July 2024 https://doi.org/10.59691/BUCX8946 Fact Sheet 30

MBMG
Montana Bureau of Mines and Geology

Critical Mineral: Europium

Ryan Davison and Adrian Van Rythoven

Overview

Europium (Eu) is a chemical element included on the United States Geological Survey's 2022 Final List of Critical Minerals. Eu is a lanthanide. It is a light rare earth element (REE). Unlike some other REEs, the terrestrial abundance of Eu is ~0.000009 wt.%, making it truly rare.

The silvery white metal is the softest and most chemically reactive of the lanthanides. Eu compounds are excellent phosphors and are common in lighting and electronic displays.

Figure 1. 300 grams of refined Eu metal held in hand. Photo by Alchemist-hp (CC-BY-SA-3.0-DE).

Supply

Eu is sourced from REE mining. It occurs in ore minerals along with the other REEs. The U.S. imports almost all of its Eu from China, the major miner and refiner. Other entities that refine Eu for export are the European Union, Korea, and Japan. The U.S. produces a small amount of Eu from the one American REE mine at Mountain Pass in California. The only other operating non-Chinese REE mine of note is Mount Weld in Australia.

Given its relative scarcity and specialty uses, there are few data on national Eu reserves. Eu is derived from any deposit where other REEs are also present in economic quantities. Much of the world's Eu is mined from carbonatite deposits and clay deposits in China under environmentally damaging conditions that would not be allowed in the developed world. Average grades of Eu in REE resources range from 0.00001 (Round Top, Texas) to 0.046 (Mt. Weld, Australia) wt.%. The proportion of Eu in the total REE grade is a function of the deposit type. Eu content is typically negligible in all REE deposits except for those hosted in carbonatite. Recent pricing for Eu in 2024 was ~$27/kg Eu_2O_3. Eu prices were much higher, but have fallen in past decades as the main applications for Eu (CRT displays, CFL bulbs) became obsolete.

Figure 2. Eu hydroxide under ultraviolet light, glowing with a reddish color that distinguishes many Eu compounds. Photo by Leo S. (CC-BY-SA-4.0).

Mineralogy

All REEs, including Eu, co-crystallize in the same minerals due to their geochemical similarities. Ore minerals are typically phosphates or carbonates such as xenotime or parisite, respectively. These occur in exotic intrusive rocks such as carbonatite, peralkaline granitoids, and some types of pegmatite. 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). Certain dense 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.

Figure 3. A sample of REE-mineralized carbonatite with ~0.01 wt.% Eu from Ravalli County, Montana. Photo by Adrian Van Rythoven (MBMG).

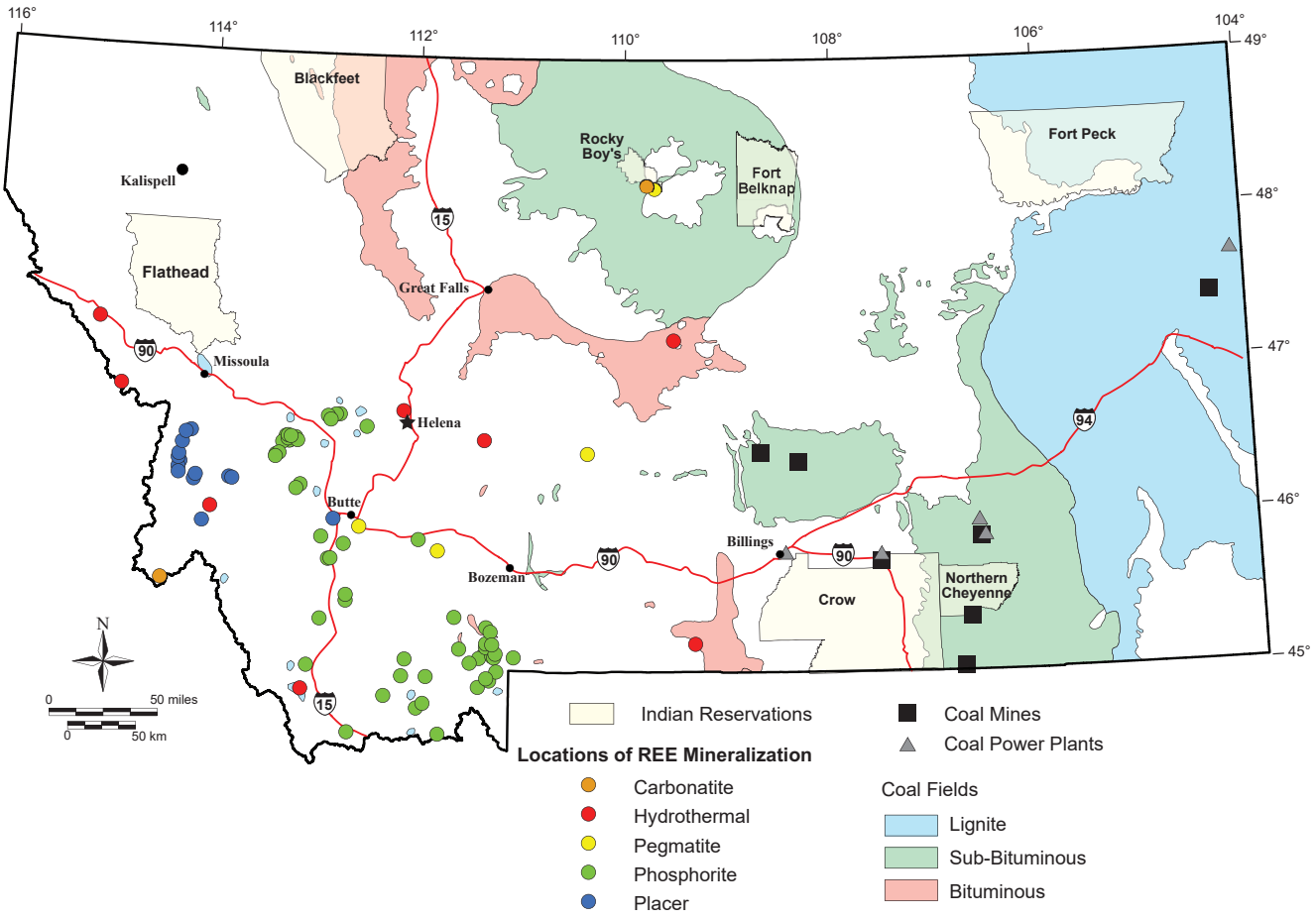

Figure 4. A map of Montana displaying known Eu occurrences, coalbeds, coal mines, and coal power plants (both active and inactive, as proxies for coal ash repositories).

Eu has been recovered from unconventional deposits. In southern China, the aforementioned clay deposits formed from tropical weathering to hold low-grade but easily extracted, amounts of REEs. Another type of unconventional REE deposit is phosphorite, 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 Eu in Montana are best shown by the Sheep Creek carbonatite complex 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. 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 also scattered throughout this quadrant (Powell, Granite, Beaverhead, Silver Bow, Madison, and Jefferson Counties).

Eastern Montana has vast coal fields, with five current or 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 have also dissolved REEs. The water in the Berkeley Pit in Butte (Silver Bow County) may represent an unconventional Eu resource.

Outlook in Montana

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