Potential of Critical Minerals on Native American Lands in New Mexico

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Definition of Critical Minerals

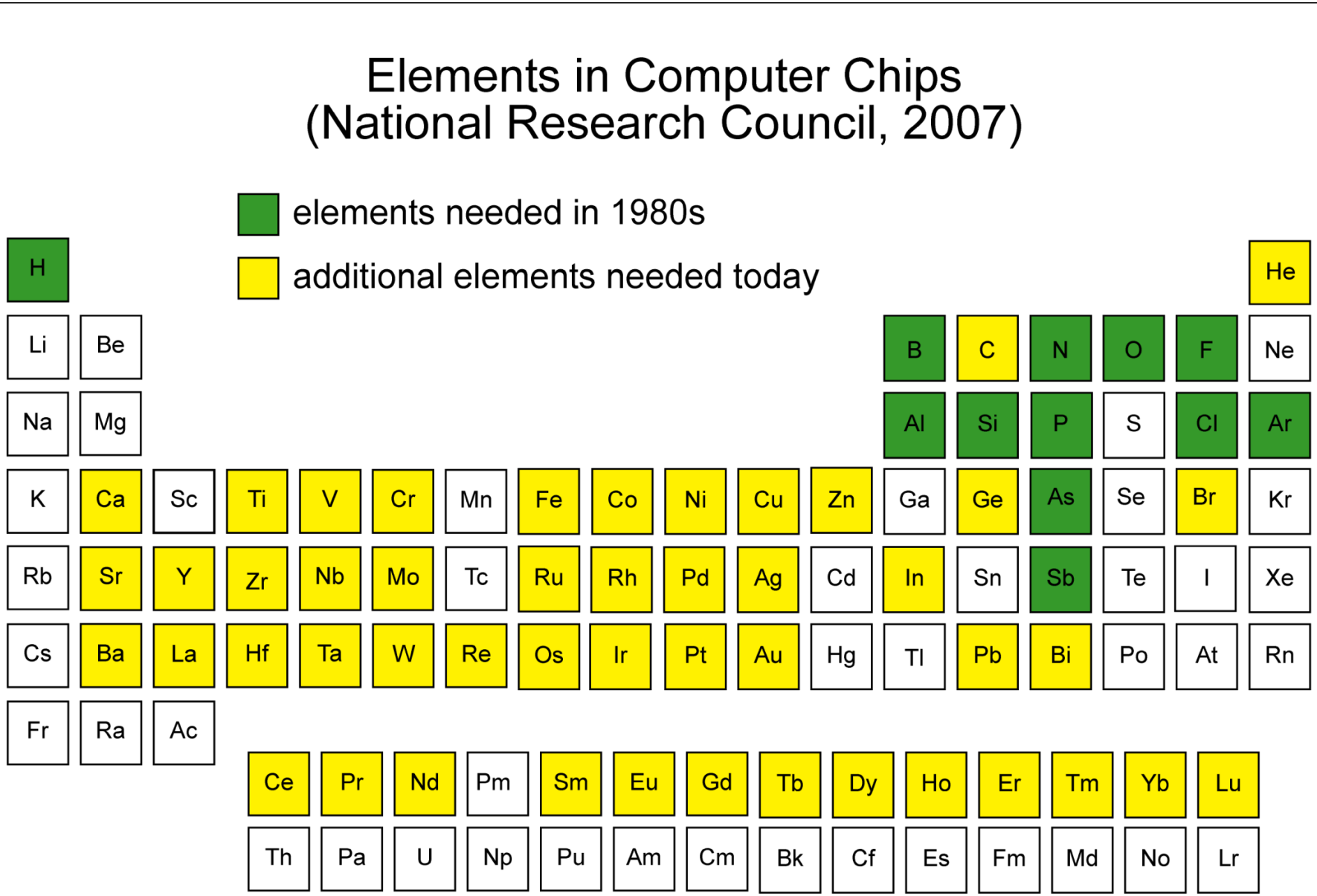
is a mineral

(1) identified to be a nonfuel mineral or mineral material essential to the economic and national security of the United States

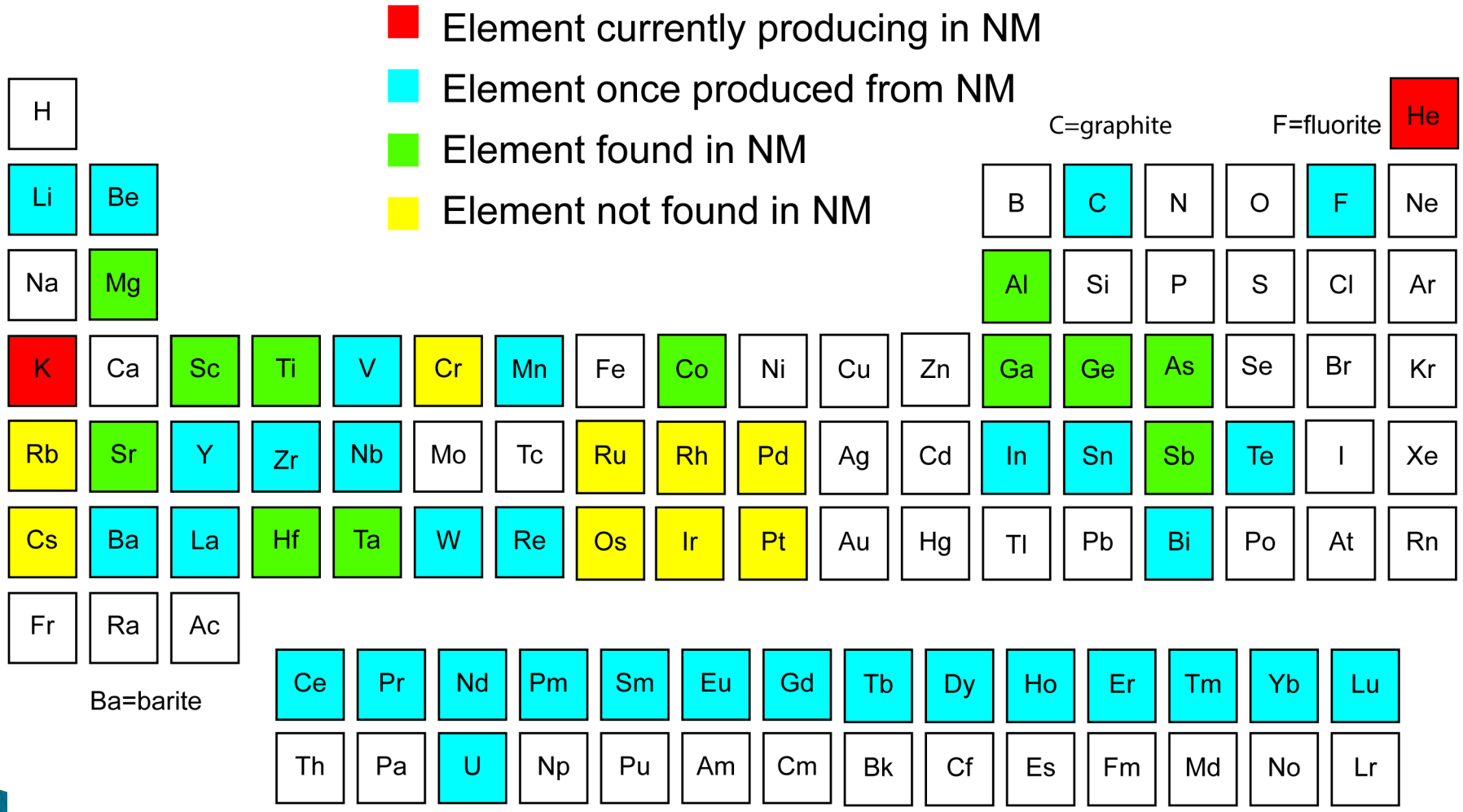
(2) from a supply chain that is vulnerable to disruption

(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

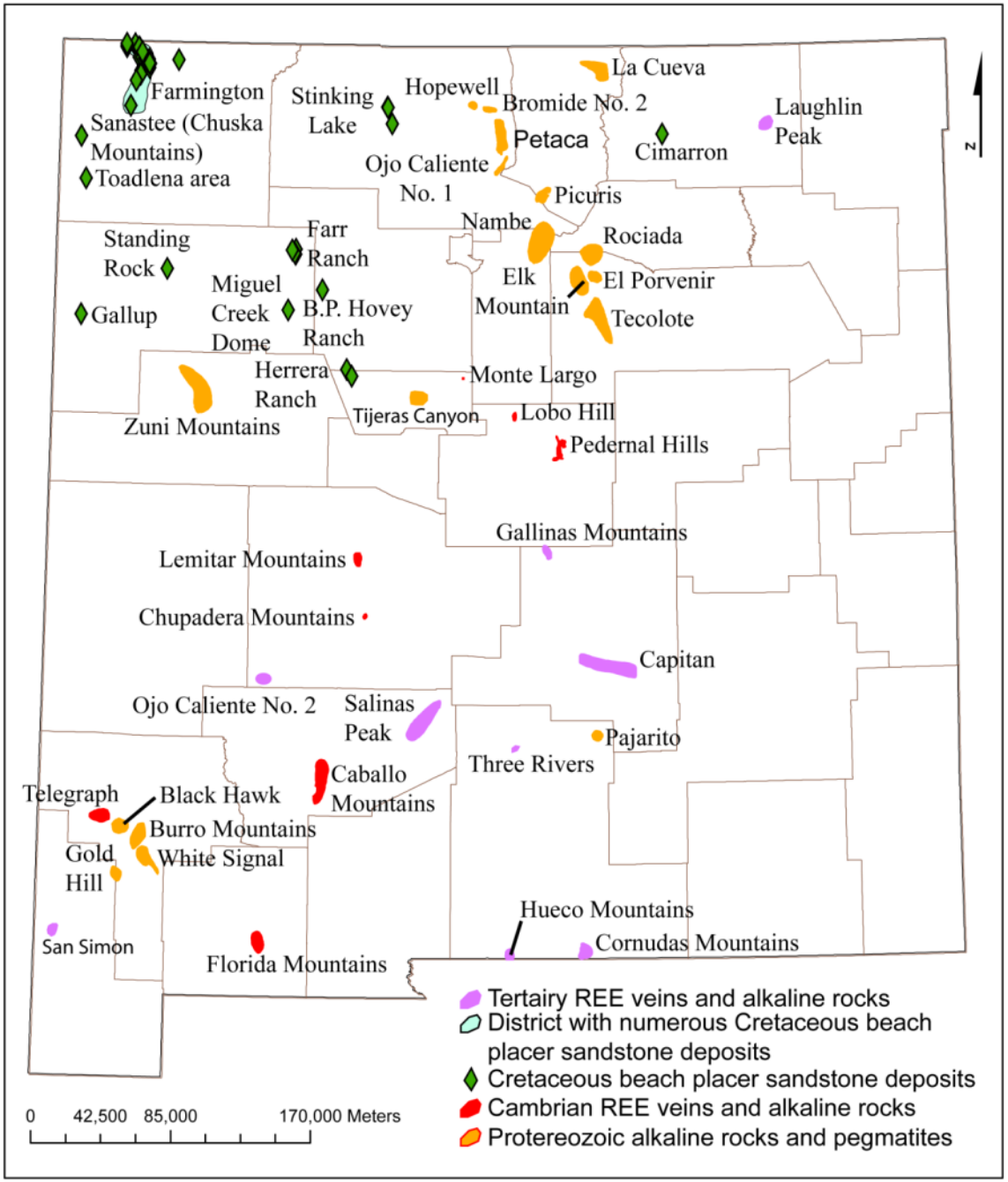
For example, computer chips…



Critical Minerals in New Mexico



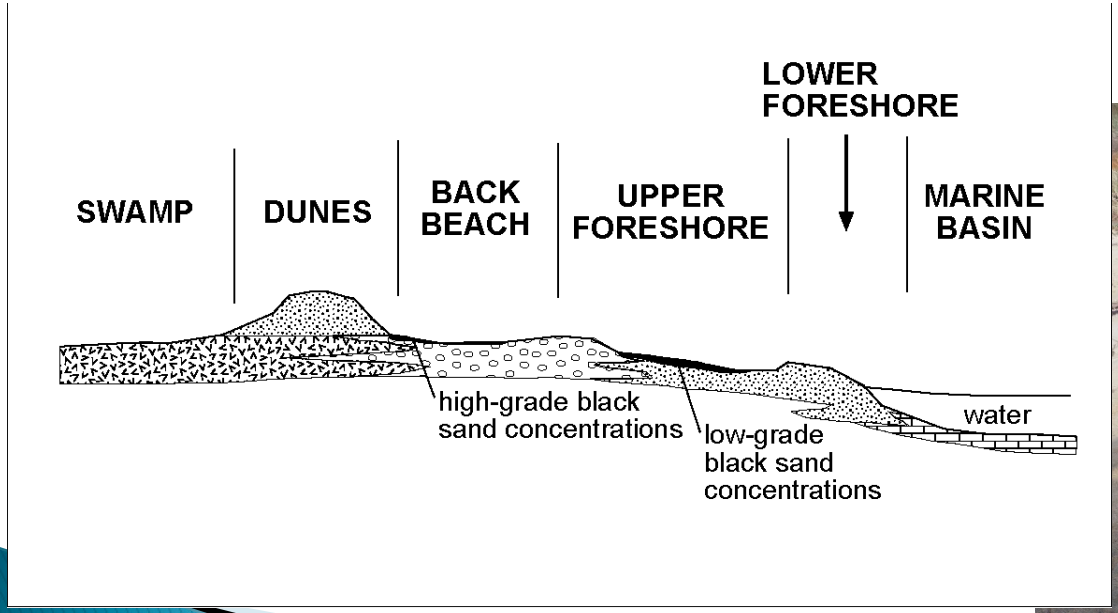
Note that any element or commodity can be considered critical in the future depending upon use and availability. Coal contains several of these critical elements.



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

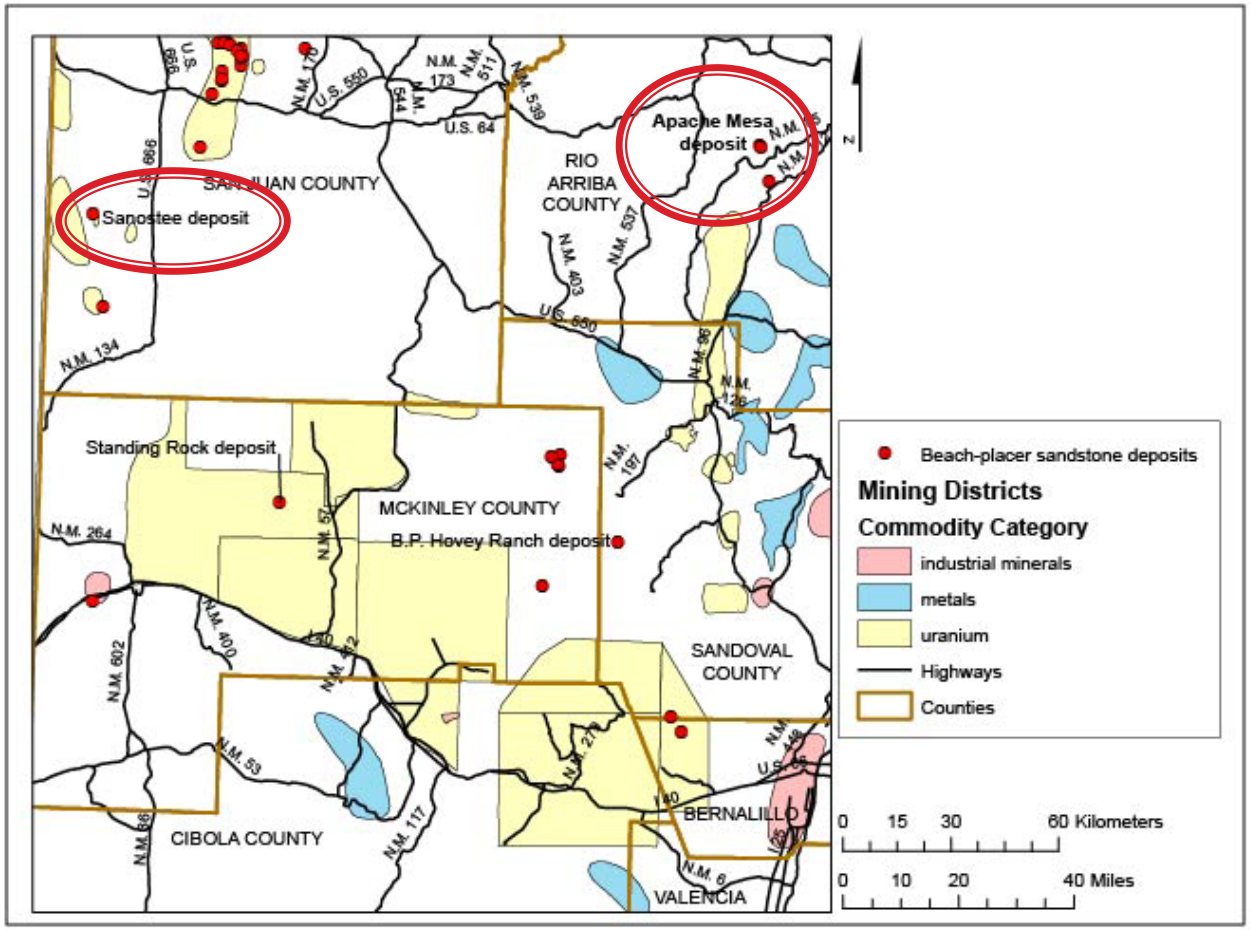
Economics of modern mineral sands

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

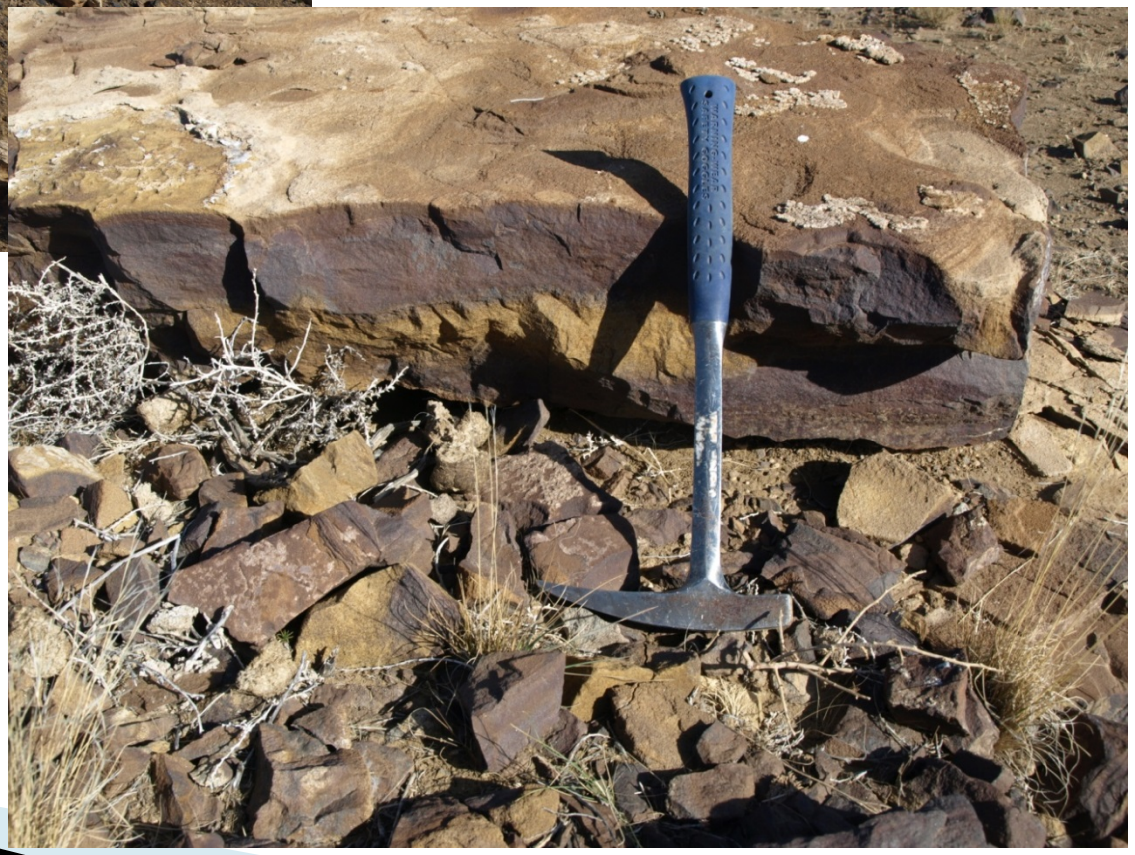
- Zirconium as zircon (1-50%)
  - Ceramic tiles, bricks used to line steel making furnaces, alloying agent in steel, laboratory crucibles
- Titanium as ilmenite (10-60%), rutile, leucoxene (titanium, 5-25%)
  - alloys in aircraft, white pigment found in toothpaste, paint, paper, glazes, and some plastics, heat exchangers in desalination plants, welding rods
- REE as monazite $(Ce,La,Y,Th)PO_4$) (<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



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)



Sanostee deposit, San Juan County

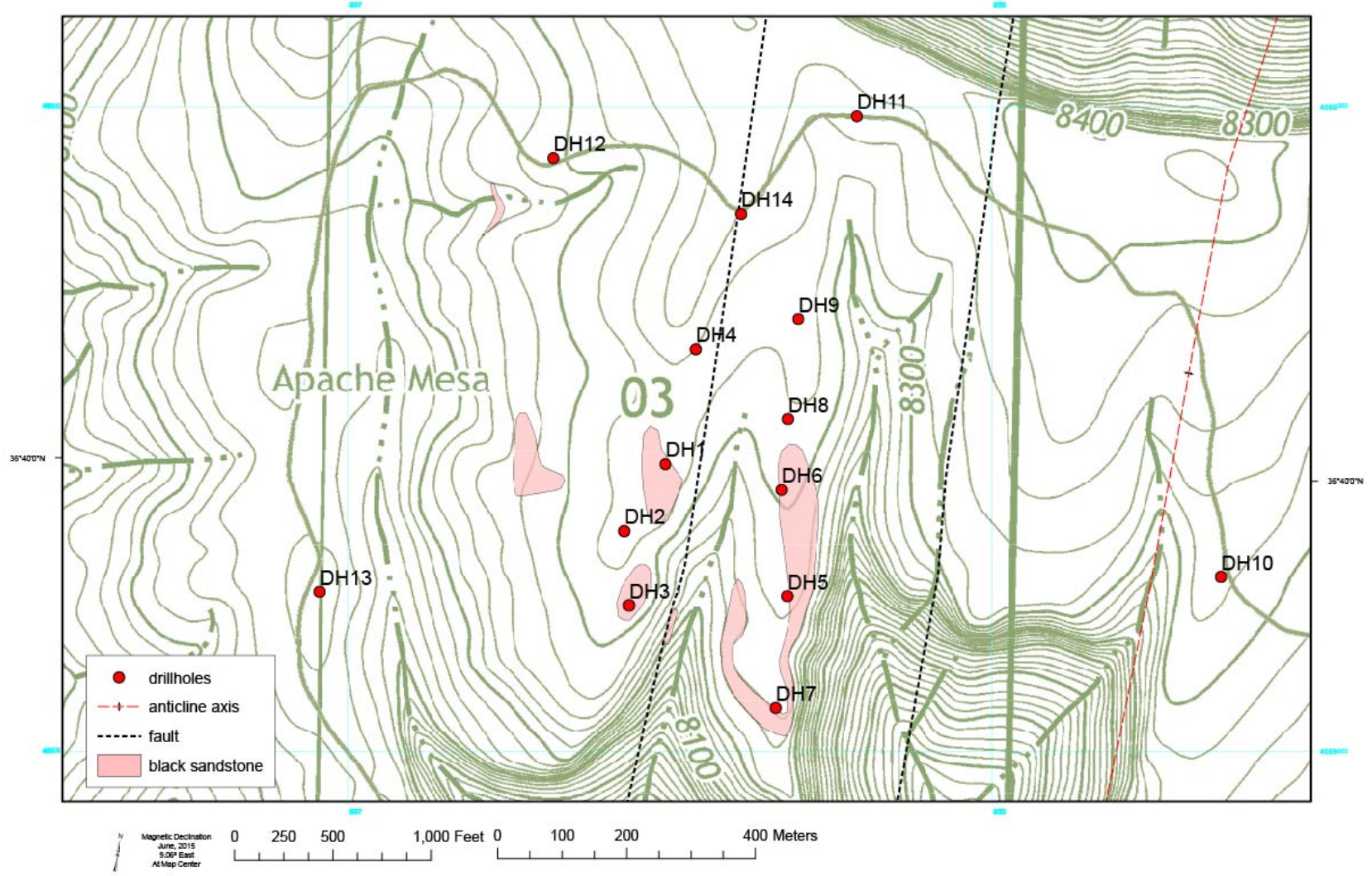
Apache Mesa, Jicarilla Indian Reservation

Drilled in August 2015

Small footprint with little land disturbance

CS 14 track drill rig by Layne Drilling Co.

Apache Mesa drill holes



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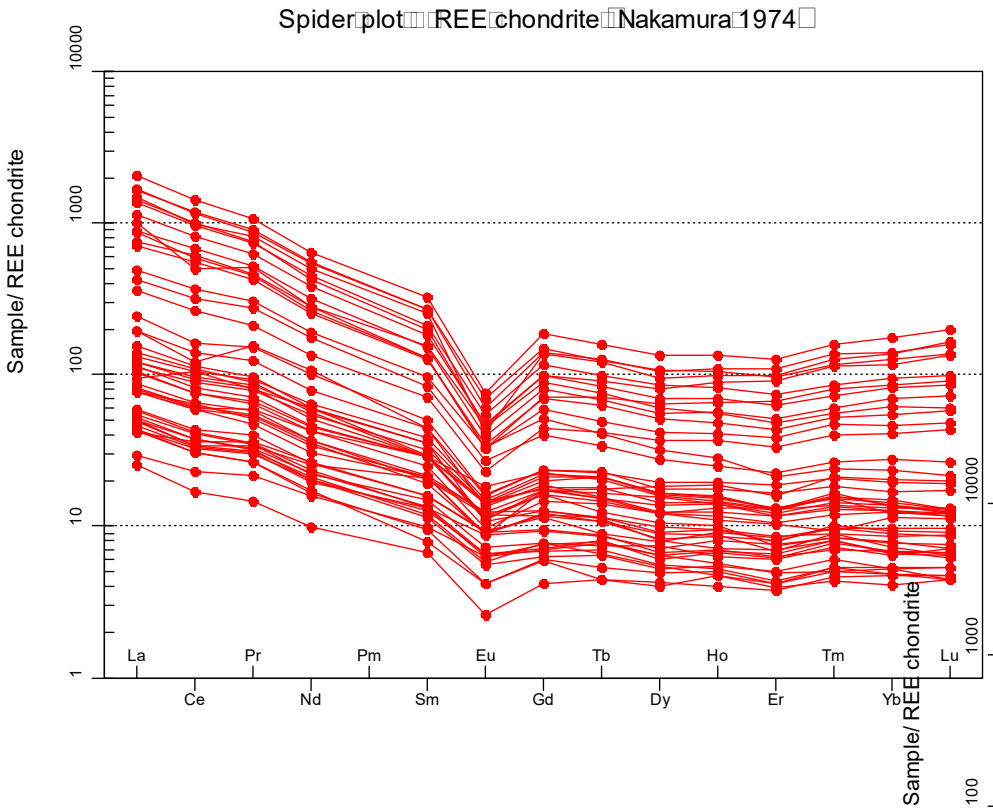
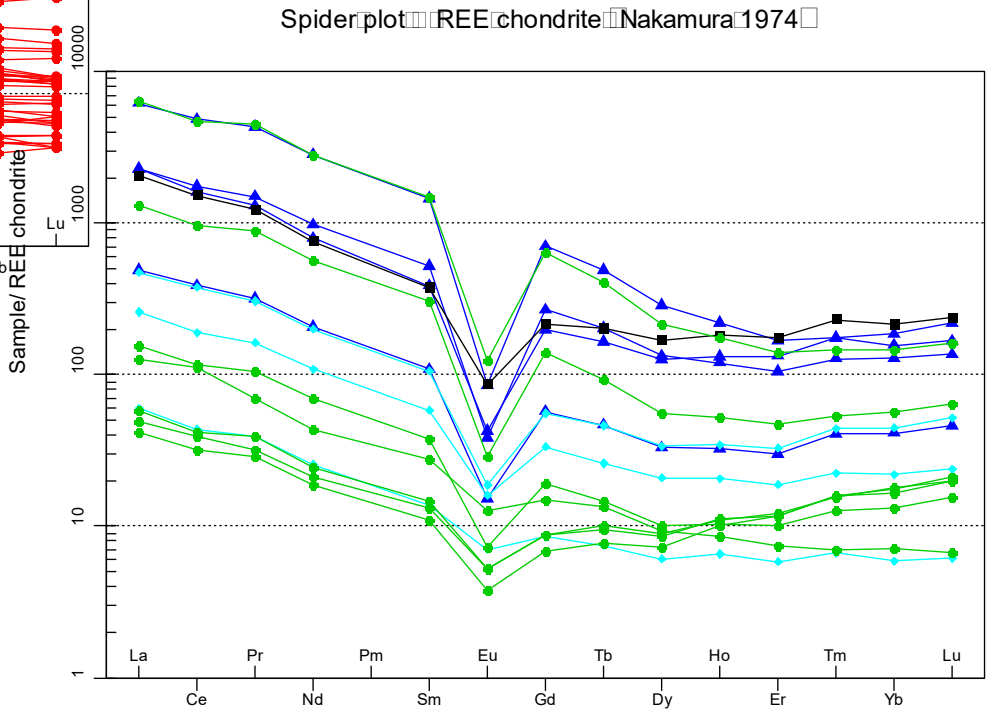
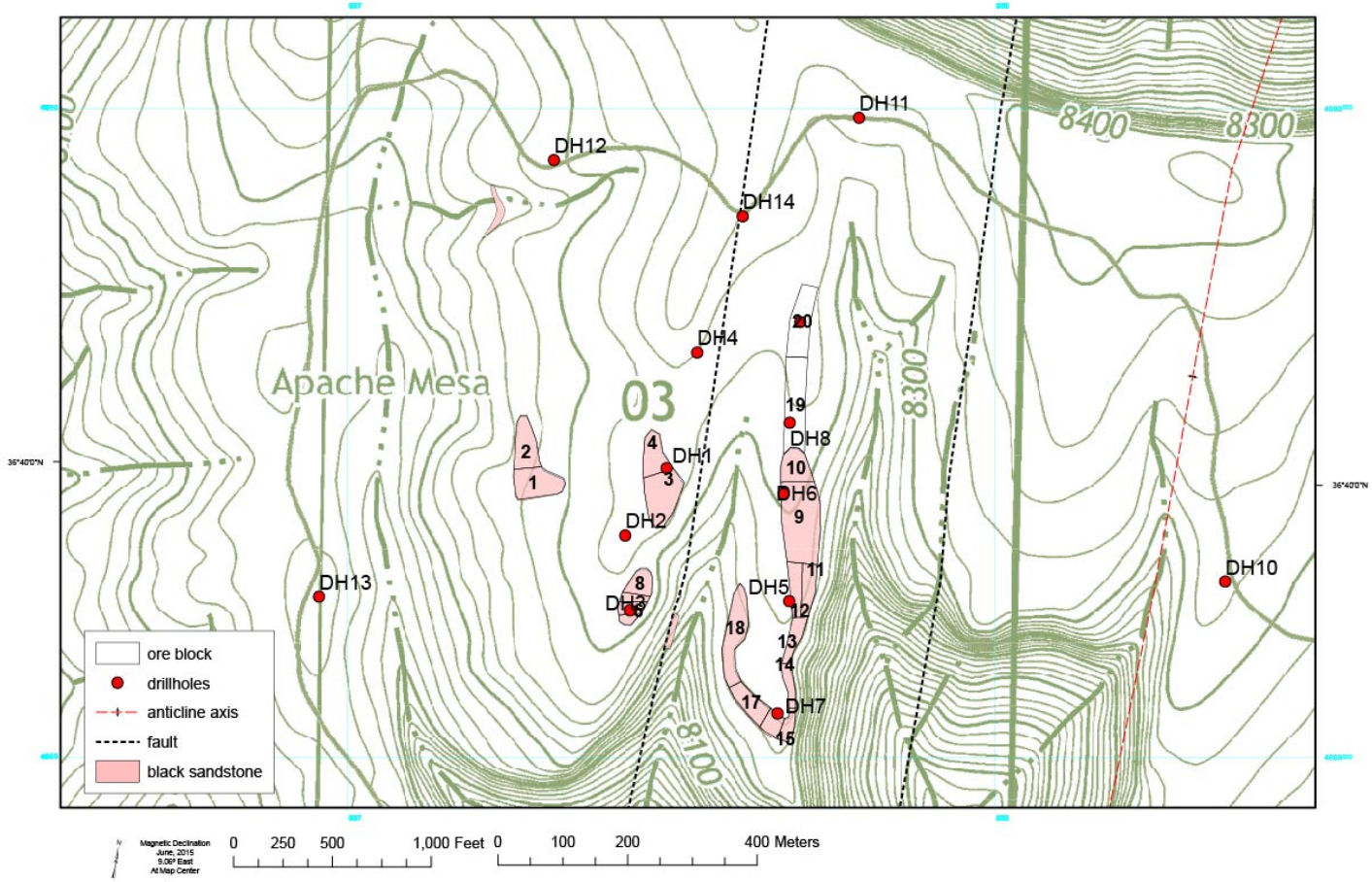


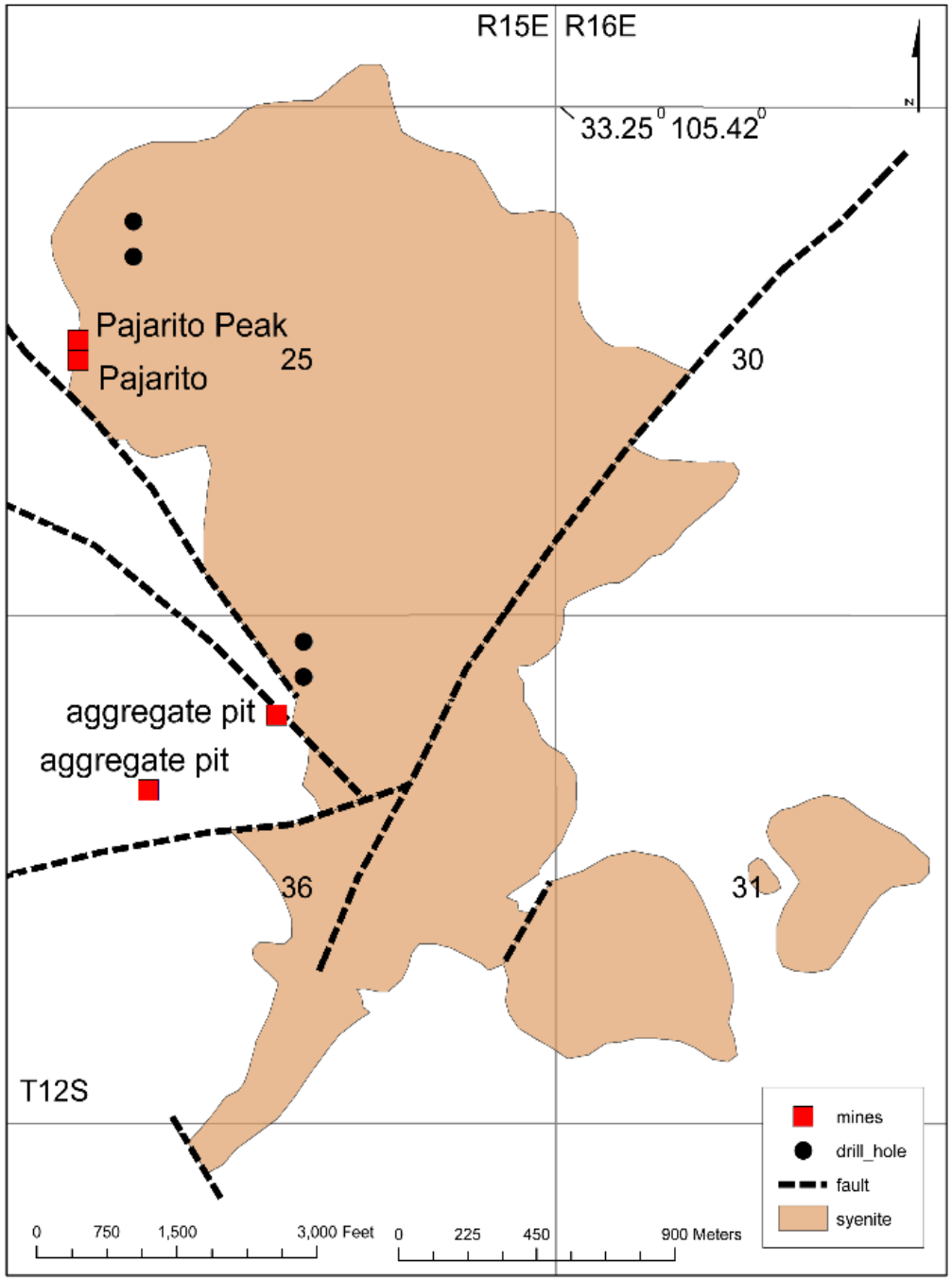


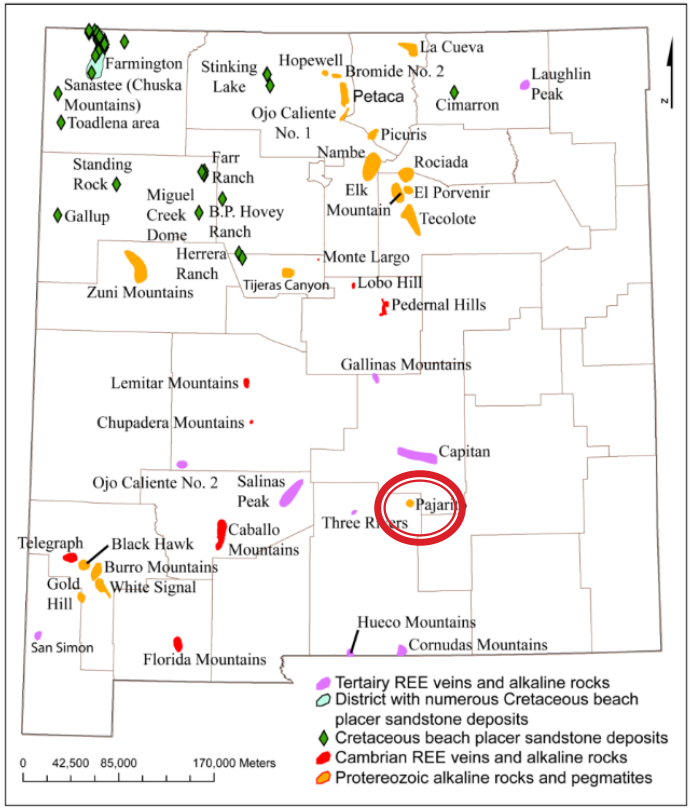
Chondrite-normalized REE plot of selected beach-placer deposits, Apache Mesa (red), Standing Rock (light blue), Sanostee (dark blue), and B.P. Hovey (black), San Juan Basin, New Mexico. Chondrite values are from Nakamura (1974).

Economics of Apache Mesa deposit

132,900 short tons (120,564 metric tons) of ore with grades of 3% TiO_2, 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

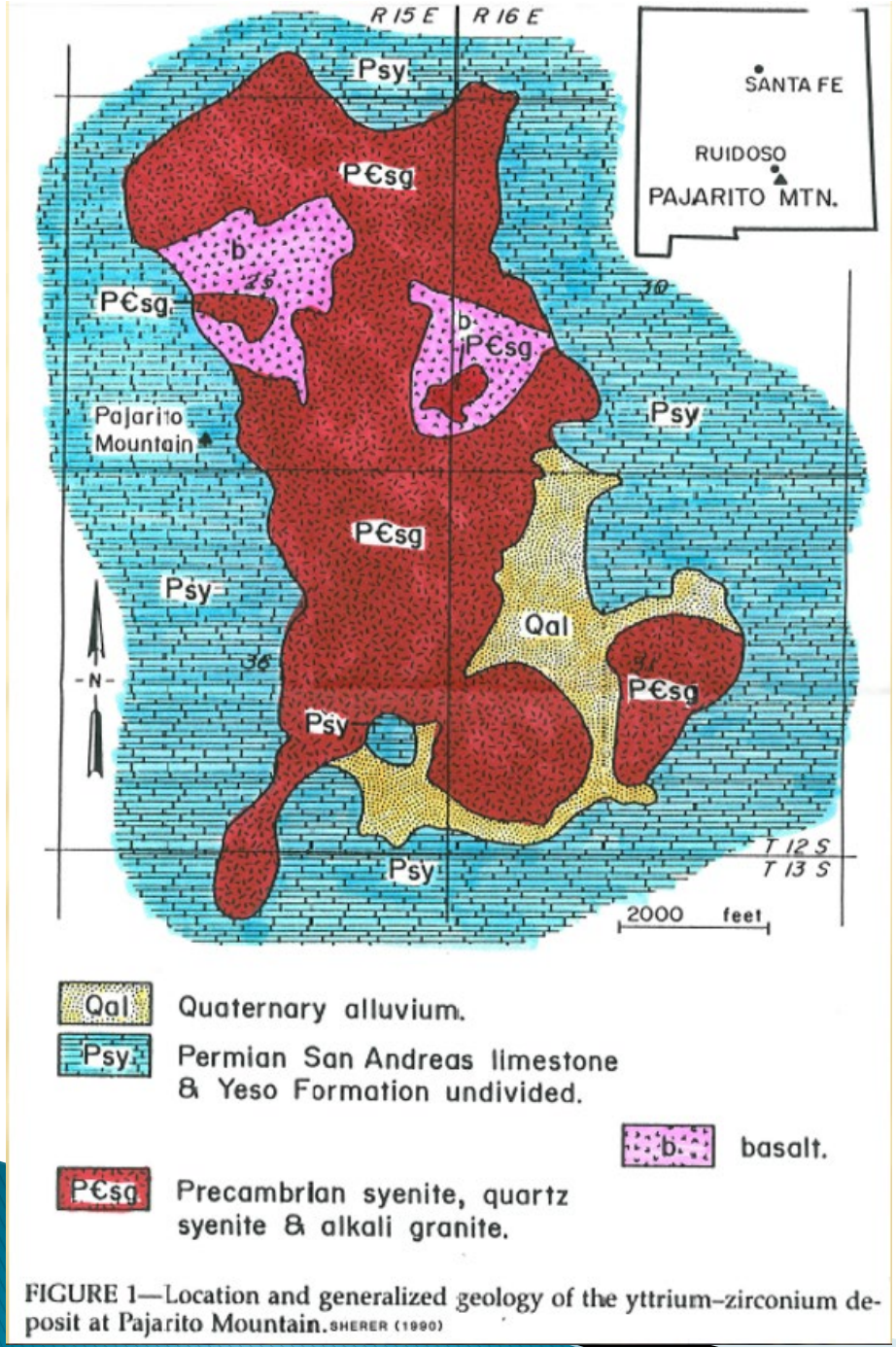
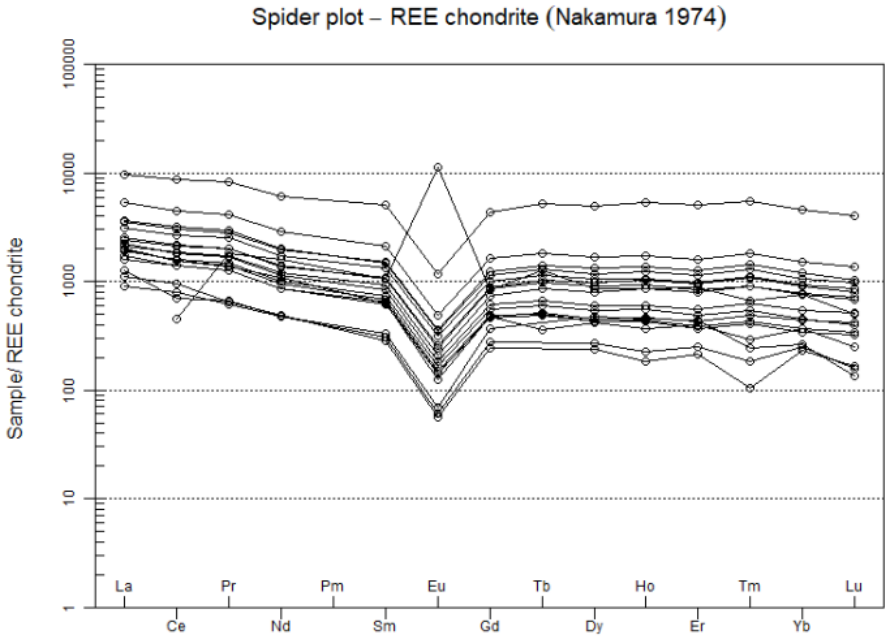


FIGURE 1—Location and generalized geology of the yttrium–zirconium deposit at Pajarito Mountain. SHERER (1990)

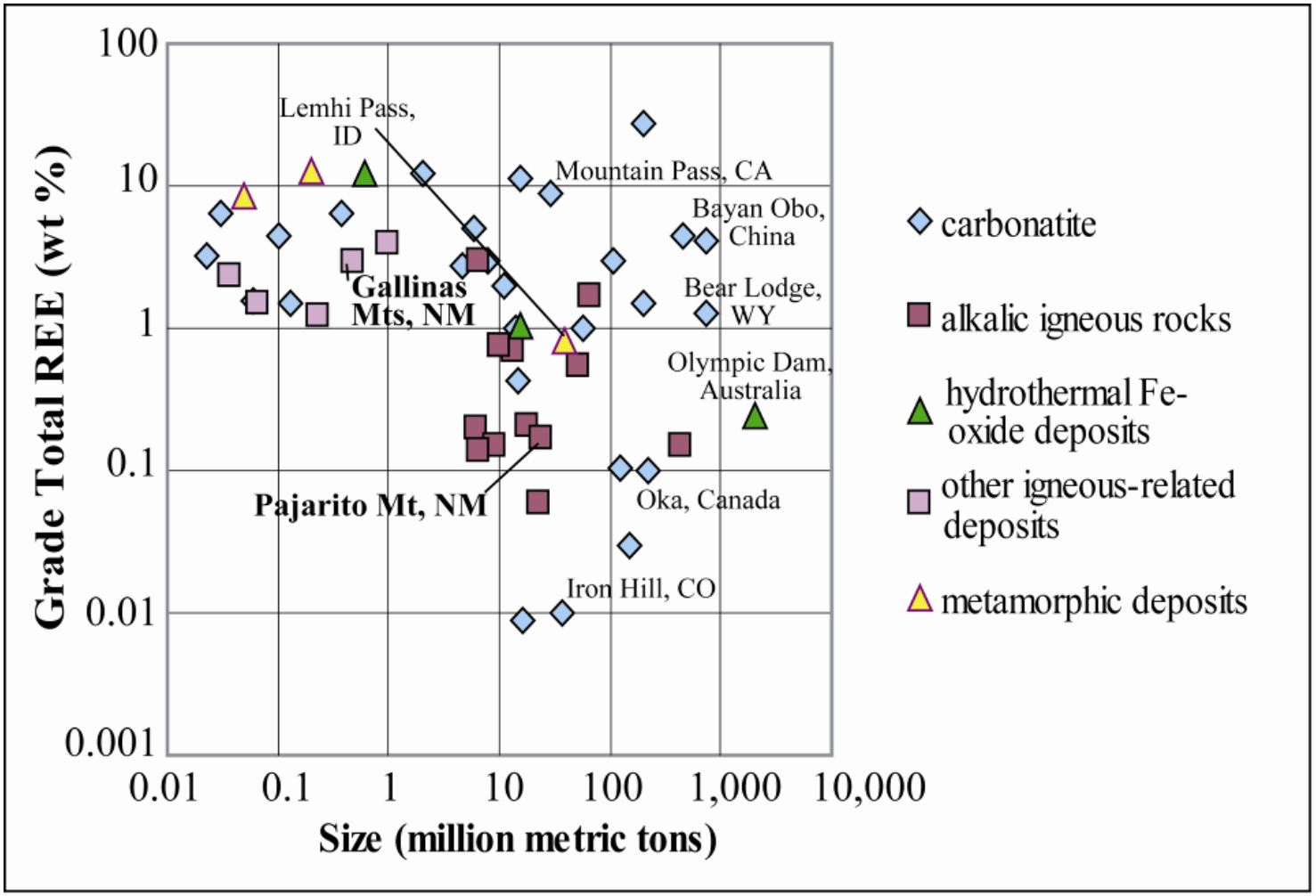


Mineralogy Proterozoic Pajarito Mountain (Berger, 2018)

- Eudialyte $Na_4(Ca,Ce)_2(Fe{+}{+},Mn,Y)ZrSi_8O_{22}(OH,Cl)_2$
- Fluorite CaF_2
- Apatite $Ca_5(PO_4)_3(OH,F,Cl)$ (with U, Th)
- Zircon ZrSiO4 (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% Y_2O_3 and 1.2% 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.

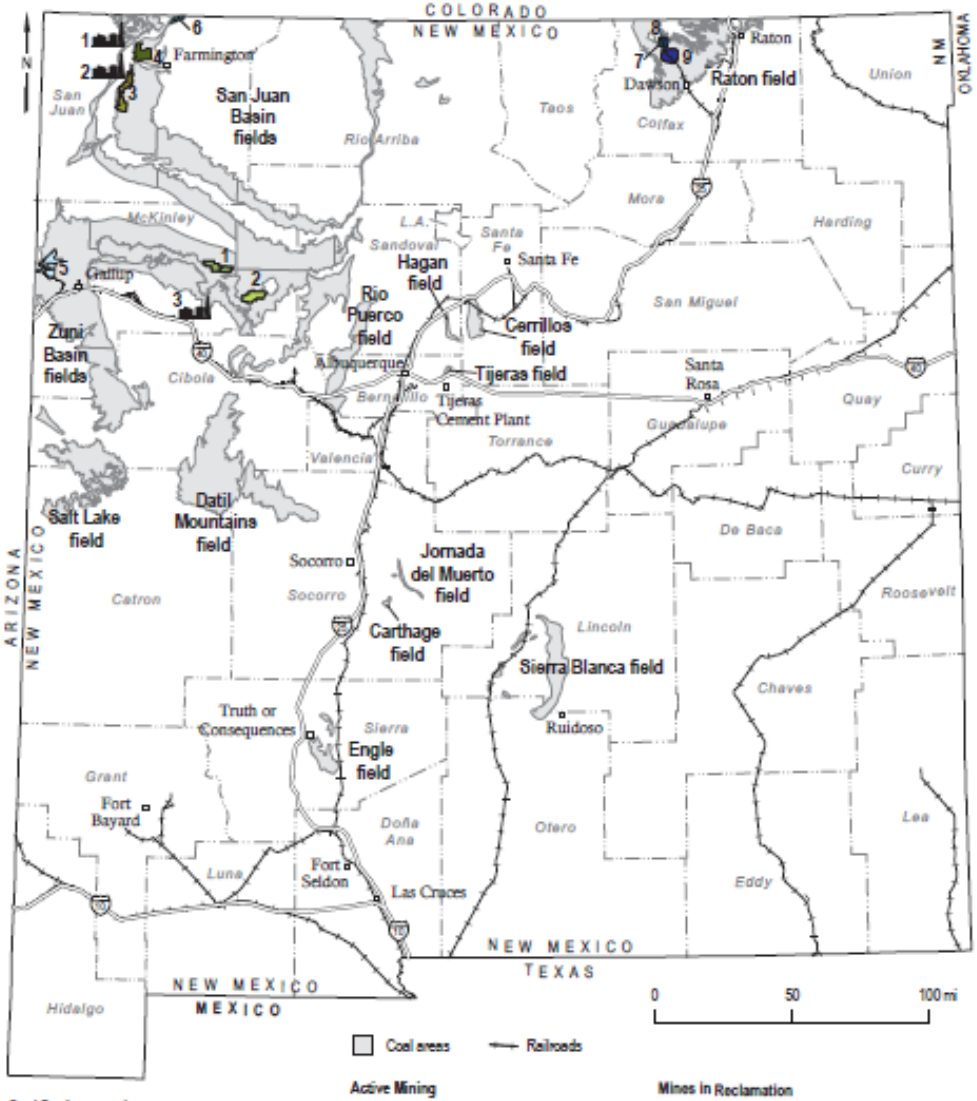
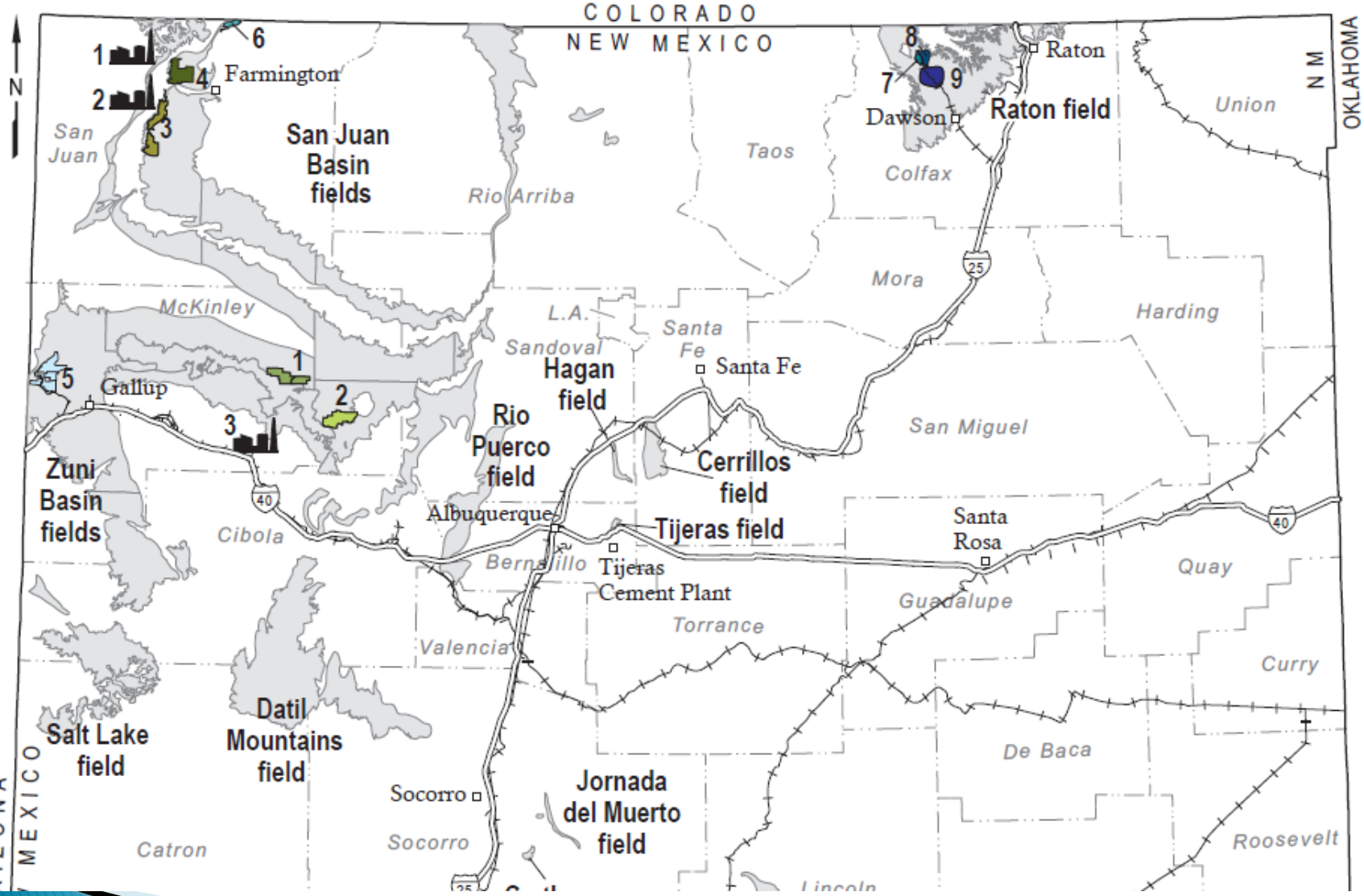


Figure 3. Coal fields of New Mexico, from Hoffman et al. (2009). Mines are surface operation unless specifically noted in legend. Lee Ranch Mining suspended in 2016.

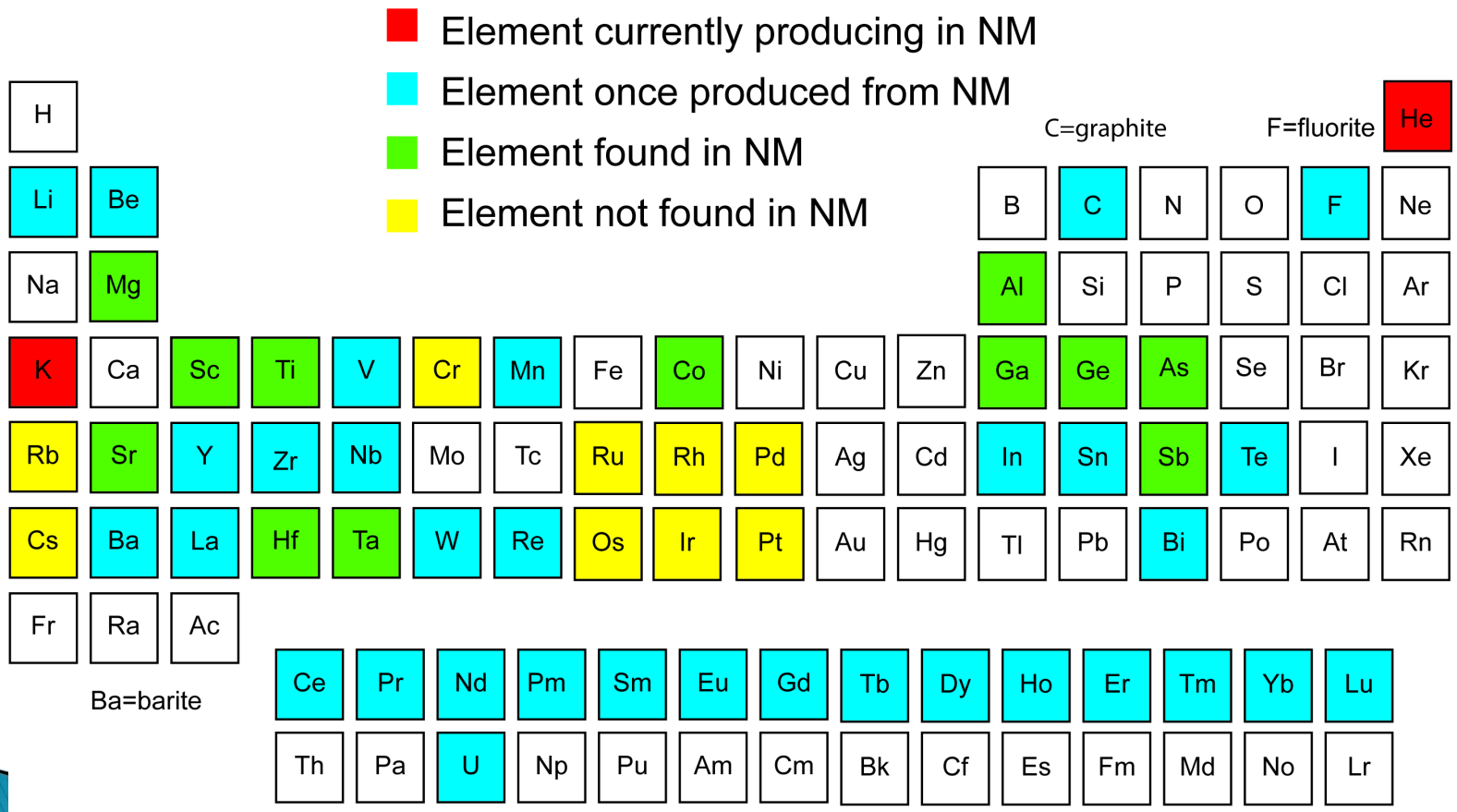
New project awarded by the DOE—REE and other critical minerals in coal deposits



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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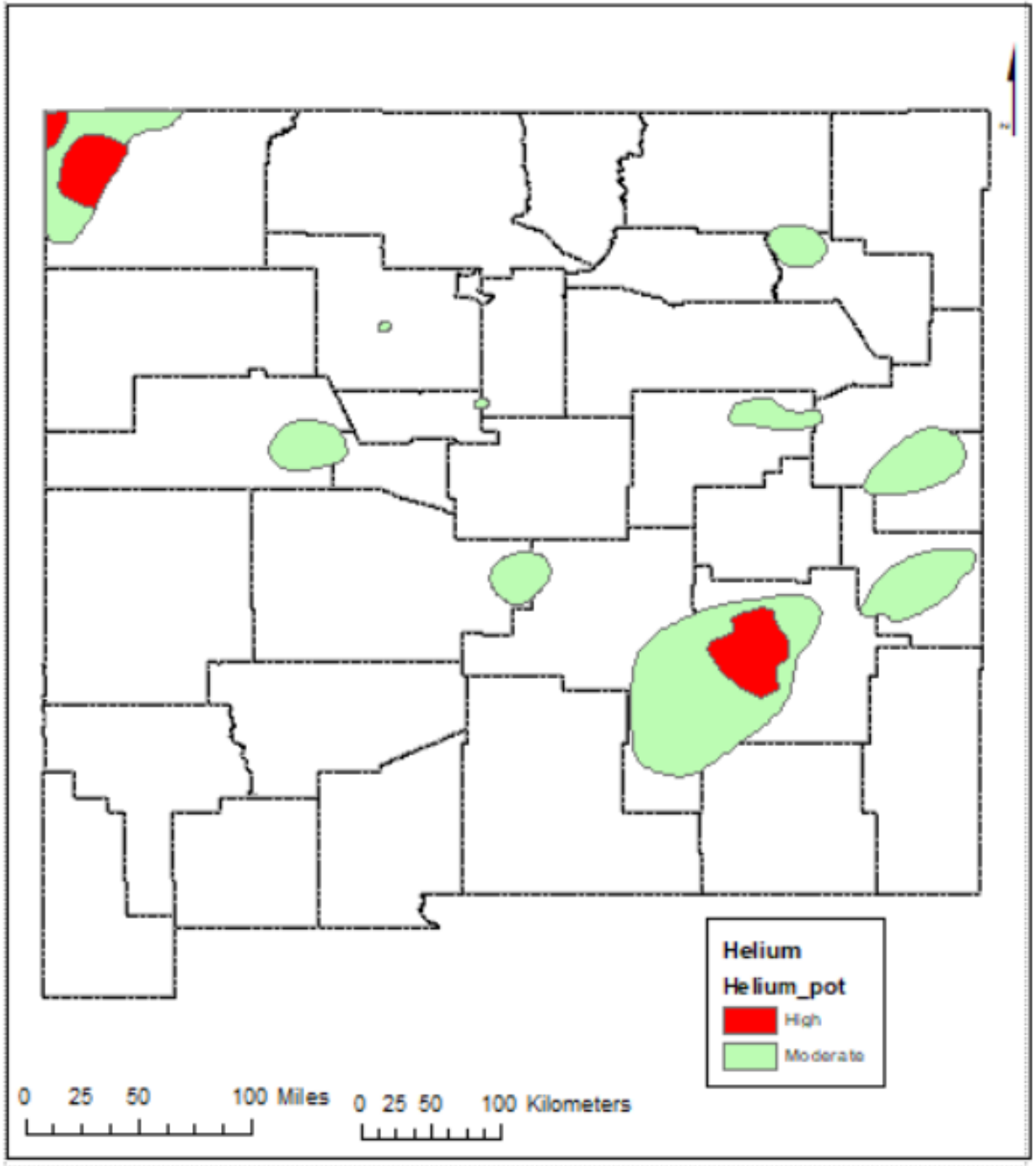
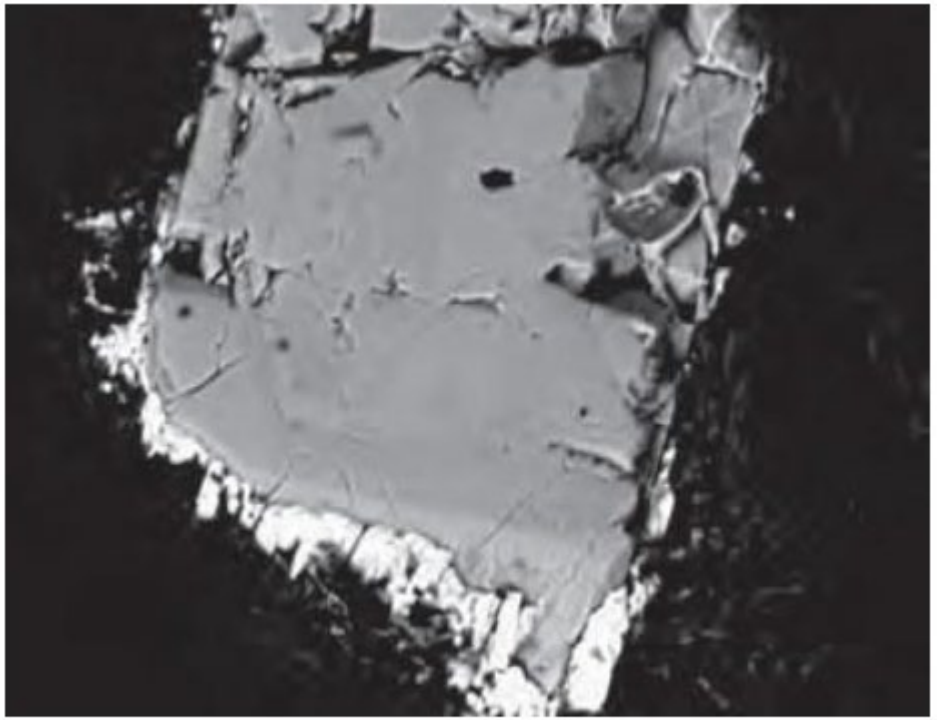


Helium potential in New Mexico

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



Backscattered electron image of an REE-rich overgrowth (clearly visible here as a bright white band) on a zoned magmatic zircon. Field of view is 150 micrometers (0.15 mm).

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