CRITICAL MINERALS IN NEW MEXICO

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Definition of Critical Minerals

are minerals
(1) identified to be a nonfuel mineral or mineral material essential to the economic and national security of the United States,
(2) from a supply chain that is vulnerable to disruption, and
(3) that serves an essential function in the manufacturing of a product, the absence of which would have substantial consequences for the U.S. economy or national security
Critical Minerals

• President Trump signed an executive order (Presidential Executive Order (EO) No. 13817) that requires the Departments of Interior and Defense to develop a list of critical minerals

• May 18, 2018 U.S. Department of Interior published the final list of critical minerals
Critical Minerals

• 35 critical minerals were identified
• New Mexico has many of these critical minerals
  – Potash is currently being produced in Carlsbad
  – Porphyry copper deposits in Grant County contain rhenium, indium, and germanium
  – Uranium deposits in the Grants district, also contain vanadium
  – 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, REE, tellurium, beryllium)
Critical Minerals in New Mexico

2020

- Red: Element currently producing in NM
- Blue: Element once produced from NM
- Green: Element found in NM
- Yellow: Element not found in NM

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.
Critical Minerals in New Mexico

2022

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U and K (potash) were removed from the critical minerals list in 2021 and Zn and Ni were added.
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.
Occurrences of Rare Earth Elements (REE) in New Mexico
Tertiary alkaline igneous-related REE deposits in New Mexico

- Part of a belt of alkaline-igneous rocks
- Extends along the eastern edge of the Rocky Mountains and Basin And Range Provinces
- From Alaska And British Columbia southward into New Mexico, Trans-Pecos Texas, And Eastern Mexico
- These alkaline rocks contain relatively large quantities of important commodities such as, gold, fluorine, zirconium, rare earth elements (REE), tellurium, gallium, and other critical minerals

Tertiary carbonatites are found in the North American Cordilleran alkaline-igneous belt in Bear Lodge (WY), Laughlin Peaks (NM), and eastern Mexico

REE in Gallinas Mountains, Lincoln County
REE in Cornudas Mountains, Otero County
Carbonatites and Episyenites (or metasomatic rocks) in New Mexico and Colorado
Episyenites is a term used to describe altered rocks that were desilicated and metasomatized by alkali-rich fluids solutions.
Geologic map of the Caballo Mountains, New Mexico
HIGH K$_2$O

- Zuni Mountains
- Burro Mountains

Graphs showing the distribution of various rock types:
- Altered granite
- Episyenite
- Mafic dike
- Metarhyolite
- Zuni granite

Graphs for Zuni Mountains and Burro Mountains.
Some episyenites are HREE-enriched
As much as 133 ppm Yb, 179 ppm Dy

They are interpreted to be related to carbonatite or alkaline fluids altering the host granite, similar to fenitization
Complex mineralogy

- Synchysite (63 wt.% LREE)
- Aeschynite (9 wt.% HREE)
- Xenotime (16 wt.% HREE)
- Thorite
- Uranophane
- Bastnaesite

Paragenesis South Red Hills
Backscatter electron image (electron microprobe) of an episyenite sample

Synchysite
$\text{Ca(LREE)(CO}_3\text{)}_2\text{F}$

Thorite
$(\text{Th, U})\text{SiO}_4$

Xenotime
$\text{YPO}_4$
Beach-placer sandstone deposits

- Accumulations of heavy, resistant minerals (i.e. high specific gravity) that form on upper regions of beaches or in long-shore bars in a marginal-marine environment
- Known in the industry as mineral sands
Beach-placer sandstone deposits

- Formed by mechanical concentration (i.e. settling) of heavy minerals by the action of waves, currents, and winds
- Composed of rutile, titanite, ilmenite, zircon, magnetite, monazite, apatite, xenotime, garnet, and allanite, among other minerals
- Ti, Zr, Fe are important economically
- Nb, Th, U, Sc, Y, and REE also can be important

Modern beach-placer sandstone deposits in Virginia
Modern examples

- Atlantic Coast, USA
- southeastern Australia
- Andhra Pradesh, India

- Mined for titanium, zircon, and monazite (a Ce-bearing REE mineral)

Stony Creek beach-placer sandstone deposit, Virginia
Economics of modern mineral sands

- Economic deposits are 10 million tons of >2% heavy minerals

- Zirconium as zircon (1-50%)
  - Ceramic tiles, bricks used to line steel making furnaces, alloying agent in steel, laboratory crucibles

- Titanium as ilmenite (10-60%), rutile, leucoxene (titanium, 5-25%)
  - Alloys in aircraft, white pigment found in toothpaste, paint, paper, glazes, and some plastics, heat exchangers in desalination plants, welding rods

- REE as monazite ($\text{Ce,La,Y,Th} \text{PO}_4$) (<15%)
  - Catalyst, glass, polishing, re-chargeable batteries, magnets, lasers, glass, TV color phosphors, wind turbines

- Other minerals
  - Garnet, starolite, kyanite trace-50%
New Mexico

Beach-placer sandstone deposits in the San Juan Basin are restricted to Late Cretaceous rocks belonging to the Gallup, Dalton, Point Lookout, and Pictured Cliffs Sandstones.
Sanostee deposit, San Juan County

Resources are estimated by the USBM as 4,741,200 short tons of ore containing 12.8% TiO$_2$, 2.1% Zr, 15.5% Fe and less than 0.10 ThO$_2$ with some REE (USBM files)
GEOCHEMISTRY

Chondrite-normalized REE plot of selected beach-placer deposits, Apache Mesa (red), Standing Rock (light blue), Sanostee (dark blue), and B.P. Hovey (black), San Juan Basin, New Mexico. Chondrite values are from Nakamura (1974).
Grade and size (tonnage) of selected REE deposits, using data from Oris and Grauch (2002) and resources data from Jackson and Christiansen (1993). Deposits in bold are located in New Mexico.
New project awarded by the DOE—REE and other critical minerals in coal deposits
Coal has potential for REE, Co, Ga, Ge, and other CM
Helium potential in New Mexico
Uses of Tellurium

- 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
Tellurium

- Production—byproduct of copper refining (refinery in Texas)
- Lone Pine, Catron County produced 5 tons of Te from Au-Te volcanic-epithermal veins
Mining districts in New Mexico with tellurium minerals or chemical assays >20 ppm Te
Lone Pine, Wilcox district, Catron County—volcanic epithermal vein
Beryllium in New Mexico

- Defense
- Telecommunications
- Nuclear energy industries
- Shielding in some of our nuclear, medical, and other equipment
- Many of our electronic devices
Grade-tonnage of beryllium deposits (modified from Barton and Young, 2002). Deposits in bold are located in New Mexico.
Apache Warm Springs beryllium deposit (Be), as determined from trenching and drilling, looking northeast (N section 6, T9S, R7W).
Mine wastes
Mine wastes

- Tailings
- Mine waste dumps
- Slags
- Smelter
Another potential source are mine wastes (mine rock piles, coal ash, tailings, acid mine drainage, etc.) at inactive mines and abandoned mine lands likely have potential for Critical Minerals, including REE, that could be recovered and pay for cleanup costs.
What are the challenges in producing critical minerals?

• Meeting the demand (quick change in supply and demand difficult for mines to meet)
• Permitting
• Fear that producing a byproduct could jeopardize production of major commodity
• Environmental issues
  – Many are associated with U/Th (radioactivity)
• Financing for both exploration/mining and development of new products
• Social license to operate
• Local infrastructure challenges
The main challenge is provide society with its needs, protect future resources, limit alteration of the landscape, and affect local communities as little as possible (i.e. sustainable development).
GENERAL COMMENTS

- Many of the critical minerals do not require the tonnages we are used to mine for metals like Fe, Cu, Pb, Zn—i.e. smaller deposits
- Some of these minerals are found in only 1-3 deposits in the world
- Some of these minerals are found in areas of the world that may not be economically unstable or particularly friendly to the U.S.
  - Minerals that provide major revenue to armed factions for violence, such as that occurring in the Democratic Republic of Congo (GSA, Nov. 2010)
- Some of these minerals come only from the refining of metal deposits and are dependent upon that production
  - Many Cu and Au deposits utilize heap leach technology, which leaves other potential minerals unrecovered in the heap leach
Summary

- New Mexico is currently producing potash
- New Mexico has produced many of the critical minerals and has potential for future production
  - Uranium—2nd in the US in resources
- Exploration for several critical minerals ongoing in NM
  - REE, Te, Co, Li, Be
- Coal deposits in NM could have potential for critical minerals
QUESTIONS?