



Critical Mineral: Niobium

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Overview

Niobium (Nb, formerly known as columbium) is a rare metal that is included on the 2022 United States Geological Survey's Critical Minerals List. This light gray crystalline metal is primarily used in alloys with iron (Fe) as ferro-niobium to increase the strength, corrosion resistance, and temperature resistance of steel. It is also found in specialty superconducting magnets such as those found in medical MRI instruments.



Figure 1. Crystals of refined Nb. Largest crystal in center is 7 mm. Photo by Artem Topchiy (CC-BY-SA-3.0).

Supply

Brazil dominates the world production of Nb, with about 85% of the market. Canada is the only other major producer, providing most of the remaining 15%. The Brazilian production is from two deposits, and one of those (the Boa Vista Mine) is owned by China Molybdenum Company Limited (CMOC Group Ltd.). The other Brazilian mine, Araxá, is larger and dominates world production of Nb. Canadian production is from one mine. Much smaller production, usually as mixed Nb–tantalum (Ta) ores, comes from Australia and sub-Saharan Africa.

The U.S. has had negligible Nb production since 1959, and imported about 9.4 kt (thousand tonnes) of Nb in 2023. Ferroniobium (about 80% Nb, 20% Fe) was valued at about \$25/kg on average in 2023.

There is one Nb-focused deposit under development in the U.S. at Elk Creek in southeastern Nebraska. Historic Nb production at a small scale was done at the Sheep Creek deposit in southwestern Montana for a few years in the 1950s. American reserves are 210 kt, whereas Brazil has 16,000 kt and Canada 1,600 kt.



Figure 2. Nb alloys are used in cases where high strength under very hot and oxidizing conditions, such as those found in this F-35 fighter jet engine, are needed. Photo by Hunini (CC-BY-SA 4.0).

Mineralogy

Nb ore minerals are columbite (or tantalite), pyrochlore (or microlite), euxenite, fersmite, samarskite, and fergusonite. Ore deposits primarily take the form of carbonatites or granitic pegmatites. Other critical minerals that commonly occur with Nb are the very similar metal Ta, rare earth elements (REE), zirconium (Zr), hafnium (Hf), titanium (Ti), and fluorite (CaF₂). These minerals are found in carbonatite or pegmatite deposits, and placer deposits formed from erosion of the former two. In rare cases, Nb can be recovered during tin (Sn) refining.

Nb is typically mined at grades of 0.41 (Oka, Canada) to 2.5 (Araxá, Brazil) wt.% Nb₂O₅ equivalent. Deposits



Figure 3. A cut grab sample of carbonatite from Ravalli County. The dark squarish mass is primarily columbite. The pinkish-white minerals are carbonates, including REE minerals. Photo by Adrian Van Rythoven, MBMG.

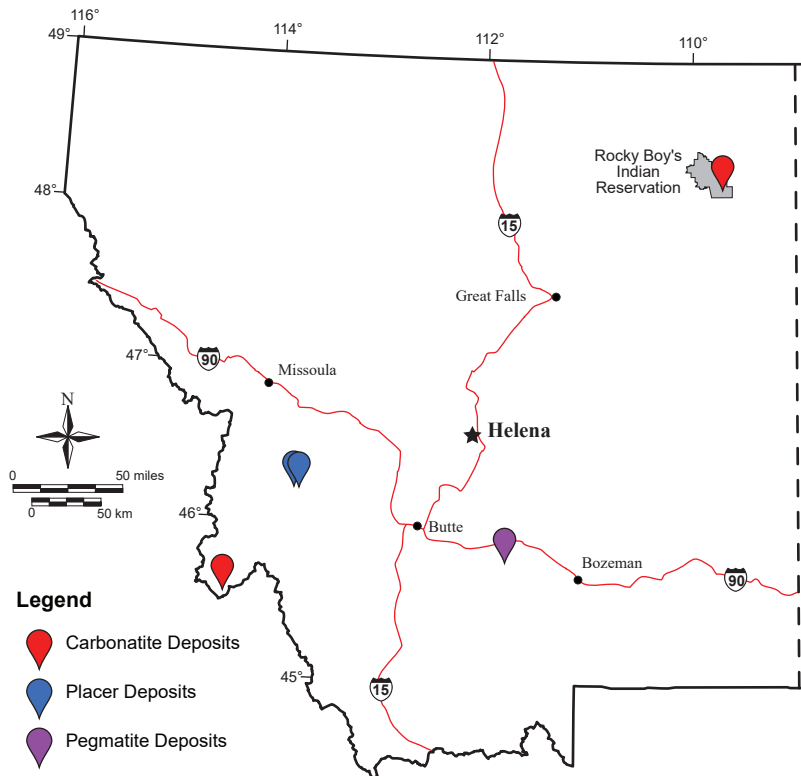


Figure 4. A map of western Montana displaying known occurrences of Nb mineralization in the State.

that are easier to mine and process can be done at lower grades, whereas deposits that are more difficult to mine require higher grades to be economic.

Deposits in Montana

Known occurrences of Nb are in carbonatite bodies at Sheep Creek (aka Mineral Hill) in Ravalli County and in carbonatitic-alkalic silicate rocks within the Rocky Boy's Indian Reservation in Chouteau and Hill Counties. Accessory Nb mineralization has been reported in scattered granitic pegmatite bodies (e.g., Sappington, Madison County), primarily in southwest Montana, and in placer deposits (e.g., Sand Basin and Ranger, Granite County) that likely formed from the weathering of similar pegmatites. Most Nb minerals are dense and weathering-resistant, leading to their relative concentrations in placer deposits with commodities such as gold (Au), Sn, REE, and/or Ta. Typically, Nb concentrations are 10x to 100x greater than Ta concentrations in all these deposits.

Most Nb-bearing pegmatites are of the NYF [Nb-yttrium (Y)-fluorine (F)] family, and even those in Montana are typically below economic grade in terms of critical mineral contents.

Outlook in Montana

There is no recent mineral exploration or development specifically focusing on Nb in Montana. Recent REE exploration regarding the Sheep Creek carbonatites is based on the historic Nb production from there. Any future production of Nb in Montana would likely be a secondary or tertiary byproduct of REE, Ta, Sn, and/or Au (in placers) mining.

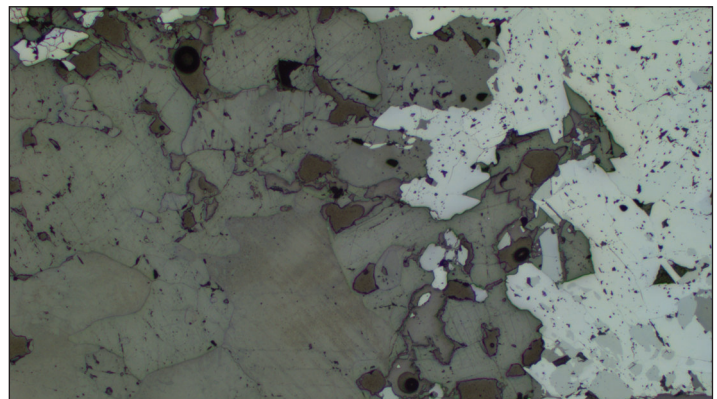


Figure 5. A reflected-light photomicrograph of carbonatite (Nb ore) from Sheep Creek, Ravalli County. This is a magnification of the squarish mass in figure 3. The brightest gray crystals are columbite; the next brightest crystals are fersmite. Darker crystals are carbonate and silicate minerals. Photo by Adrian Van Rythoven, MBMG. Field of view is ~4 mm.

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.