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MBMG
Montana Bureau of Mines and Geology

Critical Mineral: Germanium

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Overview

Germanium (Ge) is a chemical element that is included on the United States Geological Survey's 2022 Critical Minerals list. Ge is a lustrous, hard-brittle metalloid that is used in many technology applications, including semiconductors, solar cells, fiber optics, polymerization catalysts, and infrared optics. Fiber optic cable manufacturing accounts for one-third of global demand.

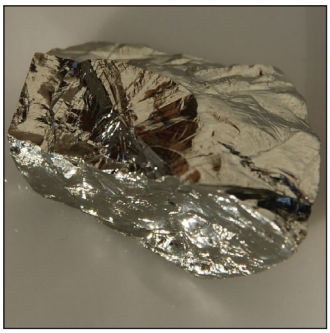

Figure 1. A 12-gram piece of refined Ge metal. Ge is also used in oxide form for some applications. Photo by Hi-Res Images of Chemical Elements (CC BY 3.0).

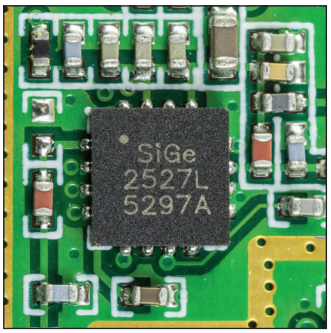

Figure 2. Silicon (Si) and Ge are often alloyed (called SiGe) to create semiconductor chips in modern electronics, such as in this circuit board for a WiFi card. Photo by Raimond Spekking (CC BY-SA 4.0).

Supply

Ge is primarily sourced from zinc (Zn, also a critical mineral) refinery residue and coal fly ash. Ge recycling, including of military surplus materials, is an important and growing secondary source of the element, with approximately 30% of the global Ge supply derived from recycled materials. China and Russia are the dominant producers of Ge worldwide, with both countries sourcing Ge from Zn refining and coal ash. Top Ge refiners are China, Belgium, Germany, and Canada. The United States has some Ge mining and refining capability, with Zn mines in Tennessee and Alaska producing byproduct Ge. Other Zn mines in the U.S. could contain Ge resources as both unmined ore and mine waste (tailings, slag, waste rock). Similarly, coal ash piles in the country could also be Ge resources. The U.S. imported 14,000 kg of Ge metal and 15,000 kg of Ge oxide in 2022, which represents over half of domestic consumption in the same year. Ore grades range from about 0.01 to 1.6 wt.% Ge, depending on the material. Ge metal prices ranged from $1,100 to $1,470 per kg in 2022. Price fluctuations are driven by global supply/demand for Ge and affect the economics of any deposit, but as Ge is typically a byproduct, the price for the main product of any mine is the dominant factor.

Mineralogy

Ge most commonly occurs as a trace component in sphalerite (Zn sulfide, a Zn ore), and very rarely as discrete Ge sulfide minerals such as renierite, germanite, briartite, and argyrodite. Ge is also present in coal at elevated amounts, and it thus significantly concentrated in the residual ash from burning that coal.

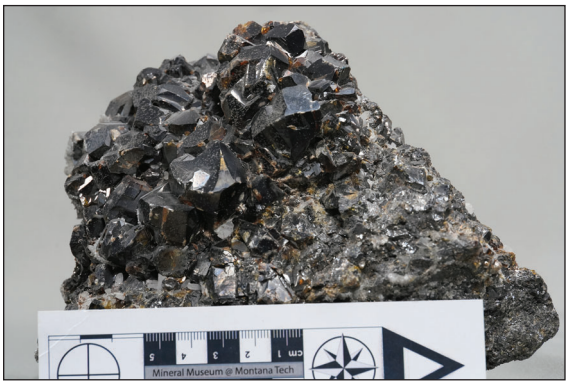

Figure 3. A specimen of sphalerite from the Ruby Mine, Jefferson County, Montana. Photo by Dr. Steven Quane.

Metal sulfide deposits are important sources of Ge, including Mississippi Valley-type Pb-Zn deposits, skarns, sedimentary exhalative, stratiform sediment-hosted copper, and polymetallic vein deposits.

Critical minerals that can occur with Ge in hydrothermal sphalerite deposits or coal include gallium (Ga) and indium (In). Other critical minerals that could also occur alongside sphalerite are arsenic (As), barite ($BaSO_4$), bismuth (Bi), cobalt (Co), tellurium (Te), and antimony (Sb). Rare earth elements (REE) may also occur with Ge in coal or coal ash. In addition to Zn mines, deposits with any significant metal sulfide content have the potential to produce Ge as a byproduct.

Deposits in Montana

Central and eastern Montana have significant deposits of bituminous, subbituminous, and lignite coal. The concentration of Ge in these deposits is not fully known. However, U.S. Geological Survey data suggest that levels of Ge are elevated. A history of coal power generation also provides coal ash deposits in eastern Montana. These could be potential Ge resources as well.

Figure 4. A subbituminous coal sample approximately 5" x 5" from the Dietz Bed of the Spring Creek Mine, Big Horn County, Montana. Photo by Ryan Davison, MBMG.

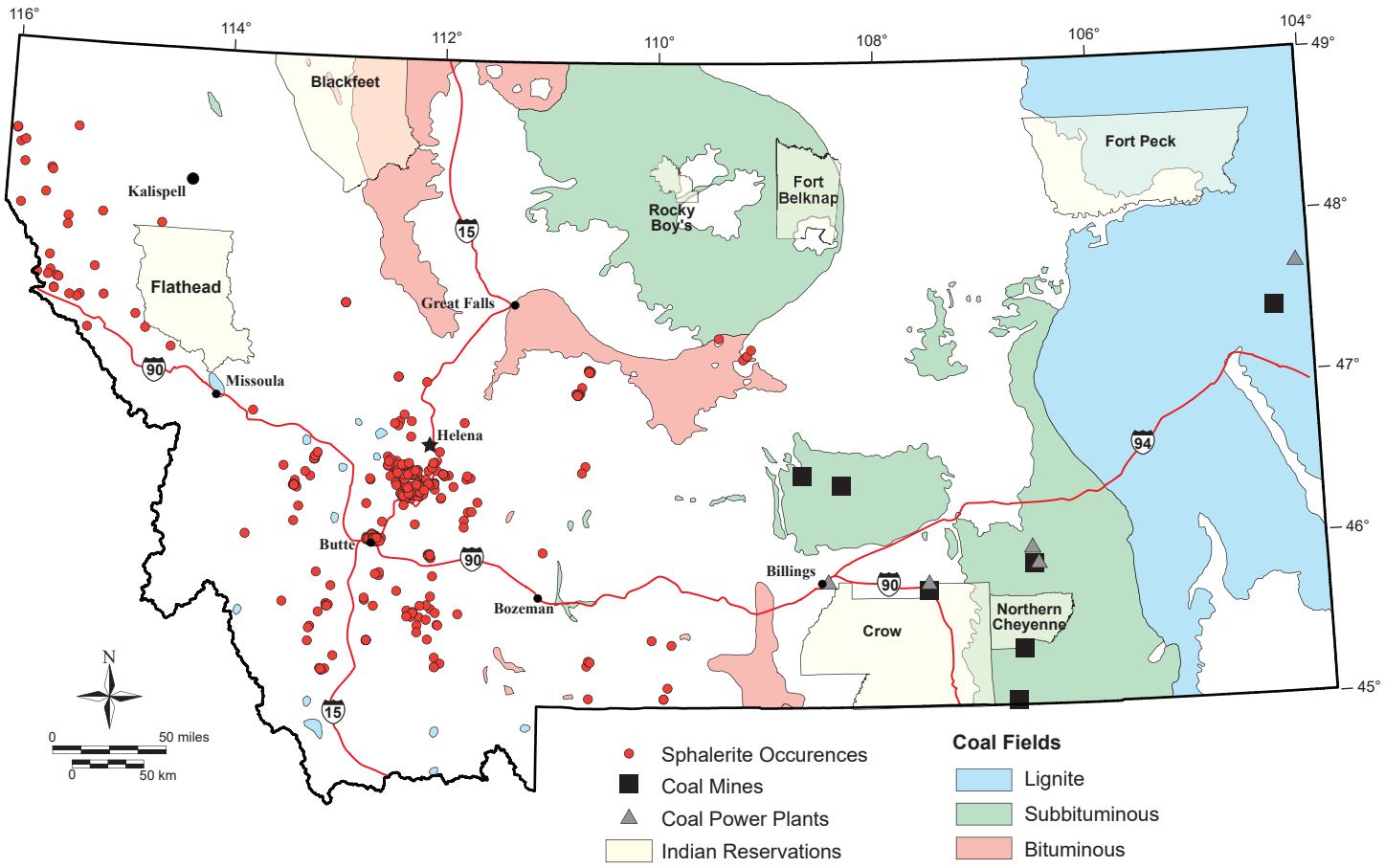

Figure 5. Known sphalerite occurrences, coalbeds, coal mines, and coal power plants (both active and inactive, as proxies for coal ash repositories) in Montana.

Western Montana has a large variety of sphalerite-bearing skarn and polymetallic vein deposits that could present potential Ge resources. In the Butte District alone (Silver Bow County), there are dozens of former polymetallic sulfide mines with reported sphalerite production. However, the currently operating Continental Pit is a porphyry-type deposit that is not typically associated with Zn (or Ge). Similarly, the historic mines of the Philipsburg District (Granite County) are prospective for Ge mineralization.

Other places with the potential for Ge mineralization are sediment-hosted deposits in Lincoln, Sanders, and Meagher Counties. Former gold–silver mines in Jefferson and Broadwater counties are also prospective for Ge.

Outlook in Montana

No Ge-specific mineral exploration, development, or mining is underway in Montana. Current mineral exploration and development in the State that could reasonably discover Ge includes examination of underground prior mine workings in the Butte district and development of mines in the northwestern part of the State. While primarily a copper (Cu) development, the Black Butte project in Meagher County has many sphalerite occurrences peripheral to the main Cu deposits. These have yet to be evaluated for Ge or other related critical minerals.

Coalbeds around the State are currently being analyzed for Ge potential. Coal ash is stockpiled in ponds or landfills on a handful of sites near current and former power plants in the eastern half of the State.

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.