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MBMG
Montana Bureau of Mines and Geology

Critical Mineral: Nickel

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Overview

Nickel (Ni) is a chemical element included in the United States Geological Survey's 2022 Final List of Critical Minerals. Pure Ni is a hard, silver-colored metal with a golden tinge. Ni is primarily combined with iron (Fe) to make stainless steel and other alloys. The element is also used for chemicals, rechargeable batteries, magnets, and corrosion-resistant plating.

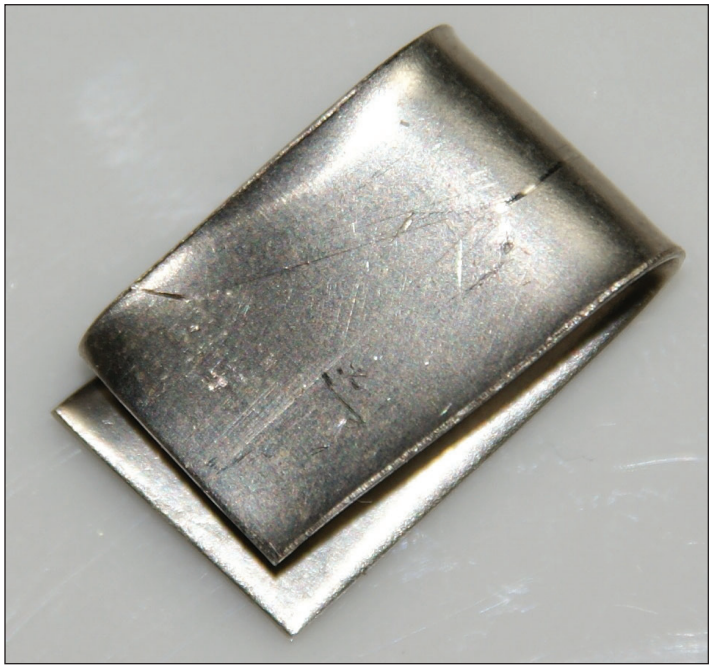

Figure 1. A 1 cm x 2 cm piece of refined Ni metal. Photo by images-of-elements.com (CC-BY-3.0).

Supply

The world's largest Ni reserves are in Indonesia at 55 Mt (million tonnes). Australia is a distant second with 24 Mt. Indonesia was also the largest Ni producer in 2023, with 1.8 Mt. The Philippines (0.4 Mt), New Caledonia (0.23 Mt), Russia (0.2 Mt), and Canada (0.18 Mt) were other significant producers. In 2020, Indonesia banned the export of raw Ni ore, citing missed realization of value from refining.

In comparison, the U.S. has 0.34 Mt of reserves (mostly in Minnesota, Michigan, Idaho, Alaska, Missouri, and Montana). Only 0.017 Mt of Ni was domestically mined in 2023. There is one primary Ni-Cu mine in Michigan, but most other domestic sources of Ni production are mines with it as a byproduct from copper (Cu), cobalt (Co), and/or platinum group elements (PGE) mining. Recycling is an important source in the U.S., accounting for ~57% of total domestic consumption (0.19 Mt).

Pricing for Ni was around $9.80/lb in 2023, down from $11.71/lb the prior year, and was $8.38/lb the year before that (2021). Reported Ni grades from deposits range from 1.2 wt.% in low-grade laterites to 6.5 wt.% in massive sulfides at the Eagle Mine (Michigan).

Figure 2. A Ni-metal hydride (NiMH) battery pack from a portable printer. NiMH batteries have about one-third the voltage of Li-ion batteries, but are much cheaper and safer. Ni is also used in the cathodes of some Li-ion batteries as well. Photo by Raimond Spekking (CC-BY-SA-4.0).

Mineralogy

Ni can be found as primary ore minerals, typically with sulfur, antimony (Sb), and/or arsenic (As), such as pentlandite, millerite, heazlewoodite, breithauptite, or nickeline, that can weather to green garnierite, purple violarite, or metallic awaruite. It can also occur as impurities in galena or limonite. Early society first encountered natural Fe-Ni alloys in meteorites.

Other commodities that are typically found with Ni are the critical minerals Co, Sb, As, PGEs, chromium (Cr), and bismuth (Bi). Other associated non-critical commodities are gold (Au), silver (Ag), lead (Pb), iron (Fe), and Cu.

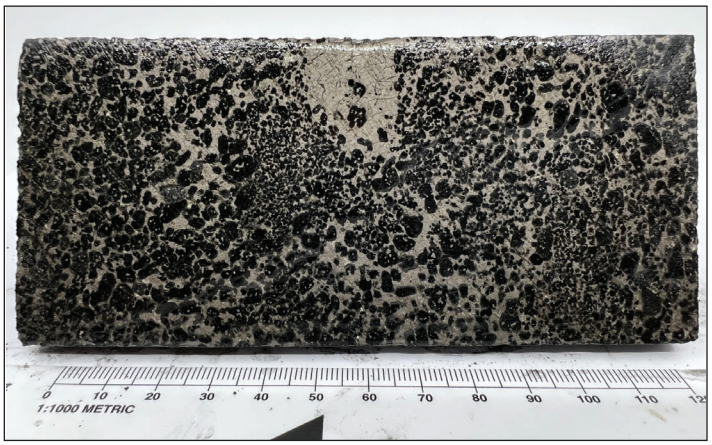

Figure 3. Photograph of a polished core sample from the Chrome Mountain Deposit, Stillwater West Project, Sweet Grass County, Montana. Black crystals are olivine, enclosing metallic minerals are pentlandite and pyrrhotite. Photo courtesy of Danie Grobler, Stillwater Critical Minerals Corp.

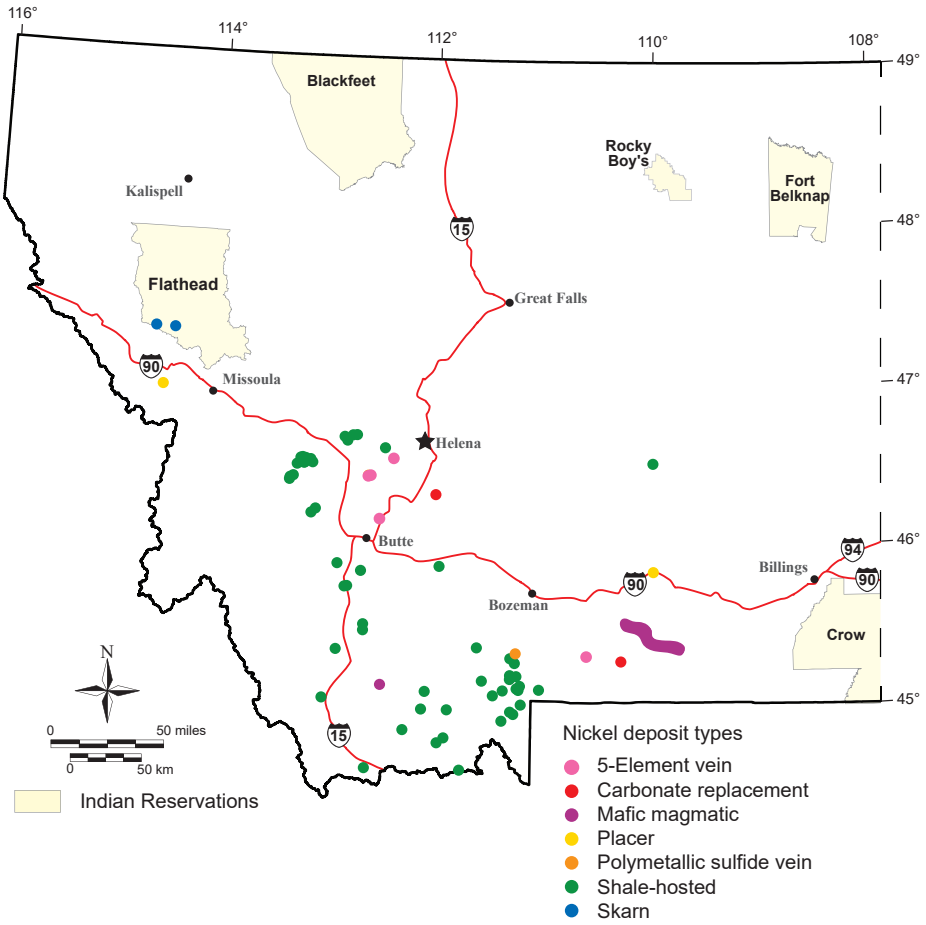

Figure 4. Map of western Montana displaying locations of prospective and known Ni mineralization.

Deposit types for Ni are laterites, serpentinites, polymetallic arsenide veins (aka 5-element vein), massive sulfides, and mafic intrusions. Byproduct Ni can also occur in other hydrothermal-magmatic deposits: skarn, carbonate replacement, and polymetallic sulfide vein. Weathering of these deposits can concentrate minerals such as awaruite into placer deposits. Most Ni mined today is from laterite or massive sulfide deposits. Ni produced in tropical countries is typically from laterite deposits.

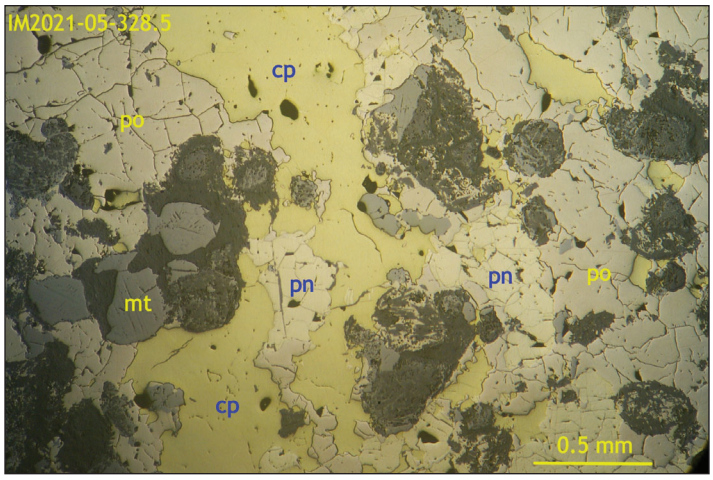

Figure 5. Reflected-light photomicrograph of Ni-Cu mineralization from the Iron Mountain Deposit, Stillwater West Project, Sweet Grass County, Montana. Dark gray crystals are silicate minerals, metallic minerals are pentlandite (pn), chalcopyrite (cp), magnetite (mt), and pyrrhotite (po). Photo courtesy of Danie Grobler, Stillwater Critical Minerals Corp.

Deposits in Montana

The largest concentration of Ni mineralization in Montana is in the Stillwater Complex, a layered mafic intrusion (Stillwater, Sweet Grass, and Park Counties). There is also reported magmatic Ni in Madison County. Five-element vein deposits of Ni with Co, Bi, and As are in Park, Jefferson, and Powell Counties. Skarns with reported Ni occur in the southwestern Flathead Reservation. Other magmatic–hydrothermal Ni occurrences are in Jefferson, Stillwater, and Madison Counties. Ni has been reported in placer deposits in Missoula and Sweet Grass Counties. Sedimentary (shale-hosted) Ni is low-grade, but prevalent throughout southwest Montana, mostly in the Phosphoria Formation.

Outlook in Montana

The only mineral exploration in Montana where Ni is a targeted commodity is the Stillwater West Ni-Cu-Au-PGE-Co project (Sweet Grass and Stillwater Counties), where an inferred resource of about 0.484 Mt Ni has been reported. The MBMG is also investigating the Phosphoria Formation in southwestern Montana that has elevated Ni contents (up to 0.03 wt.%). Other black shale-type deposits in Montana can also host elevated Ni, in some cases associated with petroleum (e.g., Wheatland County). Finally, there are many mine waste sites throughout southwestern Montana that have potential for Ni (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.