Potential Sources of Critical Mineral Commodities in Montana

Montana Bureau of Mines and Geology

Critical mineral commodities are essential to national security and the U.S. economy. These commodities are used to manufacture everything from electric batteries to computer and car parts to military equipment. Critical mineral commodities are "critical" because their supply is vulnerable to inadequate U.S. reserves and geopolitical complications related to foreign supply chains.

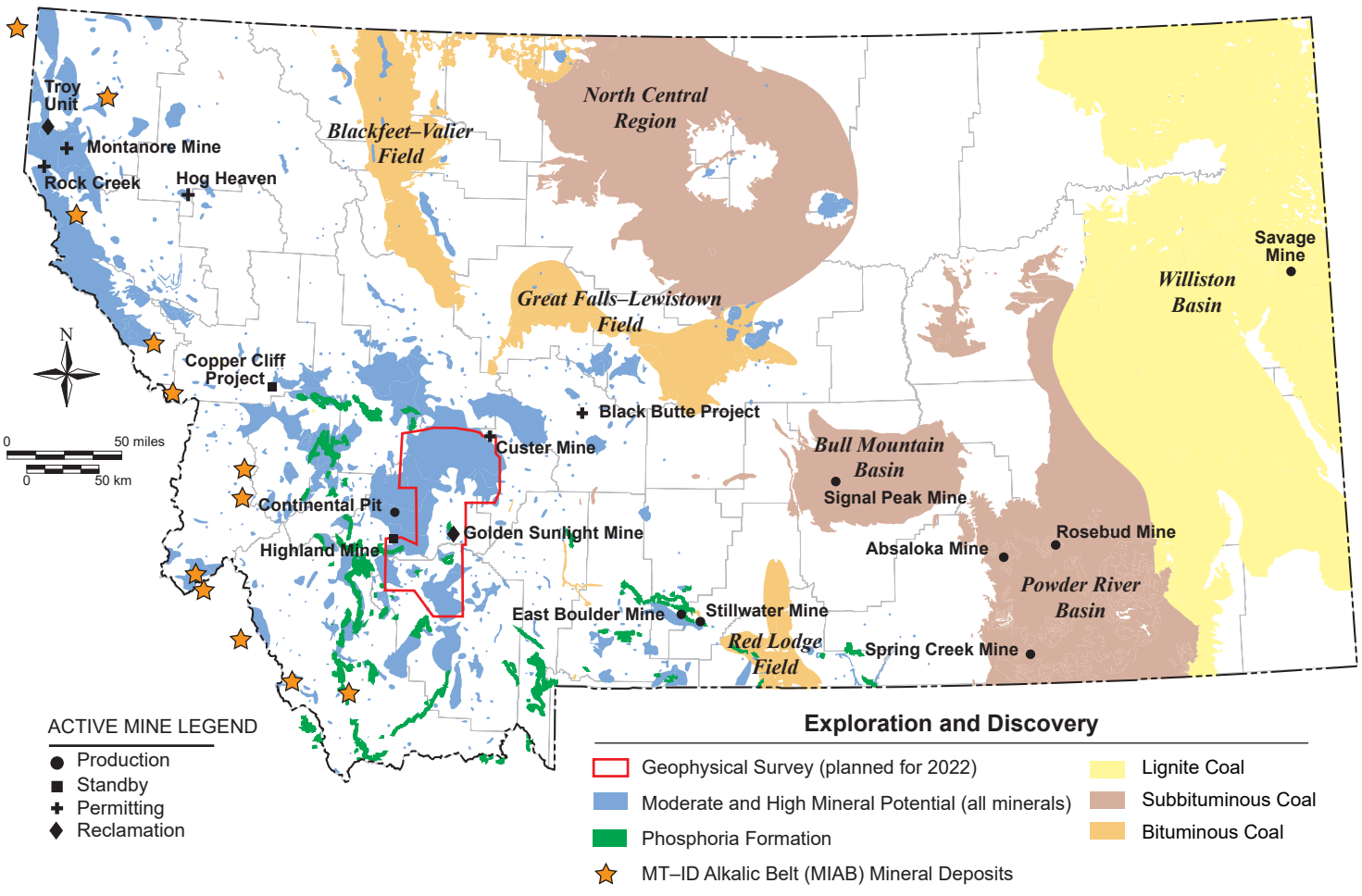
Critical mineral commodities occur as rocks, minerals, or elements that are concentrated in specific rock formations in Montana. The U.S. Geological Survey (USGS) and the White House Office of Science & Technology recently designated a total of 50 commodities, including 15 rare earth elements (REEs, underlined) and platinum group elements (PGEs, italics): aluminum, antimony, arsenic, barite, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, *iridium*, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, *palladium*, *platinum*, praseodymium, *rhodium*, rubidium, *ruthenium*, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium.

Critical Mineral Commodity Potential in Montana

The Montana Bureau of Mines and Geology (MBMG) presents a Critical Mineral Commodity Potential Map for Montana (below) based on in-house records related to historic mineral assessments, our abandoned–inactive mines inventory, and production data from our mine archives database. The MBMG is actively working to update and publicly deliver Montana's historic mining records in the modern context of critical mineral commodity potential.

Blue areas on the Critical Mineral Commodity Potential Map have high to moderate mineral potential for base and precious metals as determined by USGS, U.S. Bureau of Mines, and MBMG field studies conducted in the 1970s and 1980s. The high to moderate potential areas are concentrated in western Montana and are considered "prospective" for critical mineral commodities because many critical commodities may occur in waste piles of historic base metal and precious metal mines throughout the State.

Beginning in 2020, the MBMG has worked with USGS scientists to identify a target region in Montana for a modern airborne geophysical survey. High-resolution geophysical surveys can be thought of as CAT-scans of the Earth's crust and are useful



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tools for locating buried concentrations of metal. The USGS has partnered with a resource company to fly airborne magnetic and radiometric surveys in summer 2022 as part of its Earth Mapping Resources Initiative, in west-central Montana (centered on the Boulder Batholith; red outline in map). The Boulder Batholith is host to many deposits that have yielded precious and base metals, and there is good preliminary evidence of potential to produce critical mineral commodities.

Abandoned Mine Lands (AML)

Critical minerals form and are concentrated by geologic processes identical to those that form precious and base metal ore deposits. The MBMG curates the technical and archived details of the State's mining history for more than 8,000 mines and mills in our Data Preservation Program. An assessment of Montana's AML, specifically clusters of REE occurrences and mining districts with significant historic precious and base metal production, are easy targets for assessing the resource potential for REE and other critical mineral commodities over large swaths of the State. The MBMG plans to sample, describe, analyze, and archive rock from AML sites throughout Montana.

Coal

Coal has had a long history of use for power generation in Montana, and may now play an important strategic role as a source for critical elements. A 2014–2015 DOE–NETL assessment of REEs likely to be found in coal deposits and associated sediments indicated that about 6 million metric tons of REEs could be recovered from coal basins in Montana, Wyoming, Colorado, Utah, New Mexico, and Arizona. Recent analyses of coal chemistry data from the USGS COALQUAL database showed that about 9–13% percent of nationwide coal samples would be classified as "promising" potential sources of REEs. Geoscientists of the North Dakota Geologic Survey recently tested coalbeds and associated sediments in the Fort Union Formation in western North Dakota and found 14% of their samples had total rare earth concentrations higher than 300 parts per million. Elevated concentrations of rare earth elements are likely to exist in coalbeds in eastern Montana as well, but few coal samples from Montana have thus far been tested for REE concentrations. There are plans to sample coalbeds, associated sediments, and coal waste streams in five major coal basins of central and eastern Montana, analyze the samples for REE and other critical element concentrations, and identify the coal-based resources with the most promising potential for REE extraction.

Alkalic Geologic Province along the MT–ID Border

Montana has a favorable geology for REE deposits, including a cluster of mineral deposits enriched in niobium and other REEs that stretches along the Montana–Idaho border from Lemhi Pass, in southwest Montana, to Canada. This recently recognized trend, termed the Montana–Idaho Alkalic Belt (MIAB), connects with the British Columbia Alkaline Province (BCAP), which itself continues northward into the Yukon Territories. Whereas the REE-rich deposits on the Canadian side are in an advanced state of exploration and development, the deposits of the MIAB are poorly understood and underexplored. Having an improved mineral deposit model for REE in the MIAB will greatly improve the odds of success for ongoing and future mineral exploration efforts.

Phosphoria

Rare earth elements are known to occur in the phosphatic shale of the Permian Phosphoria Formation, which occurs as folded, faulted, discontinuous beds in southwest Montana. There are multiple sedimentary beds or members with variable lithologies; the Mead Peak and Retort members are the most important source for phosphate and are estimated to have a total statewide resource of 1.5 billion tons. Phosphate products were typically extracted from the phosphate mineral apatite-(CaF), which is also a known host of REEs. Phosphate beds in Idaho have been sampled and analyzed for REEs; they show an average grade of 1,200 ppm light REE and 600 ppm heavy REE. These same phosphate beds are also located in Montana. There are 11 mining districts within five counties, with 6 districts being past phosphate producers and 5 reporting occurrences. Mapping and sampling of individual phosphatic sedimentary beds is expected to isolate favorable horizons for REE resources within the Phosphoria Formation. Once these favorable sedimentary horizons are identified, these same phosphatic sedimentary beds could be recognized at locations outside the known mining districts. A geologic model for the distribution of REE in the Phosphoria Formation will be developed from the mapping and sampling data.

Waste

Montana, and much of the Northern Rocky Mountains, has a long and varied history of mining activities and ore processing. Mining consists of both underground and open-pit development for coal and metal mining (i.e., gold, silver, copper, lead, and zinc) extending from far northwest Montana to southeast Montana. Associated with the major mine developments are various types of waste deposits, ranging from waste rock and leach dumps to tailings impoundments. Some sites, like the Butte–Anaconda area, also have waste piles from the ore processing facilities that operated near the mining.

Thirteen general study areas have been identified based upon existing knowledge of waste sources and potential volumes. The 13 areas can be grouped into metal mining/processing, phosphate mining/processing, and coal acid mine drainage. Limited information exists for sites within several of the categories, e.g., acid mine drainage from metal and coal mines, while favorable geologic conditions exist for the presence of REE at other sites. A sampling and analysis program will collect and analyze a statistically representative volume of each viable waste source to develop an estimate of REE present in each source for a review of economic potential for recovery.

About the MBMG

The MBMG routinely publishes reports and maps related to all aspects of Montana's geology, hydrogeology, environment, energy, and mining—users purchased or downloaded more than 160,000 of our reports and maps in 2021. Our Data Center provides direct access to our data related to groundwater, abandoned mines, coal, geologic maps, earthquakes, and historic mining. The MBMG Data Preservation Program accessions and preserves historical mining and geology information, and converts it to digital media, increasing its access and use by public and private users from Montana and throughout the country. In 2020, public users accessed the Data Preservation webpage more than 30,000 times, about 1,300 times a month; more than 2,000 users accessed the online database for 27,000 queries. The online presence has certainly increased public awareness of our preservation efforts, which has led to acquisition of several new collections. Development of more sophisticated digital processing and online archival information availability increased the demand for our data from government agencies, consulting firms, private geologists, and the public.