Potential of Critical Minerals on Native American Lands in New Mexico

Virginia T. McLemore

New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, Socorro, NM
Definition of Critical Minerals

is a mineral

(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

(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
For example, computer chips...

Elements in Computer Chips
(National Research Council, 2007)

- Green: Elements needed in 1980s
- Yellow: Additional elements needed today

Periodic Table of Elements
Critical Minerals in New Mexico

- Element currently producing in NM
- Element once produced from NM
- Element found in NM
- 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.
Occurrences of Rare Earth Elements (REE) in New Mexico
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

Modern beach-placer sandstone deposits in Virginia
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 (Ce,La,Y,Th)PO₄ (<15%)
  - Catalyst, glass, polishing, re-chargeable batteries, magnets, lasers, glass, TV color phosphors, wind turbines

- Other minerals
  - Garnet, starolite, kyanite trace-50%
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)
Apache Mesa, Jicarilla Indian Reservation
Drilled in August 2015
Small footprint with little land disturbance

CS 14 track drill rig by Layne Drilling Co.
Apache Mesa drill holes
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).
Economics of Apache Mesa deposit

132,900 short tons (120,564 metric tons) of ore with grades of 3% TiO₂, 108 ppm Cr, 46 ppm Nb, 2,187 ppm Zr, 40 ppm Th, and 522 ppm TREE
Proterozoic
Pajarito Mountain, Mescalero, NM
Proterozoic
Pajarito
Mountain

FIGURE 1—Location and generalized geology of the yttrium–zirconium deposit at Pajarito Mountain. Sherer (1990)

Spider plot – REE chondrite (Nakamura 1974)
Mineralogy Proterozoic Pajarito Mountain (Berger, 2018)

- Eudialyte $\text{Na}_4(\text{Ca},\text{Ce})_2(\text{Fe}^{++},\text{Mn},\text{Y})\text{ZrSi}_8\text{O}_{22}(\text{OH},\text{Cl})_2$
- Fluorite $\text{CaF}_2$
- Apatite $\text{Ca}_5(\text{PO}_4)_3(\text{OH},\text{F},\text{Cl})$ (with U, Th)
- Zircon $\text{ZrSiO}_4$ (with U, REE)
- 2 REE-bearing silicates
Proterozoic Pajarito Mountain

- In 1990, Molycorp, Inc. reported historic resources of 2.7 million short tons grading 0.18% $\text{Y}_2\text{O}_3$ and 1.2% $\text{ZrO}_2$ as disseminated eudialyte
- Historic REE resources—537,000 short tons of 2.95% total REE (Jackson and Christiansen, 1993)
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
Potential for other critical minerals in San Juan Basin (helium, Li, graphite, etc.)

Critical Minerals in New Mexico

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<tr>
<th>Element currently producing in NM</th>
<th>Element once produced from NM</th>
<th>Element found in NM</th>
<th>Element not found in NM</th>
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Helium potential in New Mexico
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.
CONCLUSIONS

- Evaluation of CM and REE in NM, including on Indian lands, is important to understand what is available in order to make appropriate land use decisions.
- As the economics for some of these elements increases because of increased demand and short supplies, the dollar value per ton of ore may rise, enhancing deposit economics.
- Ultimately, economic potential will most likely depend upon production of more than one commodity and more than one deposit in the San Juan Basin and elsewhere on Indian lands in NM.