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MBMG
Montana Bureau of Mines and Geology

Critical Mineral: Erbium

Ryan Davison and Adrian Van Rythoven

Overview

Erbium (Er) is a chemical element included on the United States Geological Survey's 2022 Critical Minerals list. Er is a lanthanide. It is the fourth heaviest of the rare earth elements (REEs).

The soft, silvery gray metal is used in fiber optics, medical lasers, exotic alloys, and nuclear control rods.

Figure 1. A 9.5-gram sample of refined Er metal. Photo by Jurii (CC BY 3.0).

Supply

Er is sourced from REE mining, and occurs in ore minerals along with the other REEs. It is most concentrated in heavy REE deposits that are also rich in more abundant yttrium (Y), terbium (Tb), and dysprosium (Dy). The U.S. imports all of its Er from China, the major miner and refiner. Other countries that refine Er for export are Germany, Korea, and Japan. The U.S. produces a near-negligible amount of Er from the one American REE mine at Mountain Pass in California. The only other non-Chinese REE mine of note is Mt. Weld in Australia (0.0005 wt.% Er).

Given its extreme rarity and niche uses, there are no comprehensive data on pricing or consumption of Er. Er is derived from any deposit where other REEs are also present in economic quantities. Most of the world's Er is mined from clay deposits in southern China under environmentally damaging conditions. Grades of Er in REE deposits range from 0.0004 (Montviel, Quebec) to 0.0419 (Browns Range, Australia) wt.%. The proportion of Er in the total REE grade is a function of the deposit type.

Figure 2. An Er-Y garnet laser (right foreground) being used to treat a facial skin condition. The specific wavelengths that Er-doped lasers produce are well suited to ablating surficial organic tissues. Photo by Alice Pien (CC BY 4.0).

Mineralogy

REEs, including Er, co-crystallize in the same minerals due to their geochemical similarities. Ore minerals are typically phosphate or carbonates such as xenotime or parisite, respectively. These occur in exotic intrusive rocks such as carbonatites, peralkaline granitoids, and some types of pegmatites. Other critical minerals that can occur in these rare rock types are fluorspar (CaF_2), barite ($BaSO_4$), niobium (Nb), tantalum (Ta), scandium (Sc), titanium (Ti), and zirconium (Zr). Heavy REE minerals, specifically xenotime and fergusonite, can resist weathering and become concentrated in placer (mineral sands) deposits along with the other REEs: Zr, Ti, Nb, and Ta.

Er has been recovered from unconventional deposits. In southern China, clay deposits formed from tropical

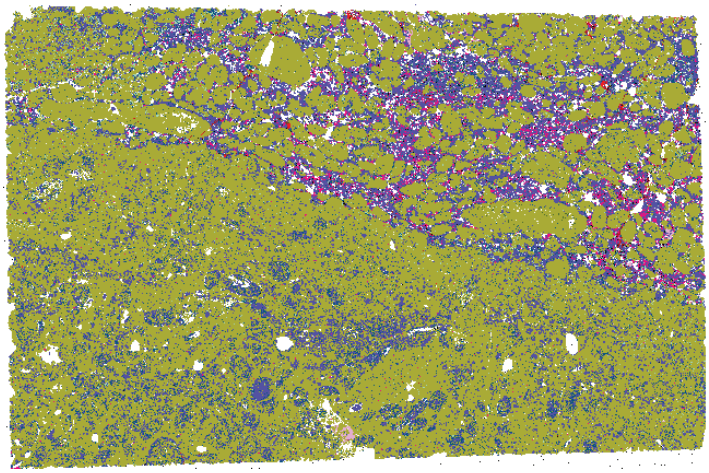

Figure 3. False-color image (taken by scanning electron microscope) of a 4-cm-wide phosphorite sample from Powell Co. Olive green is Er-bearing apatite, blue is quartz, purple is clay, and pink is calcite. Sample has 0.005 wt.% Er. Photo by Adrian Van Rythoven, MBMG.

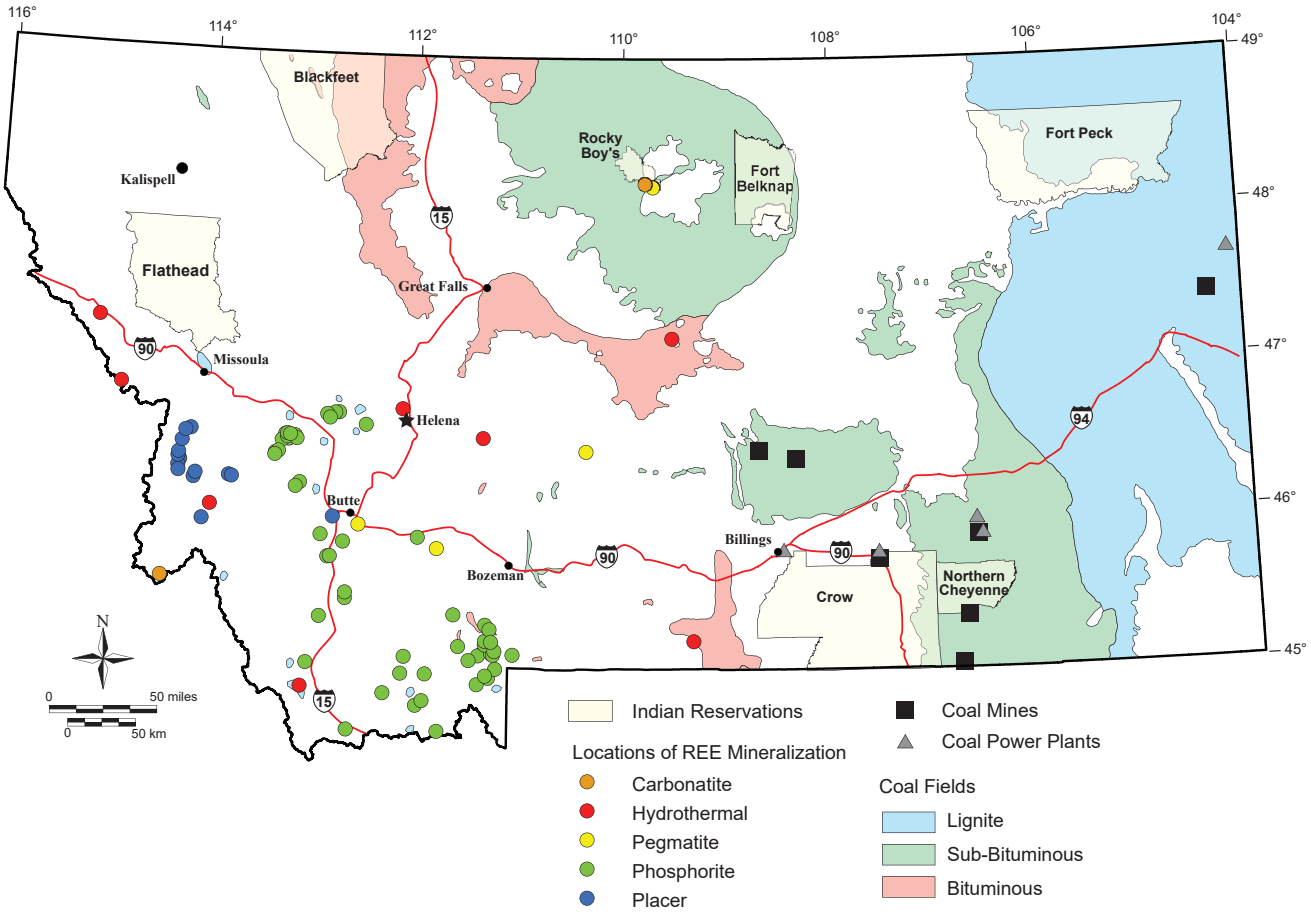

Figure 4. A map of Montana displaying known Er occurrences, coalbeds, coal mines, and coal power plants (both active and inactive, as proxies for coal ash repositories).

weathering hold low-grade, but easily extracted, REEs. Another type of potential REE deposits is phos-phorite, a sedimentary rock. These are typically mined for phosphorous (P), but can also contain high levels of REEs. Other critical minerals that can occur in phosphorite are CaF_2, vanadium (V), chromium (Cr), nickel (Ni), and zinc (Zn). Coal can contain elevated levels of REEs that are then concentrated in coal ash after combustion. Coal, and particularly coal waste, may also be a potential resource for REEs, along with other critical minerals such as germanium (Ge).

Deposits in Montana

Conventional "hard rock" deposits of Er in Montana are best shown by the Sheep Creek carbonatite instrusions in the far southwest of the State (Ravalli County), and the Rocky Boy carbonatite and pegmatite intrusions in the center of the State (Hill and Chouteau Counties). There are a few scattered pegmatite, hydrothermal, and placer deposits in the southwestern quadrant of the State (e.g., Beaverhead County). The most notable of these is the Snowbird deposit on the Idaho border (Mineral County), a hydrothermal fluorite–parisite deposit containing abundant REEs. In addition to the other REE deposit types, phosphorite deposits are scattered throughout this quadrant (Powell, Granite, Beaverhead, Silver Bow, Madison, and Jefferson Counties).

Eastern Montana has vast coal fields, with five current and former coal power plants that represent significant coal ash repositories on or near site. Finally, the more well-known metal sulfide mines throughout the State have a legacy of acid mine drainage that may also have dissolved REEs. The water in the Berkeley Pit in Butte (Silver Bow County) may represent an unconventional Er resource.

Outlook in Montana

Active REE exploration is largely restricted to the Sheep Creek carbonatite. Academic research is focused on Er potential in unconventional deposits such as phosphorite, coal, coal ash, and mine waste. This research could support the exploration and development on such deposits.

About the MBMG

Established in 1919, the Montana Bureau of Mines and Geology (MBMG) continues to fulfill its mandate to collect and publish information on Montana's geology to promote orderly and responsible development of the energy, groundwater, and mineral resources of the State. A non-regulatory state agency, the MBMG provides extensive advisory, technical, and informational services on the State's geologic, mineral, energy, and water resources. The MBMG is increasingly involved in studies of the environmental impacts to land and water caused either by past practices in hard-rock mining or by current activities in agriculture and industry. The Montana Bureau of Mines and Geology is the principal source of Earth science information for the citizens of Montana. More information is available at mbmg.mtech.edu.