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Mineral Deposits of Beaverhead County, Montana

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INTRODUCTION

The complex geologic history of Beaverhead County in southwestern Montana has generated a variety of ore deposit types, and yielded major historic production of gold, silver, copper, lead, and zinc, with lesser tungsten, antimony, bismuth, iron, manganese, molybdenum, nickel, tin, phosphorus, and vanadium reported. Famous historic mining districts in the county include Bannack (placer gold), Argenta (silver), and Hecla/Bryant (silver, lead, zinc), and part of the Ruby District (Ruby Range) extends into Beaverhead County and contains industrial minerals such as talc, graphite, garnet, corundum, and vermiculite (fig. 1; Geach, 1972). Much of the base and precious metal mineralization in Beaverhead County is derived from magmatic-hydrothermal activity associated with intrusion of the granitic Late Cretaceous Pioneer Batholith (80–64 Ma; Scarberry and others, 2020).

GEOLOGY OVERVIEW

The geology of Beaverhead County includes Archean schists, gneisses, and marbles; Precambrian argillites, siltites, and quartzites of the Belt Supergroup; and the Paleozoic–Mesozoic marine and terrestrial sedimentary sequence found throughout southwestern Montana. The Sevier–Laramide Orogeny created a fold and thrust belt that deformed all existing rock types, and this was accompanied by the intrusion of magmas and volcanic eruptions. During the Cenozoic, extension superimposed Basin-and-Range-style block faulting onto existing structures and additional volcanism occurred. Recent sediments have been deposited in the basins that separate the mountain ranges of Beaverhead County.

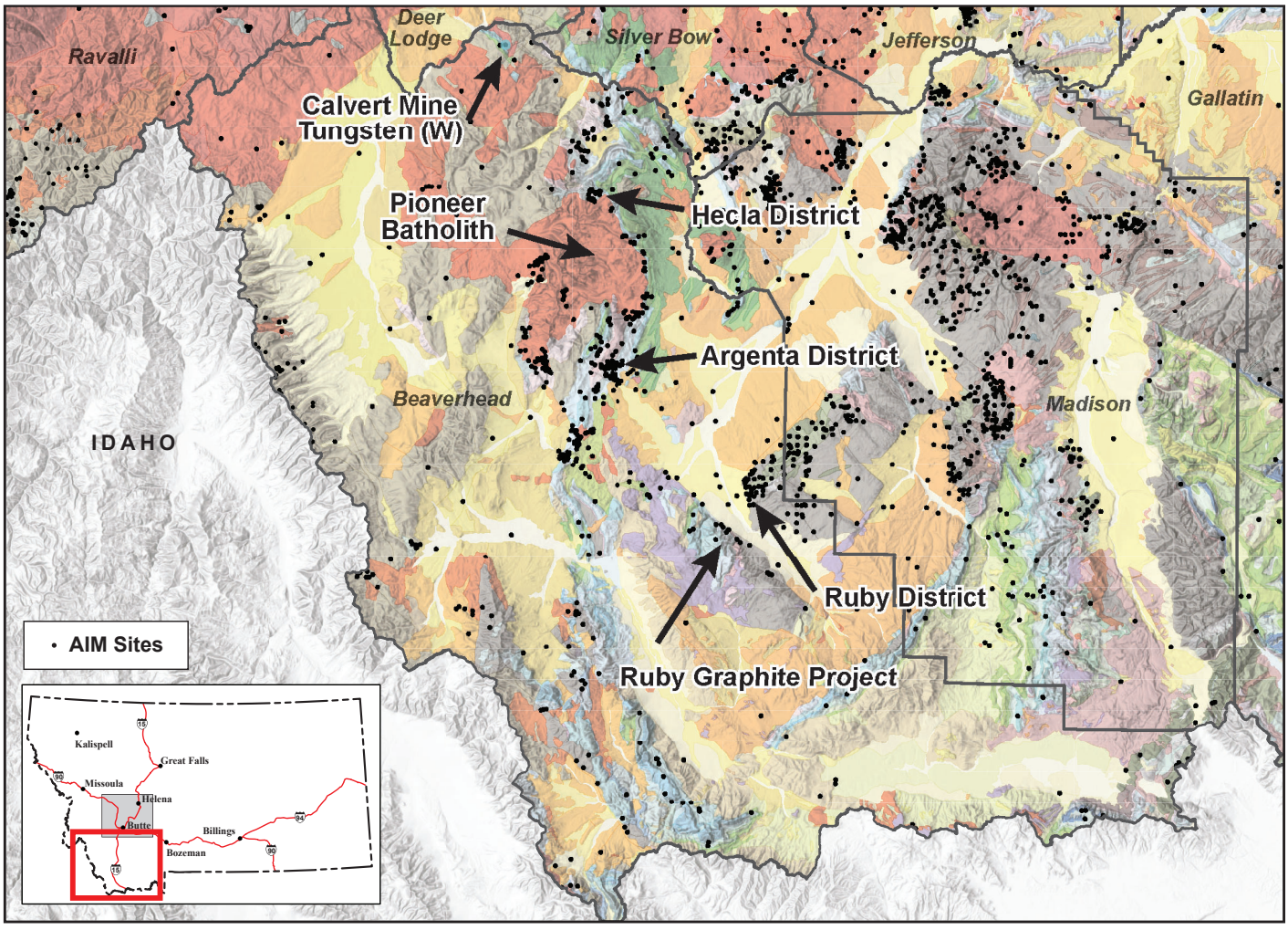

Figure 1. Overview map of Beaverhead County, showing bedrock geology (Vuke and others, 2007), important mining districts and mine sites, and abandoned and inactive mine (AIM) sites (black dots).

Figure 2. View of the Calvert Hill tungsten skarn and pit lake. Photo by Kyle Eastman, MBMG.

THE PIONEER BATHOLITH AND MINERALIZATION

Intrusion of granitic magmas during the Late Cretaceous created hydrothermal and contact metamorphic ore deposits, including porphyry–epithermal gold–copper–molybdenum (Au-Cu-Mo) mineralization, skarns (commonly W), and distal carbonate replacement Ag-Pb-Zn deposits. Porphyry Mo deposits are present in Beaverhead County, and represent the northern extent of the "White Cloud–Cannivan porphyry Mo belt" (Armstrong and others, 1978), which extends SW–NE across the Idaho border. The Cannivan Gulch porphyry Mo deposit hosts 300 million tons at 0.06% Mo (Worthington, 2007). Porphyry deposits of the Pioneer Batholith are more commonly Mo deposits, whereas Cu dominates the porphyry systems in the Boulder Batholith. Similarly, the skarns associated with the Pioneer Batholith are commonly W skarns, whereas the Boulder Batholith generated more Au-Cu skarn deposits and fewer W skarns (Gammons and others, 2020). The Lentung and Calvert Hill skarns (fig. 2) are notable W deposits in the Pioneer Mountains.

CASE STUDIES—HISTORIC DISTRICTS

The most important historical producers in Beaverhead County are the Bannack District (placer gold), Argenta District (lode Ag-Pb), and the Hecla/Bryant District (lode Ag-Pb-Zn). Placer gold was discovered at Grasshopper Creek in what would become the Bannack District in 1862, and lode deposits of gold, silver, lead, zinc, and copper were discovered in the area (Albright, 2004). The Grasshopper Porphyry prospect, east of Bannack, is a well-zoned Cu-Mo-Au-Ag porphyry centered around a dacite intrusion (Meyer, 1980). At Argenta, argentiferous galena veins were mined and a large but low-grade porphyry Cu system is known to exist (Gammons and others, 2020). The Ag-Pb-Zn carbonate replacement ore deposits of the Hecla (Bryant) District (fig. 3) are derived from magmatic-hydrothermal fluids associated with an intrusion at depth (Eastman and others, 2016).

Figure 3. Mine waste piles at the Ag-Pb-Zn Hecla District. Photo by Kyle Eastman, MBMG.

FUTURE CRITICAL MINERALS POTENTIAL

The Montana Bureau of Mines and Geology (MBMG) is researching the occurrence, distribution, and genesis of critical commodities—those mineral materials essential to the economic and national security of the United States. The MBMG also collaborates with Montana Tech and other academic programs to provide hands-on training for students interested in critical commodity exploration and geologic mapping.

In Beaverhead County, potential critical commodities include graphite (fig. 4), tungsten (W), zinc (Zn), manganese (Mn), arsenic (As), antimony (Sb), bismuth (Bi), tellurium (Te), indium (In), gallium (Ga), and germanium (Ge). Many of these elements are byproduct commodities in porphyry-epithermal or skarn mineralization that is associated with intrusion of the Pioneer Batholith granitic magmas.

Rare earth elements (REE) occur in the Phosphoria Formation, which was previously mined for phosphorous (P) at the Canyon Creek, Maiden Rock, and other smaller mines throughout the county (Emsbo and others, 2015). The Phosphoria Formation extends northward to Silver Bow County, eastward to Madison County, and southward into Idaho. The Phosphoria Formation may also be a potential source of the critical minerals vanadium (V), chromium (Cr), nickel (Ni), and Zn. A few REE placer deposits can be found along the Montana–Idaho border, where there are well-documented bedrock deposits (e.g., Austin and others, 1970), and similar deposits may occur on the Montana side of the border.

GEOPHYSICAL SURVEYS

The MBMG and the U.S. Geological Survey have partnered to image geology using airborne geophysical techniques. In 2022, a geophysical survey was flown for the eastern portion of the Boulder Batholith, and the summer 2023 survey expands that area to cover portions of the Pioneer Mountains in Beaverhead County, as well as the Flint Creek Range, Boulder Mountains, and Butte District (fig. 5). This new survey covers 2,700 square miles, and collects magnetic and radiometric data types that will inform the MBMG's geologic mapping, critical minerals, geohazards, and groundwater programs. A low-flying helicopter with an

Figure 4. A 1-cm-thick graphite vein from Eastern Property (Ruby Graphite Project). Photo courtesy of Reflex

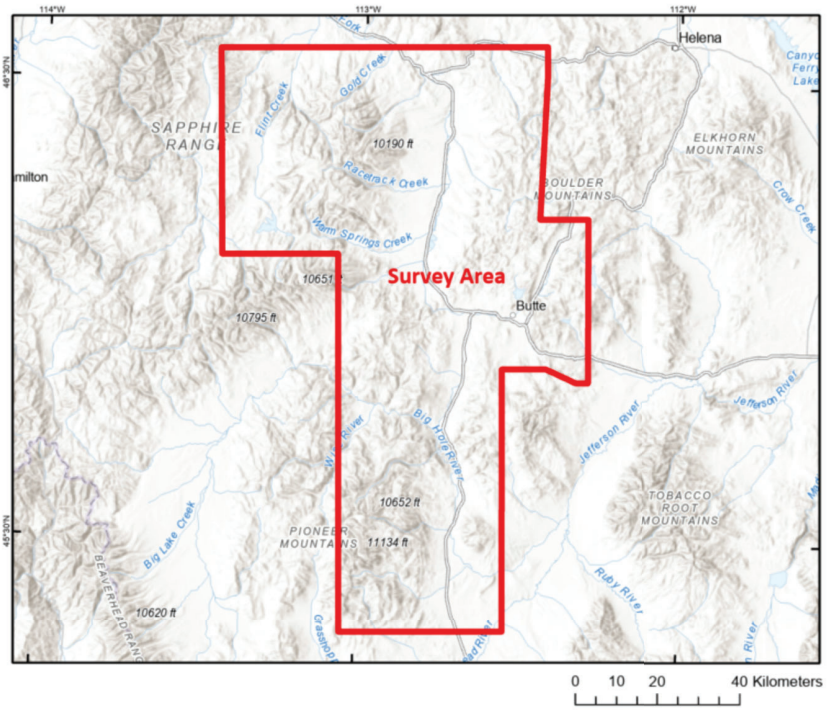

Figure 6. The summer 2023 geophysical survey area.

instrument attachment may be observed in the area during summer 2023; the instruments are passive with no emissions that pose a risk to humans, animals, or plant life, and no photography or video data will be collected.

Scan the QR code to visit the USGS News Release on this geophysical survey:

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.

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