Critical Mineral: Rhodium

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Overview

Rhodium (Rh) is a chemical element that is included on the U.S. Geological Survey's 2022 Final List of Critical Minerals. Pure Rh is an unreactive, dense, malleable, and silver-white precious (noble) metal. Rh is best known for its use in plating jewelry, but has societal importance for its use in chemical catalysts and electrical components.

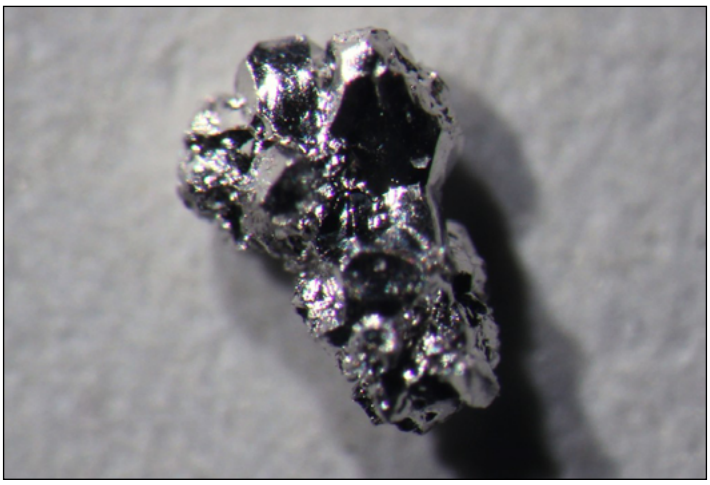

Figure 1. A 1.5-mm-long cluster of metallic Rh crystals. Photo by RhAgchem (CC-BY-SA-4.0).

Rh is part of the platinum group elements (PGEs). The PGEs are Rh, platinum (Pt), palladium (Pd), osmium (Os), ruthenium (Ru), and iridium (Ir). Pd and Pt are by far the most abundant of the six. These elements are found together in most natural deposits. They also have similar physical characteristics. Rh is rare, with a very low crustal abundance of 0.0002 g/t.

Like Pd and Pt, Rh is a catalyst used in some catalytic converters, primarily to breakdown NO_x compounds in automobile exhaust. It catalyzes other chemical reactions to synthesize organic compounds such as menthol or acetic acid. Other uses are in specialty electrodes, X-ray filters, and neutron detectors.

Supply

PGEs are typically reported as combined grades and masses of all six contained metals. South Africa has the largest PGE reserves at 63,000 t (metric tonnes). Russia (16,000 t), Zimbabwe (1,200 t), and the USA (820 t) round out the runners-up.

Given the rarity of Rh, there are no global data on Rh production, but using Pt, production as a proxy, South Africa, Zimbabwe, Russia, and Canada produced the most in 2024. The U.S. was fifth in Pt production in the same year. The U.S. imported 15 t of Rh in 2024, and exported only about 1 t. The U.S. is a net Rh consumer. Average Rh value in 2024 was $147,893,220/t, down significantly from a few years ago. Grades of Rh in deposits ranges from the byproduct level of <0.1 g/t (grams Rh per tonne of ore) to very high grades of 1.5–2 g/t.

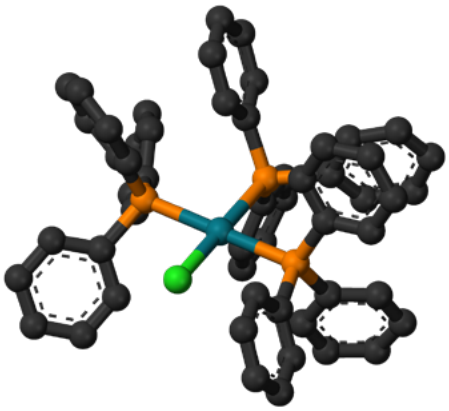

Figure 2. A ball-and-stick 3D model of Wilkinson's catalyst: $RhCl(PPh_3)_3$, where Ph = phenyl group and the teal ball is the Rh atom. Wilkinson's catalyst is an organometallic complex that catalyzes the hydrogenation of alkene molecules. Figure by Benjah-bmm27 (public domain).

Mineralogy

Rh can be found as natural alloys of PGEs in a native "nugget" state. It can also occur substitutionally in place of Pt or Pd as sulfide, arsenide, antimonide, or telluride minerals such as braggite, vysotskite, mertieite, stibnopalladinite, or merenskyite. Aside from arsenic (As), antimony (Sb), tellurium (Te), and other PGEs, critical minerals that can be found with Rh are bismuth (Bi), chromium (Cr), cobalt (Co), nickel (Ni), titanium (Ti), and vanadium (V). Other non-criti-

Figure 3. Photograph of a sample of sulfide PGE ore from the Johns–Manville (JM) Reef taken from the Stillwater Mine in the Beartooth Mountains, Stillwater County. Here, reefs are layers in igneous intrusions that are rich in sulfide minerals. The brassy sulfide mineral pyrrhotite contains PGE minerals. Field of view is ~4.6 cm wide. Photo by James St. John (CC-BY-2.0).

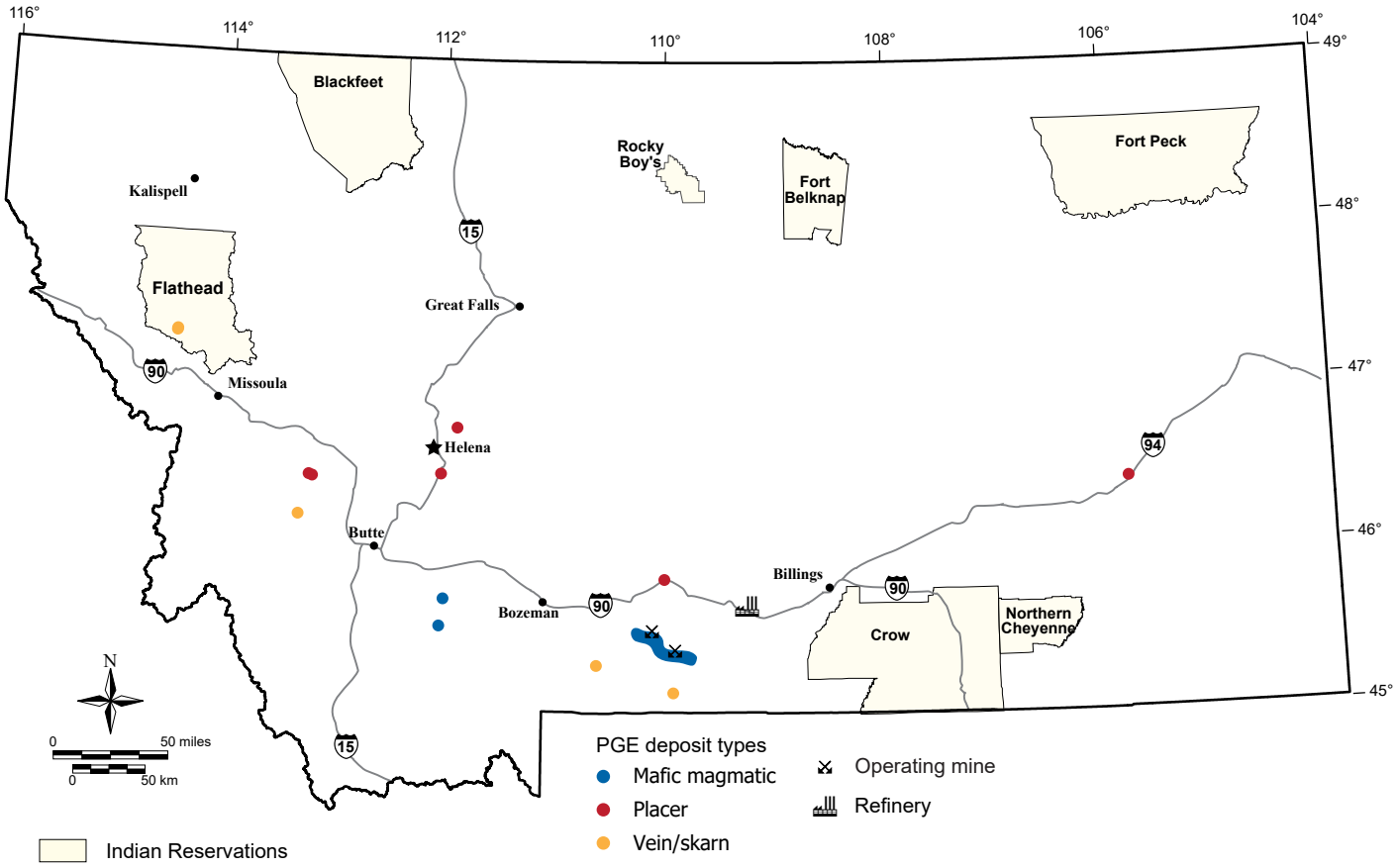

Figure 4. Map of western Montana displaying locations of prospective and known Rh (PGE) mineralization.

cal commodities commonly found with Rh are copper (Cu), gold (Au), silver (Ag), and iron (Fe).

The main primary deposit type for Rh is ultramafic–mafic intrusion. Byproduct Rh can also occur in other hydrothermal–magmatic deposits: skarn, massive sulfide, porphyry-type, and polymetallic sulfide vein. Weathering of these deposits can concentrate native Rh in placer deposits.

Deposits in Montana

The largest concentration of Rh mineralization in Montana is in the Stillwater Complex, a layered mafic intrusion (Stillwater, Sweet Grass, and Park Counties). The Complex has geologic similarities to the Bushveld Complex in South Africa that hosts the bulk of the Rh in that country. There is also reported magmatic Rh in Madison County. Elevated Rh has been reported in some magmatic–hydrothermal vein and skarn deposits in Sanders (Flathead Reservation), Deer Lodge, and Park Counties. In general, placer PGE minerals have been reported over a much wider area: Granite, Jefferson, Lewis & Clark, Sweet Grass, and even Custer Counties.

Outlook in Montana

PGE ore is produced from two mines within the Stillwater Complex: the Stillwater Mine in Stillwater County and the East Boulder Mine in Sweet Grass County. These mines produce Rh as a byproduct from Pt and Pd recovery. The Stillwater West Project, near these two mines, has reported samples with Rh grades from 0.167 to 5.78 g/t. Mineral exploration at the Project is ongoing as of 2025.

There is also a major PGE refinery in Columbus, Montana, where ore from the two mines is processed. PGE-bearing catalytic converters from older automobiles are also recycled here.

Researchers at the MBMG are sampling legacy mine sites across the State in order to assess their economic potential for critical minerals, including PGEs. 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 domestic supply chains for critical minerals, (2) lower mining impacts on the landscape as the material is already fragmented and at surface, (3) increase employment for legacy mining communities, and (4) rehabilitate 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.