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Montana Bureau of Mines and Geology

Critical Mineral Commodity Potential in the Butte Mining District

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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.

The Butte Mining District is a 25-square-mile area in the southern extent of the Boulder Batholith that includes the city of Butte, Montana. The ores beneath Butte formed in what is termed a zoned porphyry copper–molybdenum deposit. The ore zones are defined by the assemblage of minerals found in each part of the district—consequently, the mines produced different ores depending on their location. The mines in the central zone (e.g., Kelley, Granite Mtn, Pilot Butte, Belmont, and Steward mines) produced predominantly copper; mines in the intermediate zone (e.g., Anselmo, Emma, Ophir, and Travona) produced predominantly zinc and/or manganese; and mines in the peripheral zone (e.g., Marget Ann and Orphan Girl/Boy) produced predominantly manganese and silver. Earning its reputation as the “Richest Hill on Earth,” the mines of Butte produced 21 billion pounds of copper between 1889, when the camp was consolidated, and 1982, when underground mining was suspended (selective vein mining was suspended in 1977). Far from being “mined out,” the Butte Mining District has remaining ore reserves in excess of 400 million tons—which includes a suite of critical mineral commodities.

Critical Commodities Produced (1880–1972)

Bismuth	4.0 million pounds
Manganese	3.7 billion pounds
Tellurium	0.2 million pounds
Zinc	4.9 billion pounds

Features of the Butte Mining District.

The Butte Mining District also hosts critical commodity minerals that were never produced; commodity price and production costs typically limit their development. Exploration of a complex ore deposit includes inventory, examination, and assessment of secondary and gangue minerals not likely to be processed; however, several of these non-economic minerals and elements have recently joined the list of critical commodities. For example, germanium is found as a trace element in sphalerite (zinc ore) and enargite (copper ore); however, processing these ores did not capture germanium. Thus germanium remained in the process waste (tailings or slag); as demand and technology change, the ore deposit with sphalerite and enargite and the waste hold potential for economic development.

Critical Commodities Reported, No Production

- Antimony in tetrahedrite
- Germanium in sphalerite and enargite
- Indium in sphalerite
- Tungsten in scheelite
- Vanadium in colusite

Although the underground workings and Berkeley Pit were allowed to flood, Montana Resources resumed mining the Continental Pit in 1986. The waters flooding the underground mines, the flooded Berkeley Pit, and 100 years of accumulated waste rock required extensive reclamation over the past 40 years, but they may also provide an opportunity to support the recent demand for critical mineral commodities. Similar to the produced ore, zinc is found in high concentrations in waters throughout the district. Dissolved zinc concentrations in mine waters range from 630 parts per million (ppm) in the Berkeley Pit to 150 ppm in the Kelley mine shaft, to 50 ppm in the Steward mine shaft. Economic recovery levels will depend on extraction methods, but one indication may be the waste sludge generated by the water treatment. Zinc concentration in the sludge, for example, is about 4.3%, and minimum ore grade is about 3%—again, the final economic value lies in the method of extraction.

Rare Earth Elements in the Butte Mining District

Historic data related to REEs in ores of the Butte Mining District, if collected, are not available; future examination will have to rely on specimens and core samples. Recent interest, however, has prompted sampling of waters and waste in the mined area. Water samples from the Berkeley Pit, leach pads at Montana Resources, and sludge from the Horseshoe Bend Water Treatment Plant suggest moderate to high potential for economic REE concentrations.

Several areas within and adjacent to the Montana Resources Continental Pit active mine area, including the Berkeley Pit, are available for further sampling and analysis to determine REE potential from inactive and active mining operations. The figure on the previous page identifies those sites. Sites include water, treatment plant sludge, historic leach material, mill tailings (Yankee Doodle Tailings), and Berkeley Pit waste (NW Dumps). The ore deposit size and grade, extraction and production costs, and market value determine the economic threshold of critical minerals, particularly REEs. Total REE concentrations greater than 300 ppm are typically considered viable for economic development.

Berkeley Pit, spring 2017.

Concentrations of REEs in selected waters of the Butte Mining District.

Site/Analyte	Nd (µg/L)	Eu (µg/L)	Tb (µg/L)	Dy (µg/L)	Er (µg/L)	Y (µg/L)	Ce (µg/L)	La (µg/L)	TREE* (µg/L)
Berkeley Pit	629	39	38	250	155	1,411	1,303	330	**4,950**
MR Leach Pad Water	411	21	19	122	72	NA	674	150	**1,890**
HsB Sludge**	50,000	3,200	3,100	21,000	13,000	113,000	102,000	26,000	**397,820**

Note. NA,not analyzed.

*TREE, total rare earth element concentration for all REE analyzed.

**HsB Sludge, concentrations of REE from water treatment plant stage 1 sludge.

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.