RARE EARTH ELEMENTS (REE) IN PROTEROZOIC PERALKALINE IGNEOUS ROCKS (PAJARITO MOUNTAIN) AND PEGMATITES IN NEW MEXICO

Virginia T. McLemore

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

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Critical Minerals

- IN 2017, 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

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,

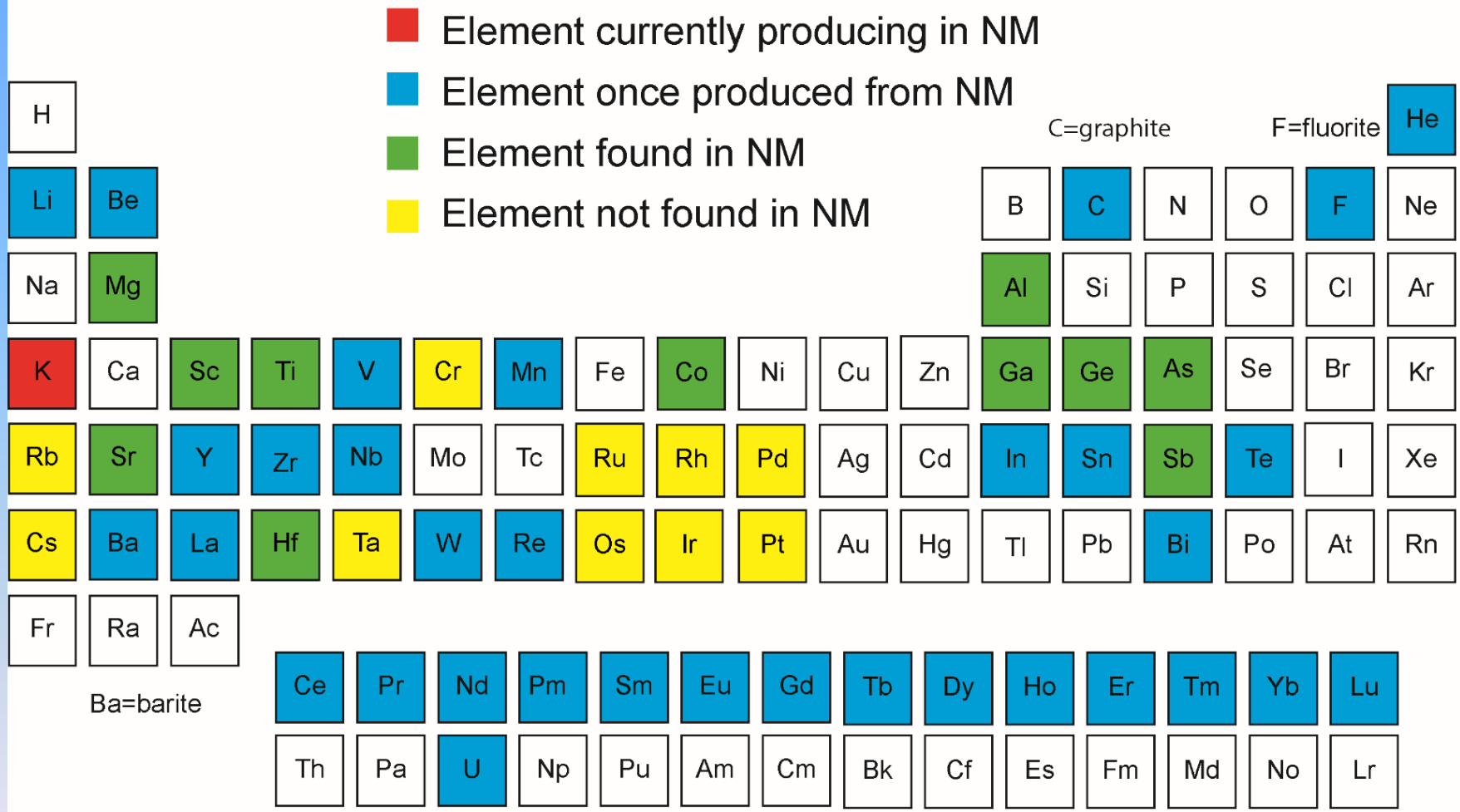
(2) from a supply chain that is vulnerable to disruption, and

(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

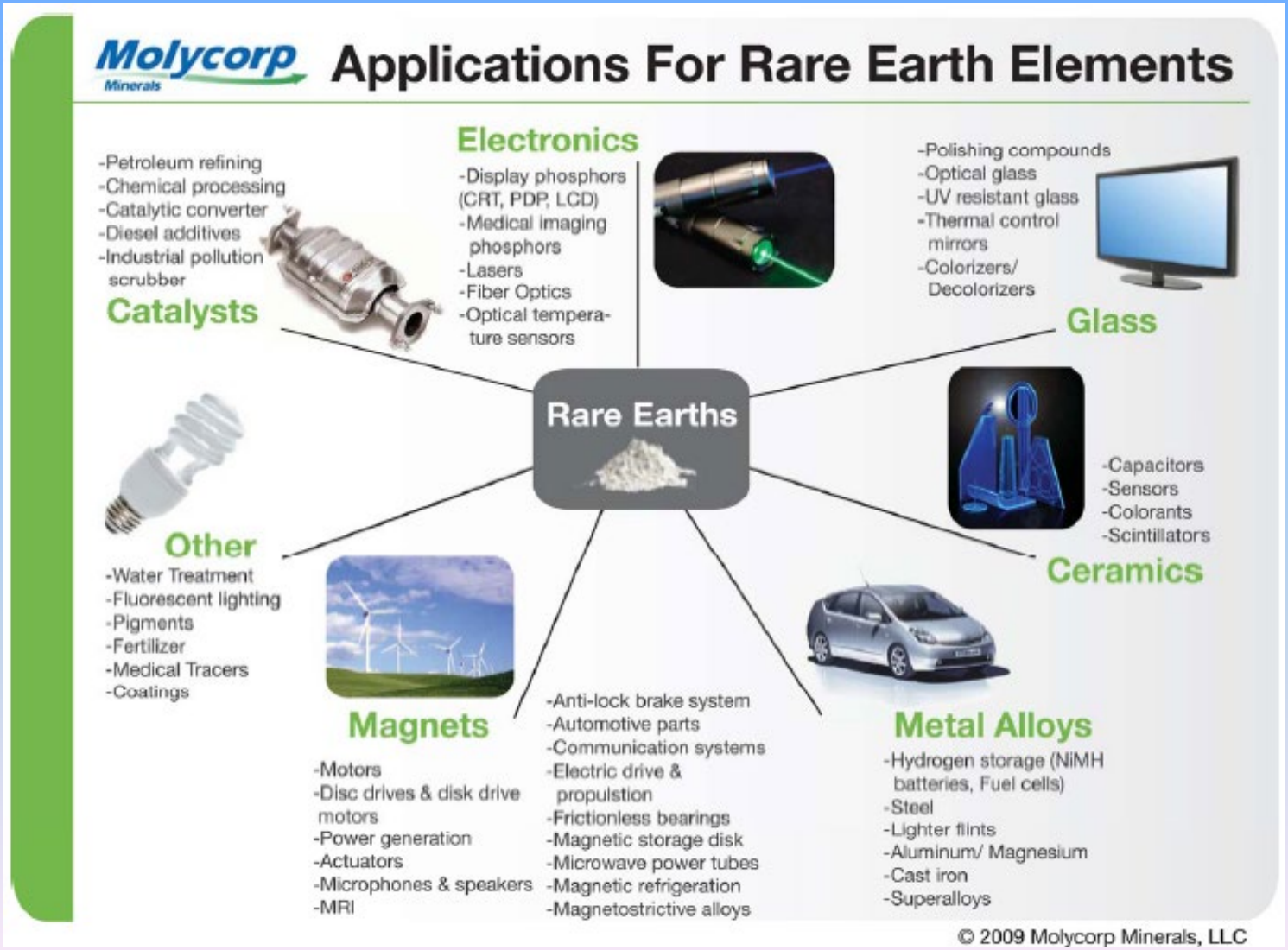
- 35 critical minerals were identified
- New Mexico has many of these critical minerals
  - Potash is currently being produced in Carlsbad
  - Porphyry copper deposits in Grant County contain rhenium, indium, and germanium
  - Uranium deposits in the Grants district, also contain vanadium
  - Exploration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

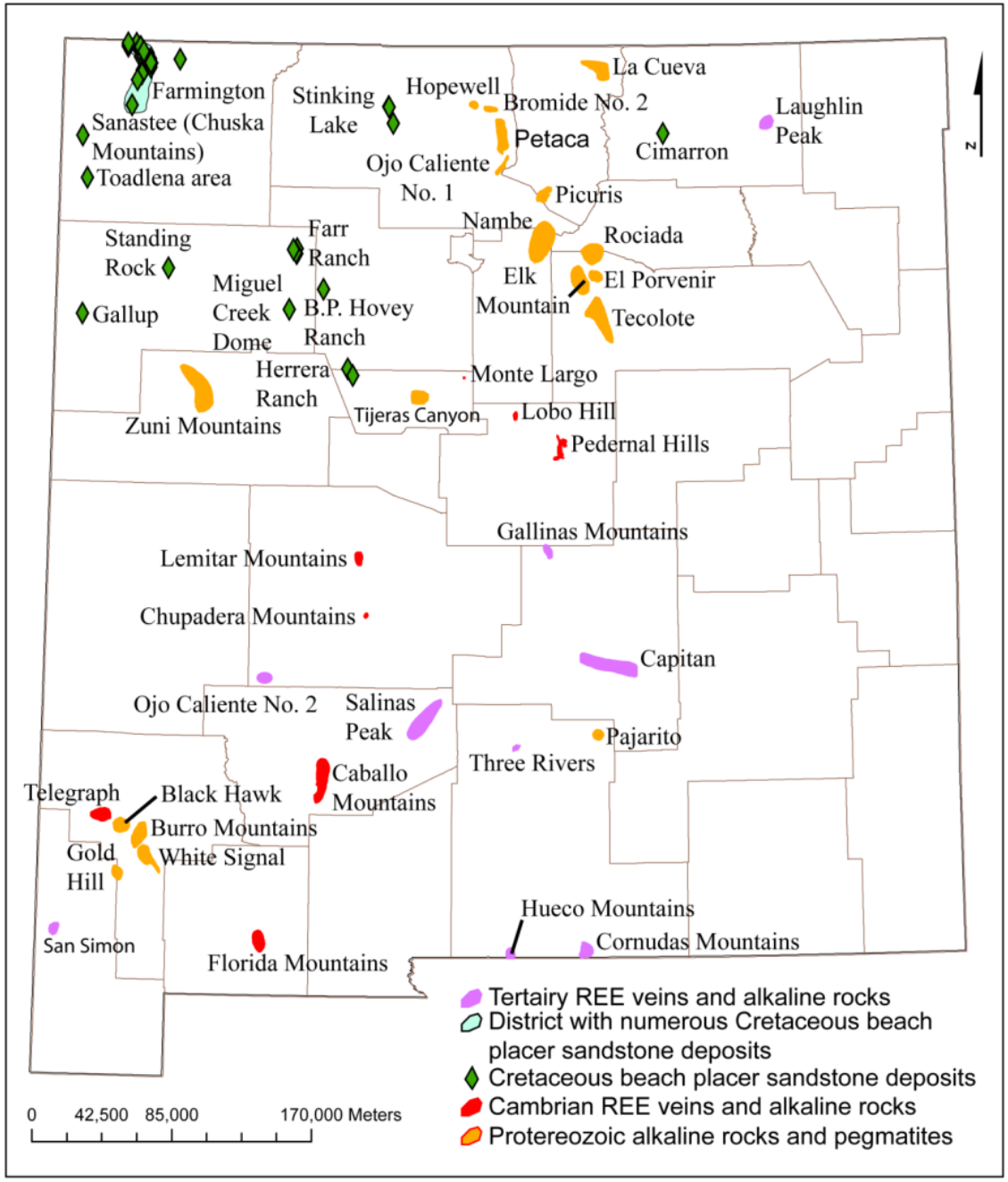
Critical Minerals in New Mexico



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.

Rare Earth Elements



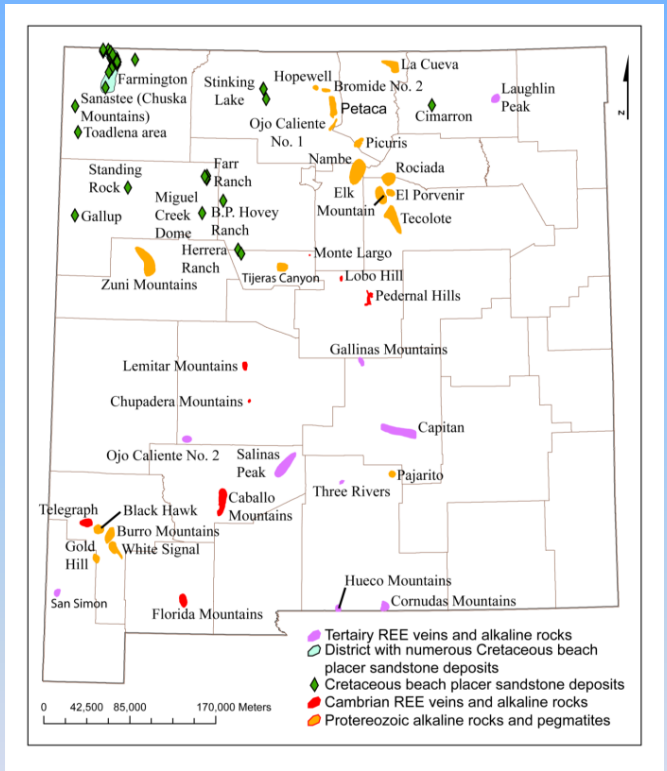


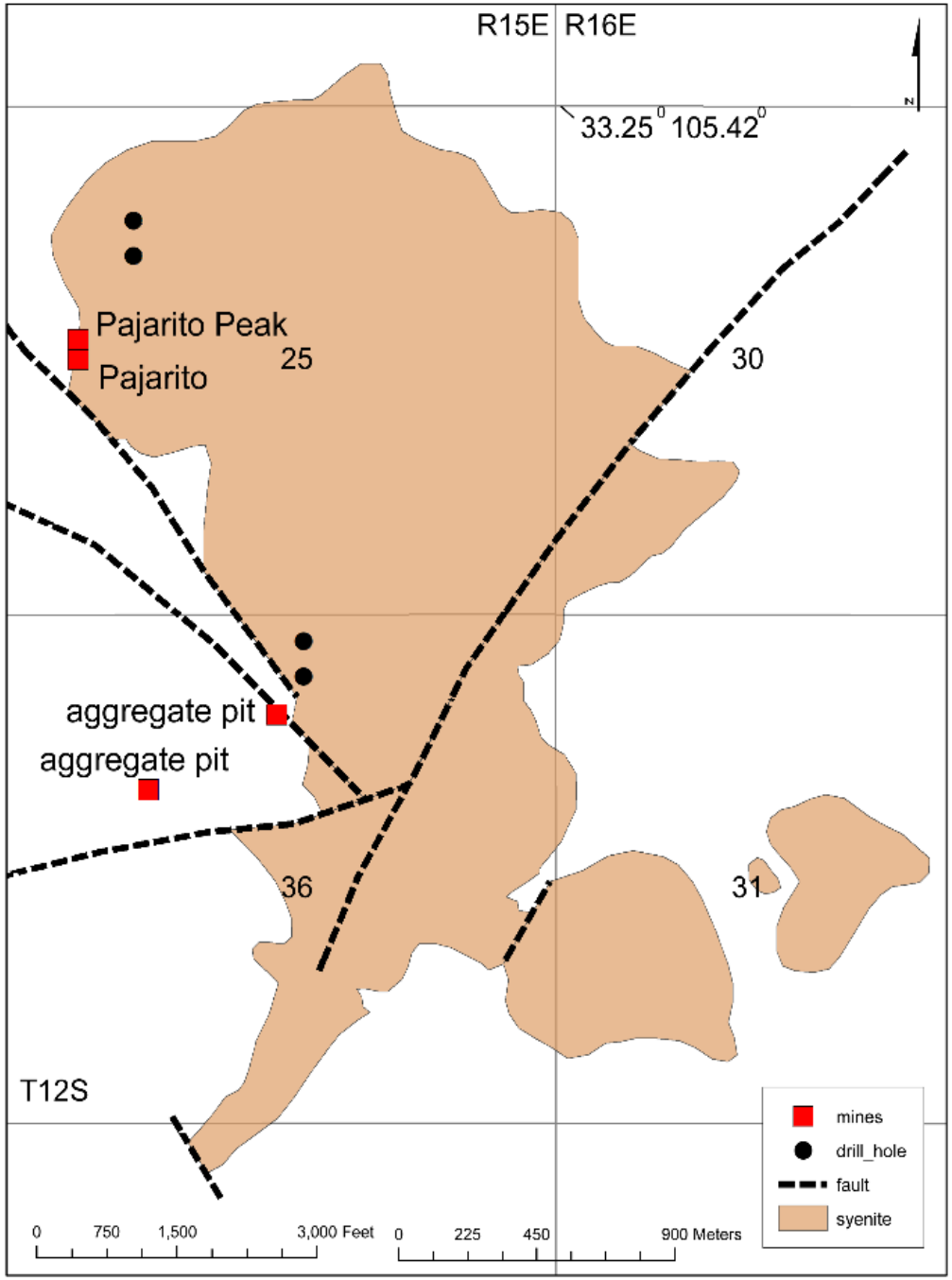
Occurrences of Rare Earth Elements (REE) in New Mexico

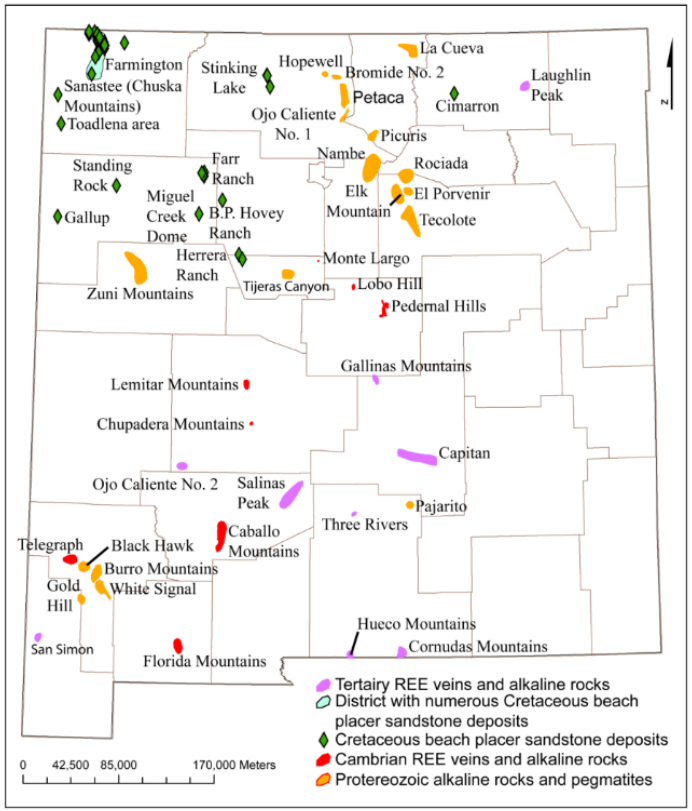
REE production from Proterozoic deposits in New Mexico

DISTRICT NAME	PRODUCTION
Gallinas Mountains	146,000 lbs of bastnasite concentrate
Petaca	112 lbs of samarskite, few hundred lbs of monazite, 12,000 lbs of Ta-Nb-REE ore
Elk Mountain	500 lbs of Ta-U-REE concentrate
Rociada	Several thousand tons of REE-Ta ore
Tecolote	$10,000 worth of beryl, tantalite-columbite and monazite
Gold Hill	REE production in the 1950s

Production of rare earth elements (REE) in New Mexico, to date.







Proterozoic Pajarito Mountain

Proterozoic Pajarito Mountain

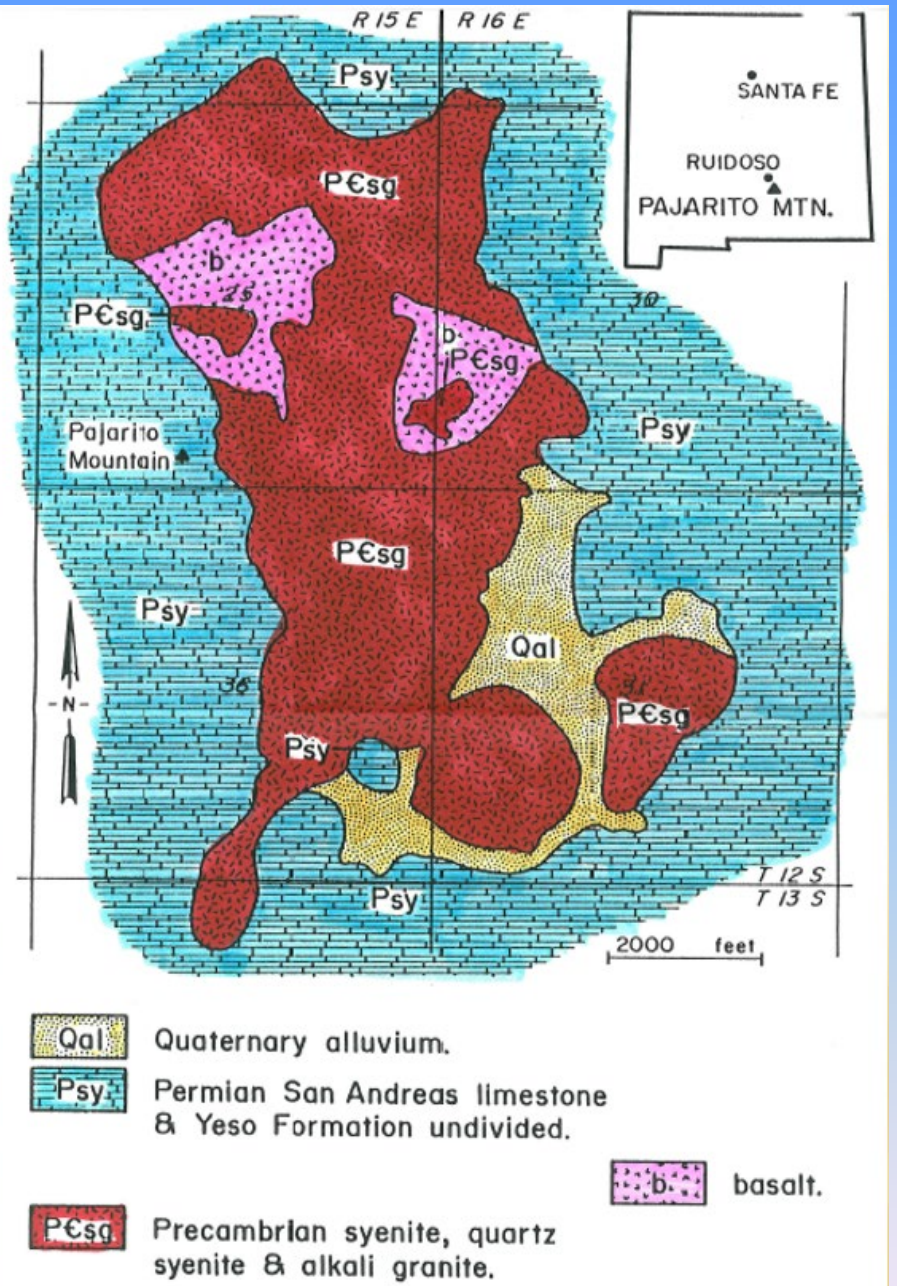
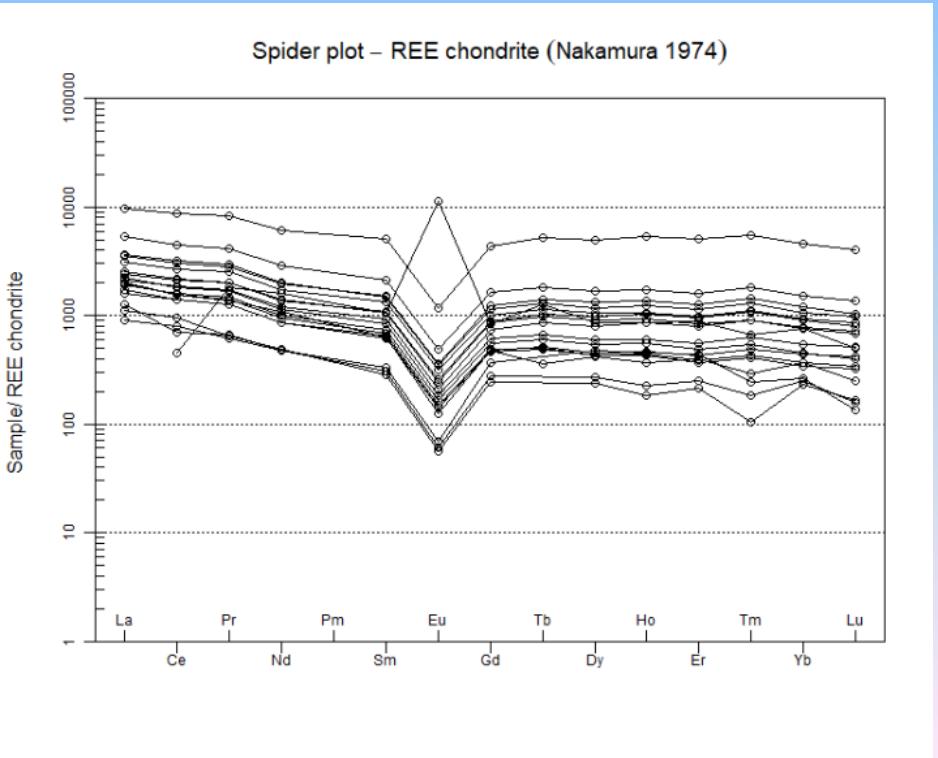


FIGURE 1—Location and generalized geology of the yttrium–zirconium deposit at Pajarito Mountain. SHERER (1990)

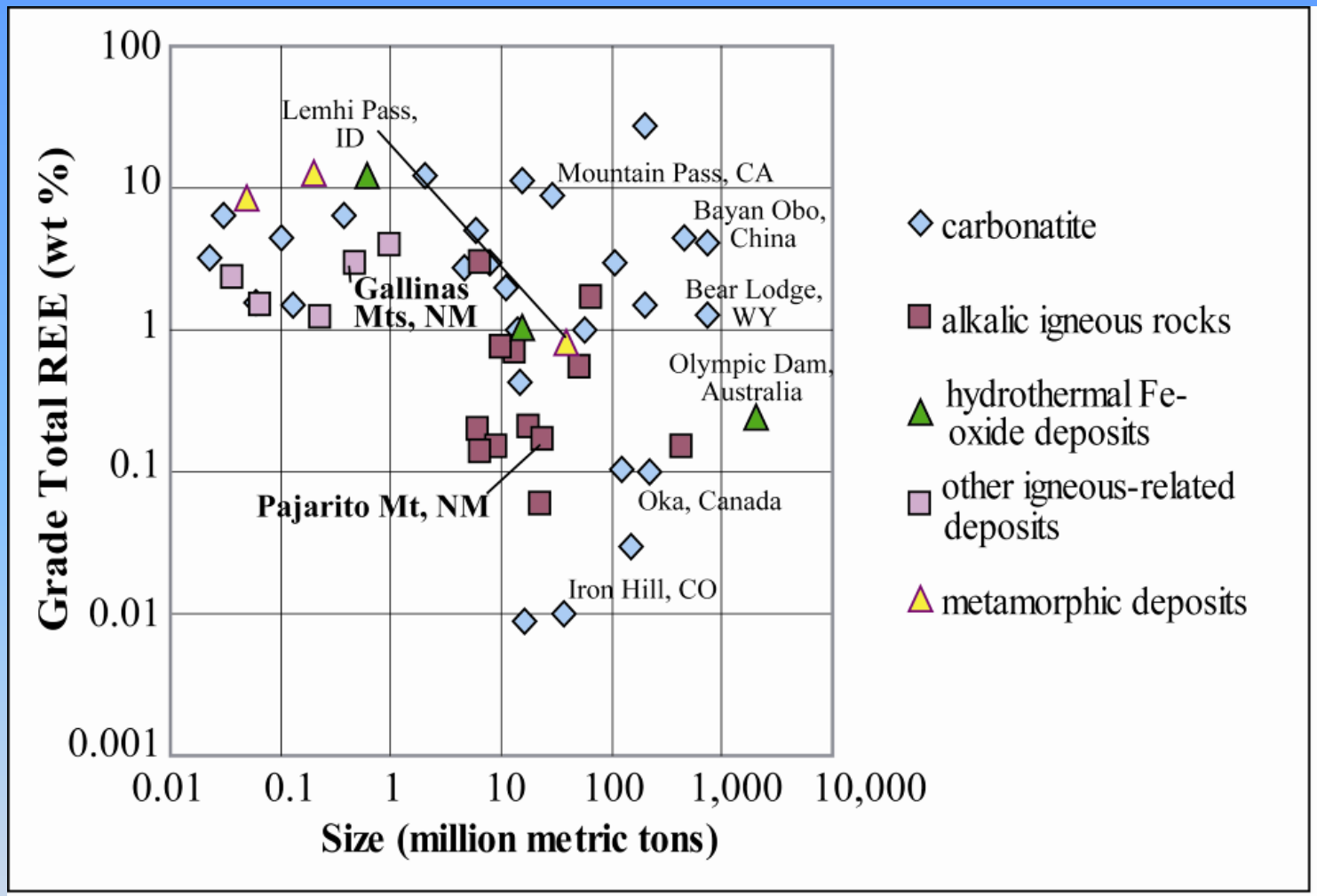


Mineralogy Proterozoic Pajarito Mountain (Berger, 2018)

- 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

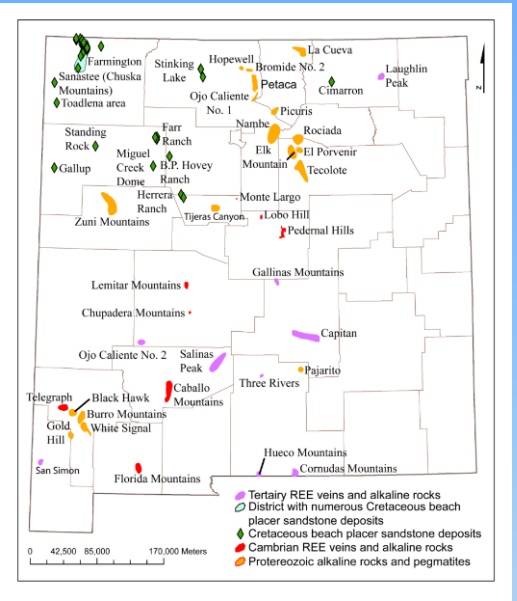
Proterozoic Pajarito Mountain

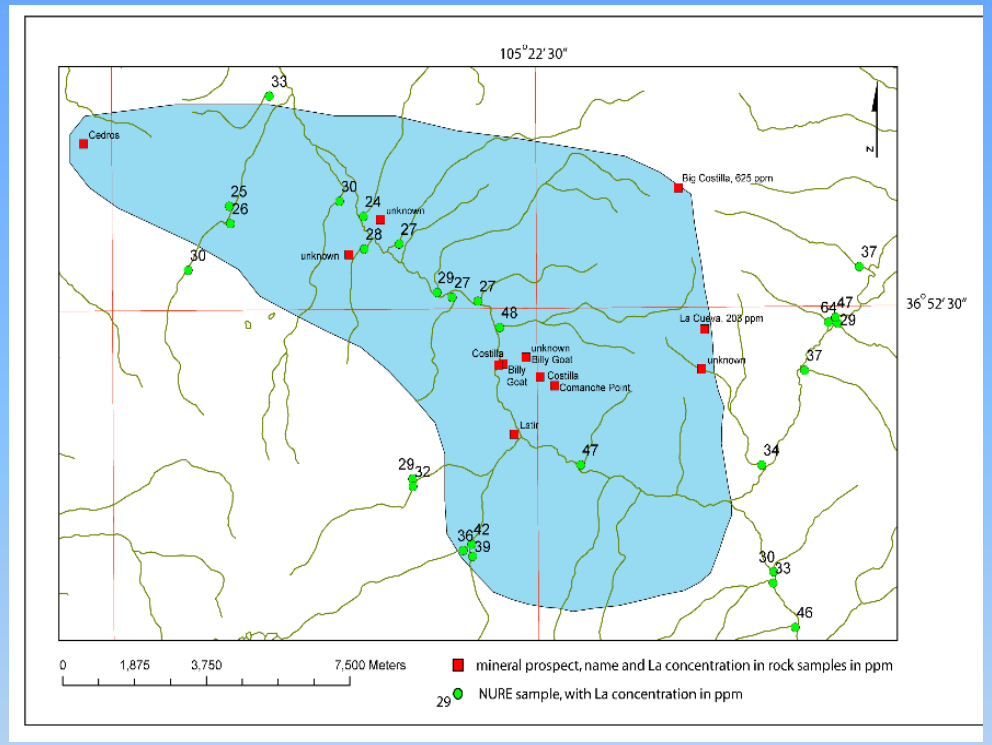
- In 1990, Molycorp, Inc. reported historic resources of 2.7 million short tons grading 0.18% Y_2O_3 and 1.2% ZrO_2 as disseminated eudialyte
- Historic REE resources—537,000 short tons of 2.95% total REE (Jackson and Christiansen, 1993)



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.

Costilla massif, La Cueva district, Taos County





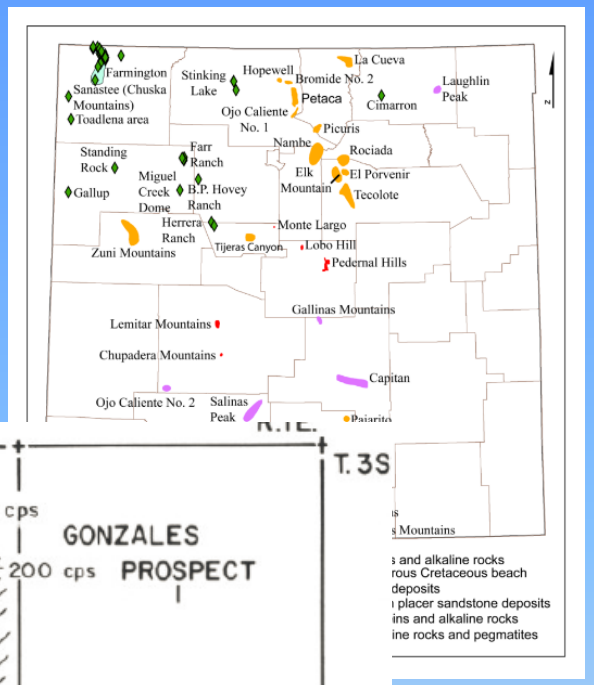
- Radioactive pegmatites intrude the granite and both intrude a complex Proterozoic metamorphic terrain of metamorphic and igneous rocks
- The granitic rocks are subalkaline, metaluminous to peraluminous.
- 1560 ppm Ce and 625 ppm La

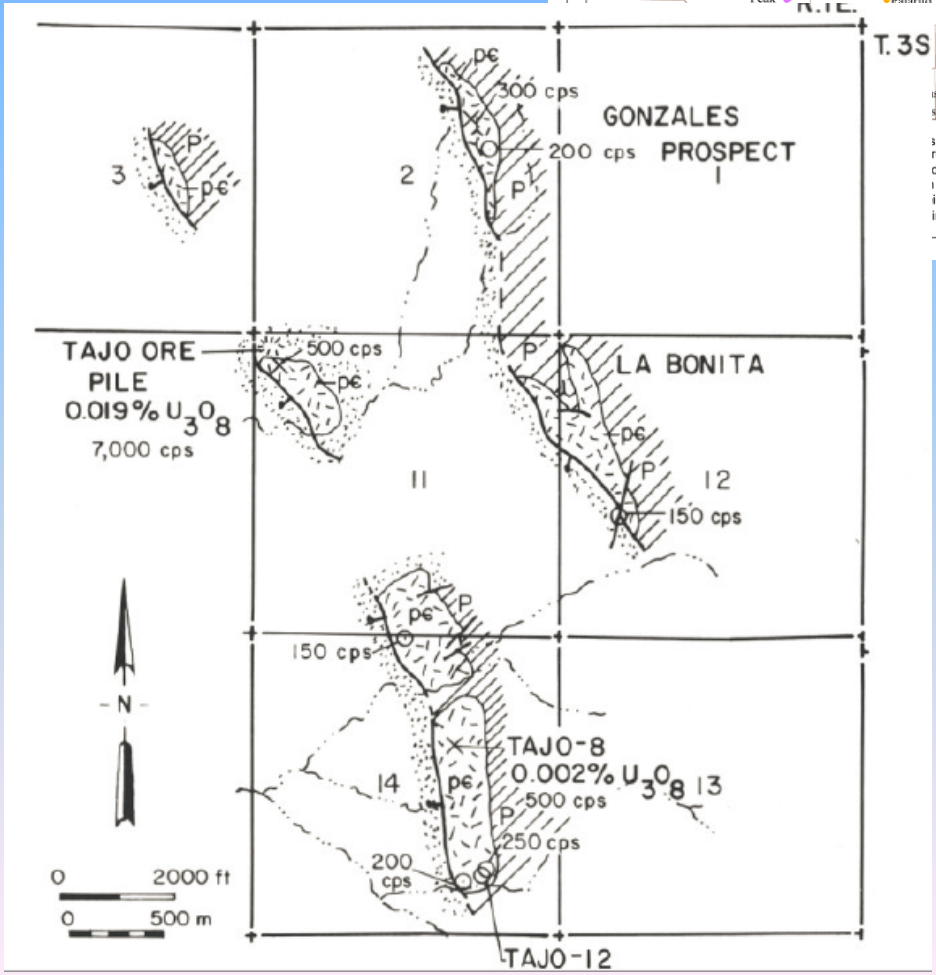
Mineralogy of Costilla massif (Zelenka, 1984)

- Uraninite UO_2 (with Ce)
- Thorite $ThSiO_4$ (with Ce)
- Uranothorite $(Th,U)SiO_4$
- Magnetite Fe_3O_4 (with U, Th)
- Zircon ZrSiO4 (with U, REE)
- Allanite $(Ce,Ca,Y)_2(Al,Fe^{+++})_3(SiO_4)_3(OH)$
- Apatite $Ca_5(PO_4)_3(OH,F,Cl)$ (with U, Th)
- Titanite $CaTiSiO_5$ (with U, Th)
- Thorogummite $Th(SiO_4)_{1-x}(OH)_{4x}$
- Uranophane $Ca(UO_2)_2SiO_3(OH)_2 \cdot 5(H_2O)$

Tajo Granite, Chupadero district, Socorro County

- Mineralogy
  - Hematite
  - Fluorite
  - Uranophane?
- Chemistry
  - 0.4350% U_3O_8
  - <1200 ppm Y

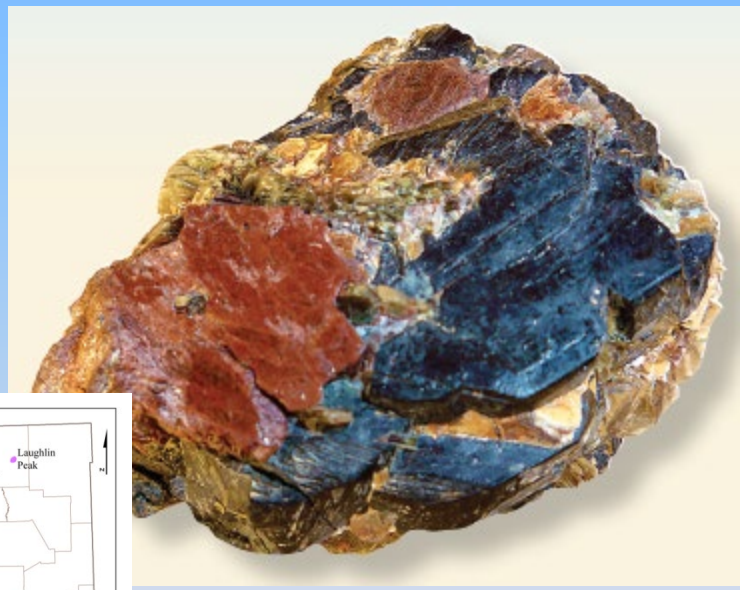


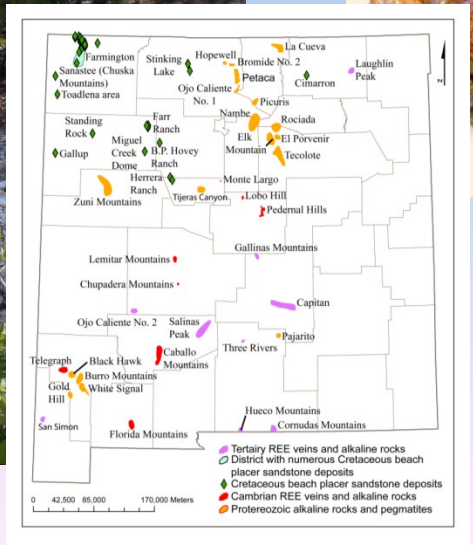


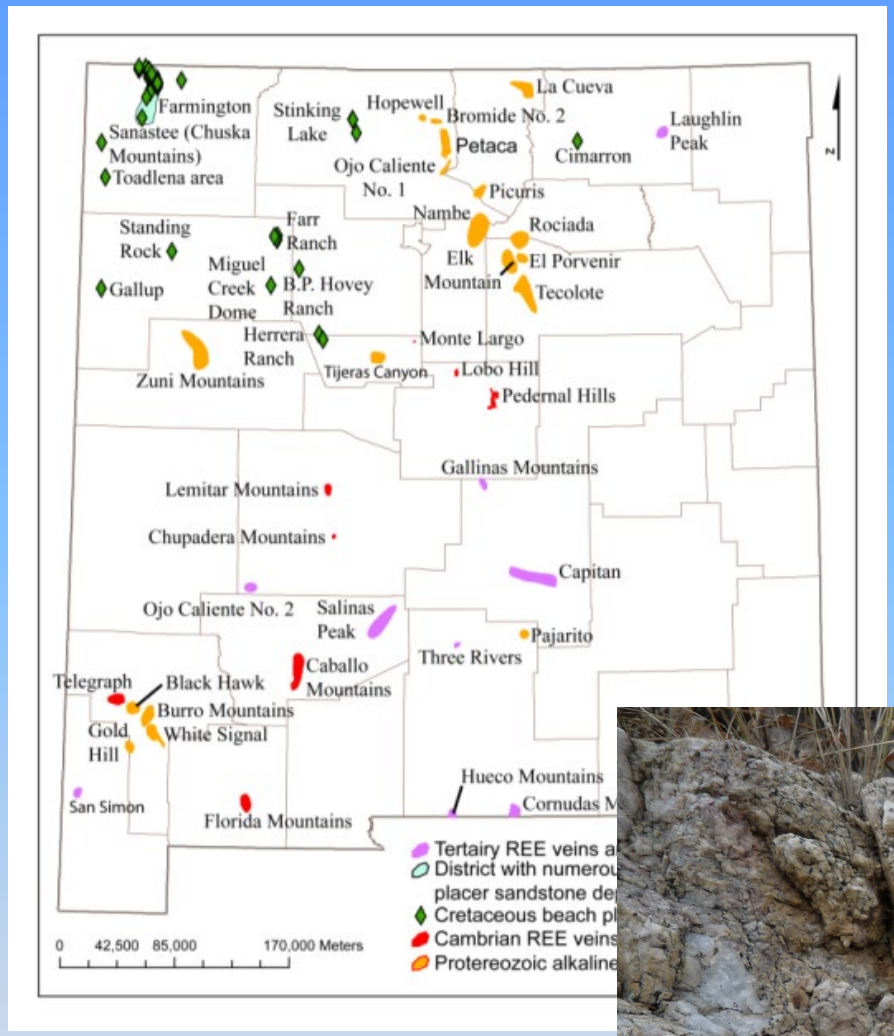
Tajo Granite

Pegmatites

Coarse-grained igneous rocks, lenses, or veins with granitic composition, contains essential quartz and feldspar, and represent the last and most hydrous phase of crystallizing magmas







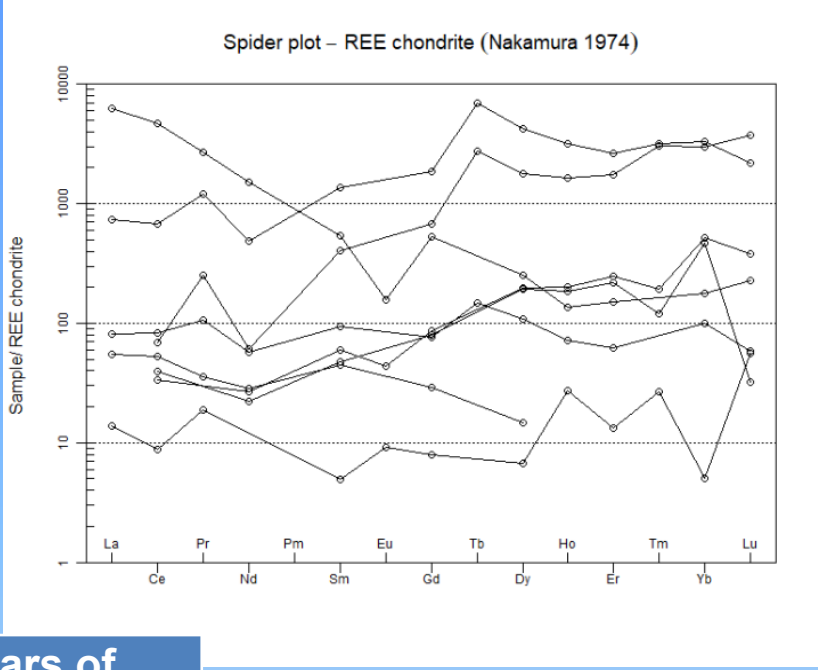
Petaca

Burro Mountains

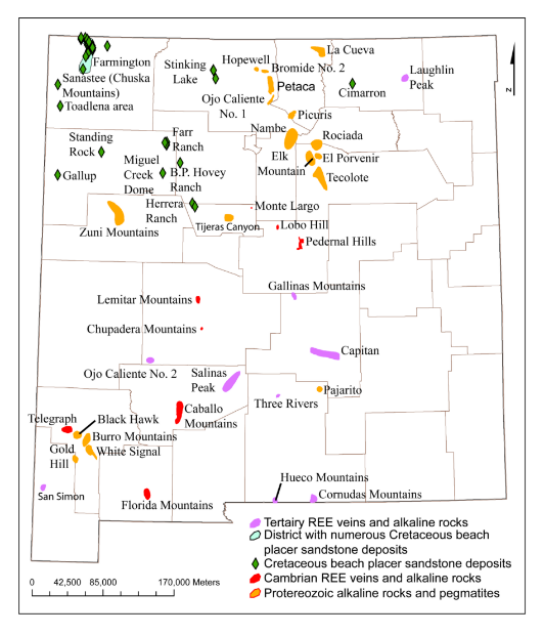
PEGMATITES

Pegmatites

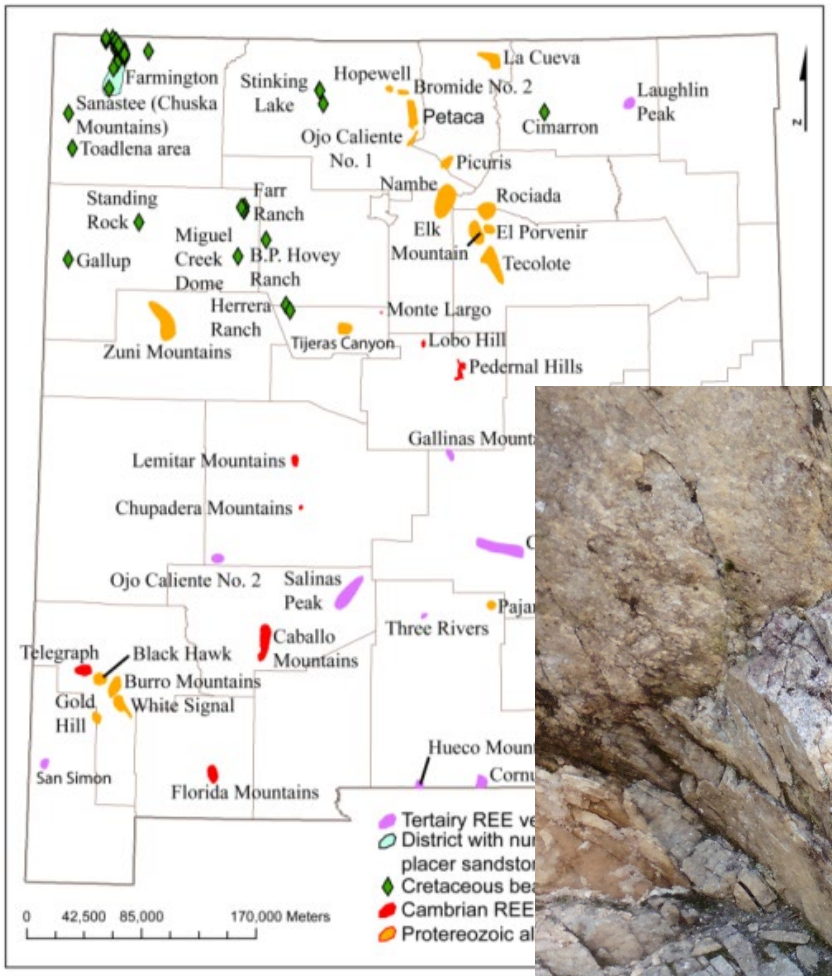
Production from the Petaca and Ojo Caliente No. 1 mining districts, Rio Arriba County w=production data withheld.



Commodity	Production	Years of production
Beryl	12,748	
Columbite-tantalite (lbs)	5,092-12,000	
Sheet mica (lbs)	604,927	
Scrap mica(short tons)	15,191	1899-1963
Feldspar	w	
Lithium (short tons)	w	1920-1963
Bismuth (lbs)	100	1943
Rare earth elements (samarskite) (lbs)	5,000	
Kyanite (short tons)	1,500	1928
Uranium	2 lbs	1954



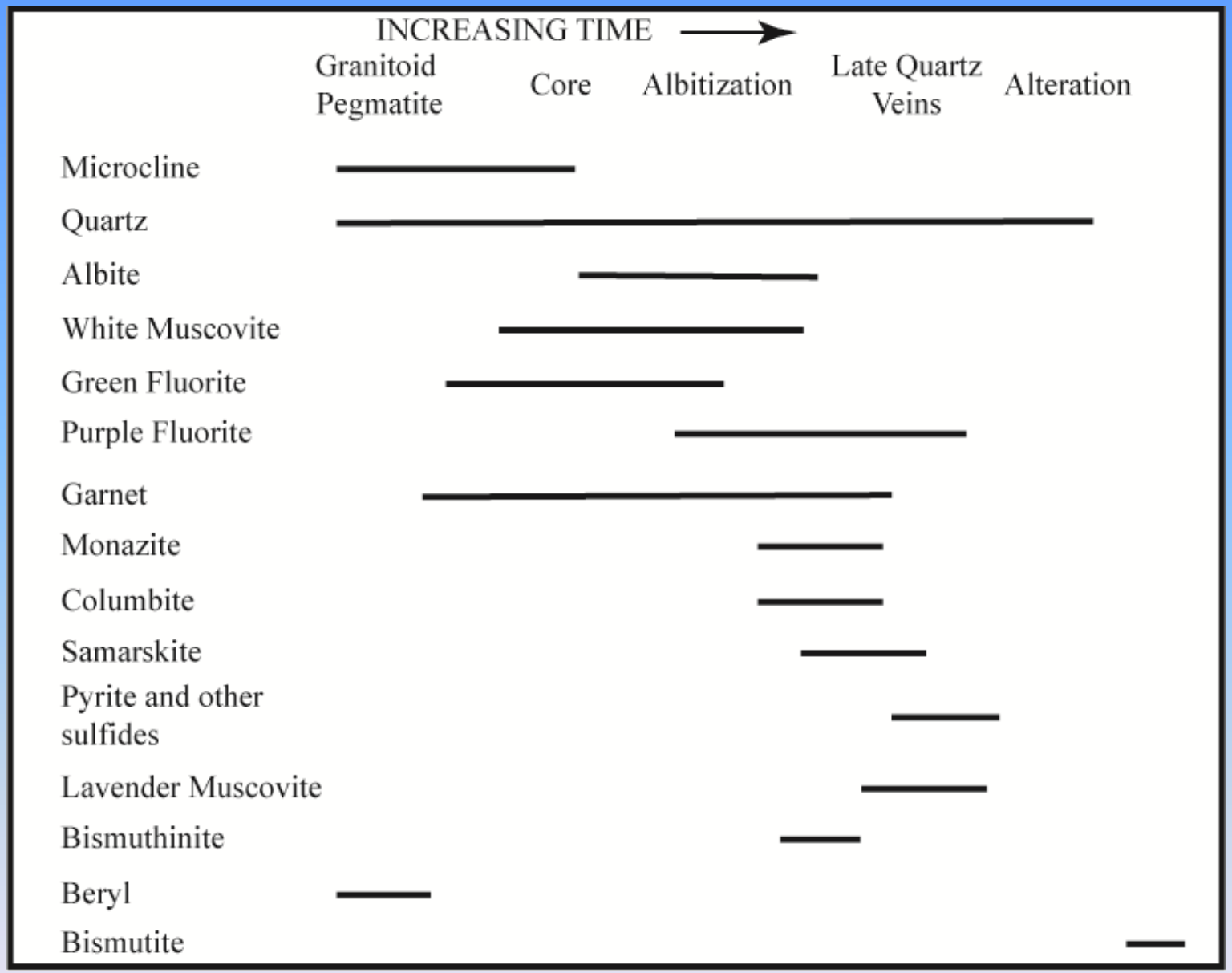
PEGMATITES



Elk Mountain

REE minerals in pegmatites

- Garnet
- Fluorite
- Columbite
- Beryl
- Gadolinite
- Euxenite
- Uraninite
- Microlite
- Allanite
- samarkite
- Cyrtolite
- Zircon
- Monazite



Paragenesis, Globe pegmatite (Petaca)

Summary

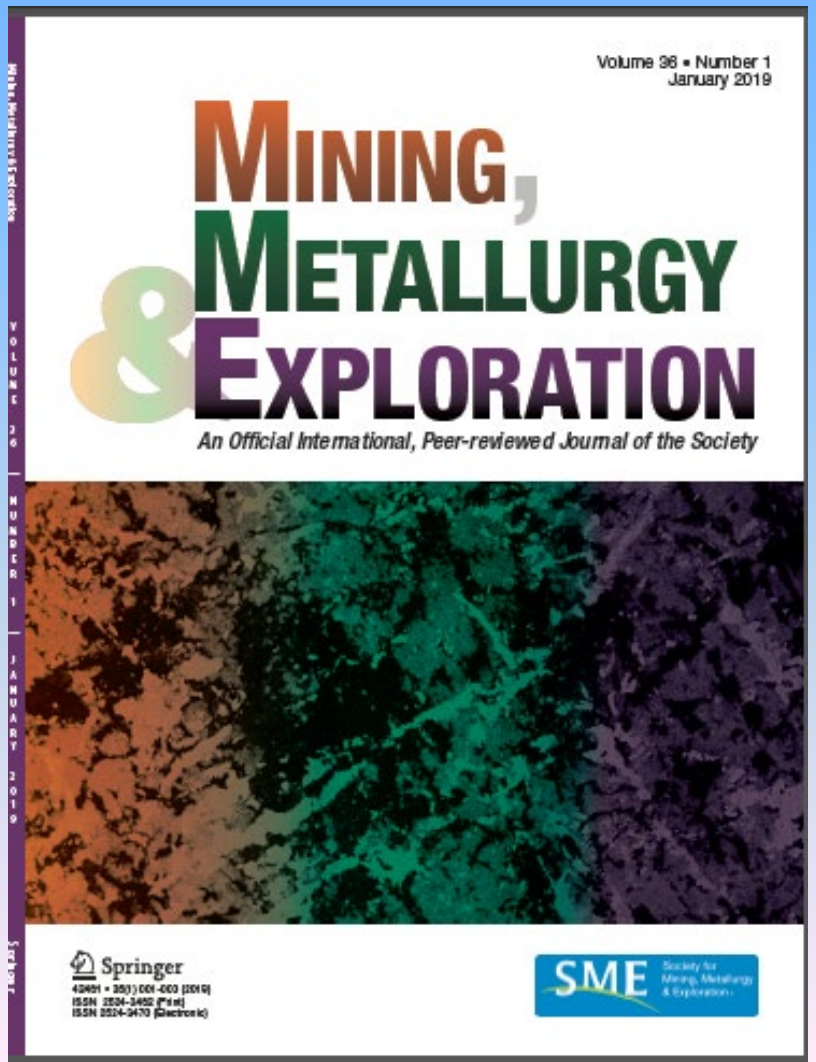
- The best potential for REE deposits in Proterozoic rocks in New Mexico—disseminated REE-Y-Zr deposits in alkaline rocks found at Pajarito Mountain, Otero County
- Additional areas
  - Proterozoic granite
    - Tajo Granite in Socorro County
    - La Cueva Granite in Taos County
    - Tusas Granite in Rio Arriba County
  - but additional geochemical studies and ultimately drilling are needed to determine the economic potential of these areas
- Most pegmatites in New Mexico probably will not constitute an economic resource because of low grade, small size, and the expensive hand-sorting techniques required in order to recover any of the commodities

CONCLUSIONS

- REE are important for green technologies as well as our entire lifestyle and new uses will be found because of their unique properties
- REE are found in specific locations based on favorable geology and there is sufficient supply for the near future
- Some of the REE required for these green technologies are found in New Mexico
- Need for understanding the mineralogy and distribution of these minerals in known ore deposits

SME has a new journal with Springer, Mining, Metallurgy, and Exploration

- Special issue in October 2019, Feb 2020 on Critical Minerals
- New articles welcome



QUESTIONS?