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Rare Earth Elements Deposits in New Mexico

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Abstract

Deposits of rare earth elements (REE) are found in New Mexico, but they have not been important exploration targets in past years because demand has been met elsewhere. However, with the projected increase in demand and potential lack of available REE production from China, the New Mexico deposits are being re-examined for their potential. REE-Th-U veins are found in the Gallinas, Caballo, Capitan, and Cornudas Mountains and Laughlin Peak-Chico Hills. A small amount of bastnaesite, a REE mineral, was recovered during processing for fluorite from the Gallinas Mountains. Four types of deposits are found in the Gallinas Mountains: epithermal REE-F veins, Cu-REE-F veins, REE-F breccia pipes and iron skarn deposits; all are associated with Tertiary alkaline to alkalic-calcic igneous rocks. Resources amount to at least 537,000 short tons of 2.95% total REE (not NI-43-101 compliant; Schreiner, 1999). The abundant rare mineralogy in the Cornudas Mountains suggests that the area has potential for undiscovered deposits of REE, niobium, and zirconium. U.S. Borax sampled and drilled in the Chess Draw area (up to 0.06% total rare-earth oxides, 10-1400 ppm Nb, 10-3000 ppm Zr, 230-13,000 ppm F). Other types of REE deposits are found in New Mexico. Carbonatites are found in the Lemitar and Chupadera Mountains, Laughlin Peak-Chico Hills, Lobo Hill, and Monte Largo (Sandia Mountains). Disseminated Y-Zr deposits in syenite are found at Pajarito Mountain, Mescalero Apache Indian Reservation near Ruidoso. 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. Two additional deposit types have potential for REE in New Mexico: Cretaceous heavy mineral, beach-placer sandstone deposits and pegmatites. Exploration is ongoing in the Lemitar, Gallinas, and Cornudas Mountains. Many challenges face the mining industry in supplying REE. Most REE deposits are associated with radioactive waste material, which will require special handling. Future development of REE-based green technologies will be challenging and demand more research in many fields.

Introduction

Before 2010 most Americans never heard of the rare earth elements (REE) family (Table 1), except maybe in high school chemistry class when studying the periodic table of elements. However, in April 2010, China announced that it would impose export quotas on REE immediately in order to: (1) address environmental issues at their REE mines; (2) regulate illegal REE mining operations; and (3) to provide for sustainable REE production and supply for China (i.e., monopoly). This announcement triggered an increase in price for REE and some panic buying. Then, in late September 2010, China halted exports of REE to Japan, following an international dispute when Tokyo arrested a Chinese fisherman whose vessel had collided with two Japanese coastguard boats on September 8, 2010. Japan uses REE in their highly profitable electric/hybrid automobiles and numerous electronic consumer products (Table 2). Although China reinstated REE exports to Japan in early November 2010, this incident placed the phrase “rare earth elements” in recent headlines and on the lips of resource planners, politicians, investors, and journalists throughout the world.

The REE family includes 15 lanthanide elements (atomic number 57-71), yttrium (Y, atomic number 39), and scandium (Sc; Table 1) and are commonly divided into two chemical groups, the light REE (La through Eu) and the heavy REE (Gd through Lu, Sc, and Y). REE are lithophile elements (or elements enriched in the crust) that have similar physical and chemical properties, and, therefore, occur together in nature. However, REE are not always concentrated in easily mined economic deposits and only a few deposits in the world account for current production (Committee on Critical Mineral Impacts of the U.S. Economy, 2008; Hedrick, 2009). Thorium (Th),

TABLE 1. Description of rare earth elements (REE) (from Taylor and McClennan, 1985; Samson and Wood, 2005; Rudnick and Gao, 2005; Castor and Hedrick, 2006; and Hedrick, 2009). * Promethium does not occur naturally.

Rare Earth Element	Symbol	Oxide	Conversion factor (% element x conversion factor = % oxide)	Atomic Number	Abundance in the upper crust (ppm)
Scandium	Sc	Sc_2O_3		21	14
Yttrium	Y	Y_2O_3	1.269	39	21
Lanthanum	La	La_2O_3	1.173	57	31
Cerium	Ce	Ce_2O_3	1.171	58	63
Praseodymium	Pr	Pr_2O_3	1.17	59	7.1
Neodymium	Nd	Nd_2O_3	1.166	60	27
Promethium	Pm	*	*	61	*
Samarium	Sm	Sm_2O_3	1.16	62	4.7
Europium	Eu	Eu_2O_3	1.158	63	1.0
Gadolinium	Gd	Gd_2O_3	1.153	64	4.0
Terbium	Tb	Tb_2O_3	1.151	65	0.7
Dysprosium	Dy	Dy_2O_3	1.148	66	3.9
Holmium	Ho	Ho_2O_3	1.146	67	0.83
Erbium	Er	Er_2O_3	1.143	68	2.3
Thulium	Tm	Tm_2O_3	1.142	69	0.30
Ytterbium	Yb	Yb_2O_3	1.139	70	2.2
Lutetium	Lu	Lu_2O_3	1.137	71	0.31
Thorium	Th	ThO_2	1.138	90	10.5
Zirconium	Zr	ZrO_2	1.351	40	193
Niobium	Nb	Nb_2O_5	1.431	41	12

TABLE 2. Prices and selected uses of REE. There is significant variation in the price of REE oxides which are dependent upon purity and product specifications. REE prices (US$/kg) are based upon 99% purity. From 1—Cordier (2011) and http://www.mineralprices.com/default.aspx#Rare (accessed 8/20/12).

REE oxide	2009 US$/kg[1]	2011US$/kg	Selected Uses
La oxide	30	35	Re-chargeable batteries, catalyst
Ce oxide	30	30	Catalyst, glass, polishing, re-chargeable batteries
Nd oxide	42	130	Magnets, lasers, glass
Pr oxide	38	120	Magnets, glass colorant
Sm oxide	130		Magnets, lighting, lasers
Dy oxide	170	1500	Magnets, lasers
Eu oxide	1600	3850	TV color phosphors
Gd oxide	150	140	Magnets, superconductors
Y oxide	44	95	Phosphors, ceramics, lasers
Tb oxide	900	2800	Phosphors, magnets
Er oxide		175	fiber-optic telecommunication cables
Lu oxide	1800		catalysts
Sc oxide		7200	High intensity lights

uranium (U), niobium (Nb) and zircon (Zr) typically are found with REE. Most deposits are radioactive because of their Th and U content.

REE have many highly specialized applications in industry (Table 2), especially in electronic devices, and for many applications there are no other known substitute (Naumov, 2008; Hedrick, 2009). The U.S. once produced enough REE for U.S. consumption, but since 1999 more than 90% of the REE required by U.S. industry have been imported from China (Haxel et al., 2002). However, the projected increase in demand for REE in China, India, U.S., and other countries has resulted in increased exploration and will likely result in production from future deposits in the U.S. and elsewhere.

REE deposits have been reported from numerous areas in New Mexico (Fig. 1; Appendix 1), but were not considered important exploration targets because the demand in past years has been met by other deposits in the world. With the projected increase in demand and potential lack of available production from the Chinese deposits, these areas in New Mexico are being re-examined for their REE potential. The purposes of this report are to: (1) summarize the resource potential for REE in New Mexico, (2) update earlier compilations by McLemore et al. (1988a, b) and Adams (1965), and (3) suggest areas in the state for future exploration. A REE occurrence is defined in this report as: (1) previous production of REE minerals, (2) whole-rock chemical analysis of greater than 1,000 ppm total REE, 500 ppm Y, or 100 ppm Sc, or (3) REE minerals found in sufficient quantities to be considered a potential mineral resource. This is a summary of a larger, more extensive report in preparation. Data used in this report have been compiled from a literature review, field examination, and unpublished data by the author. A summary of the mining districts in New Mexico containing REE deposits is in Appendix 1 and the districts are shown in Figure 1.

Mining and exploration of REE in New Mexico

REE are found throughout New Mexico and exploration is ongoing in the Lemitar, Gallinas, and Cornudas Mountains (Fig. 1). New Mexico mines produced small amounts of REE as early as the 1940s from pegmatite deposits found in San Miguel, Santa Fe, Rio Arriba, and Taos Counties in northern New Mexico and in Grant County in southwestern New Mexico and from the Gallinas Mountains vein deposits (Table 3).

Types of REE deposits in New Mexico

Alkaline igneous rocks

Many alkaline igneous rocks, typically of syenite or granite composition, have higher

TABLE 3. REE production from New Mexico deposits.

District Number	Name	Production	Reference
DIS092	Gallinas Mountains	146,000 lbs of bastnaesite concentrate from fluorite production from veins	Griswold (1959), Adams (1965), McLemore (2010a)
DIS148	Petaca district	112 lbs of samarskite, few hundred lbs of monazite, 12,000 lbs of Ta-Nb-REE ore from pegmatites	Bingler (1968), Jahns (1946)
DIS162	Elk Mountain-Spring Mountain	500 lbs of Ta-U-REE concentrate from pegmatites	Jahns (1946), Holmquist (1946)
DIS164	Rociada	Several thousand tons of REE-Ta ore from pegmatites	Sheffer and Goldsmith (1969), Jahns (1953)
DIS166	Tecolote	$10,000 worth of beryl, tantalite-columbite and monazite from pegmatites	Redmund (1961)
DIS058	Gold Hill	Unknown production in 1950s from pegmatites	Gillerman (1964)

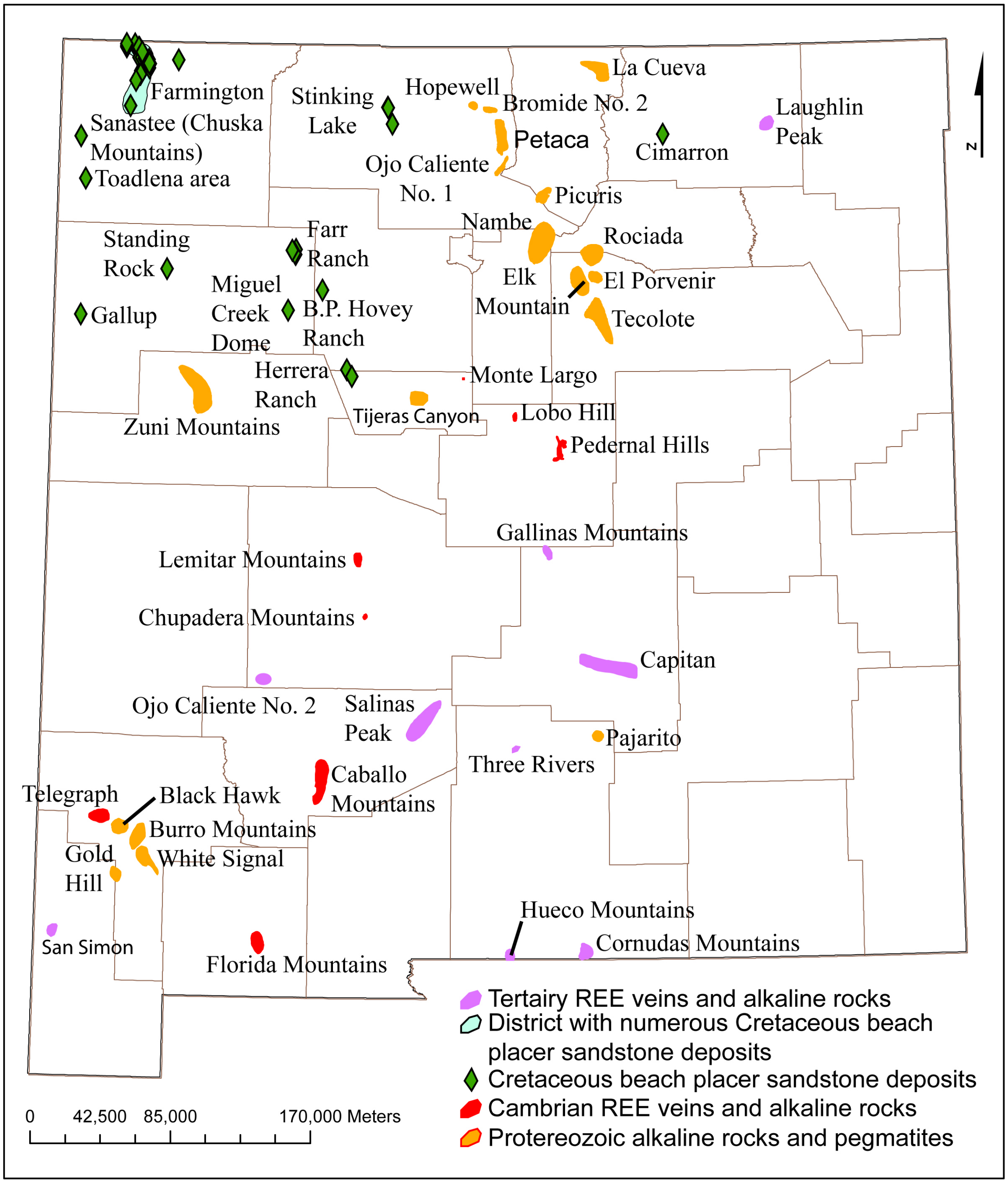

FIGURE 1. Mining districts in New Mexico that contain rare earth elements (REE) deposits (modified from McLemore et al., 2005a, b; McLemore, 2011). Summary of districts is in Appendix 1.

concentrations of REE then other types of igneous rocks. Alkaline rocks are defined as rocks with $Na_2O+K_2O>0.3718(SiO_2)-14.5$ (MacDonald and Katsura, 1964) or rocks with mol Na_2O+mol K_2O>mol Al_2O_3 (Shand, 1951). Peralkaline rocks are particularly enriched in heavy REE, Y, and Zr. Some REE deposits have been found in these rocks, but known REE deposits in alkaline rocks are typically low grade (Castor, 2008). In these alkaline-related REE deposits, REE, Zr, Be, Nb, Ta, and other elements are found in accessory minerals disseminated in the igneous rock.

Disseminated Y-Zr deposits in syenite are found at Pajarito Mountain, Mescalero Apache Indian Reservation near Ruidoso (Fig. 1). Several varieties of syenite, quartz syenite, alkali granite, and gabbro are exposed at Pajarito Mountain and are intruded by pegmatite and gabbroic dikes. The mineralogy of the alkaline rocks is complex consisting of various amounts of essential potassium-feldspar, plagioclase, arfvedsonite and accessory riebeckite, quartz, eudialtye, fluorite, monazite, apatite, biotite, rutile (?), titanite, aegirine-augite, ziconium silicates, lanthanide and yttrium minerals and zircon. Selected unpublished chemical analyses indicate these alkaline Proterozoic rocks are anomalously high in light-REE (La as high as 1500 ppm, Ce as high as 3910 ppm) and niobium (200 ppm). 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. Additional feasibility studies are required to confirm the economic viability of this historic resource.

FIGURE 2. Fine-grained, REE mineral-bearing episyenite dike intruding Northern Caballo granite in the Caballo Mountains.

Other areas in New Mexico have potential for REE, especially Cambrian-Ordovician syenites and metasomatic bodies found in the Caballo, Burro, and Zuni Mountains (Appendix 1). The Cambrian-Ordovician alkaline magmatic event is well-documented in southern Colorado and New Mexico and is characterized by carbonatites, syenites, lamprophyres, episyenites and other alkaline rocks dated between 664 and 457 Ma (McMillan and McLemore, 2004). This includes REE-carbonatites, REE-Th-U veins, and disseminations in alkaline rocks in the Caballo, Burro, Zuni Mountains, Lobo and Pedernal Hills. The alkaline episyenites are nonfoliated, nonmetamorphosed igneous rocks, cross-cut Proterozoic foliations and are enriched in REE, U, Th, Nb, and other elements.

McLemore (1986), McLemore et al. (1988a, b; 2012) and Long et al. (2010) briefly described the known REE-Th-U and Nb veins and episyenite deposits in the Red Hills, Palomas Gap, Longbottom Canyon, and

Apache Gap areas of the Caballo Mountains. The REE episyenite deposits are spotty, discontinuous tabular bodies, narrow lenses, and occur in breccia zones along faults, fractures, and shear zones (Fig. 2) and contain local high concentrations of REE, niobium, thorium, and uranium. Select samples of episyenites from the Red Hills area in the Caballo Mountains contain as much as 20,000 ppm Th, 1,600 ppm U, 500 ppm Nb, 5,000 ppm Y, 600 ppm Be, 7,500 ppm Ga, and 200 ppm La.

Carbonatites

Carbonatites are carbonate-rich rocks containing more than 50% magmatic carbonate minerals, less than 20% SiO_2, are of apparent magmatic derivation (LeMaitre, 1989, 2002), and typically found in zoned complexes consisting of alkaline igneous and/or carbonatite stocks, ring dikes, and cone sheets (Fig. 3).

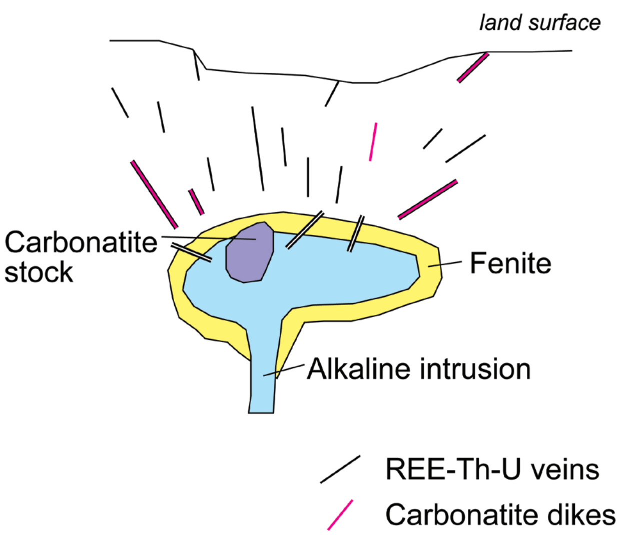

FIGURE 3. Relationship of Th-REE veins to alkaline rocks and carbonatites (modified from Staatz, 2000).

Carbonatites generally contain REE, U, Th, Nb, Ta, Zr, Hf, Fe, Ti, V, Cu, Sr, apatite, magnetite, vermiculite, and barite (Singer, 2000). Typically, carbonatites occur in continental shields and continental rift environments. Fenitization (alkaline metasomatism associated with intrusive alkaline rocks, carbonatites, and kimberlites) is the predominant alteration associated with carbonatites; fenites are the altered rocks produced by fenitization. Many carbonatites are associated with Th-REE veins (Fig. 3). The Mountain Pass carbonatite is the largest economic carbonatite in North America; bastnaesite was produced from 1954 to 2002 and in 2012. Current reserves at Mountain Pass are estimated at more than 20 million metric tons of ore grading 8.9% total REE oxide (Castor, 2008).

Carbonatites are found in the Lemitar and Chupadera Mountains, Laughlin Peak-Chico Hills, Lobo Hill, and Monte Largo (Sandia Mountains) in New Mexico (Fig. 1). Although carbonatites have not been found in the Gallinas Mountains, they are suspected to occur in the subsurface based upon mineralogy and alteration (McLemore, 2012). Compositionally, the carbonatites found in New Mexico are sövites, silicocarbonatites, rauhaugites, and silicocarbonatites. Carbonatite dikes are typically 3-5 feet wide (Fig. 4) and up to 1500 feet long, and contain anomalously high concentrations of REE, U, Th, and Nb.

REE-Th-U hydrothermal veins

REE-Th-U vein and breccia deposits (model 11d; Staatz, 2000) consist of various Th and REE minerals found in hydrothermal veins and are commonly associated with alkaline igneous rocks and carbonatites. REE-Th-U vein and breccia deposits in New Mexico are typically found as tabular bodies, narrow lenses, and breccia zones along faults, fractures and shear zones. They are a few feet to 1000s of feet long, as much as 10 feet wide, and can be discontinuous along strike, with varying grades and mineralogy. Elsewhere in the world, REE-Th-U veins are typically associated with carbonatites and alkaline rocks (Fig. 3).

REE-Th-U veins are found in New Mexico in the Gallinas, Caballo, Capitan, and Cornudas Mountains and Laughlin Peak-Chico Hills (Fig. 1). Past production of bastnaesite has come from the Gallinas Mountains. Four types of deposits are found in the Gallinas Mountains: epithermal REE-F veins, Cu-REE-F veins, REE-F breccia pipes and iron skarn deposits; all are associated with Tertiary alkaline to alkalic-calcic igneous rocks (McLemore, 2010a). Resources amount to at least 537,000 short tons of 2.95% total REE (not NI-43-101 compliant; Schreiner, 1999).

The abundant rare mineralogy in the Cornudas Mountains suggests that the area has potential for undiscovered deposits of REE, niobium, and zirconium (Schreiner, 1994). U.S. Borax sampled and drilled in the Chess Draw area (up to 0.06% total rare-earth oxides, 10-1,400 ppm Nb, 10-3,000 ppm Zr, and

230-13,000 ppm F). An analysis of a dike reported by McLemore et al. (1988a, b) contained 1,235 ppm Ce, 700 ppm La, 270 ppm Nd, and 242 ppm Y (sample #7368). Analyses reported by Schreiner (1994) are as much as 3,790 ppm total REE, 2,332 ppm Nb, 92 ppm Be, and 3,137 ppm F. Additional geologic, geochemical, geophysical, and other exploration techniques are required to properly evaluate this area, especially in dikes and along intrusive contacts with the limestones.

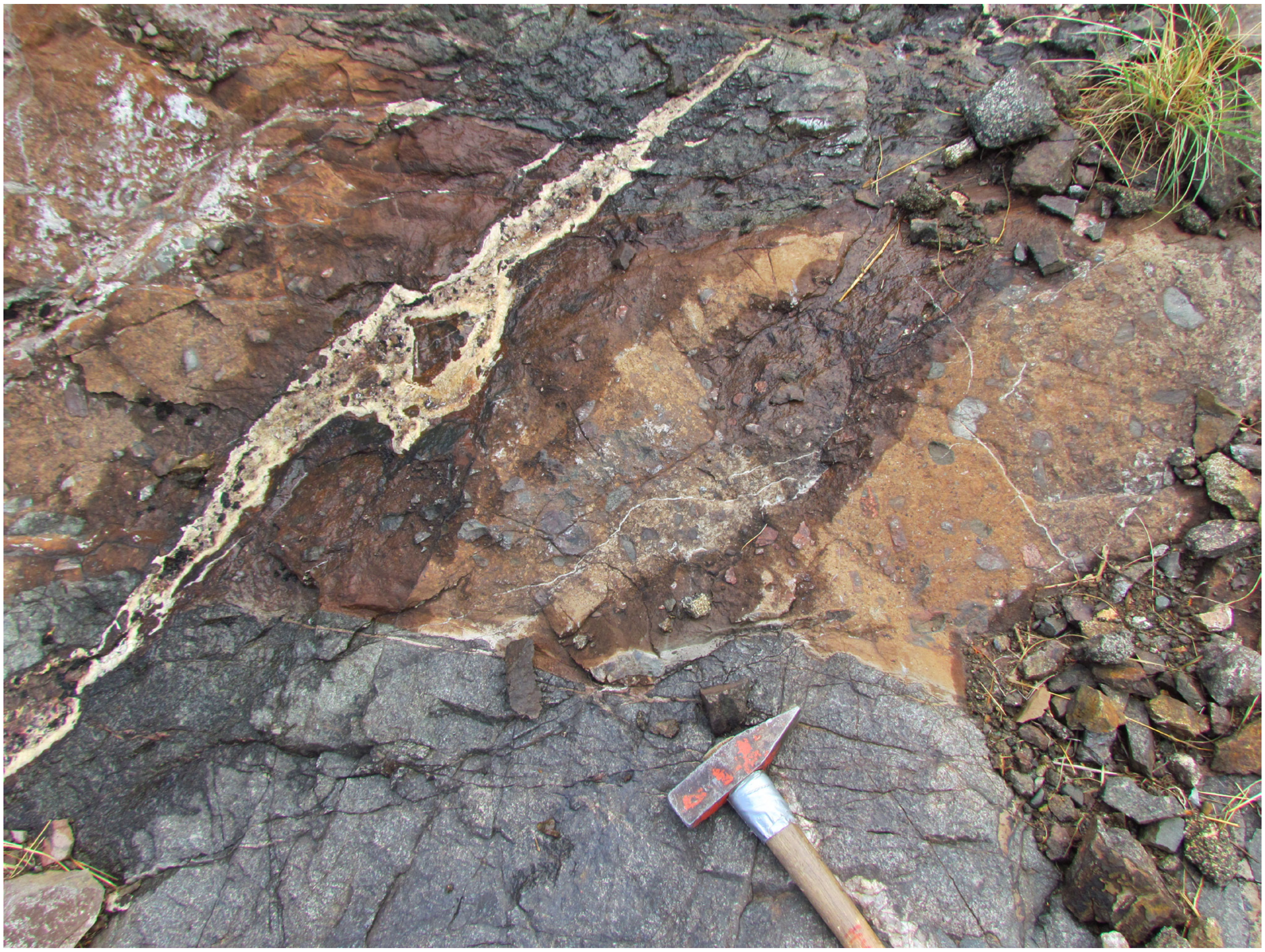

FIGURE 4. Carbonatite dike (brown) intruding Proterozoic diorite and cut by calcite vein in the Lemitar Mountains.

Pegmatites

Pegmatites are coarse-grained igneous rocks, lenses, or veins with granitic composition, contain essential quartz and feldspar, and represent the last and most hydrous phase(s) of crystallizing magmas (Page and Page, 2000; Ercit, 2005). Complex pegmatite bodies include mineralogical and/or textural zones. Pegmatites can contain a variety of economic minerals, including, mica, quartz, feldspar, Li, REE, Cs, Ta, Nb, Rb, Y, Sc, U, Th, Sn, B, Be and others. A number of pegmatites in New Mexico have yielded REE production in the past (Table 3), but in general pegmatites in New Mexico are poor mining targets, because the REE minerals are generally scattered throughout the pegmatite and are difficult to selectively mine and process.

Placer deposits

Placer deposits form by mechanical concentration of heavy minerals in a sedimentary environment, such as a river or beach. Ilmenite, rutile, magnetite, zircon, monazite and xenotime are main economic minerals. Modern placer examples are Eneabba, western Austalia and Andhra Pradesh, India. In New Mexico, beach-placer sandstone deposits that formed on beaches or in longshore bars in a marginal-marine environment bear heavy minerals and REE (Fig. 5; Houston and Murphy, 1970, 1977; McLemore, 2010b). Many beach-placer sandstone deposits contain high concentrations of Th, REE, Zr, Ti, U, Nb, Ta, and Fe. Detrital heavy minerals comprise approximately 50-60% of the sandstones and typically consist of titanite, zircon, magnetite, ilmenite, monazite, apatite, and allanite, among others. In New Mexico, these deposits are in Cretaceous sedimentary rocks (Fig. 1; Appendix 1). The Sanostee deposit is the largest of the beach placer sandstone deposits in New Mexico (Fig. 6); additional sampling and drilling are required to fully delineate the deposit and evaluate the REE resource potential (McLemore, 2010b).

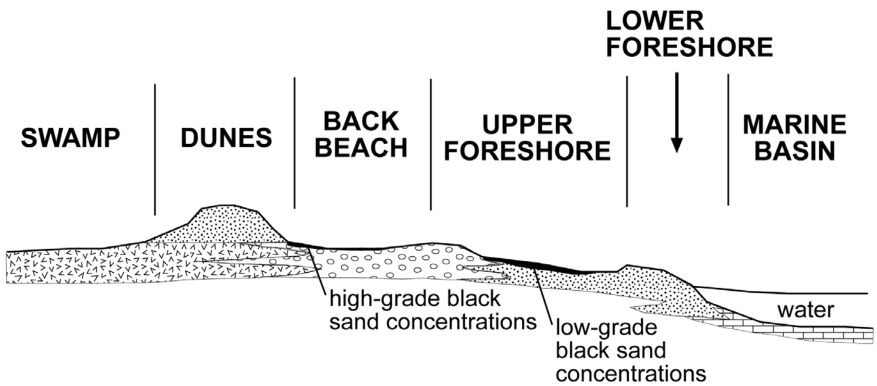

FIGURE 5. Idealized cross-section of formation of beach placer sandstone deposits (Houston and Murphy, 1970).

Another type of placer deposit found in New Mexico is residual placer deposits down-slope of REE-enriched pegmatites. Residual placer deposits are reported from Ojo Caliente district in Rio Arriba County, where REE minerals are found in the modern sediments derived from pegmatites (Fig. 1; Appendix 1).

Other REE-bearing deposits

Minor amounts of REE can be found in U, Th, and phosphate deposits and REE potentially could be recovered as a by-product (Jackson and Christiansen, 1993). Other placer deposits (fluvial, alluvial placers) could carry anomalous amounts of REE, too. Fluorite veins can host high concentrations of REE, especially Y. Some Proterozoic granites in New Mexico could have pegmatitic zones that are enriched in REE. Tertiary alkaline igneous rocks associated with gold veins east of the Rio Grande rift should be examined for REE concentrations. REE also can be associated with uraninite and other U-bearing minerals suggesting that sandstone uranium deposits should be examined for their REE potential, especially as a potential by-product of future uranium production.

Potential for New Mexico REE deposits

Consumers are demanding more cell phones, televisions, computers, I-pods, video games, wind turbines, hybrid/electric cars, solar panels that require more REE. Although predictions of the amounts of REE needed in the future are uncertain, it is likely that future production can be met by 6-10 new REE mines in the world. The new mines that can meet current regulations and obtain mining permits first will likely be the next REE producers, even if better deposits are discovered later. New Mexico has some deposits that are in the early exploration stage and it will take years for these deposits to be developed, if they are economic. However, it is important to understand the REE potential in New Mexico, even if deposits are not produced in the next few years, because these resources could be important in the future and it takes many years to obtain mine permits.

There are no known substitutes for REE for most applications. New research is ongoing to develop technologies that will require less REE. Manufacturers are finding ways to be more careful about how they use rare earth elements. Just as aluminum cans became thinner as the price of that metal soared, companies will learn to make better use of those REE that are available. The Japanese are researching ways to develop synthetic REE, but that technology, if developed, will take years to come to fruition.

The best potential for REE development in New Mexico is the disseminated Y-Zr deposits in syenites at Pajarito Mountain, carbonatites, and REE-Th-U hydrothermal vein and breccia deposits. Strategic Resources Ltd. drilled in the Lemitar Mountains in 2011 and in the Galinas Mountains in 2011-2012. Geovic Mining Corp. drilled in the Cornudas Mountains area in 2012. BE Resources Inc. announced that the Apache Warm Springs beryllium deposit in rhyolite contains anomalous REE, but has since dropped the project. Additional surface sampling and staking of mining claims throughout New Mexico has occurred by various companies. New Mexico pegmatites typically are too small to be mined for REE today. However, residual placers from the pegmatites could have future potential. REE are found in

FIGURE 6. Beach placer sandstone deposits forming top of cliffs at the Sanostee deposit.

Cretaceous beach-placer sandstone deposits in the San Juan Basin in northern New Mexico, but these deposits also are too small to be mined today.

Acknowledgments

This report is part of on-going studies of mineral resources and the geology of carbonatites and alkaline igneous rocks in New Mexico, supported by the New Mexico Bureau of Geology and Mineral Resources, L. Greer Price, Interim Director and State Geologist. I thank my many colleagues who contributed to and reviewed manuscripts over the years that form the foundation upon which this work is based upon.

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Appendix 1. Mining districts in New Mexico containing REE

This is a list of mining districts containing REE in New Mexico, including districts with REE in NURE stream sediments. Names of districts are after File and Northrop (1966) wherever practical, but many districts have been combined and added. Districts may extend into adjacent counties or states or into Mexico. District (DIS) or Mines (NM) Identification Number is from the New Mexico Mines Database (McLemore et al., 2005a, b).

District or Mines Identification number	District (Aliases)	Commodities Produced (Present)	Age of REE Deposits	Type Of REE Deposit
Bernalillo County				
NMBE0007	Monte Largo	(REE, U, Th, Nb)	Cambrian-Ordovician	Carbonatite
NMBE0005	Herrera Ranch	(REE, U, Th, Ti)	Cretaceous	Beach placer sandstone
DIS004	Tijeras Canyon	(REE, U, Th)	Proterozoic	Pegmatite
Cibola County				
DIS017	Zuni Mtns (Copper Hill, Coopperton, Montezuma, New Cornwall)	Cu, Au, Ag, F, Pb (U, V, Ba, Fe, REE)	Proterozoic	Precambrian veins/ replacements, fluorite veins, REE-Th-U veins in alkaline rocks
Colfax County				
DIS020	Laughlin Peak (Chico Hills)	Au, Ag, REE, U, Th, Nb, Fe)	32.3-22 Ma (Staatz, 1985, 1986; Stroud, 1997)	REE-U-Th veins, carbonatite
NMCO0004	Cimarron	(U, Th, REE, Ti)	Cretaceous	Beach placer sandstone
Grant County				
DIS044	Black Hawk	Au, Ag, F (REE, Co, Ni, U)	Laramide, Proterozoic	Polymetallic vein, pegmatite
DIS046	Burro Mtns (Tyrone)	Au, Ag, Cu, Mo, Pb, Zn, F, W, Mn, Bi, U, turquoise (Te, Be, REE)	Proterozoic	Porphyry copper, polymetallic vein
DIS058	Gold Hill (Camp Bobcat)	Au, Ag, Cu, Pb, W, F, Be, REE (U, Th, Ta, Ba, Mn, Nb, Bi)	Proterozoic, Tertiary	Polymetallic vein, epithermal Mn, pegmatite
DIS067	Telegraph (Red Rock, Anderson, Ash Creek, Wild Horse Mesa, Clarks Peak)	F, Cu, Au, Ag, Pb, Zn, Mn (U, Th, Ba, REE)	Cambrian-Ordovician	Polymetallic vein, volcanic-epithermal, Precambrian vein/ replacement, disseminated Y-Zr deposits in alkaline rocks
DIS068	White Signal (Cow Spring)	Cu, U, Au, Ag, Pb, Bi, F, Ra, garnet (Th, Zn, Nb, Ta, turquoise, Zn, Be, REE, Ba, mica)	Proterozoic, Cambrian-Ordovician	Polymetallic vein, pegmatites
Hidalgo County				
DIS080	San Simon (Granite Gap)	Cu, Pb, Zn, Au, Ag, W, Sb (Bi, Be, F, U, REE)	33.2 Ma (^{30}Ar/^{29}Ar)	Carbonate-hosted Pb-Zn, skarn
Lincoln County				
DIS091	Capitan Mtns	Fe, U, Mn, coal (Th, REE, Cu, Au, Ag)	34.0 Ma (K/Ar, Allen and McLemore, 1991)	REE-U-Th veins
DIS092	Gallinas (Red Cloud)	Au, Ag, Cu, F, Fe, Zn, REE, Pb (U, Th)	30.7 Ma (K/Ar, Allen and Foord, 1991),	REE-U-Th veins

District or Mines Identification number	District (Aliases)	Commodities Produced (Present)	Age of REE Deposits	Type Of REE Deposit
Luna County				
DIS106	Florida Mtns	Cu, Pb, Zn, Au, Ag, Mn, F, agate (Ba, Ge, Fe, REE)	Cambrian-Ordovician	Epithermal fluorite, disseminated Y-Zr deposits in alkaline rocks
McKinley County				
DIS117 NMMK0072	Gallup (Torriva anticline)	(U, Th, REE, Ti, Nb, Zr)	Cretaceous	Beach placer sandstone
NMMK0108	Miguel Creek Dome	(U, Th, Ti, Fe, Zr, REE)	Cretaceous	Beach placer sandstone
NMMK0261	Standing Rock	(U, Th, Ti, REE, Zr, Fe)	Cretaceous	Beach placer sandstone
NMMK0060	Farr Ranch	(U, Th, REE, Ti)	Cretaceous	Beach placer sandstone
Otero County				
DIS128	Cornudas Mtns (Wind Mtn)	(Ag, Be, Au, U, REE)	36.3 Ma ($^{40}Ar/^{39}Ar$, NMBMMR file data)	REE-U-Th veins, disseminated Y-Zr deposits in alkaline rocks
DIS255	Hueco Mtns	(Cu, Ag, Zn, Au, Ag, REE)	34.5-34.7 Ma	disseminated Y-Zr deposits in alkaline rocks
DIS130	Pajarito Fe	(REE, Y, Zr, F)	1230-1140 Ma (K/Ar, Kelly, 1968; Moore and Foord, 1986)	disseminated Y-Zr deposits in alkaline rocks
DIS132	Three Rivers (Apache No. 1, White Mtn)	Fe (Ba, REE?)	~45.3 Ma	Replacement iron (REE anomalies in ground water)
Rio Arriba County				
DIS139	Bromide No. 2	Au, Ag, Cu, U (Fe, REE, Th, F, Ba)	1750 Ma	Precambrian veins/ replacement
DIS145	Hopewell (Headstone)	Au, Ag, Cu, Pb (Zn, Fe)	~1467 Ma, Recent	Precambrian veins/ replacement
DIS147	Ojo Caliente	mica (Bi, Nb, REE)	Proterozoic	Pegmatite, Placer REE
DIS148	Petaca	mica, Nb, Ta, Be, quartz, feldspar, kyanite, REE (Sn, U, Th, Cu, Bi, F)	Proterozoic	Pegmatite
Sandoval				
NMSA0028	B.P.Hovey Ranch	(U, Th, Ti, REE)	Cretaceous	Beach placer sandstone
NMSA0049	Herrera Ranch	(U, Th, Ti, REE)	Cretaceous	Beach placer sandstone
San Juan County				
NMSJ0088	Sanastee	U, V (Ti, REE, Th, Y, Zr, Fe)	Cretaceous	Beach placer sandstone
DIS154	Farmington (Hogback)	U, V (REE, Ti, Th, Fe, Nb, Zr)	Cretaceous	Beach placer sandstone
DIS159	Toadlena	(U, V, Ti, REE, Th, Zr, Nb, coal)	Cretaceous	Beach placer sandstone

District or Mines Identification number	District (Aliases)	Commodities Produced (Present)	Age of REE Deposits	Type Of REE Deposit
San Miguel County				
DIS162	Elk Mtn-Spring Mtn	Mica, Ta, REE, U (Ag, Pb, Nb)	Proterozoic	Pegmatite, Precambrian veins/replacements, disseminated Y-Zr deposits in alkaline rocks
DIS161	El Porvenior	Mo (Cu, Ag, Au, Th, U, F, W, Bi, Ta, Nb, mica, REE)	Proterozoic	Precambrian veins/ replacements, pegmatite
DIS164	Rociada	Li mica, REE, Ta (Cu, Pb, Ag, Au, Zn, U, Mo, Be)	<1,720 Ma, Pennsylvanian-Permian	Precambrian veins/ replacements, pegmatite
DIS166	Tecolote (Villanueva, Mineral Hill, Rio de la Vaca)	Cu, Pb, Ag, Au, Be, Ta, Nb, mica (U, V, REE, Mo)	Proterozoic, Precambrian Pennsyvanian-Permian	veins/ replacements, pegmatite
Santa Fe County				
DIS185	Nambe (Aspen Ranch)	Nb, mica (Be, Cu, REE)	Proterozoic	Pegmatites
Sierra County				
DIS190	Caballo Mtns (Palomas Gap, Red Hills)	Cu, Pb, V, F, Mn, Au, Ag, Fe, Mo (U, Th, Ba, REE, Ti, Nb),	Cambrian-Ordovician	Fluorite veins, Precambrian veins/ replacements, Cu-Ag (U) veins, REE-Th-U veins in alkaline rocks
DIS203	Salinas Peak (Good Fortune Creek, Bearden Canyon, Bear Den)	Au, Ag, Cu, Pb, Zn (Mo, Bi, Ba, F) (REE in stream sediments)	Tertiary	Fluorite veins
Socorro County				
DIS210	Chupadera Mtns (Coyote Hill)	(Au, Ag, Cu, Pb, Zn, Ba, U, Th, Nb, Ti, F, REE)	Cambrian-Ordovician	Precambrian vein/ replacement, carbonatite, REE-Th-U veins in alkaline rocks
DIS219	Lemitar Mtns	Ag, Cu, Pb, Ba, Mn, Ba (F, Zn, U, Th, Nb, Ti, REE)	449 Ma	RGR, Precambrian vein/replacement, carbonatite, REE-Th-U veins in alkaline rocks
DIS230	Ojo Caliente No. 2	Au, Ag, Cu (Be, U, Mn, REE)	Tertiary	Volcanic epithermal vein, rhyolite-hosted beryllium
Taos County				
DIS232	La Cueva (Costilla Creek)	(Au, Cu, U, Th, Nb. beryl, mica, REE)	Proterozoic	Precambrian vein/ replacement, pegmatite, REE-Th-U veins
DIS236	Picuris (Copper Hill, Harding)	Au, Ag, Cu, W, turquoise, Nb, Ta, Be, Li, mica, feldspar (U, Sb, Cr, V, Ba, Be, REE)	Proterozoic	Precambrian vein/ replacement, pegmatite

District or Mines Identification number	District (Aliases)	Commodities Produced (Present)	Age of REE Deposits	Type Of REE Deposit
Torrance County				
DIS256	Lobo Hill	Aggregate (REE, U, Th, Cu, Nb, Y)	518 Ma	Carbonatite, REE-Th-U veins in alkaline rocks
DIS245	Pedernal Hills	(Cu, Ag, Au, U, Th, REE, Fe) are 1660-1650 Ma, REE are 469 Ma	Multiple, Precambrian	Precambrian vein/ replacement, REE-Th-U veins in alkaline rocks

Elements

As—arsenic
Au—gold
Ba—barium
Be—beryllium
Bi—bismuth
Co—cobalt
Cu—copper
F—fluorine
Fe—iron
Ga—gallium
Ge—germanium
Mn—manganese
Mo—molybdenum
Ni—nickel
Pb—lead
REE—rare-earth elements
Sb—antimony
Sn—tin
Te—tellurium
Th—thorium
U—uranium
V—vanadium
W—tungsten
Zn—zinc