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MBMG
Montana Bureau of Mines and Geology

Critical Mineral: Chromium

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Overview

Chromium (Cr) is a chemical element that is included on the United States Geological Survey's 2022 Final List of Critical Minerals. Pure Cr is a hard, brittle, and silvery gray metal. Cr is primarily combined with iron (Fe) to make stainless steel and other alloys. Cr-plating on steel is termed "chrome" and provides extreme resistance to corrosion while taking on a hard and high polish. It is also an essential nutrient. Other uses are the manufacture of chemicals, glasses, and lasers. Cr compounds were used in some paint pigments. Cr use in paint is being reduced due to the extreme toxicity of Cr(VI) ("chromium-six"), a particular form of Cr that is less common than safe Cr(III) ("chromium-three") or metallic Cr. However, Cr in paint can result in high infrared reflectance, useful in military camouflage.

Figure 1. A piece of refined low-carbon ferrochromium alloy. Photo courtesy of Michael Devlin, Evolution Metals and Mining Technologies, LLC.

Supply

The world's largest Cr reserves are in Kazakhstan at 230 Mt (million metric tonnes). South Africa is a close second with 200 Mt. India, Turkey, and Finland round out the top five with 79 Mt, 27 Mt, and 8.3 Mt, respectively. Of these countries, South Africa mined the most Cr in 2023 (18 Mt). The other four produced between 2 and 6 Mt in the same year.

In comparison, the U.S. has 0.63 Mt of estimated reserves. Most of this is in the Stillwater Complex in Montana. Oregon, Washington, California, and Alaska also have some deposits. Low-grade ores mined in Pennsylvania and Maryland supplied much of the world's Cr in the 1800s.

Given its uses in armor and weapons, domestic Cr mining was highest during the wars of the first half of the 20th century. No significant Cr mining has occurred in the U.S. since ~1962. The Department of Defense considers Cr a strategic mineral and currently holds 920 tonnes of ferrochromium (a mixture of Fe and Cr used to make steel alloys) in stockpile. A modern low-carbon ferrochromium refinery was recently constructed in eastern Pennsylvania.

Figure 2. A component made of Cr-alloy for a Royal Navy (U.K.) nuclear submarine being machined. Photo courtesy of Michael Devlin, Evolution Metals and Mining Technologies, LLC.

The U.S. consumed ~380,000 tonnes of Cr in 2023. Recycling accounted for 26% of this, with the other 74% as imports. 2023 pricing for Cr was $12,125.41 per tonne. Ore grades are typically between 40 and 62 wt.% Cr_2O_3.

Mineralogy

The main Cr ore mineral is chromite, an Fe-Cr oxide mineral that can also contain aluminum (Al), magnesium (Mg), and/or titanium (Ti) in some cases. Chromite is mined and converted into ferrochromium by refining it in a furnace with coke as a reducing agent.

Chromite deposits occur in a couple of geologic settings. Layered mafic intrusions can host stratiform chromite deposits. Ophiolite complexes can host podiform chromite deposits. Other critical minerals that occur in these deposits are nickel (Ni), cobalt (Co), and the platinum group elements (PGEs).

Figure 3. Bands of black chromite ore in green pyroxenite from the closed Mountain View Cr Mine, Stillwater County, Montana. Marker for scale. Photo by Adrian Van Rythoven.

Figure 4. Photograph of a disrupted chromite strata from the Chrome Mountain Deposit, Stillwater West Project, Sweet Grass County, Montana. Lenses of black metallic chromite are suspended in tan gangue (waste) silicate minerals. Photo courtesy of Danie Grobler, Stillwater Critical Minerals Corp.

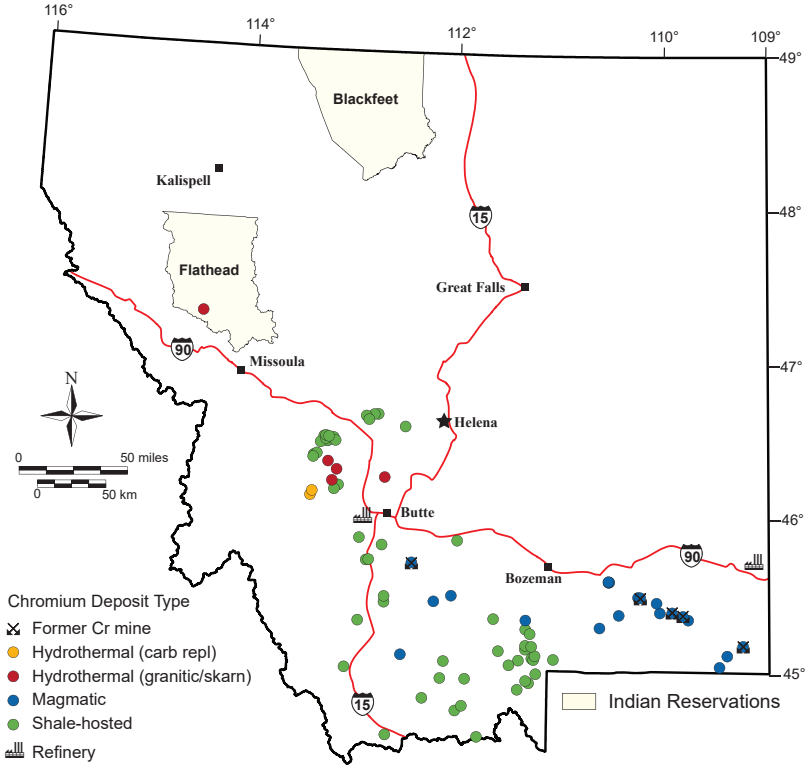

Figure 5. Map of western Montana displaying locations of prospective and known Cr mineralization. Closed mines that had Cr as a main product are also shown.

Cr may be a byproduct from certain hydrothermal deposit types (e.g., skarns or carbonate replacement). High Cr has also been noted in certain shale-rich sedimentary formations along with high vanadium (V), zinc (Zn), and Ni.

Deposits in Montana

The largest concentration of Cr mineralization in Montana is in the Stillwater Complex, a layered mafic intrusion (Stillwater, Sweet Grass, and Park Counties). There is also reported magmatic Cr in the counties to the east and the west of the Complex: Carbon, Madison, and Gallatin Counties. Decades ago, chromite was mined in Montana from five mines across Stillwater, Sweet Grass, Madison, and Carbon Counties. The last of these ended production in the 1960s.

A few hydrothermal base and precious metal deposits have noted Cr mineralization. These are in Granite, Sanders, and Deer Lodge Counties. Very low grade Cr has been identified in the shale-rich units of the Phosphoria Formation in Beaverhead, Granite, Silver Bow, Deer Lodge, Powell, and Madison Counties.

Outlook in Montana

The only modern resource estimate for Cr in the State is the Stillwater West Project, with an inferred 1 Mt of contained Cr along with Ni, PGE, Co, and copper (Cu). Exploration at this project is ongoing.

No other Cr exploration or production is in Montana at present. Research by the MBMG is evaluating older mines and prospects for critical mineral potential, including for Cr. Slag from phosphate and PGE ore smelting has been found to have up to 0.3 wt.% Cr_2O_3.

Recent government efforts to document the critical mineral content of mine waste, especially older (legacy) waste is a recent initiative. The appeal of this initiative is fourfold: (1) secure and domestic supply chains for critical minerals, (2) lower mining impacts on the landscape as the material is already fragmented and at surface, (3) increased employment for legacy mining communities, and (4) rehabilitation of legacy mine sites that cause pollution.

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.