



Critical Mineral: Cobalt

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Overview

Cobalt (Co) is a chemical element that is included on the United States Geological Survey's 2022 Critical Minerals list. Co is a very hard and lustrous silver-colored metal in its pure form. Co or Co-bearing compounds are used in hardened metal alloys, magnet alloys, lithium (Li)-ion battery cathodes (as Co-oxide), other rechargeable batteries, catalysts, pigments, and micronutrients.



Figure 1. A 3-gram fragment of refined Co metal. Photo by *images-of-elements.com* (CC BY 1.0)

Supply

The world's largest Co reserves are in the Democratic Republic of the Congo (DRC) at 4 Mt (million tonnes). Australia is a distant second with 1.5 Mt. Indonesia, Cuba, and the Philippines complete the remaining top five for Co reserves. It should be noted that much of the Co mined in the DRC is done so under environmentally damaging, primitive, and exploitative conditions that would be illegal in the USA. Co mined under these unethical conditions is then blended with Co produced under more ethical terms, before being used in manufactured goods.

The DRC was by far the largest Co producer in 2022, with 130 kt (thousand tonnes). Indonesia (10 kt), Russia (8.9 kt), Australia (5.9 kt), and Canada (3.9 kt) were other significant producers.

In comparison, the U.S. has 69 kt of reserves (mostly in Minnesota, Michigan, Idaho, Alaska, Missouri, and Montana). Only 800 t of Co was domestically mined in



Figure 2. A Co cutting tip used in millwork to shape metals. Photo by *Metrónomo* (CC-BY-SA-4.0)

2022. There is one sporadically operating primary Co mine in Idaho, but most other domestic sources of Co production are mines with it as a byproduct from nickel (Ni) and/or copper (Cu) mining. Recycling is an important source, contributing 1,900 t domestically in 2022. For comparison, domestic recycling and mining only total 25% the amount of Co imported in the same year.

Pricing for Co was around \$30/lb in 2022, up from \$24/lb the prior year, and was \$15/lb the year before that (2020). Most recently, the price in 2023 was back down to ~\$15/lb. Reported Co grades from deposits range from 0.01 wt.% in the Duluth Complex (Minnesota) to 1.72 wt.% at Kisanfu (DRC).

Mineralogy

Co can be found as primary ore minerals, typically with sulfur and/or arsenic (As), such as cattierite, siegenite, cobaltite, safflorite, or skutterudite, that can weather to blue-green heterogenite or bright pink erythrite. It can also occur as impurities in pyrite, arsenopyrite, coronadite, or hollandite.

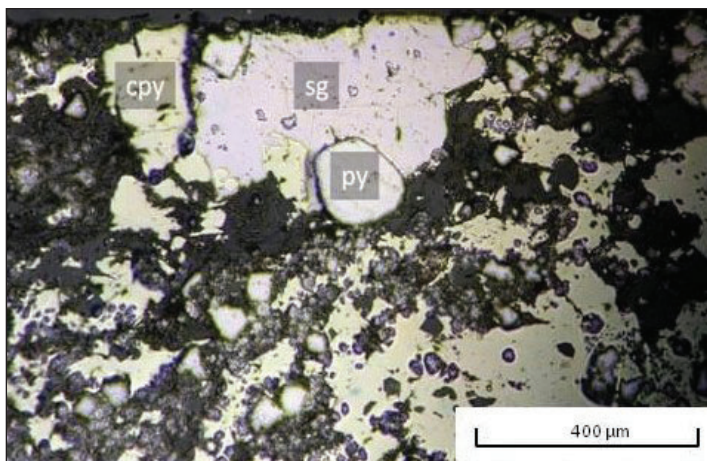


Figure 3. A reflected light photomicrograph of ore from the Black Butte Cu Project, Meagher Co. Labeled are siegenite (sg), chalcopyrite (cpy), and pyrite (py). Photo by *Joshua White* (2012).

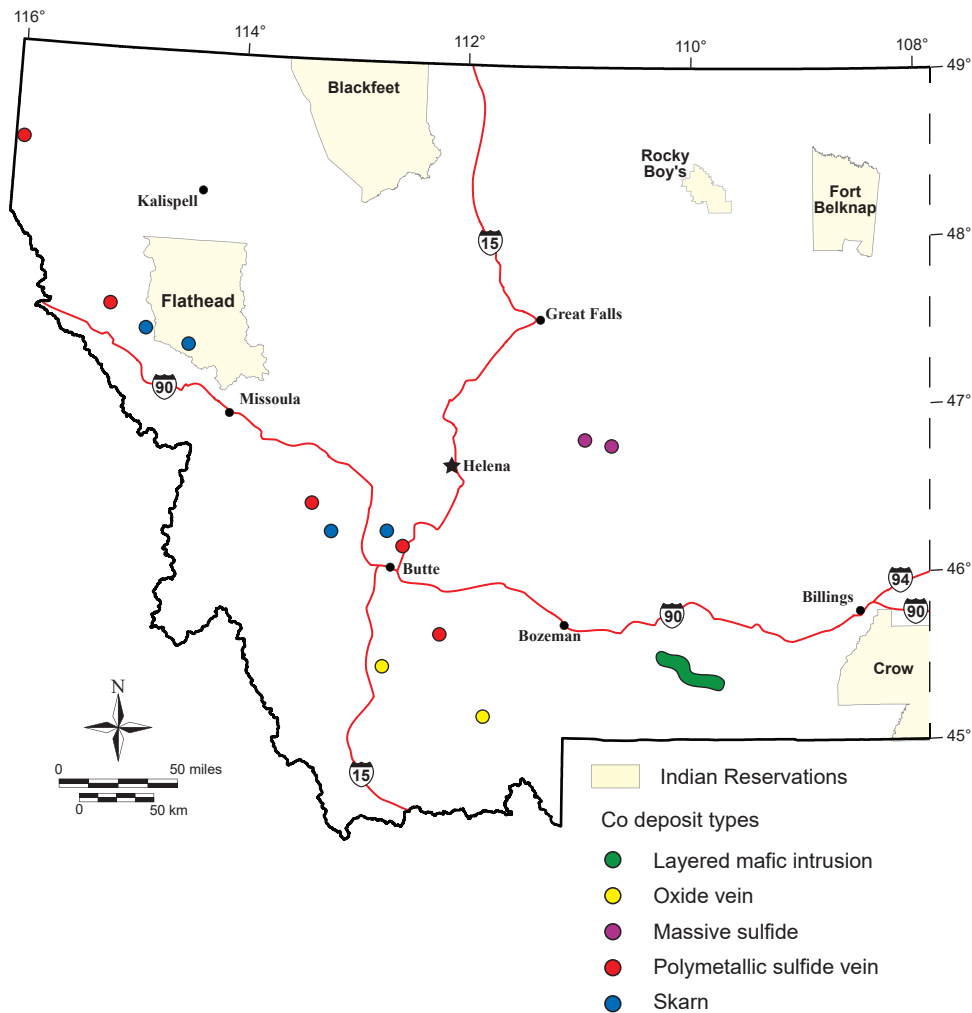


Figure 4. A map of western Montana displaying locations of prospective Co mineralization.

Other commodities that are typically found with Co are the critical minerals Ni, As, platinum group elements (PGEs), bismuth (Bi), manganese (Mn), antimony (Sb), and zinc (Zn). Other associated non-critical commodities are gold (Au), silver (Ag), lead (Pb), uranium (U), and Cu.

Deposit types with Co are laterites, polymetallic sulfide veins, oxide veins, skarns, massive sulfides, and layered mafic intrusions. Deposits mined primarily for Co are typically laterites or sulfide deposits.

Deposits in Montana

The largest concentration of Co mineralization in Montana is in the Stillwater layered mafic intrusion (Stillwater, Sweet Grass, and Park Counties). Oxide vein deposits of Co with Mn, U, and As are in Madison and Beaverhead Counties. Polymetallic vein and skarn deposits with reported Co are in Silver Bow, Granite, Madison, Sanders, Missoula, Lincoln, and Mineral Counties. Of specific note are massive sulfide deposits with Cu and Co in Meagher County.

Outlook in Montana

The only mineral exploration in Montana where Co is a targeted commodity is the Stillwater West Ni-Cu-Au-PGE-Co project (Sweet Grass and Stillwater Counties), where an inferred resource containing 51 kt Co has been reported (at 0.2 wt.% Co). Recovery of Co during Cu processing is being investigated at the Black Butte Cu project in Meagher County. There are also many mine waste sites throughout southwestern Montana that have potential for Co (and other critical mineral) recovery if they were reprocessed.

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.