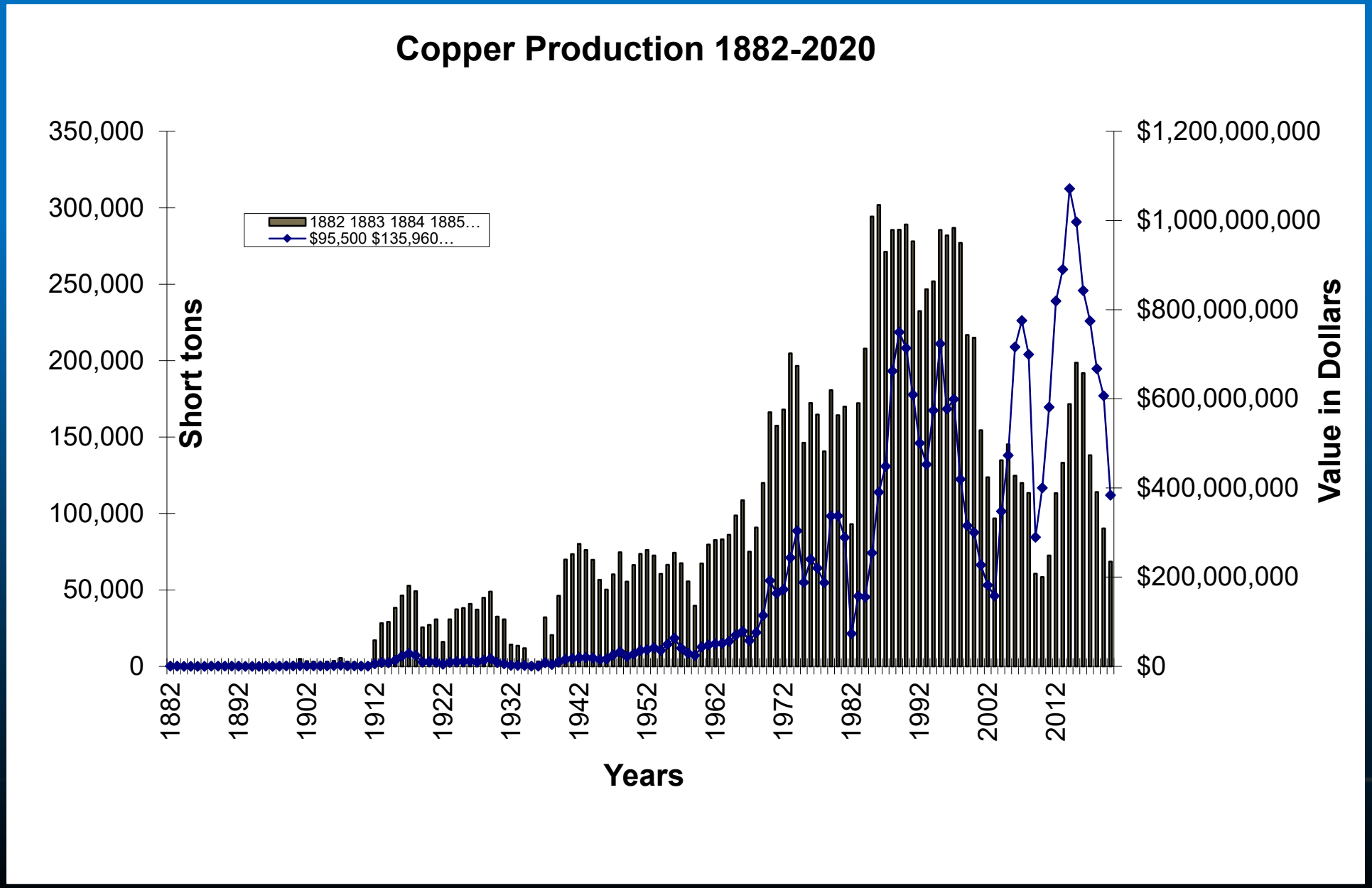
EMNRD_AnnualReport_2022_final.pdf (nm.gov)

Uses of Copper

- Building construction, 46%; electrical and electronic products, 21%; transportation equipment, 16%; consumer and general products, 10%; and industrial machinery and equipment, 7%
- Approximately 4.7 tons of copper are needed in a 3 MW wind turbine (for cable, wiring, turbines, and transformers)
- 5.5 tons of copper are needed in solar panels (for heat exchangers, wiring, and cables)
- Hybrid car uses 88 lbs of copper and a fully electric car uses 183 lbs of copper, compared to 48 lbs of copper needed in a regular car run by an internal combustion engine

- **Copper demand is expected to increase in the future**

Copper—3rd in copper production in 2021 (Chino, Tyrone)

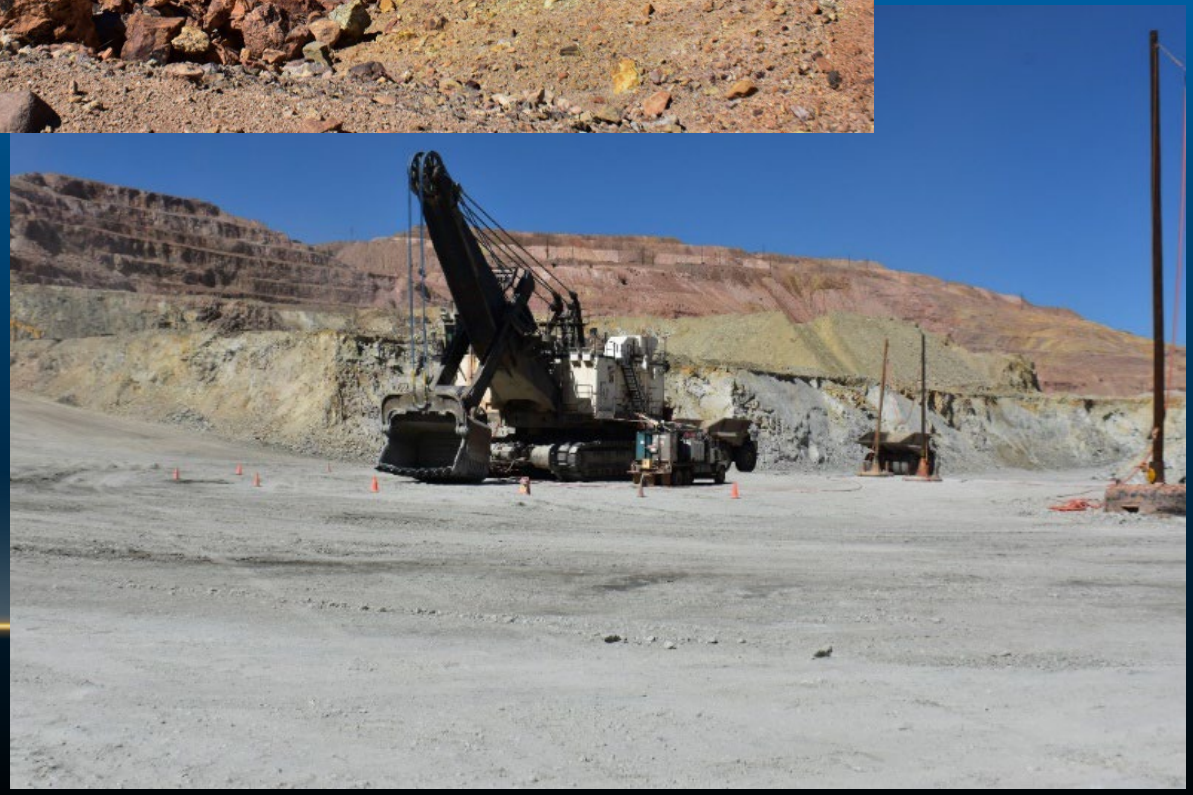


CHINO MINE

- In operation since 1910
- 36,000 metric ton-per-day concentrator and 150 million pound-per-year SX/EW plant
- Closed in April 2020 in response to COVID
- Reopened in January 2021
- Production was 92 million pounds in 2020, 175 million pounds in 2019
- Mine life is 2039
- Updating of permits for planned expansion underway

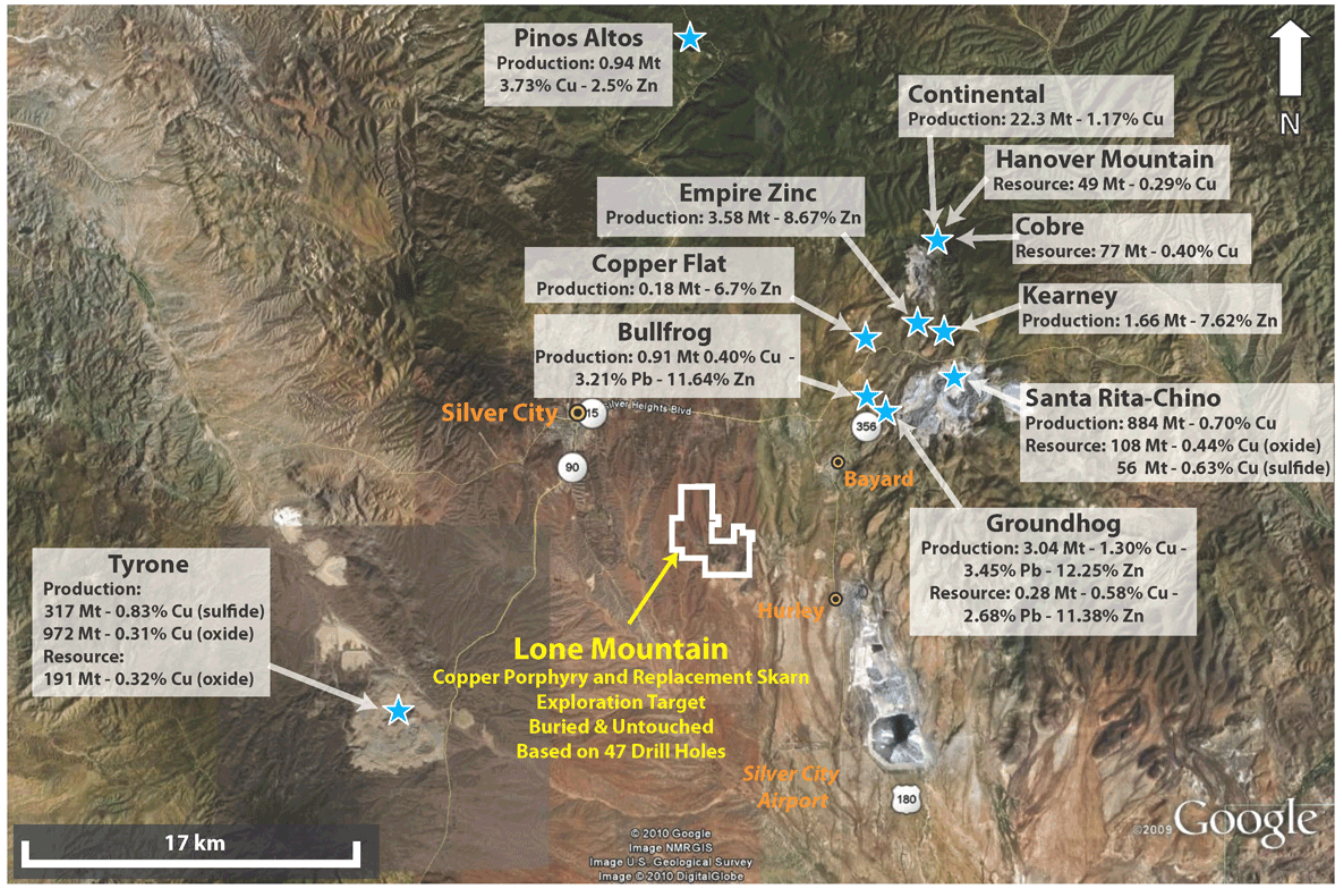
TYRONE MINE

- In operation since 1967
- 100 million pound-per-year SX/EW plant
- Production 45 million pounds in 2020, 48 million pounds in 2019
- Mine life is 2027
- Updating of permits for planned expansion underway
- Exploration at the Emma deposit



COPPER RESERVES—2021

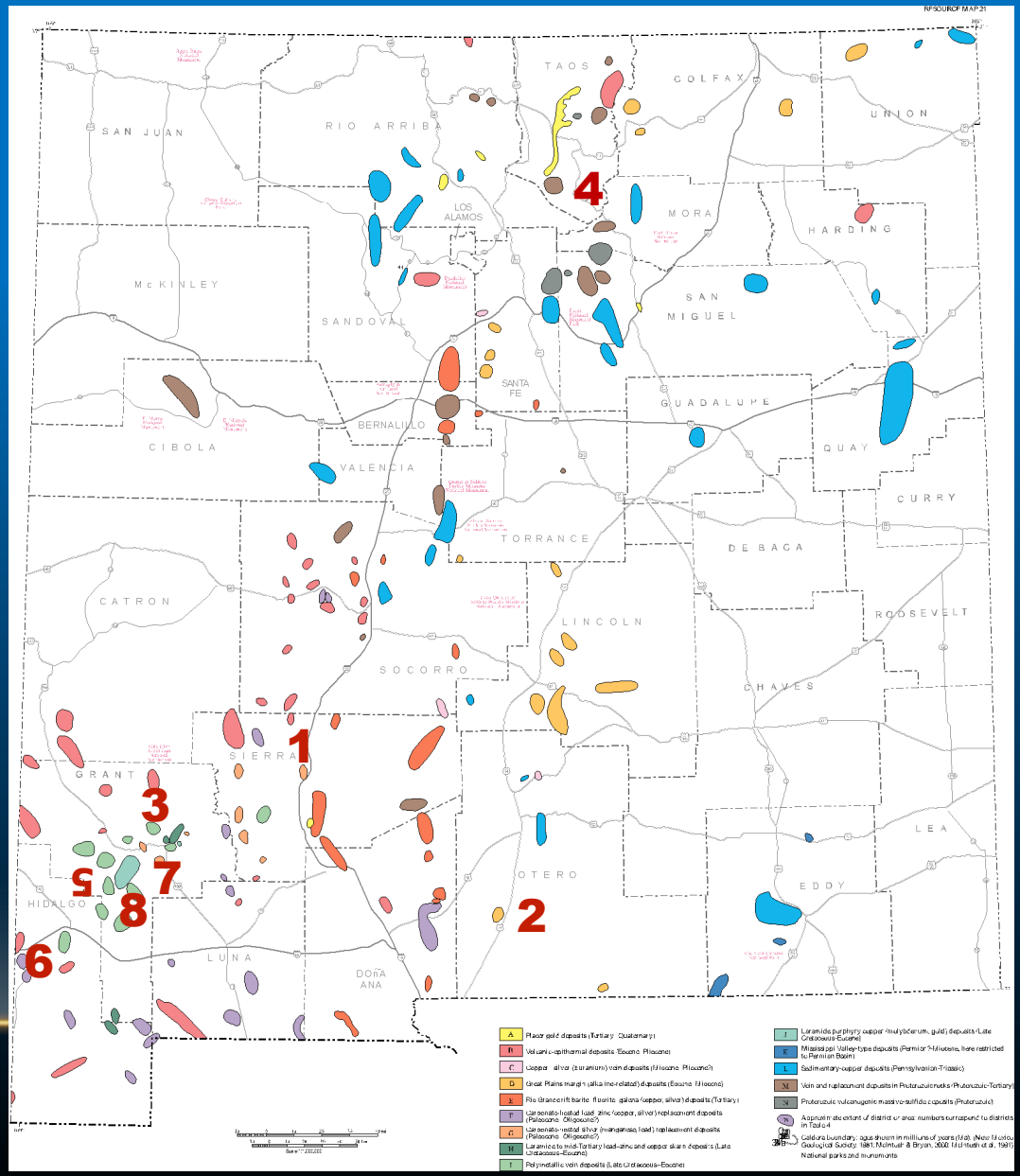
- Reserves are decreasing
- Chino (incl. Hanover, Cobre, Continental)
  - milling reserves are 213 million metric tons of 0.51% copper, 0.05 g/t gold, 0.9 g/t silver and 0.01% molybdenum
  - leaching reserves are 100 million tons of 0.28% Cu
- Tyrone (incl. Little Rock)
  - leaching reserves are estimated as 33 million metric tons of ore grading 0.27% Cu



Production & Resource Figures from Major Copper Mines in New Mexico

POTENTIAL COPPER DEPOSITS

1. Copper Flat (98.1 million short tons at 0.31% Cu, 0.009% Mo, 0.003 oz/short ton Au, and 0.07 oz/ short ton Ag)
2. Orogrande
3. Hanover Mountain (80 mill st reserves at 0.38% Cu)
4. Copper Hill, Picuris district (46.5 mill st of ore at 0.42% Cu)
5. Lone Mountain (7.5 mill st at 2-3% Cu, 1.2% Pb, 4-5% Zn, 203 opt Ag, .01-.02 opt Au)
6. McGhee Peak, Pelloncillo Mountains
7. Mimbres, Grant Co
8. Oak Grove, Grant Co

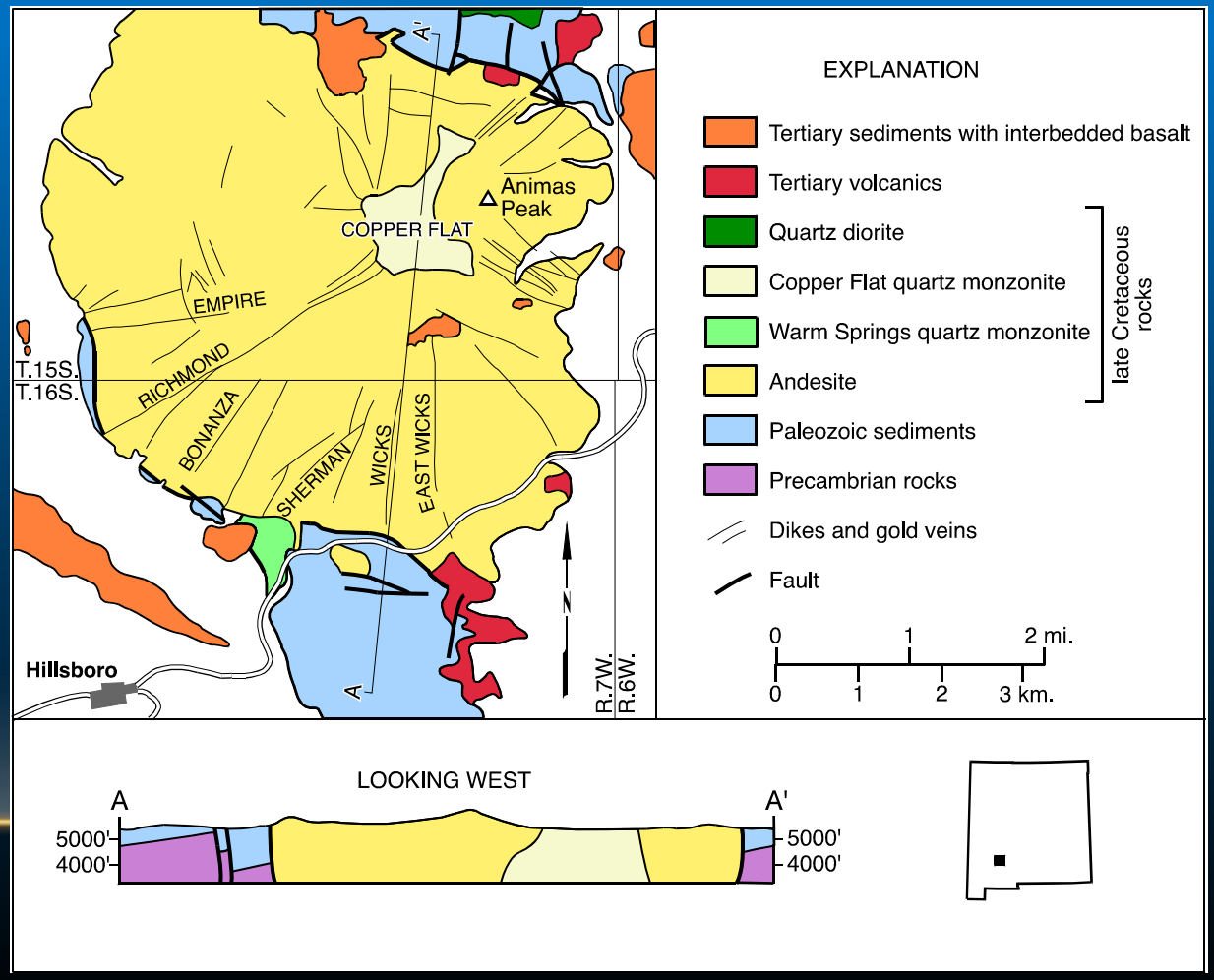


Copper Flat, Themax Resources

Planned production per year for ~15 yrs

- 50.76 mill lbs Cu
- 1.01 mill lbs Mo
- 12,750 oz Au
- 455,390 oz Ag

Start in 2020s?



GOLD AND SILVER PRODUCTION

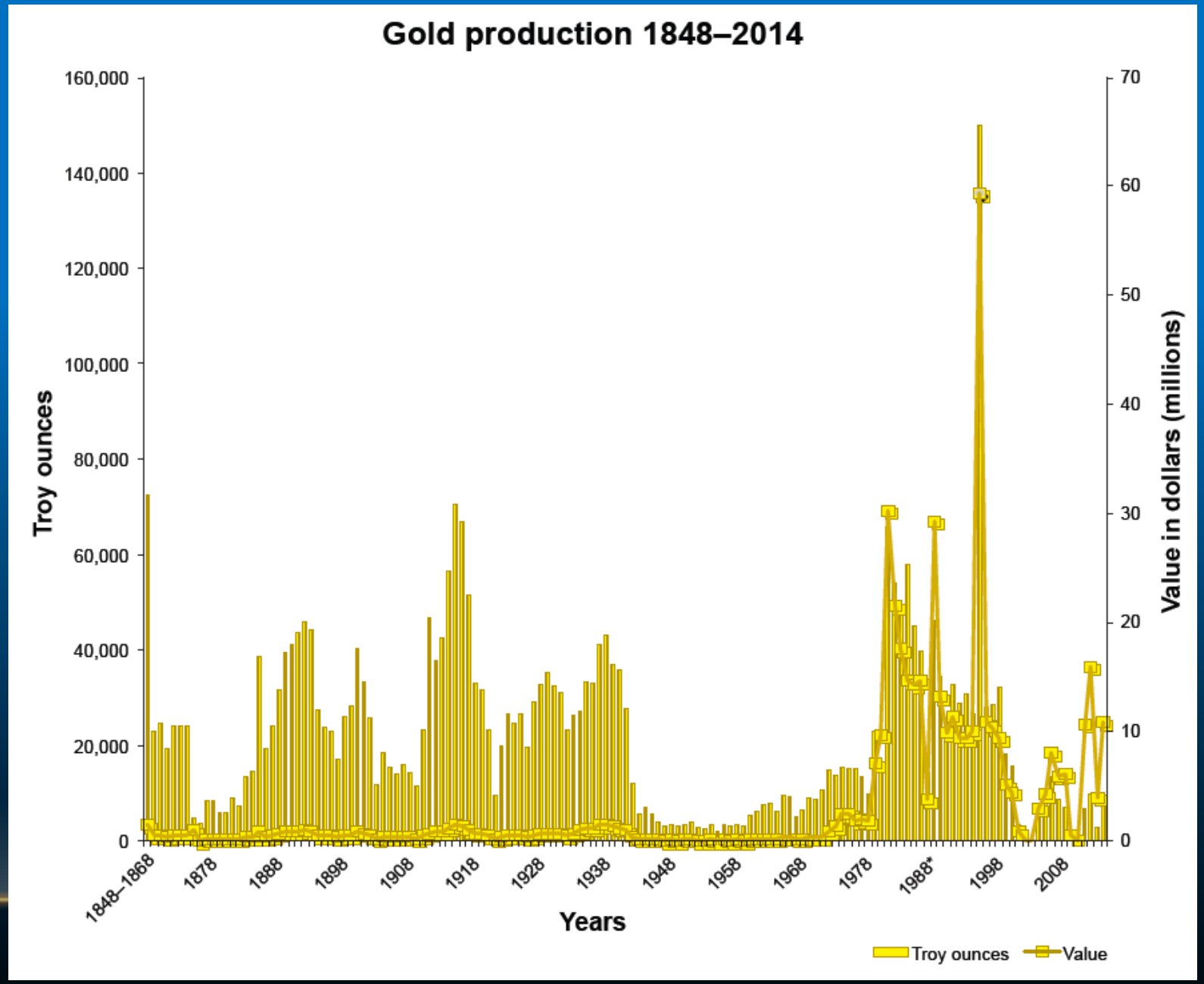
- In 2004-2022 as a byproduct of copper production from the Ivanhoe concentrator (Freeport-McMoRan)
- 9th in gold production
- 10th in silver production

11313B - Gold, San Pedro

11439A - Gold, Magdalena

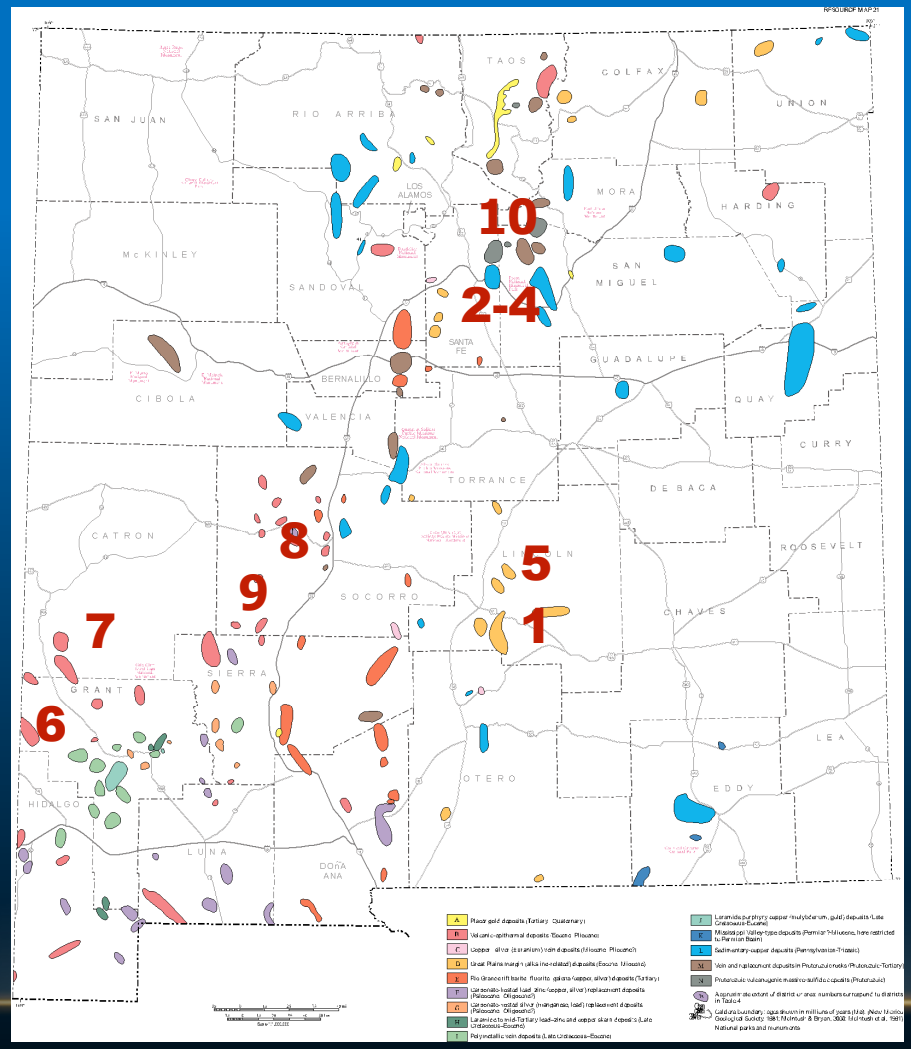
15811 - Gold, San Lazurus Gulch, San Pedro

1804-2015 >3.3 million troy ounces Au worth >$487 million



GOLD AND SILVER

1. Vera Cruz, Lincoln Co
2. Carache Canyon, Santa Fe Co
3. Lukas Canyon, Santa Fe Co
4. San Lazarus, Santa Fe Co
5. Jicarilla Au placers
6. Steeple Rock district
7. Mogollon, Catron Co
8. Magdalena, Socorro Co
9. Rosedale, Socorro Co
10. Terrero, Santa Fe



USES

- Currency (Coinage, Bullion, Backing)
- Jewelry
- Electronic products like computers, telephones, and home appliances, industries, medical field, etc.
- Glassmaking (red or purple colors in glass, thin film of gold in windows in tall buildings, airplanes, space craft, reflects much of the very intense solar radiation, mirrors)
- Dentistry
- Drug to treat a small number of medical conditions

INDUSTRIAL MINERALS

Any rock, mineral, or other naturally occurring material of economic value, excluding metals, energy minerals, and gemstones, generally nonmetallic

Many critical minerals are considered industrial minerals

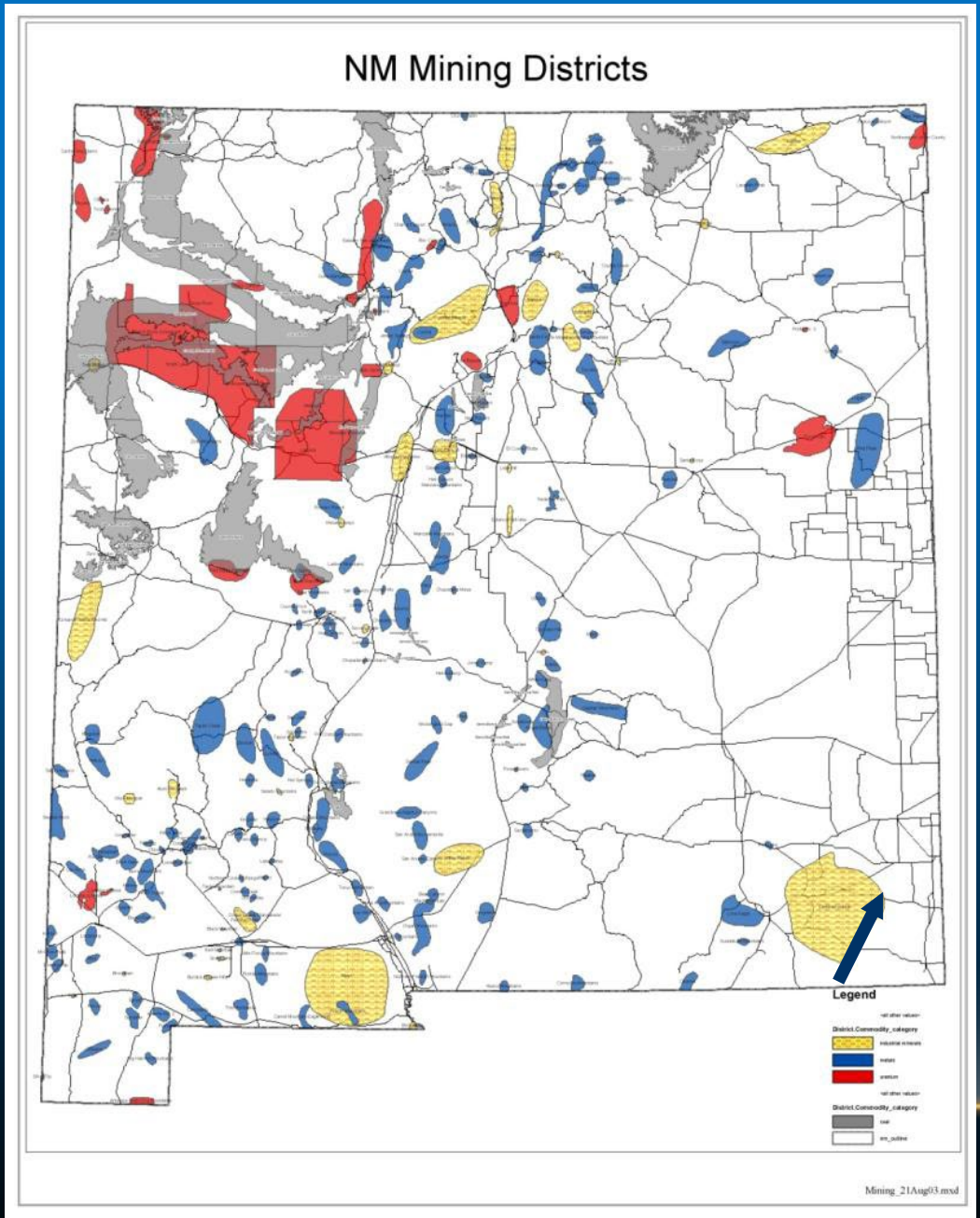
Every American Born Will Need...
3.02 MILLION POUNDS of minerals, metals, and fuels in their lifetime

- 1,832 lbs. BAUXITE (ALUMINUM)
- 55,461 lbs. CEMENT
- 10,685 lbs. CLAYS
- 251,998 lbs. COAL
- 1,018 lbs. COPPER
- 1.34 Troy oz. GOLD
- 18,317 lbs. IRON ORE
- 814 lbs. LEAD
- 1 lb. LITHIUM
- 12,720 lbs. PHOSPHATE ROCK
- 27,476 lbs. SALT
- 4 lbs. SILVER
- 1.36M lbs. STONE, SAND & GRAVEL
- 468 lbs. ZINC
- +1.03M lbs. OTHER MINERALS, METALS & FUELS

SME FOUNDATION
MEC
MINERALS EDUCATION COALITION

Learn more: **MineralsEducationCoalition.org**

Mining & Mineral Usage Statistics | Minerals Education Coalition



Potash Production

1st in US

1951-2021 123 million tons worth >$17 billion

Reserves in Carlsbad District

Potash (>553 million tons)

Potash is used in fertilizers among other uses

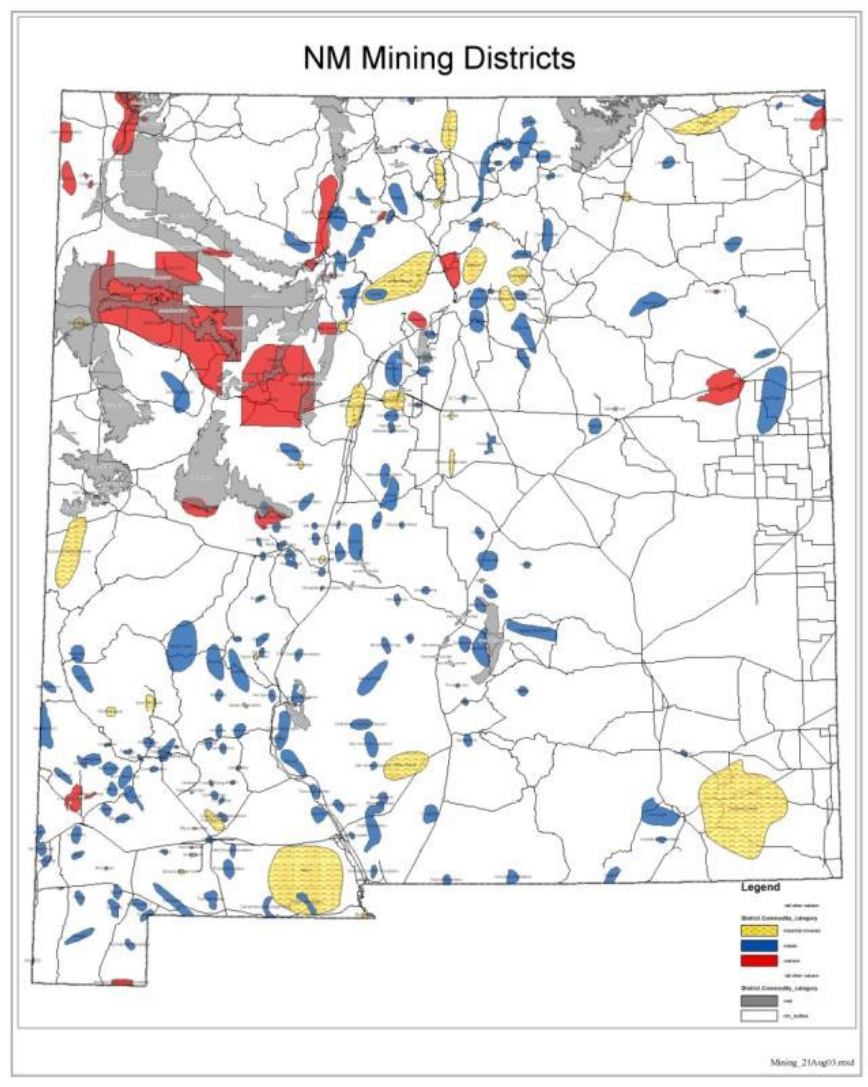
Intrepid closed one mine

Competition from Canadian deposits

- Intercontinental Potash Corp. (IPC) plans are on hold to mine polyhalite at the Ochoa deposit SE of the district
- Intrepid Mining NM LLC is using solution mining techniques at the HB Solar Solution mine (old potash workings)

1ST IN POTASH IN 2021 (MOSAIC, INTREPID MINING)

ADDITIONAL INDUSTRIAL MINERALS IN NEW MEXICO



- 1st in zeolite (St. Cloud, Sierra County)
- 5th in pumice (6 operations)
- 1st in perlite (4 operations)
- 11th in salt (4 operations, Carlsbad)
- Humate is important and expanding

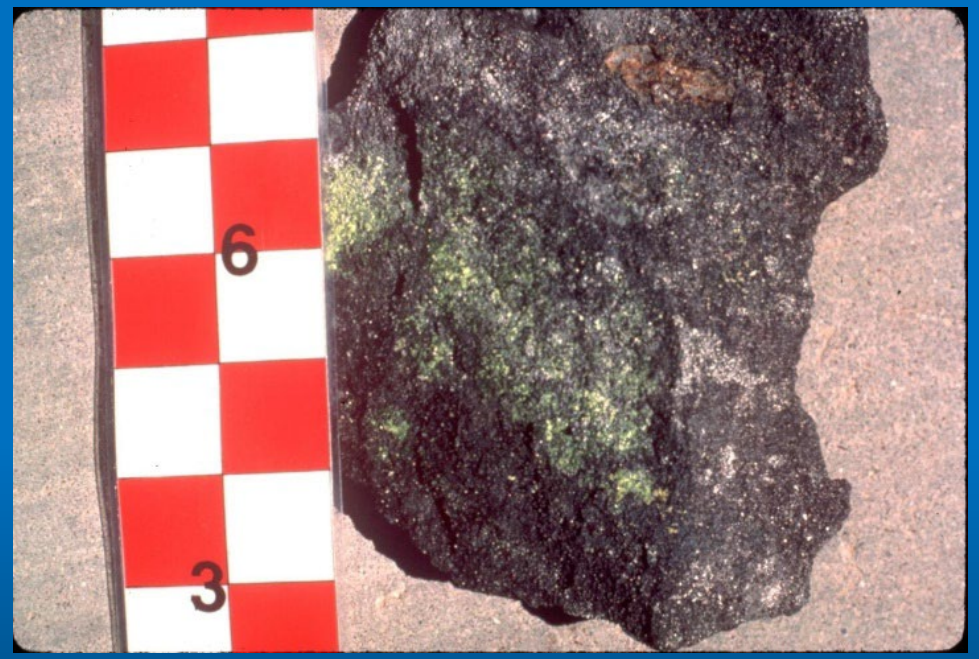
OTHER INDUSTRIAL MINERALS DEPOSITS

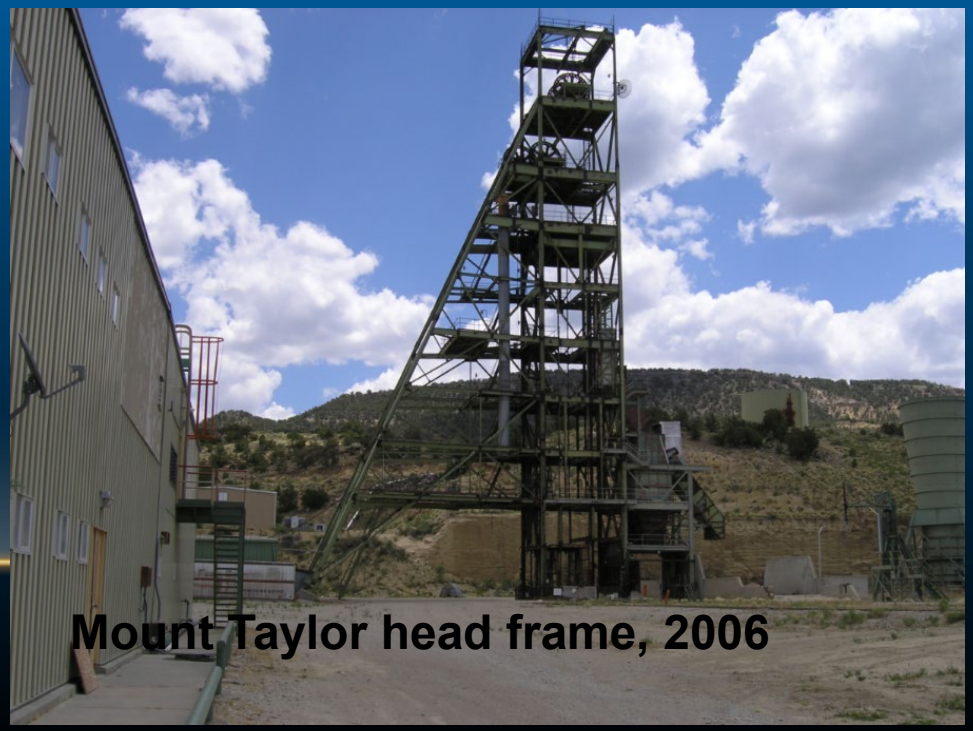
- Aggregates
- Gypsum for wallboard
- Brick and clay in El Paso, Albuquerque areas
- Cement in Tijeras Canyon
- Humate in the San Juan Basin
- Sulfur, helium, carbon dioxide
- Travertine (dimension stone), Meso del Oro, west of Belen
  - 477.6 million tons of travertine

White Mesa gypsum mine

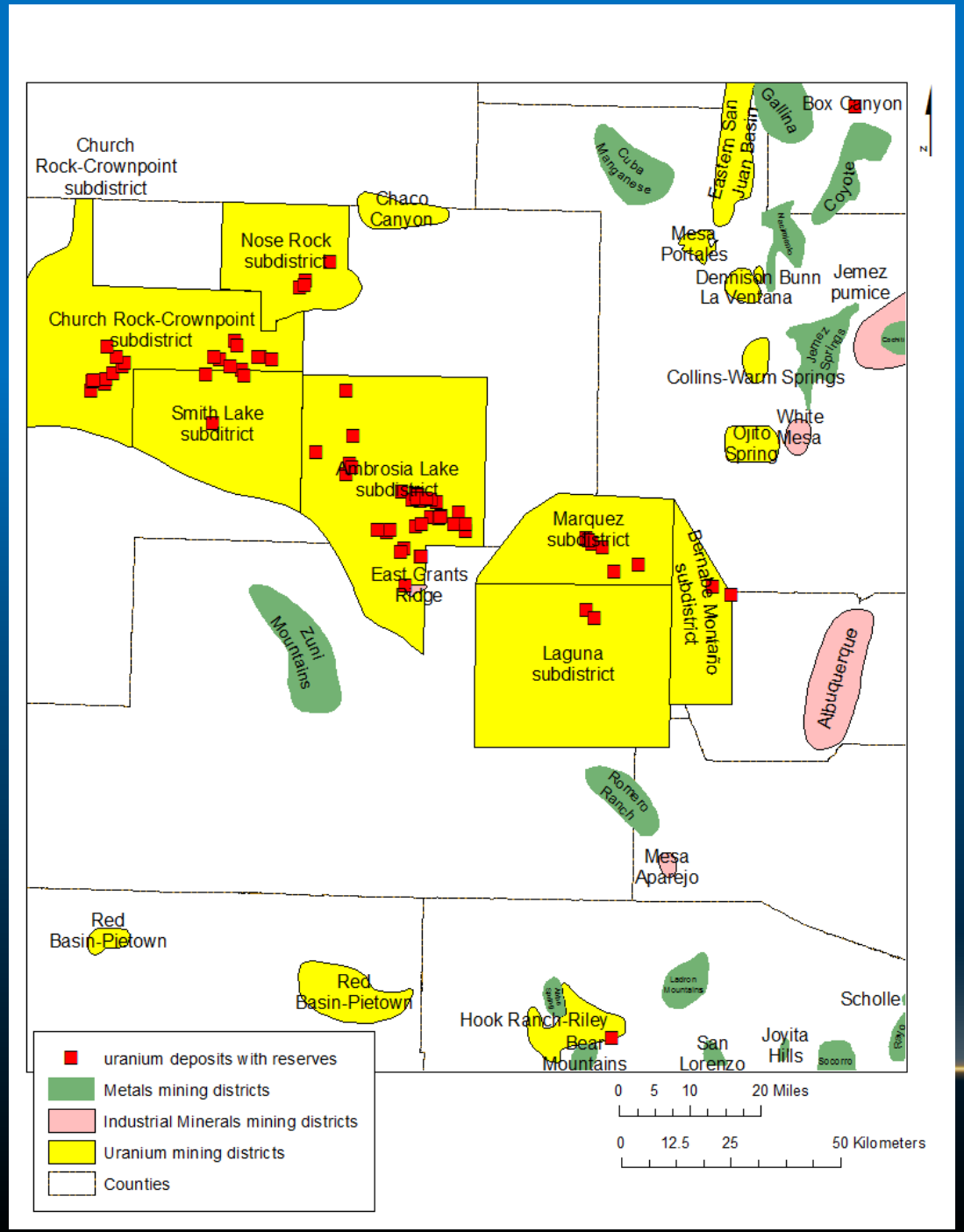
URANIUM IN NEW MEXICO 2023

- 2nd in uranium resources 15 million tons ore at 0.277% U3O8 (84 million lbs U3O8) at $30/lb (DOE estimates in 2002)
- Numerous companies have acquired properties (Strathmore, Energy Minerals, Laramide Resources, among others)
- Energy Fuels acquired Strathmore in 2013 and is now permitting the Roca Honda mine
- HRI, Inc. awaiting permits for in situ leach in Church Rock, Ambrosia Lake areas
- Several exploration permits approved or in progress
- Mt. Taylor mine changed status from active to reclamation





Mount Taylor head frame, 2006



Deposits with uranium resources in New Mexico (McLemore and Chenoweth, 2019). Only major mines and deposits are included here.

Associated critical minerals include V, REE, possibly Re.

CRITICAL MINERALS IN NEW MEXICO

Critical minerals change with time and country

In the United States, a critical mineral is a nonfuel mineral commodity that is essential to the economic and national security of the United States, and is from a supply chain that is vulnerable to global and national disruption.

Critical Minerals in New Mexico

Element currently producing in NM
Element once produced from NM
Element found in NM
Element not found in NM

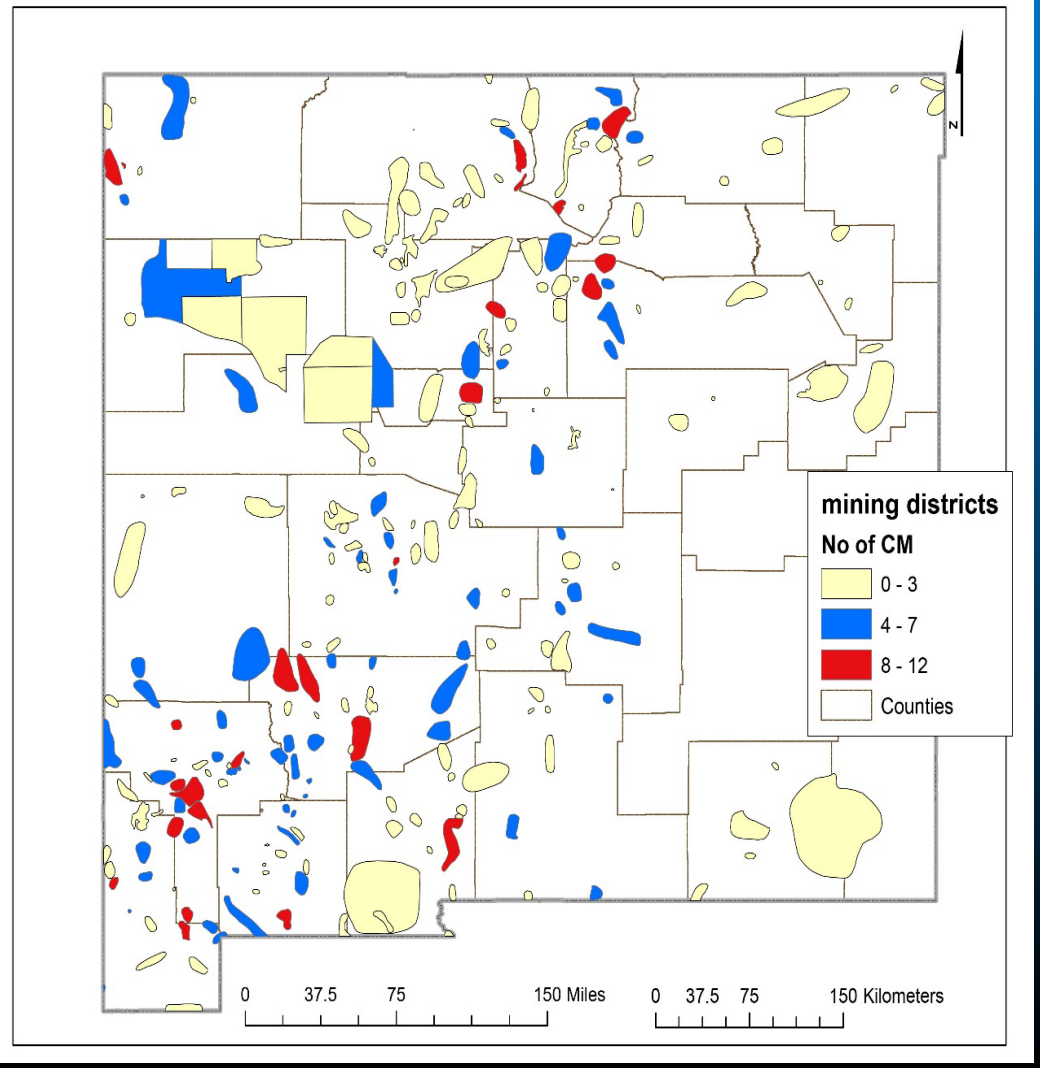
C=graphite
F=fluorite
Ba=barite

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

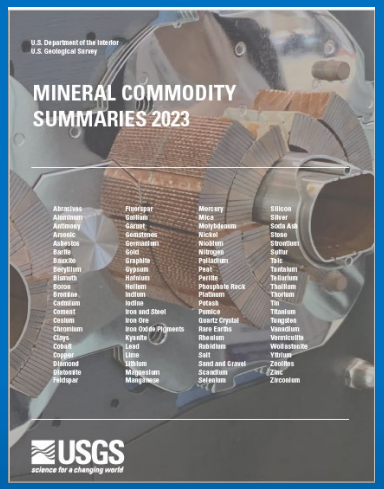
Note that any element or commodity can be considered critical in the future depending upon use and availability. Coal contains several of these critical elements.

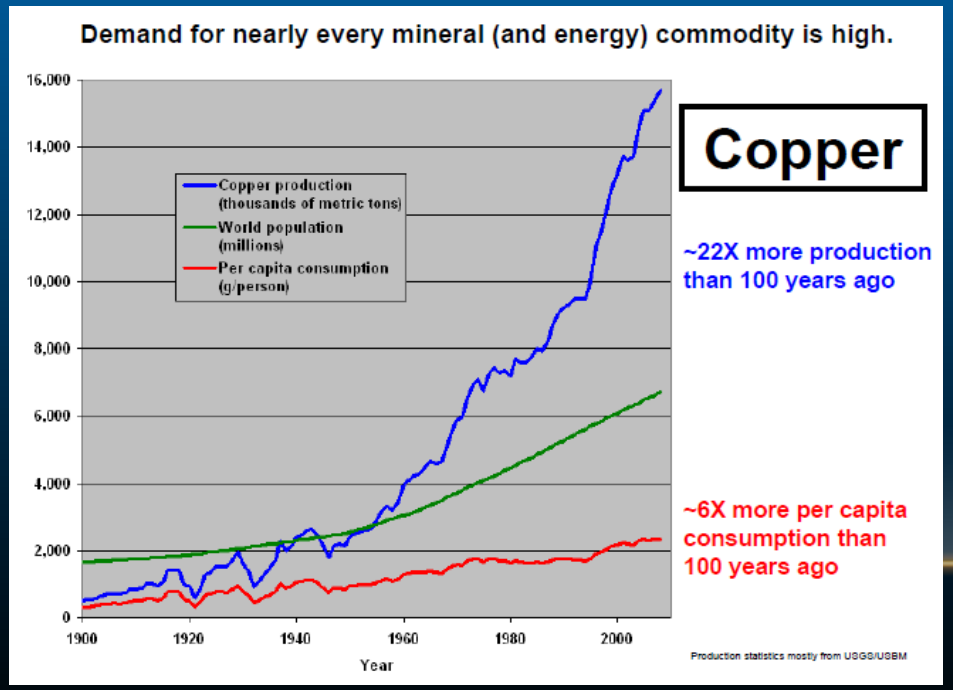
U, Re, He, and K (potash) were removed from the critical minerals list in 2022 and Zn and Ni were added.



Why isn't copper a critical mineral in the U.S.?

- Ready availability of copper
- Import only 41% of our consumption
- Abundant reserves



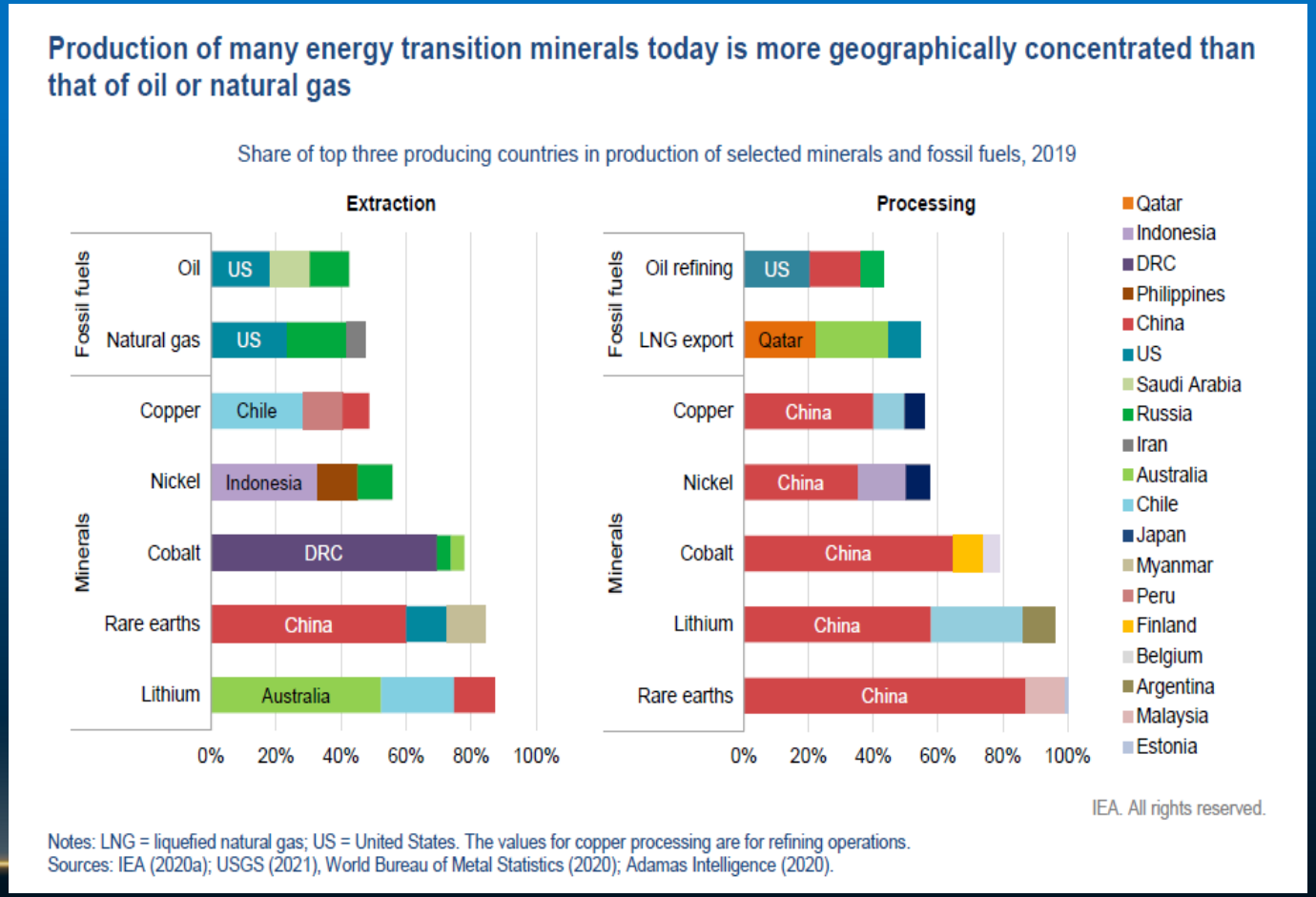


Salient Statistics—United States:	2018	2019	2020	2021	2022[e]
Production:					
Mine, recoverable copper content	1,220	1,260	1,200	1,230	1,300
Refinery:					
Primary (from ore)	1,070	985	874	922	960
Secondary (from scrap)	41	44	43	49	40
Copper recovered from old (post-consumer) scrap[2]	141	166	160	[e]170	160
Imports for consumption:					
Ore and concentrates	32	27	2	11	15
Refined	778	663	676	919	810
Exports:					
Ore and concentrates	253	356	383	347	330
Refined	190	125	41	48	30
Consumption:					
Reported, refined metal	1,820	1,810	1,770	1,770	1,800
Apparent, primary refined and old scrap[3]	1,820	1,820	1,660	1,960	1,900
Price, annual average, cents per pound:					
U.S. producer, cathode (COMEX + premium)	298.7	279.6	286.7	432.3	410
COMEX, high-grade, first position	292.6	272.3	279.9	424.3	400
London Metal Exchange, grade A, cash	296.0	272.4	279.8	422.5	400
Stocks, refined, held by U.S. producers, consumers, and metal exchanges, yearend	244	110	118	117	120
Employment, mine and plant, number	11,700	12,000	11,000	11,400	12,000
Net import reliance[4] as a percentage of apparent consumption	33	37	38	44	41

thousand metric tons of contained copper

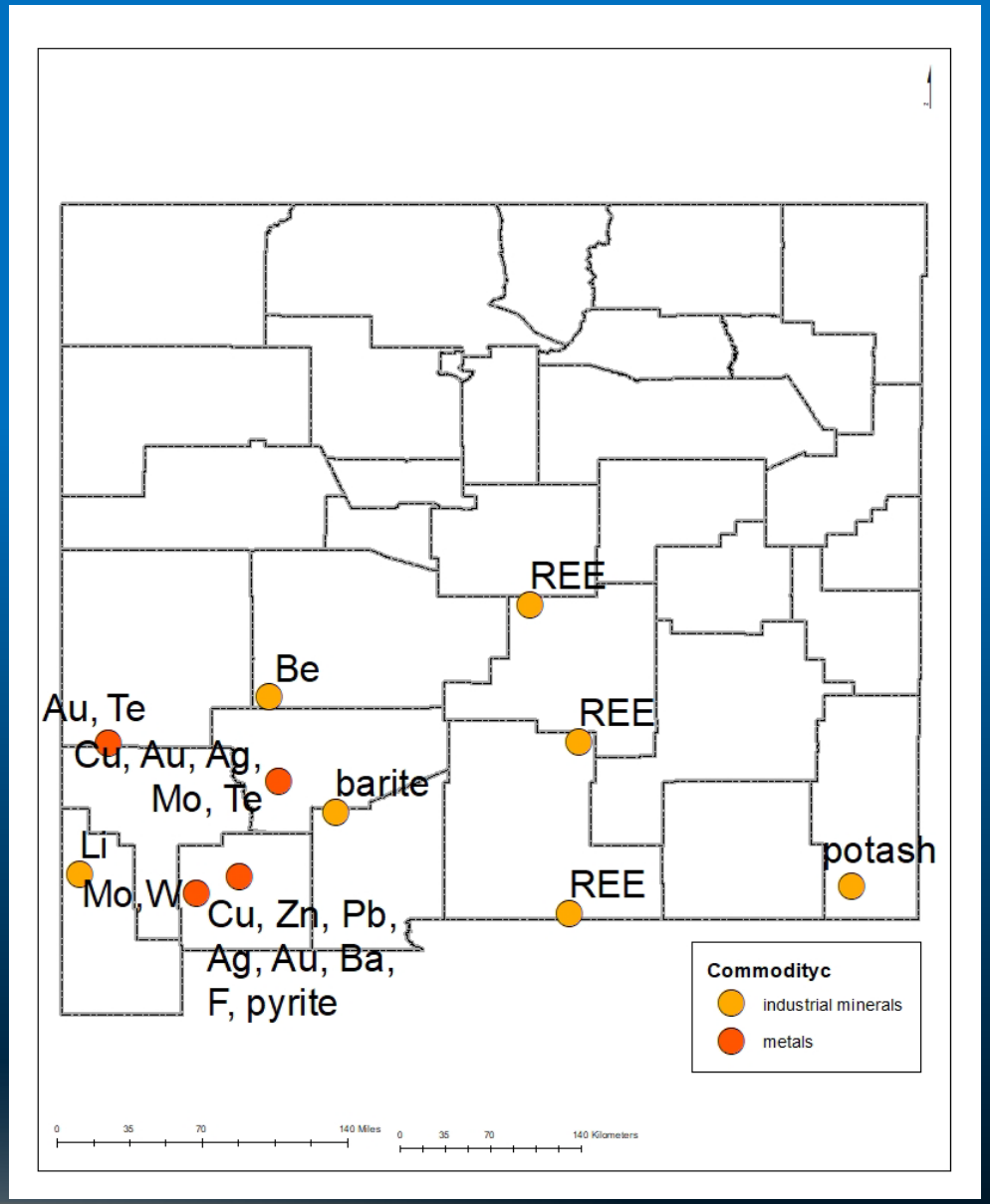
But should copper be a critical mineral?

- Copper is mostly produced from Chile, Peru, Congo and other countries
- **However, most of the world's refinery production of copper is from China and Chile**
- The opening of several large copper mines (Resolution, Mission, and Pumpkin Hollow) are continued to be delayed by technical, political, and social issues
- Peru has been in political unrest since December, which will affect the supply of copper from that country
- Labor disputes are common throughout the world, which also affects the supply chain
- Other critical minerals are produced from copper deposits



CRITICAL MINERALS

- Over 50 critical minerals are identified
- New Mexico has many of these critical minerals
  - Copper deposits in Grant County contain rhenium, indium, gallium, germanium, and zinc
  - Uranium deposits in the Grants district contain Se, REE, V, Mo
  - Exploration for other critical minerals include REE, tellurium, lithium, beryllium, cobalt
  - Other critical minerals were once produced from New Mexico (tin, vanadium, manganese, fluorspar, barite, graphite, zinc)



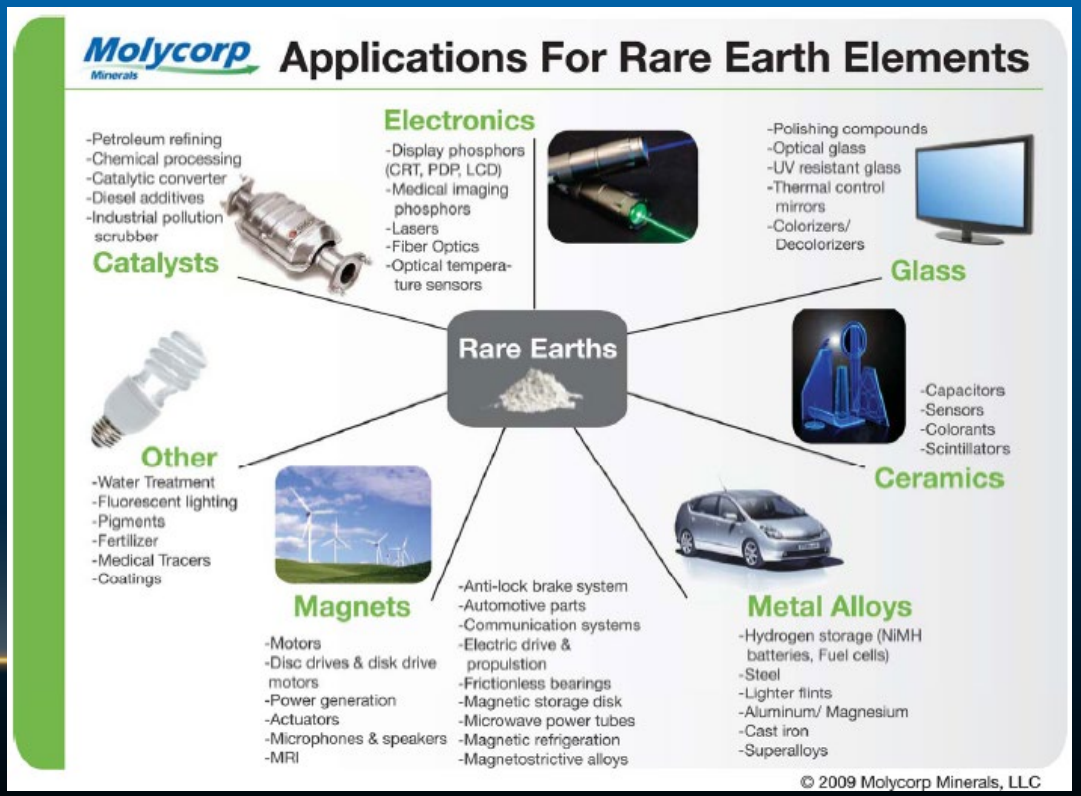
Selected exploration sites of critical minerals in New Mexico

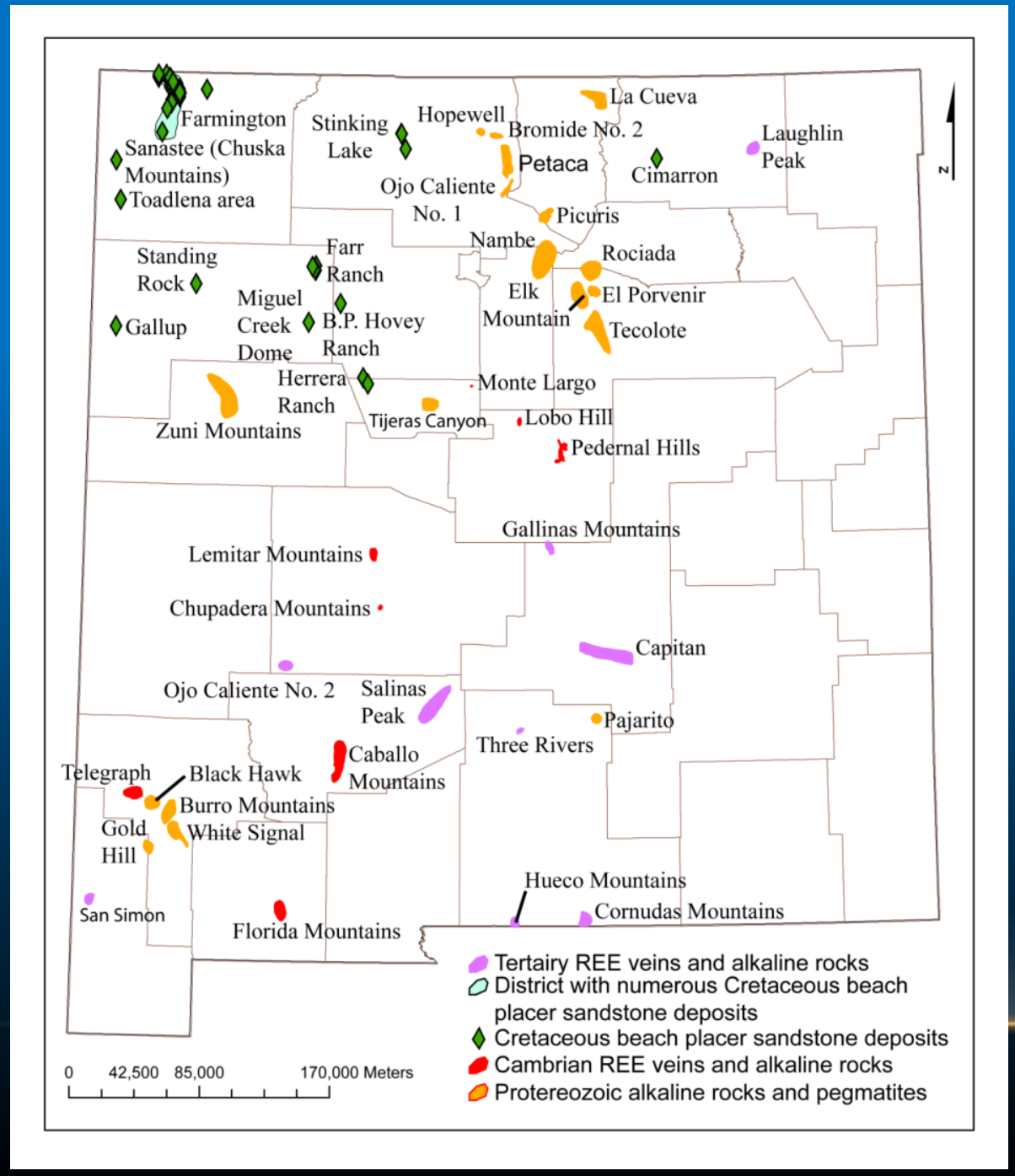
RARE EARTH ELEMENTS

Rare earth elements (REE) are a group of critical minerals that are used to manufacture most of our electronic devices, wind turbines, solar panels, magnets, electric and hybrid cars, and many other products. New Mexico has an abundance of REE deposits, although none are currently in production.

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun								

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

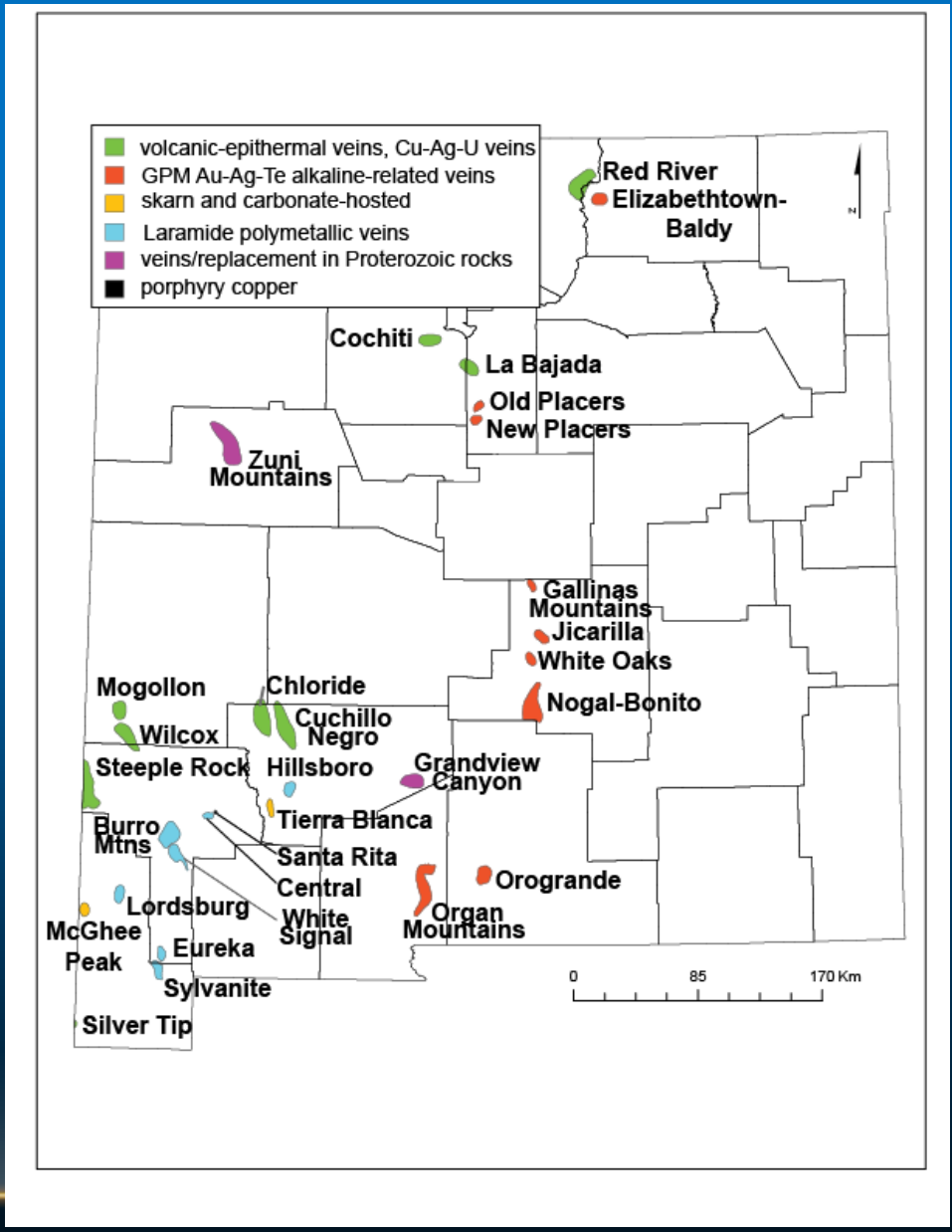




Occurrences of Rare Earth Elements (REE) in New Mexico

Tellurium in New Mexico

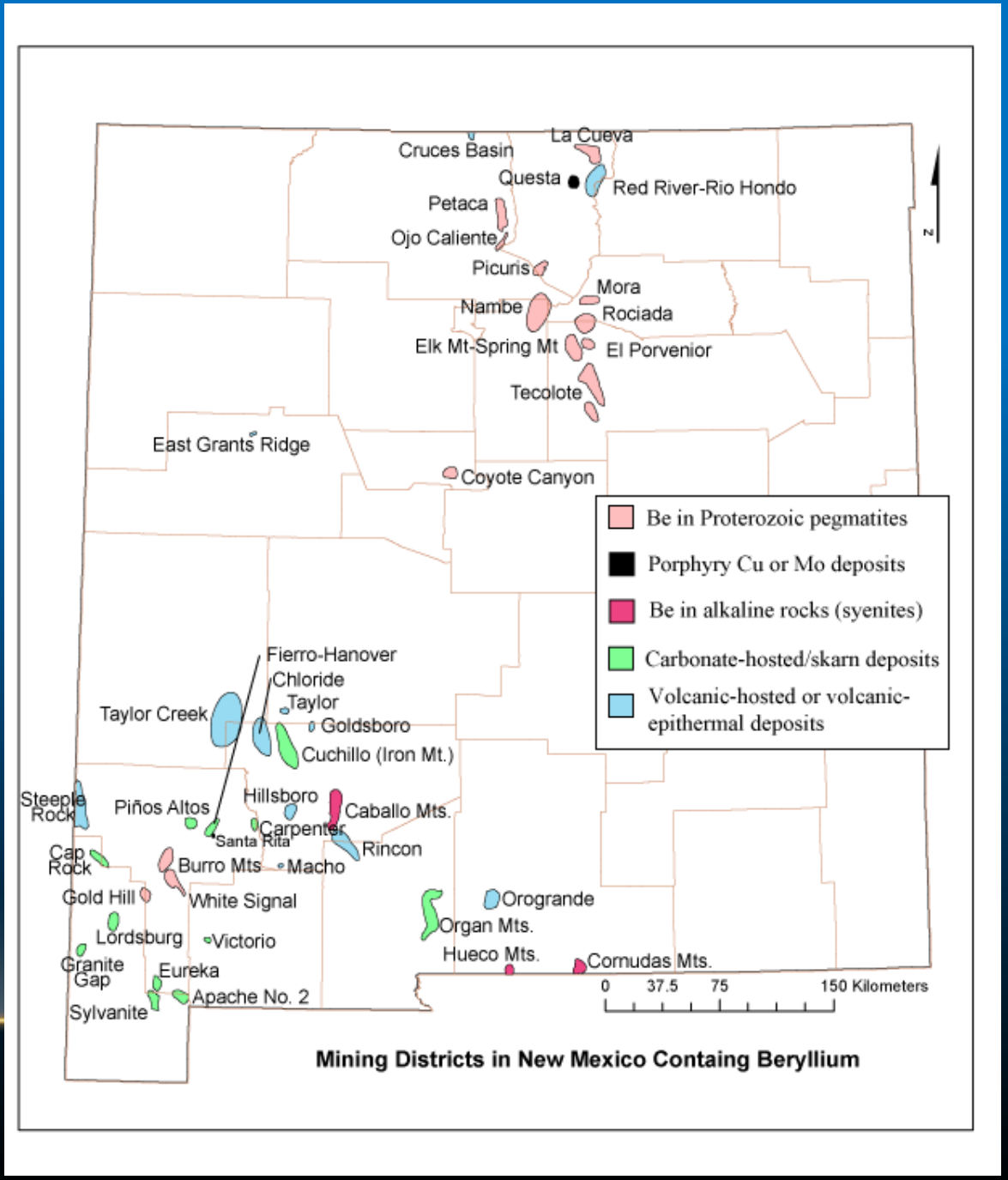
- Alloying additive in steel to improve machining characteristics
- Processing of rubber
- As a component of catalysts for synthetic fiber production
- As pigments to produce various colors in glass and ceramics
- **Thermal imaging devices**
- Thermoelectric cooling devices, such as summertime beverage coolers
- Thermoelectronics
- **Solar panels/cells**



Mining districts in New Mexico with tellurium minerals or chemical assays >20 ppm Te

Beryllium In New Mexico

- Defense
- Telecommunications
- Nuclear energy industries
- Shielding in some of our nuclear, medical, and other equipment
- Many of our electronic devices

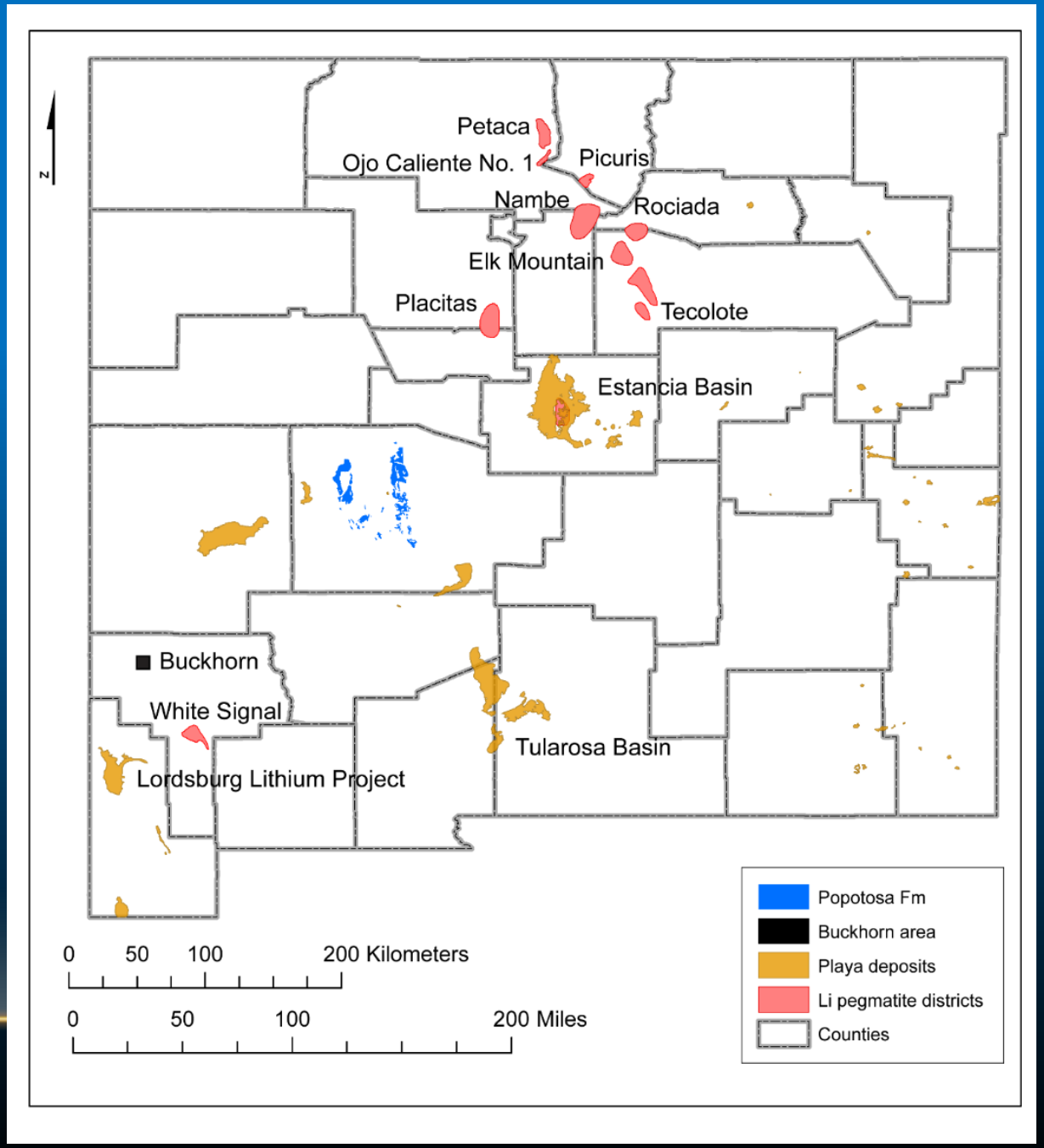


Lithium in New Mexico

TYPES OF LITHIUM DEPOSITS IN NM

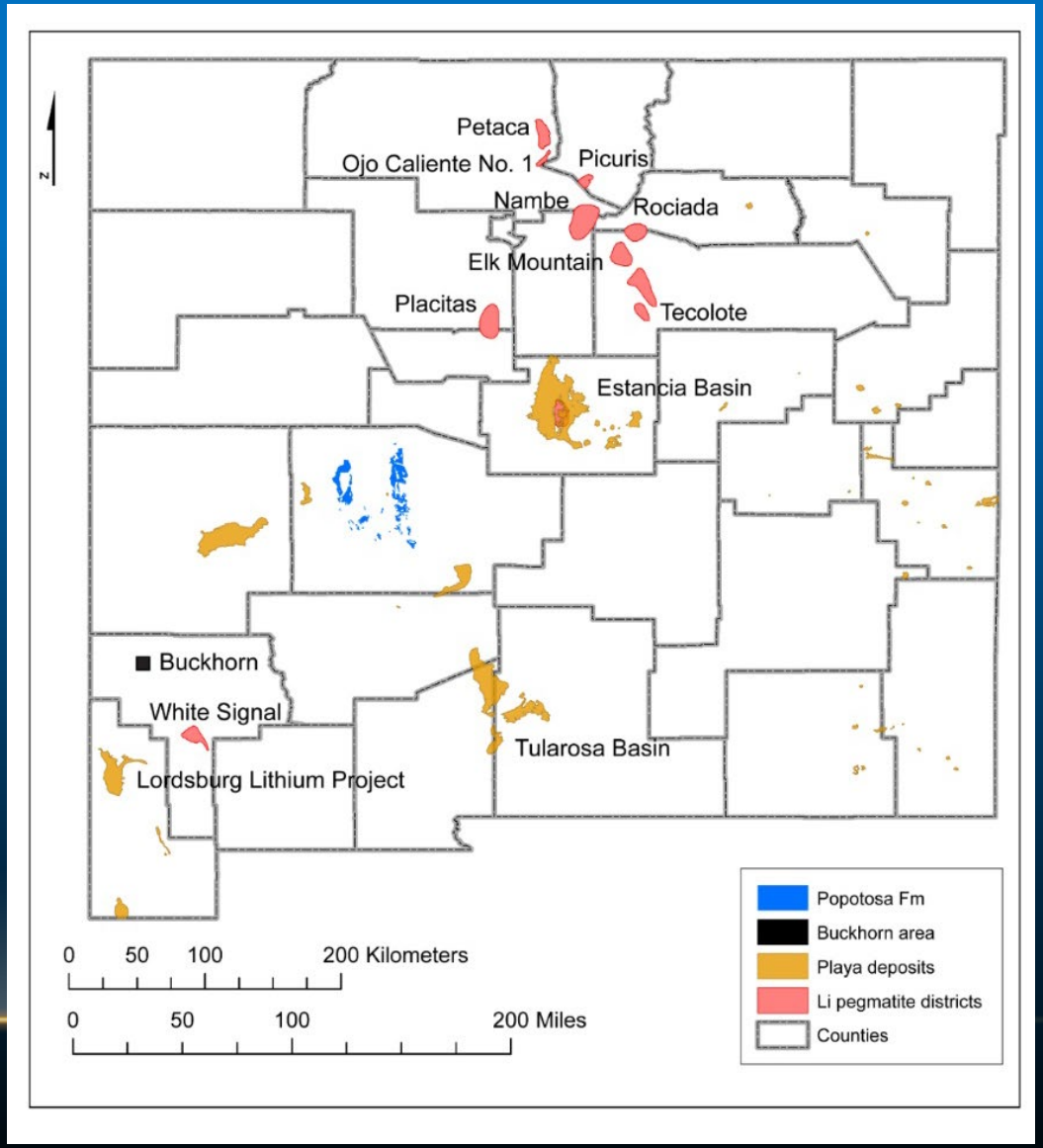
More than 13,000 short tons of lepidolite ore and several hundred short tons of spodumene ore have been produced from pegmatites in New Mexico in 1920-1950.

Lithium is used in batteries, lubricants, pharmacials, glass, chemical industry



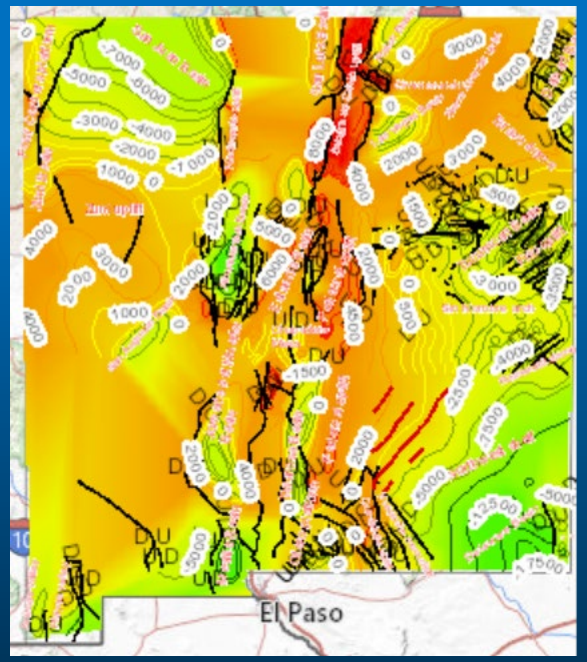
BRINE, HYDROTHERMAL (GEOTHERMAL), AND PLAYA DEPOSITS

- Closed basins
- Derived from weathering of lithium-enriched rhyolite and other volcanic rocks
- Locally associated with geothermal springs and wells



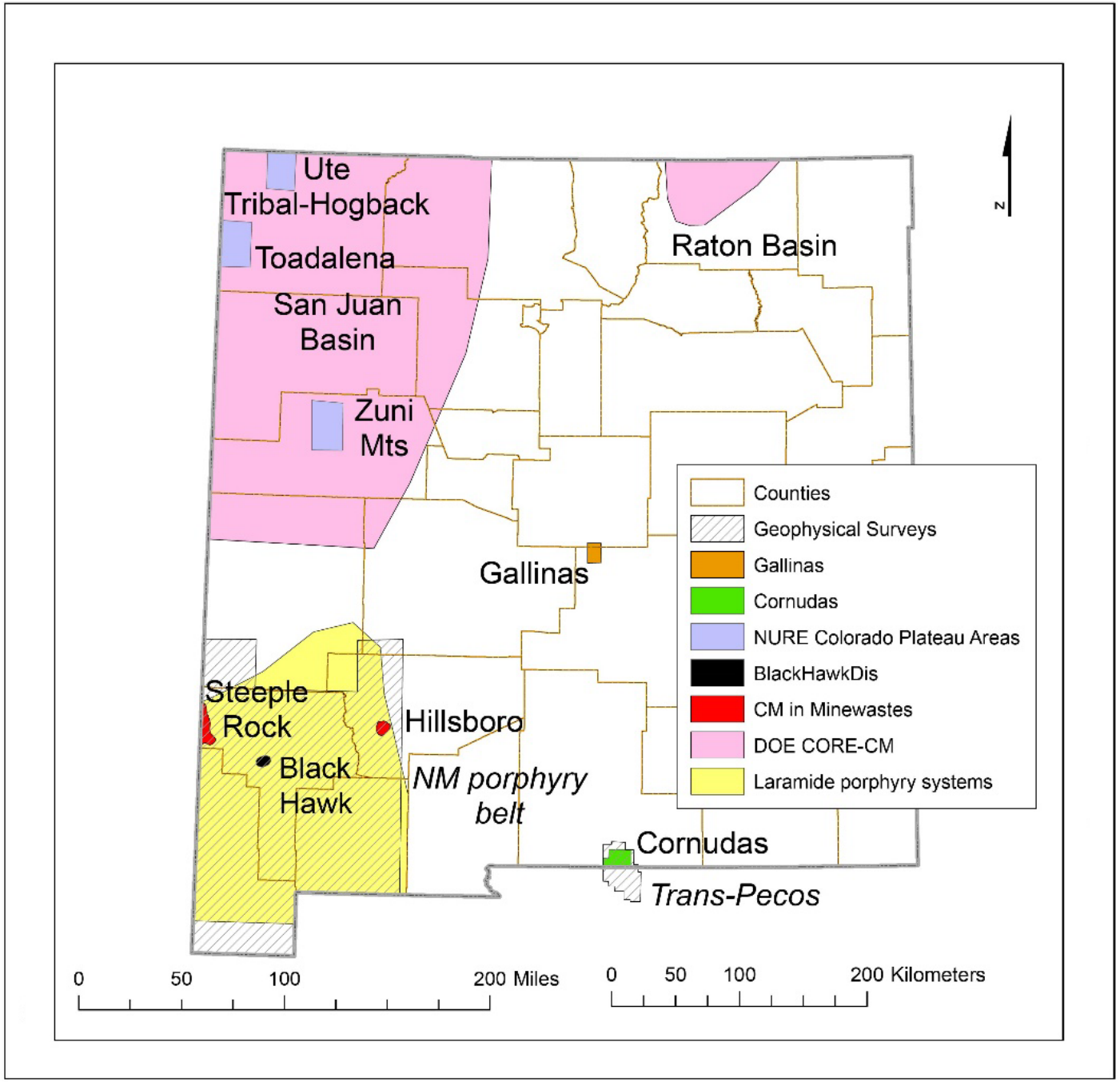
NATIONAL GEOLOGICAL AND GEOPHYSICAL DATA PRESERVATION PROGRAM (NGGDPP)—CRITICAL MINERALS

- 5th year we have received funding
- Funds graduate and undergraduate students
  - Published papers on some of this work (with extra funding from other sources)
- Some of our accomplishments
  - State-wide geochemical database of rocks and mineralized deposits containing critical minerals
  - Depth to Precambrian basement
  - Long range plan to evaluate critical minerals in New Mexico
  - Comprehensive database of critical minerals and other minerals deposits (New Mexico Mines Database)
  - Photograph and describe drill core with critical minerals potential
  - Inventory and storage of samples from areas containing critical minerals
  - Identify districts with critical minerals in New Mexico



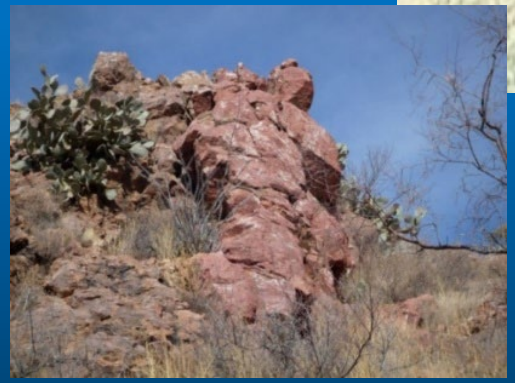
Depth to Precambrian basement

EARTH MRI AND DOE CORE-CM PROJECTS IN NEW MEXICO

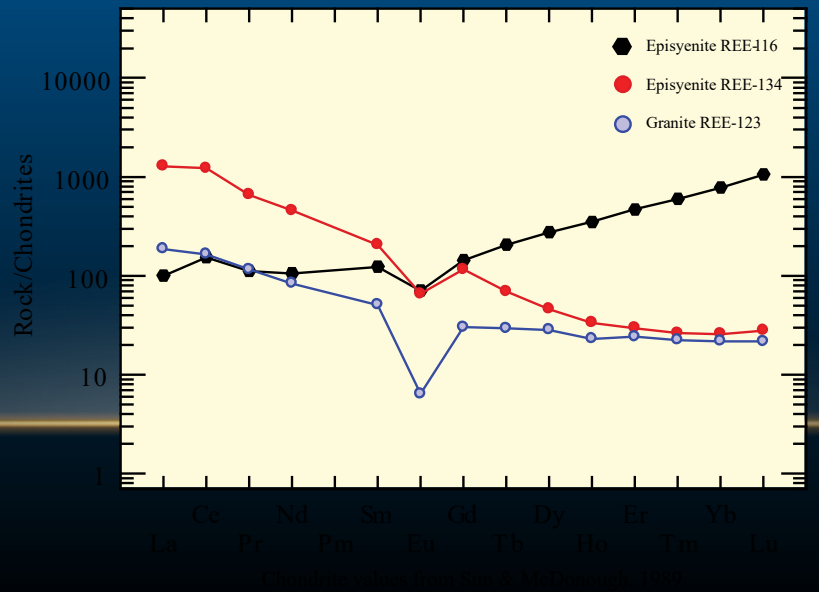


USGS MRERP
Mapping and origin of REE in Cambrian-Ordovician Episyenites in the Caballo and Burro Mountains, southern NM (2012-2022, continuing)

Virginia McLemore, Nelia Dunbar, Matthew T. Heizler, O. Tapani Rämö and many students



- Brick-red episyenites are metasomatic in origin, possibly related to alkaline or carbonatite intrusions at depth
- REE minerals are associated with altered amphiboles, magnetite, secondary chlorite, hematite, zircon, and fluorite
- Samples have low-moderate TREE, Th, and U; but some samples have relatively high HREE



Contact between granitic gneiss and episyenite in Caballo Mtns

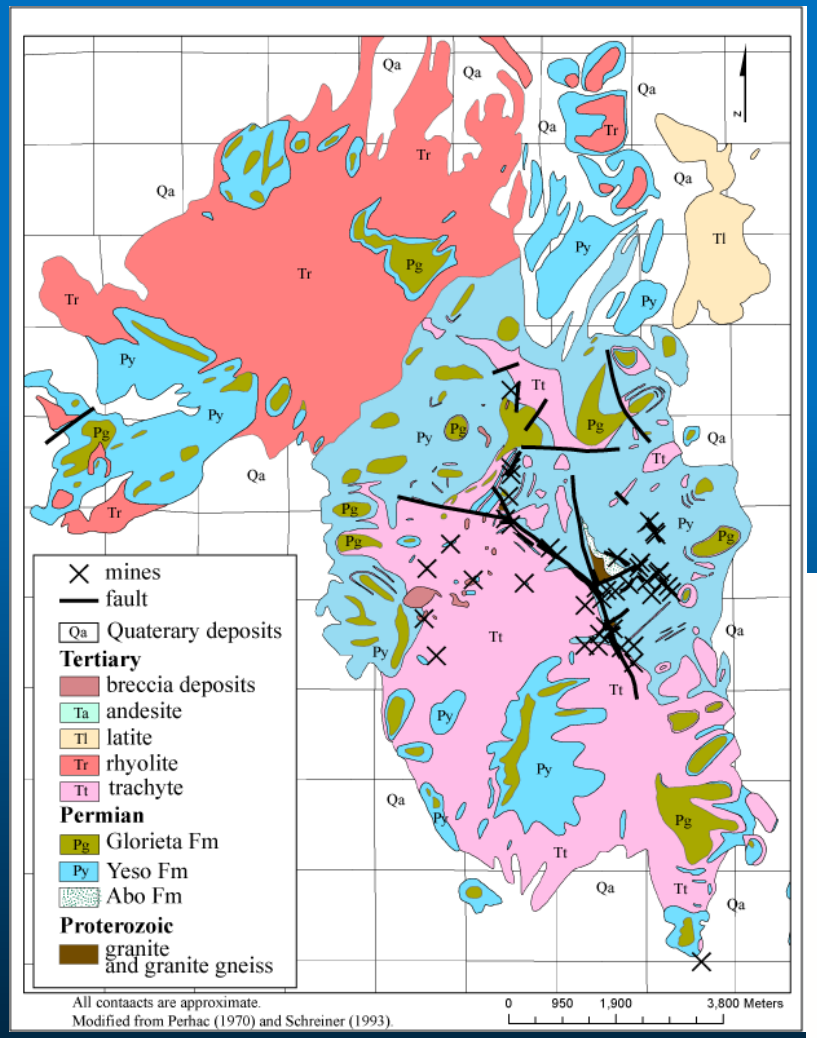
USGS Earth MRI Project Mapping REE in Gallinas Mountains, Lincoln County, NM (2019-2021, continuing)

Virginia McLemore, Shari Kelley, Matt Zimmerer, Evan Owen, Alex Gysi and many students

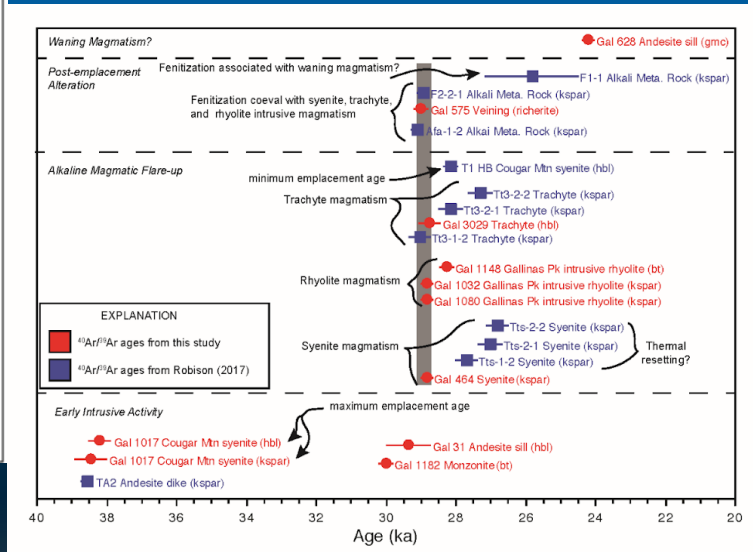
- REE breccia and vein deposits are mostly along minor faults with small displacements and short lengths, and fracture zones, as much as 8% TREE
- Positive correlation between TREE, F, Ba, and Sr
- Possible carbonatite at depth
- Industry provided chemical analyses

Yellow bastnäsite [(Ce,La)(CO_3)F] in purple fluorite breccia from the Red Cloud mine (length is ~8 mm). Bastnäsite is the most common REE mineral mined in the world today.

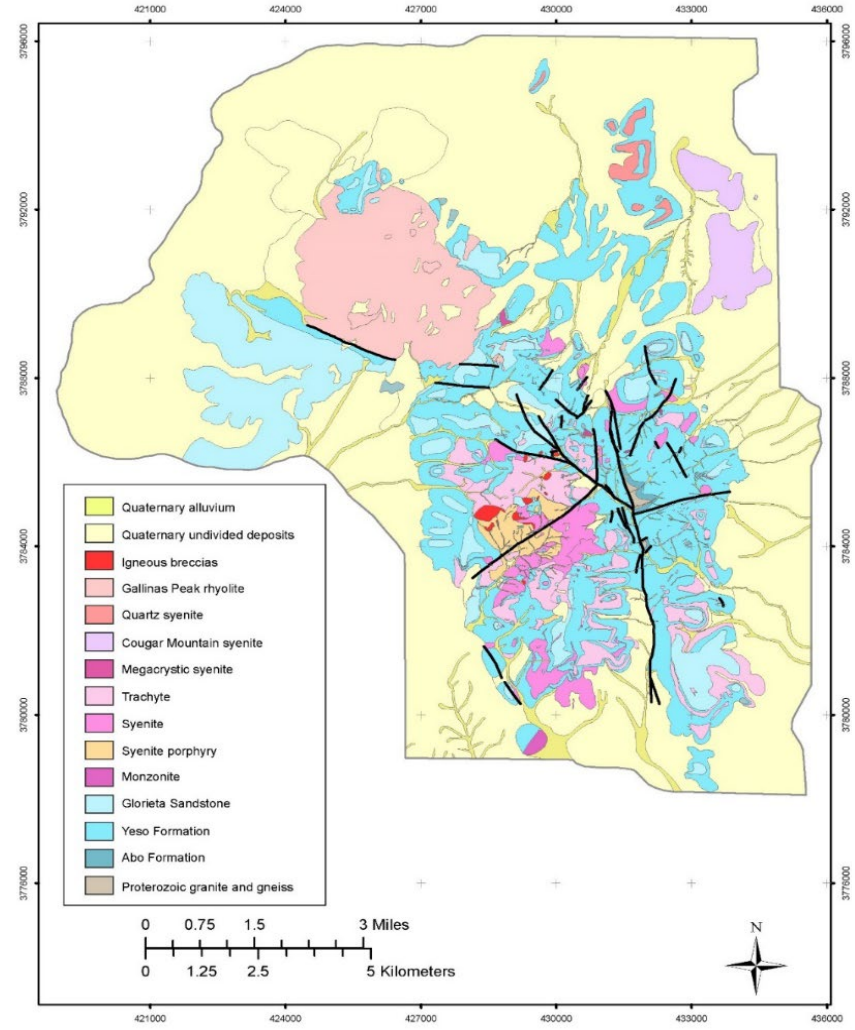
New mapping identified numerous mines and prospects, veins, faults, and subdivided the igneous intrusions



Historic geologic map of the Gallinas Mountains, Lincoln and Torrance Counties, New Mexico (Perhac, 1970)



Summary of new (red) and published (blue; from Robison 2017) $^{40}Ar/^{39}Ar$ ages.

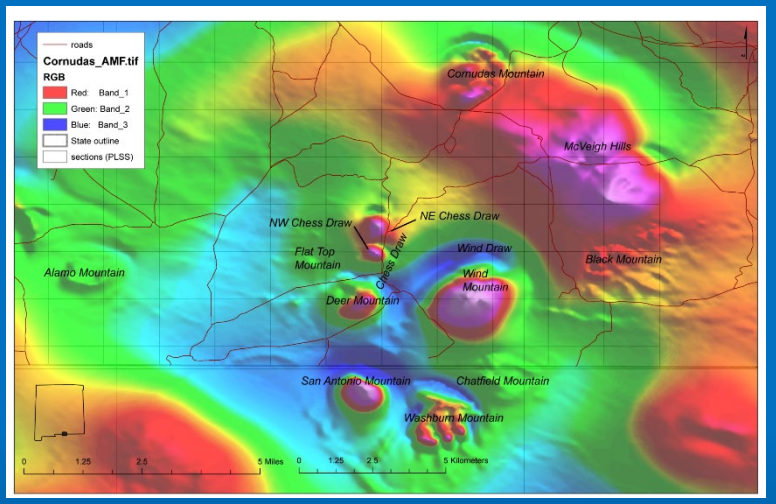


New geologic map of the Gallinas Mountains, Lincoln and Torrance Counties, New Mexico

USGS Earth MRI Project Mapping REE in Cornudas Mountains, Otero County, NM (2020-2023)

Virginia T. McLemore, Nels Iverson, Evan Owen, Snir Attir, and several students

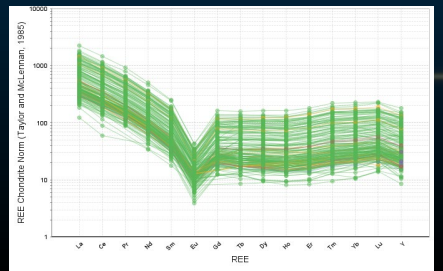
IN COOPERATION WITH TEXAS



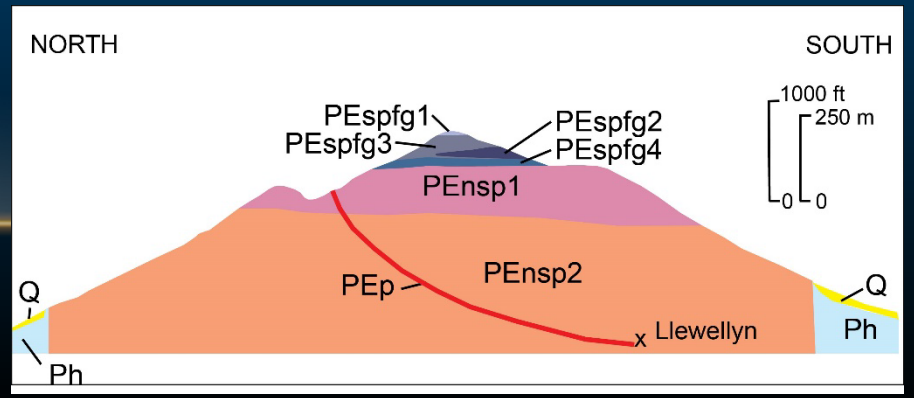
- Finishing up the GIS geologic map
- Differential cooling of the magma resulted in the textural variations at Wind Mountain
  - 36.32±0.15 Ma
- Eudialyte is primary REE mineral
- Chemical analyses—3790 ppm total REE, 2332 ppm Nb, 92 ppm Be, and 3137 ppm F
- Industry provided core, chemistry

Pink eudialyte in black phonolite dike in contact with skarn

Map of the anomalous magnetic field (AMF) of the Cornudas Mountains (Bultman, 2021, 2022) showing intrusive laccoliths and plugs (red anomalies) that extend deep into the subsurface, with additional intrusions potentially buried in the subsurface.

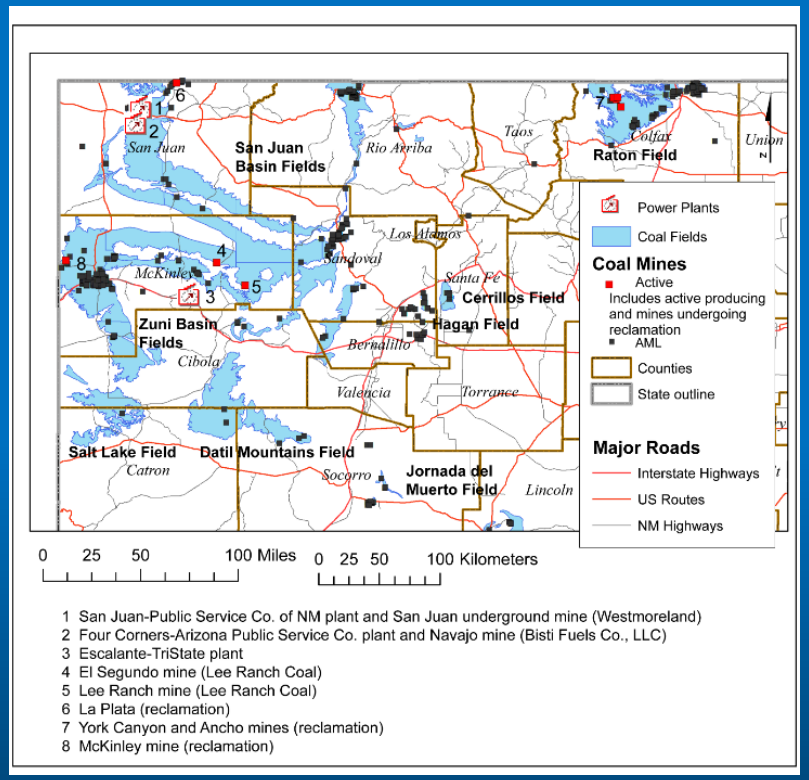


Wind Mountain laccolith



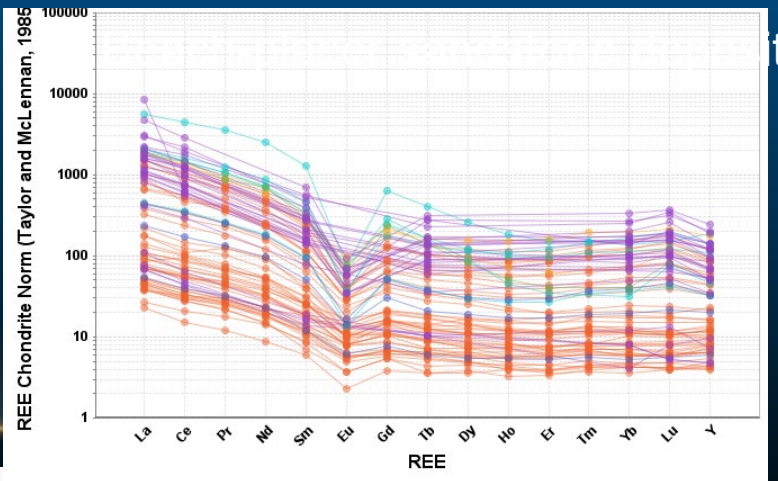
DOE CORE-CM project—San Juan River-Raton Basin, New Mexico DOE contract (Oct 2021-Sept 2023, extension requested)

Virginia T. McLemore, Navid Mojabai, Shari Kelley, Evan Owen, many students and staff



- **CORE-CM=Carbon Ore, Rare Earth and Critical Minerals**
- Identify and quantify the distribution of REE and CM in coal beds and related stratigraphic units in the San Juan and Raton basins
- Identify, sample, and characterize coal waste stream products
- Sandia: Microscale characterization techniques to identify where REEs and critical metals are hosted
- LANL: Field-portable, in situ LIBS/RAMAN analysis

Industry provided access to mines

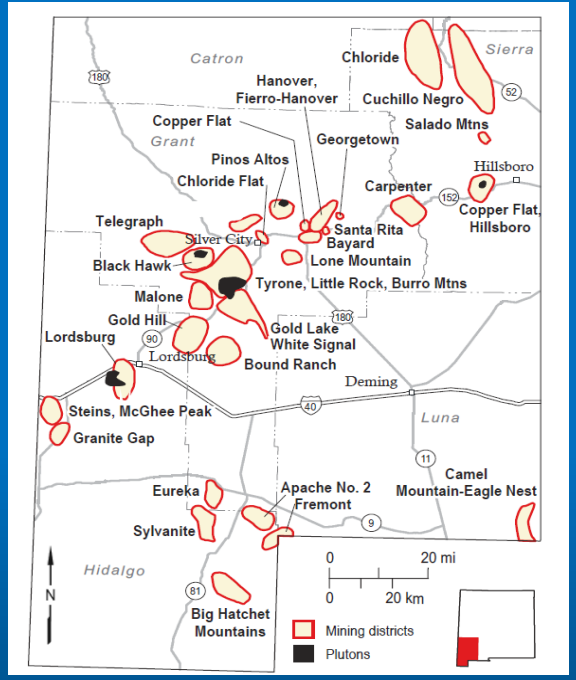


CRITICAL MINERALS IN LARAMIDE PORPHYRY COPPER DEPOSITS (AUG 2022—JULY 2025)

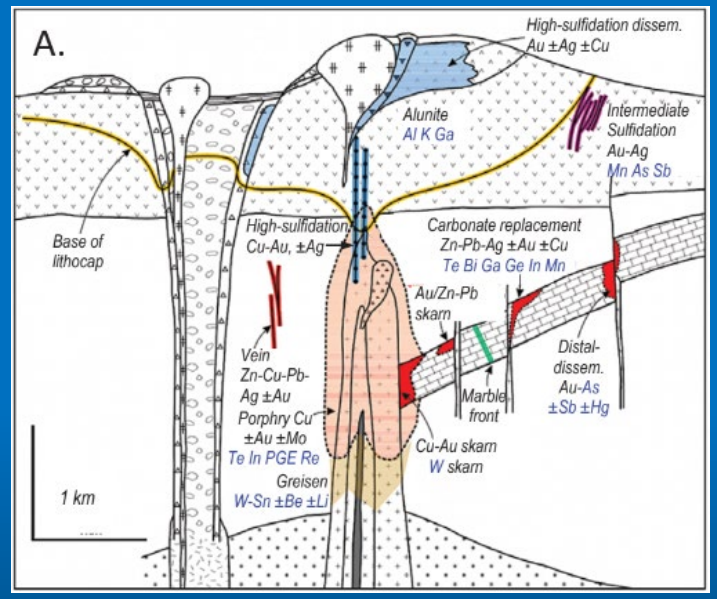
Virginia T. McLemore, Evan Owen, Nels Iverson, Shari Kelley, and many students

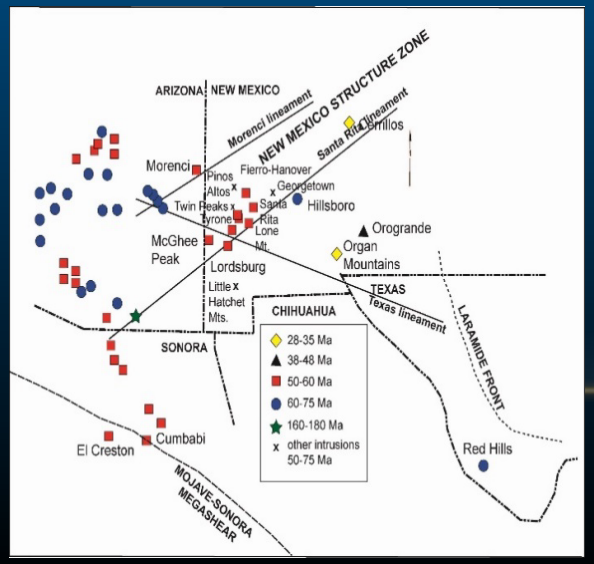
IN COOPERATION WITH ARIZONA GEOLOGICAL SURVEY

- What are the ages
- Where in the porphyry copper deposits are there critical minerals
- Cooperate with industry

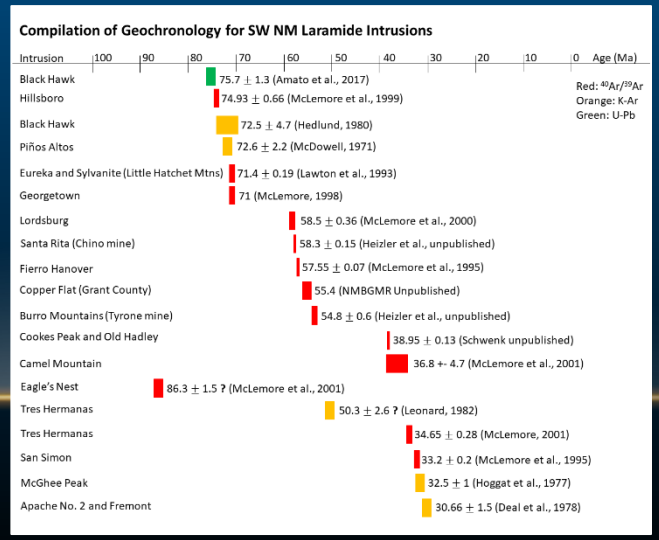


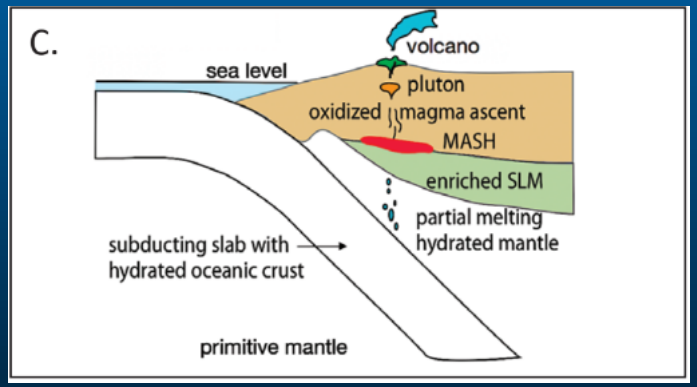
Districts with Laramide deposits and plutons (black) in southwestern New Mexico





Laramide porphyry copper deposits in southwestern United States and northern Mexico. The Copper Flat porphyry copper deposit is in the Hillsboro district.



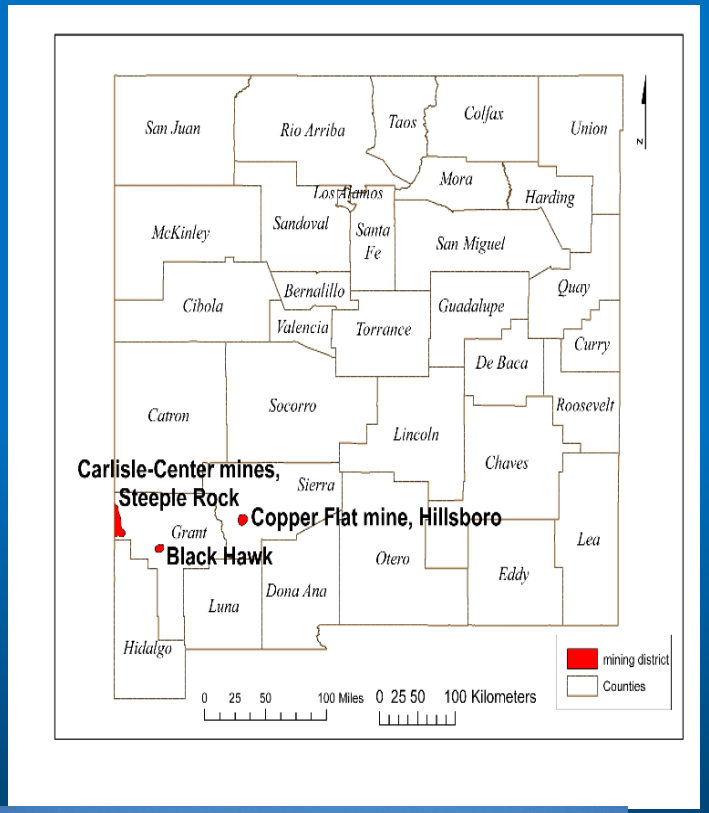


Simplified settings of porphyry copper and associated deposit types Hofstra and Kreiner (2020), top image modified from Sillitoe (2010), bottom from Tosdal et al. (2009)

USGS EARTH MRI PROJECT CRITICAL MINERALS FROM MINE WASTES (AUGUST 2022-JULY 2024)

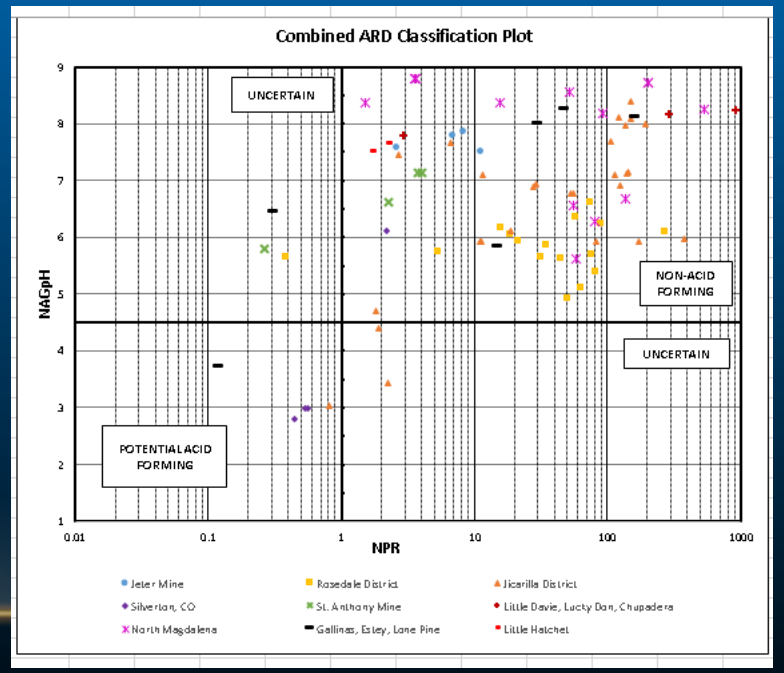
Virginia T. McLemore, Bonnie Frey, Evan Owen, Dan Jones, and students

- Test USGS protocols for sampling mine wastes
- Characterize mine wastes for critical minerals potential
- Includes tailings, mine waste rock piles, stockpiles, pit lakes
- Acid-base accounting to determine acid generating potential
- Industry provided access to sites



Sampling stockpile at Copper Flat

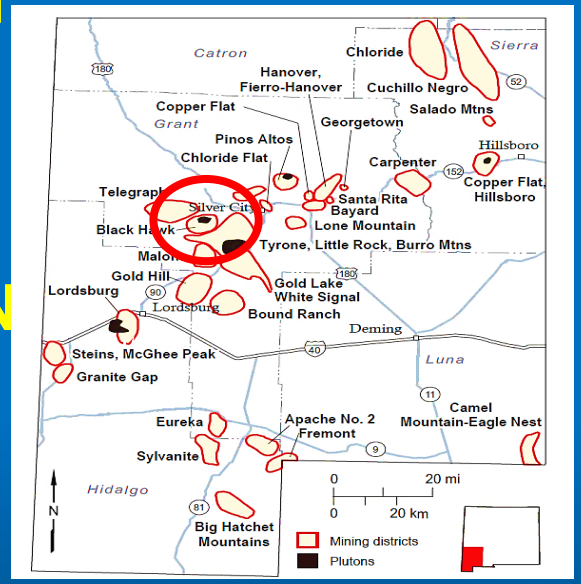
Pit in Copper Flat tailings



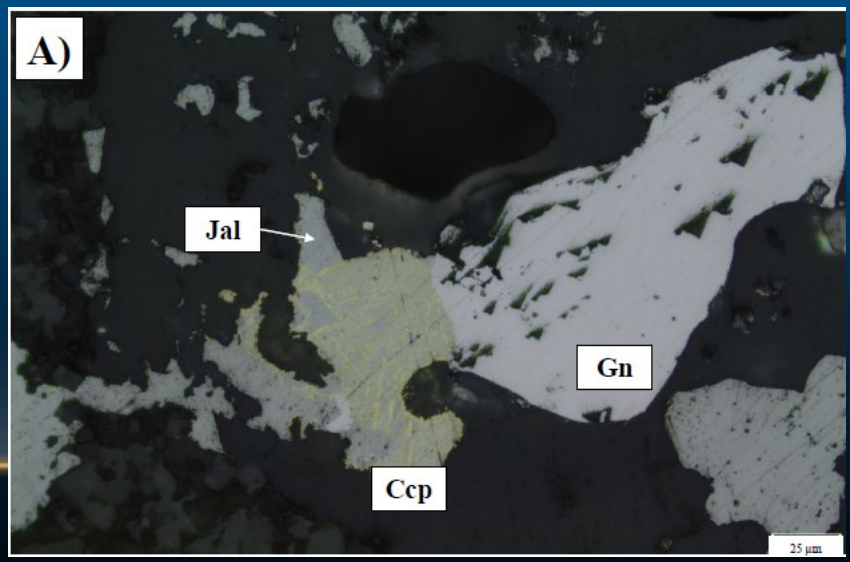
Acid rock diagram for mine waste rock piles in NM

USGS EARTH MRI PROJECT GEOCHEMISTRY AND DETAILED MAPPING OF THE BLACK HAWK ARSENIDE-5 ELEMENT VEIN SYSTEM

Virginia T. McLemore, Evan Owen, Nels Iverson, and several students



- Five-element vein deposits contain Ag, As, Bi, Ni, and Co ± U, Sb, Zn, Cu, Pb
- These deposits are unusual and not well understood
- Like other worldwide example of five-element veins, the Black Hawk district contains silver (Ag) and various critical minerals including nickel (Ni), cobalt (Co), bismuth (Bi), arsenic (As) and local uranium (U), zinc (Zn), and antimony (Sb)
- Industry provided access



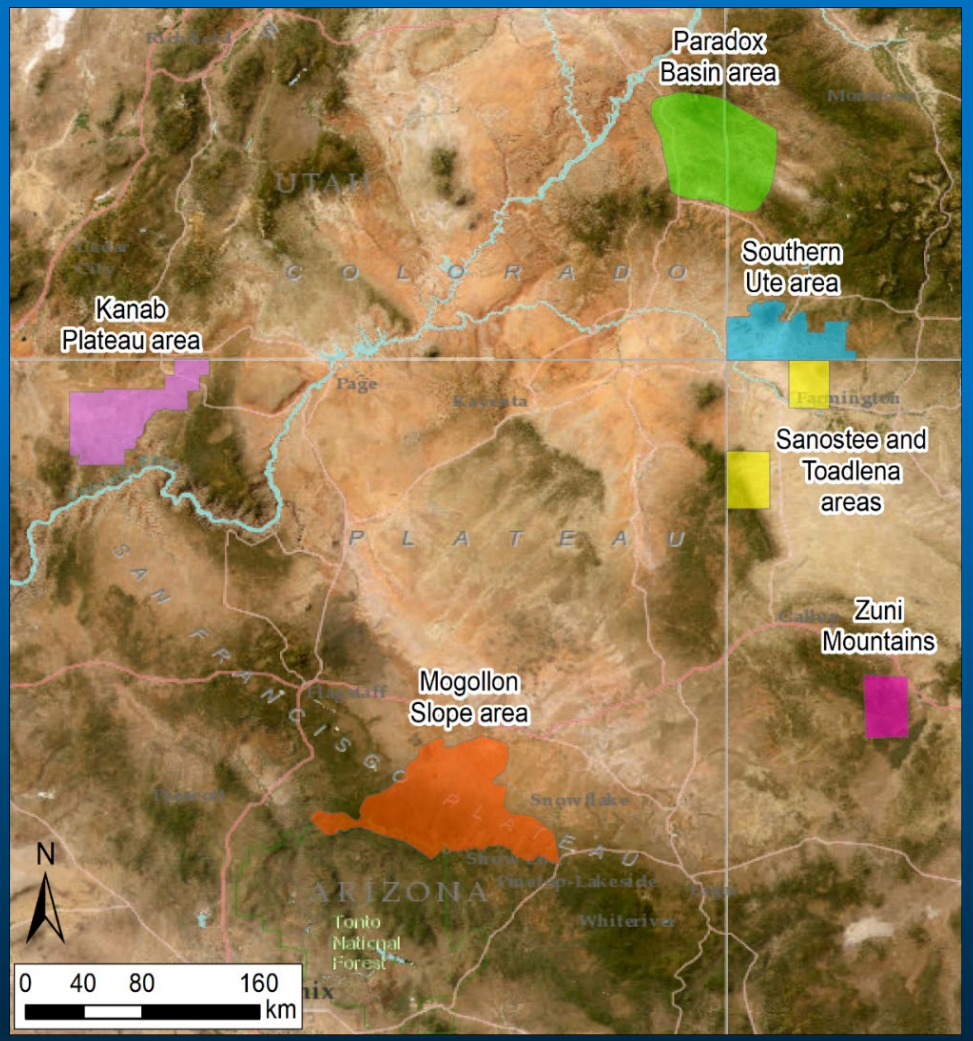
Colloform growths of native Ag, Ni-Co arsenides, anduraninite

USGS EARTH MRI PROJECT GEOCHEMICAL REANALYSIS OF NURE SAMPLES FROM THE COLORADO PLATEAU, NEW MEXICO, UTAH, COLORADO, AND ARIZONA (AUGUST 2023-JULY 2026)

Virginia T. McLemore, Evan Owen, and several students

IN COOPERATION WITH ARIZONA, UTAH, AND COLORADO GEOLOGICAL SURVEYS

Stephanie Mills, Jake Alexander, Taylor Boden, Mike O'Keeffe, Andrew Giebel, and Carson Richardson



- Reanalysis of a select group of existing NURE sediment pulps by the USGS using modern geochemical methods where critical minerals are found
- Resample additional areas
- New Mexico will use this as part of a graduate course (Exploration Geochemistry)

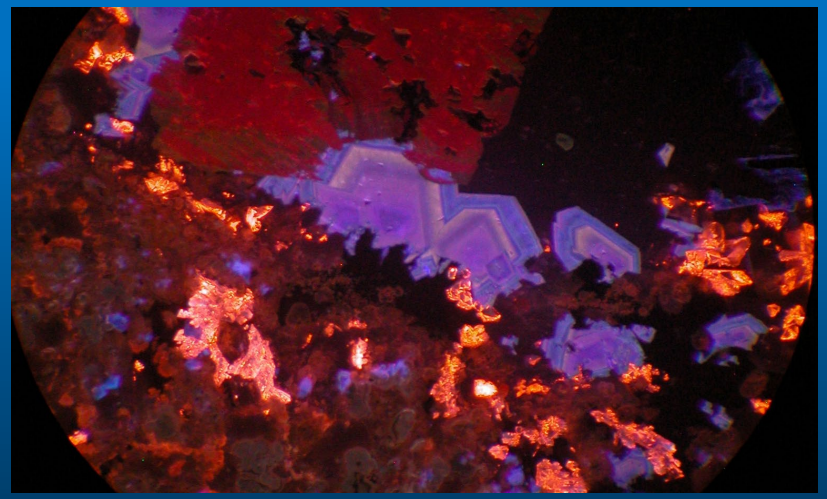
NURE=National Uranium Resource Evaluation

OTHER RESEARCH

Ore Deposits and Critical Minerals Research Group

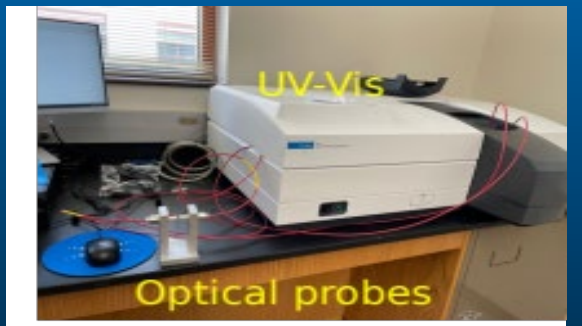
Alexander Gysi
NM Bureau of Geology and Mineral Resources, Department of Earth and Environmental Science, NMIMT

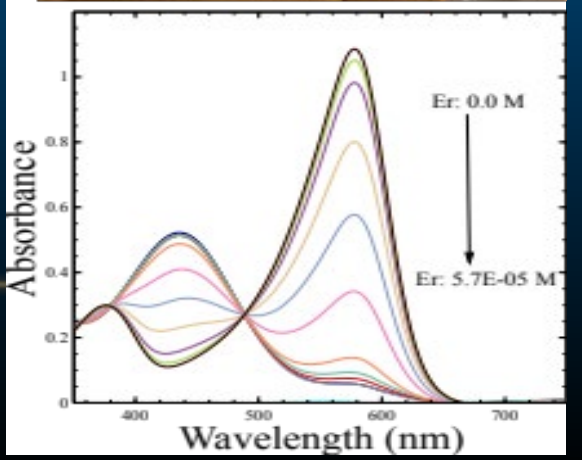
- Research
  - Ore deposits and critical minerals experimental laboratory
  - Development of the MINES thermodynamic database
  - Field observations in critical mineral deposits
- Funding of ~ $3M from DOE and NSF-EAR/-CAREER
- Team: 3 PhD and 2 MS students, 1 undergraduate students and 2 Postdoctoral Fellows
- New U.S. geoscience critical minerals experimental – thermodynamic research hub NMT-LANL-IUB plus search for 3 new PhD and 3 Postdocs



Ore Deposits and Critical Minerals Experimental Lab

- Hydrothermal fluid-mineral experiments
  - Synthesis/dissolution of REE minerals (xenotime, monazite)
  - REE incorporation into calcite, fluorite, apatite
- **Thermodynamic properties of critical minerals and their solid solutions**
  - Hydrothermal solution calorimetry (enthalpy of mixing), heat capacity measurements, and mineral stability
- UV-vis spectrophotometry
  - High temperature complexation of aqueous REE species
  - Flow-through experiments
- NEW Raman laser – hydrothermal diamond anvil cell facility – NSF MRI/DOE research hub





MINING ISSUES FACING NEW MEXICO

- Many inactive mines still have the potential to contaminate the environment or present a hazard to health and safety
  - Gold King spill
  - AML sites (Abandoned mine lands)
  - Grants uranium district

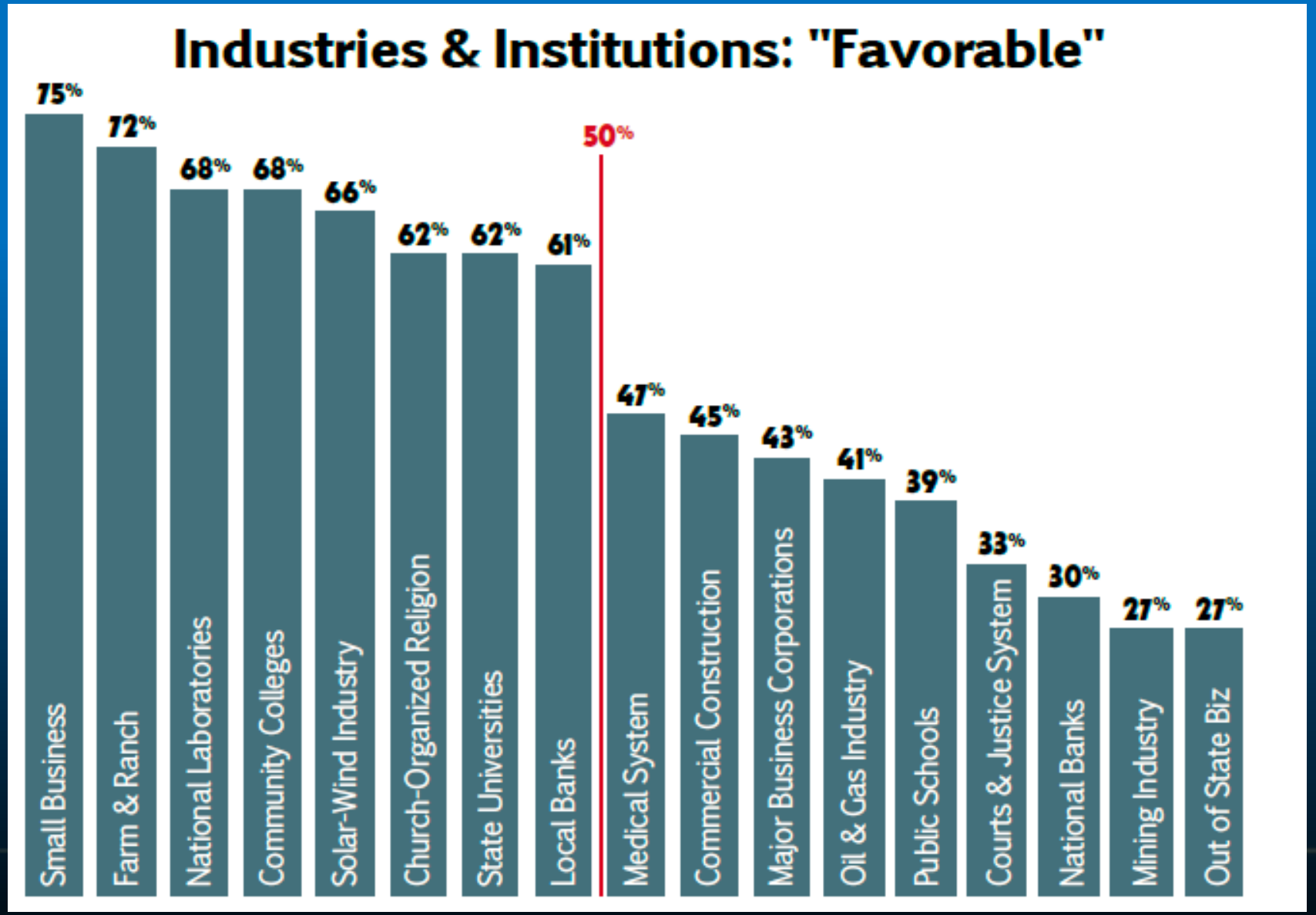
MINING ISSUES FACING NEW MEXICO

- Some current mines are reaching the end of their life and will close over the next decade=decreasing minerals production
- There are not many new mines to replace them
- Mining requires water and their environmental effects must not impact water supplies
- Results in unemployment and decrease in revenues
  - Affects rural economies
  - Affects state revenues
- Legacy issues of past mining activities form negative public perceptions of mining
  - Abandoned or legacy mines, especially Grants uranium district and Questa mine
  - Gold King spill
  - Not in my backyard!!!!!!

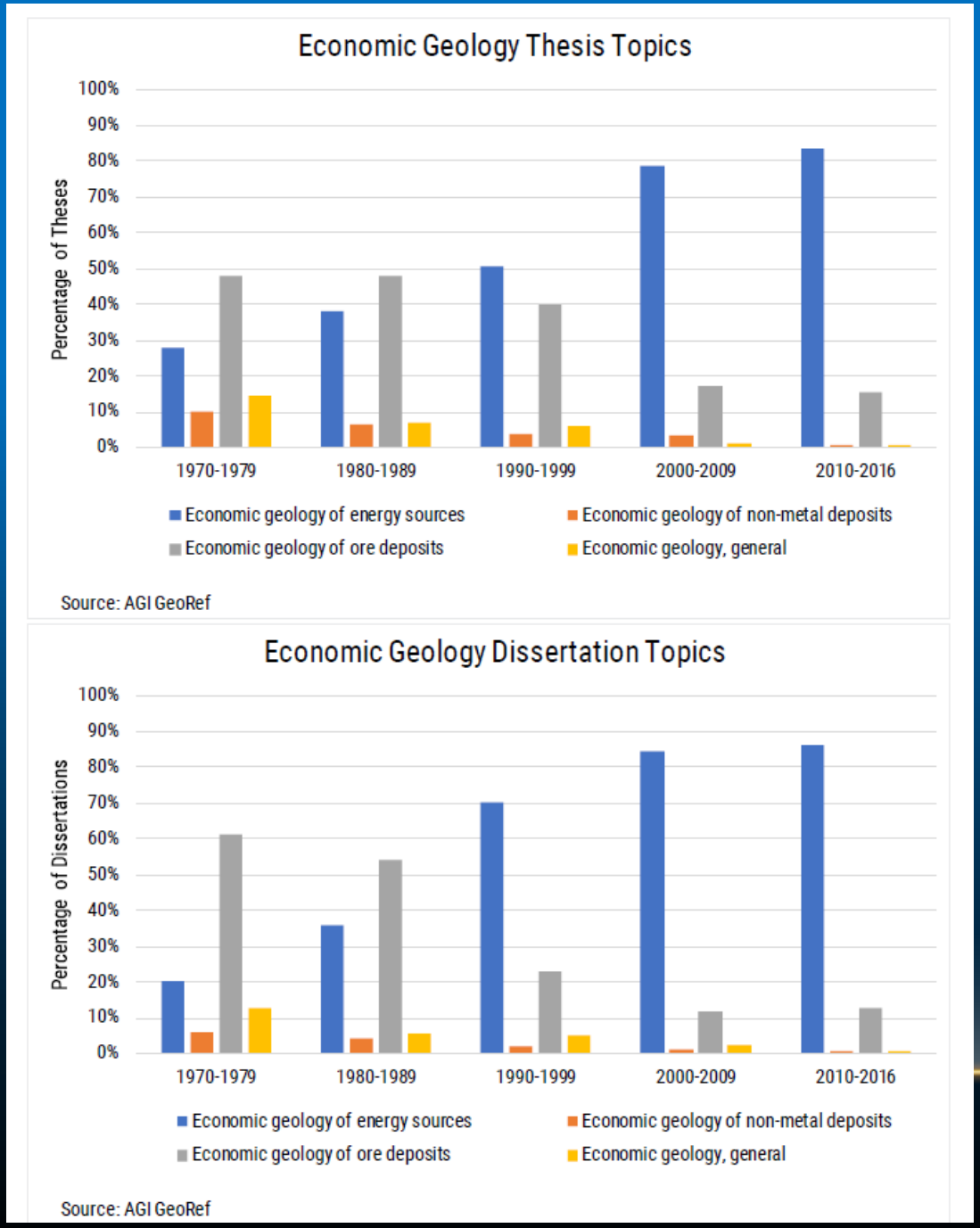
MINING ISSUES FACING NEW MEXICO—CONTINUED

- Global competition is closing some of our mines
- Exploration for new deposits often results in drill targets based upon regulatory minimal impact regulations rather than optimum geological criteria
- Permitting for exploration can take longer than exploration funds are available
- Lower prices=closed mines, little exploration
- In some areas conflicts arise between mining and other activities
  - Grants uranium district
  - Otero Mesa
  - Pecos/Tererro mine
  - **Water, don't want a mine in their backyard**
- Shortage of young geologists and engineers to explore for, develop, mine, permit these commodities and evaluate their effect on the environment—math, science skills critical

Mining is viewed as favorable by only 27% of New Mexicans



http://garritypr.com/sites/default/files/uploads/documents/2017_Garrity_Perception_Survey.pdf



Number of thesis and dissertations on non-energy economic geology has decreased

http://www.multibriefs.com/briefs/aipg/DataBrief_2019_008_EconomicGeologyThesesDissertations.pdf

EDUCATION OUTREACH

ROCKIN' AROUND NEW MEXICO

This program has served teachers for **25** years!

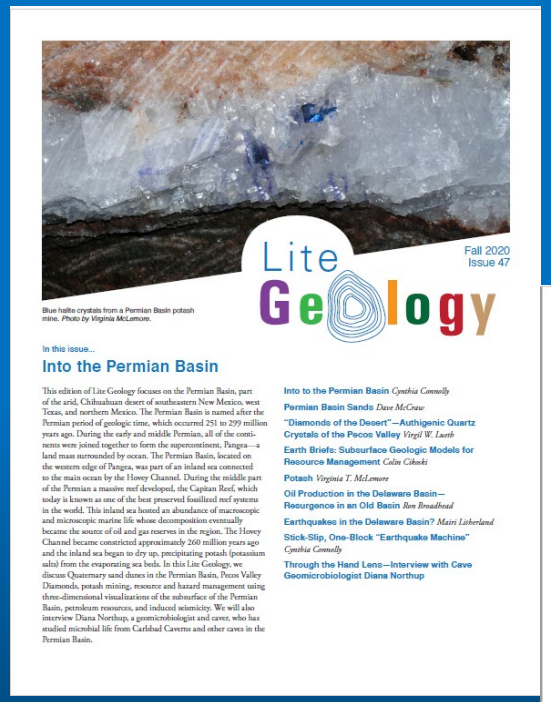
The location of ranm changes annually

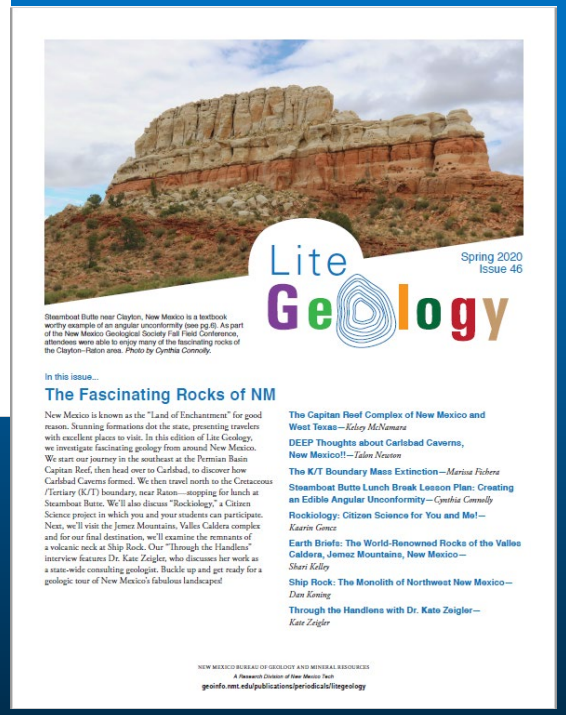
Each year up to 30 K-12 teachers attend

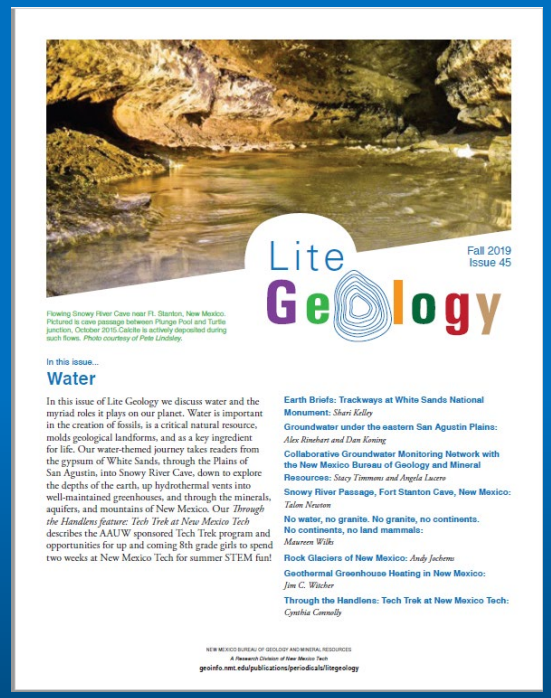
All costs for workshop materials and fees for K-12 teacher professional development are covered by our rockin' DHSEM (division of homeland security and emergency management) grant

The theme of RANM generally focuses on **hazard and hazard mitigation** to qualify for DHSEM funding

NMBGMR Mineral Museum Curator Kelsey McNamara teaches educators about morphological elements during Rockin'2018.







Lite Geology

Lite Geology is an online education outreach publication produced biannually by the New Mexico Bureau of Geology and Mineral Resources for K-12 teachers

An edition of Lite Geology will be dedicated to the collaborative research and results from the REE Project

Pictured are the covers of some of our latest editions of Lite Geology. These editions discussed the Permian Basin, Rocks of New Mexico and Water. You can read this online publication at https://geoinfo.nmt.edu/publications/periodicals/litegeology/home.cfml

SUMMARY

- New Mexico has a wealth of mineral resources
- The New Mexico Bureau of Geology and Mineral Resources has a long history in critical minerals research
  - We have a number of ongoing research projects in the broad field of critical minerals, with strong field and laboratory components
  - Archiving samples for future studies
- Exploration and permitting takes many years before a deposit can be mined in NM, >10 yrs
- Legacy issues are being addressed
- Negative public perceptions are major issue as is funding
- Global competition is a major challenge
- NMBG/NMT research is addressing some of these issues, as well as actively training future geologists and engineers

IMPORTANCE OF MINING REE AND CRITICAL MINERALS IN NEW MEXICO

- Future mining of REE and Critical Minerals will directly benefit the economy of New Mexico
  - Will delineate favorable geologic terranes and priority areas containing potential REE and CM deposits
- Mineral resources must be identified before land use decisions are made by government officials
- Crucial to re-establish a domestic source of REE and Critical Minerals minerals in the U.S. to help secure the nation's clean energy future, reducing the vulnerability of the U.S. to material shortages related to national defense, and to maintain our global technical and economic competitiveness
- Training of the future workforce because students at New Mexico Tech and San Juan College will be hired to work on this project and outreach activities train high and middle school students as well as their teachers

MORE INFORMATION

- NM Mines and Minerals Division

  http://www.emnrd.state.nm.us/MMD/

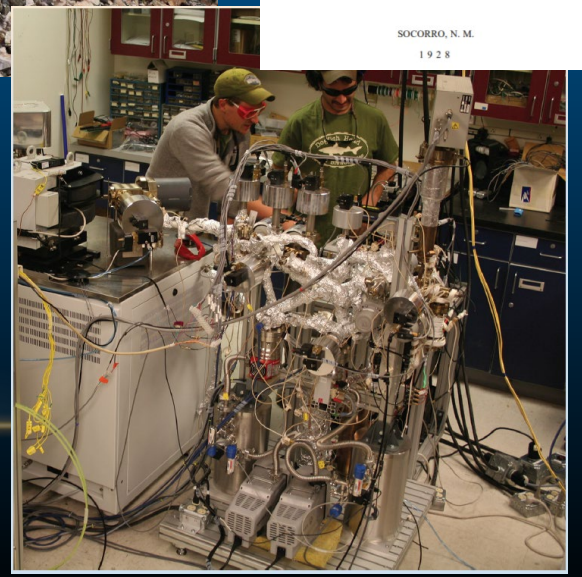
  Virginia McLemore web page

  http://geoinfo.nmt.edu/staff/mclemore/home.html

- New Mexico Bureau of Geology and Mineral Resources

  http://geoinfo.nmt.edu/

NMBGMR ECONOMIC GEOLOGY GROUP RESEARCH



NEW MEXICO SCHOOL OF MINES

STATE BUREAU OF MINES AND MINERAL RESOURCES

E. H. WELLS, PRESIDENT AND DIRECTOR

BULLETIN NO. 4

Fluorspar In New Mexico

BY

WILLIAM DRUMM JOHNSTON, JR.

SOCORRO, N. M.

1928

QUESTIONS?