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MBMG
Montana Bureau of Mines and Geology

Critical Mineral: Yttrium

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Overview

Yttrium (Y) is a chemical element that is included on the United States Geological Survey's 2022 Critical Minerals list. Y is typically grouped with the lanthanides (lanthanum to lutetium on the periodic table) as a rare earth element (REE). It is a silvery transition metal used in LEDs, phosphors, alloys, chemical catalysts, ceramics, nuclear medicine, and optics (primarily lasers). It is also a battery metal, and used in some types of lithium-ion batteries.

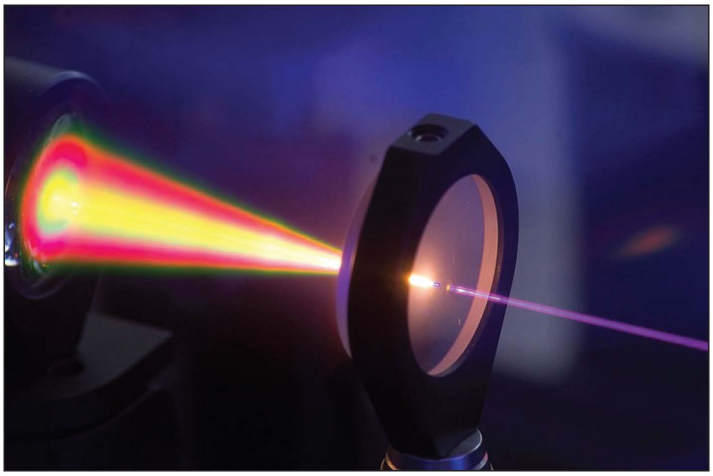

Figure 1. A supercontinuum generated by focusing an 800-nm femtosecond pulsed laser into a yttrium aluminium garnet crystal. Photo by Neath G. (CC BY 4.0).

Supply

Y is sourced from REE mining, and occurs in REE minerals along with the other lanthanides. It is most concentrated in heavy REE deposits also rich in less-abundant terbium (Tb), dysprosium (Dy), and holmium (Ho). The U.S. imports all of its Y from China, the major miner and refiner. Other countries that refine Y for export are Germany, Korea, and Japan. The U.S. produces a near-negligible amount of Y 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.

The U.S. imported about 1,000 tonnes of Y in 2022. Y metal prices averaged $43/kg in 2022. Y is derived from any deposit where any other REEs are also present in economic quantities. Most REEs come from dedicated REE mines, but the world's largest REE mine, Bayan Obo in China, is actually an iron ore mine with REE byproducts. Grades of Y in REE deposits range from 0.007 to 0.5 wt.%. The proportion of Y in the total REE grade is a function of the deposit type.

Mineralogy

REEs, including Y, co-crystallize in the same minerals due to their geochemical similarities. Ore minerals are typically phosphates or carbonates such as xenotime or bastnaesite, 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 the rest of the REEs, fluorspar (CaF_2), barite ($BaSO_4$), niobium (Nb), tantalum (Ta), scandium (Sc), titanium (Ti), and zirconium (Zr). Some Y 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.

Y has been recovered from unconventional deposits. In southern China, clay deposits formed from tropical weathering hold low-grade, but easily extracted, amounts of REEs. Another type of potential REE deposit is phosphorite, a sedimentary rock. These are typically mined for phosphorous (P), but can also contain high levels of REE. Other critical minerals that can occur in phosphorite are CaF_2, vanadium (V), chromium (Cr), 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), gallium (Ga), and indium (In).

Figure 2. Photo of REE-bearing phosphorite rock from the Phosphoria Formation in Granite County. Photo by Adrian Van Rythoven.

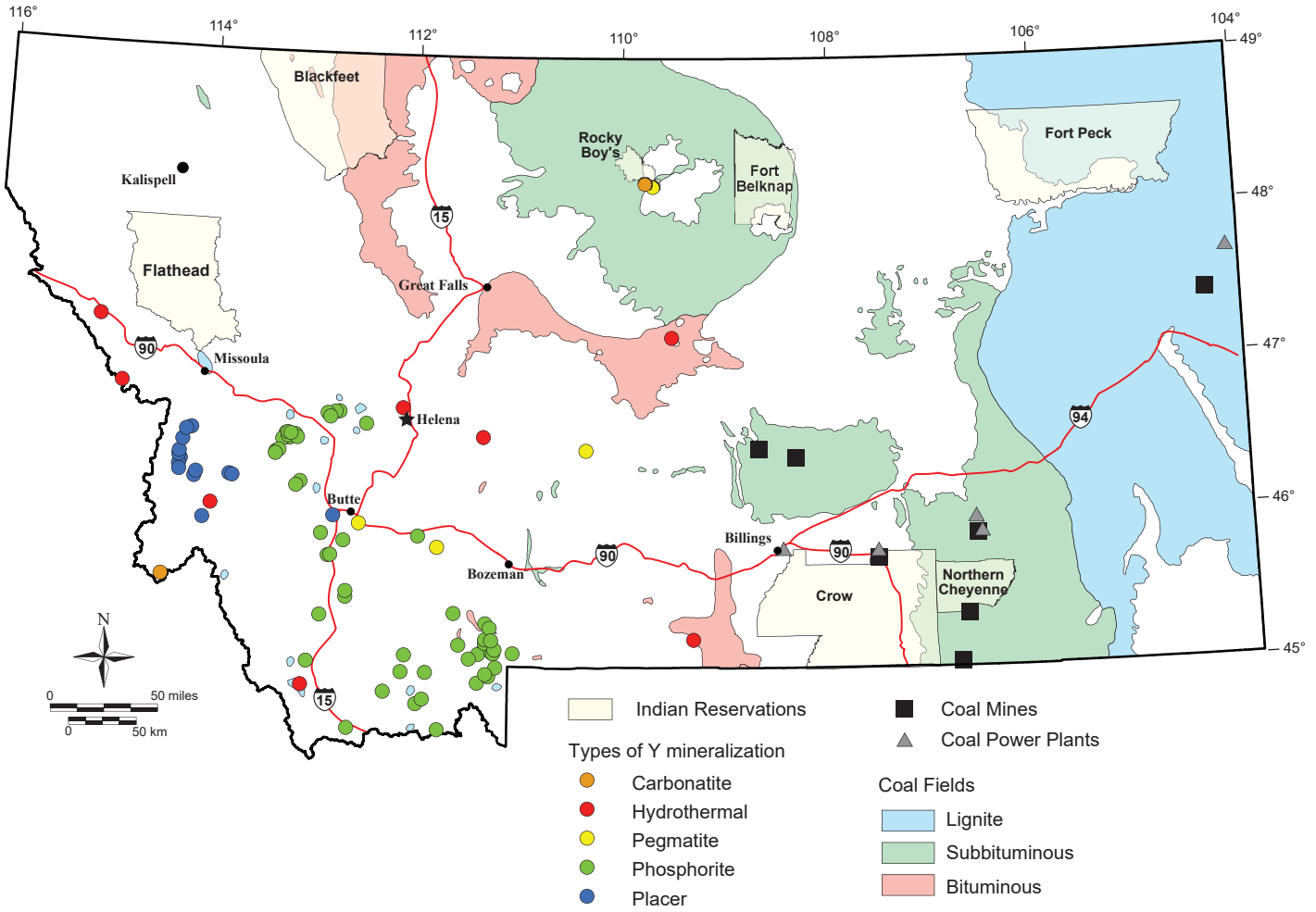

Figure 3. A map of Montana displaying known Y occurrences, coalbeds, coal mines, and coal power plants (both active and inactive, as proxies for coal ash repositories).

Deposits in Montana

Conventional "hard rock" deposits of Y in Montana are best shown by the Sheep Creek carbonatite complex in the far southwest of the State (Ravalli Co.), and the Rocky Boy carbonatite and pegmatite intrusions in the center of the State (Hill and Chouteau Cos.). 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 Co.), a hydrothermal fluorite–parisite deposit containing abundant REEs. Phosphorite deposits are also scattered throughout this quadrant of the State (Powell, Granite, Beaverhead, Silver Bow, Madison, and Jefferson Cos.).

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 have also dissolved REEs. The water in the Berkley Pit in Butte (Silver Bow Co.) may represent an unconventional Y resource.

Outlook in Montana

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

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.