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Montana Bureau of Mines and Geology

Critical Mineral: Tin

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Overview

Tin (Sn) is a chemical element included on the United States Geological Survey's 2022 Final List of Critical Minerals. The silvery gray and soft metal is commonly alloyed with copper (Cu) to make bronze. Modern society requires Sn to make lead (Pb)-free solders for electronic and plumbing connections. Sn is also combined with fellow critical mineral indium (In) to make In-Sn-oxide, a compound used in many electronics displays. "Tin cans" for food used to be made of Sn-plated steel, but plastic-coated steel is far more common due to the higher cost of Sn.

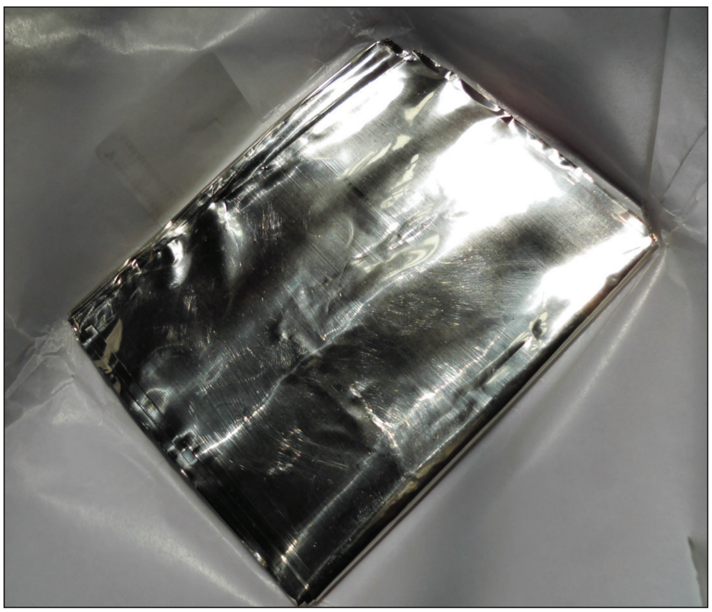

Figure 1. Thin foil of Sn metal weighing 100 grams. Photo by Leiem (CC BY-SA 4.0).

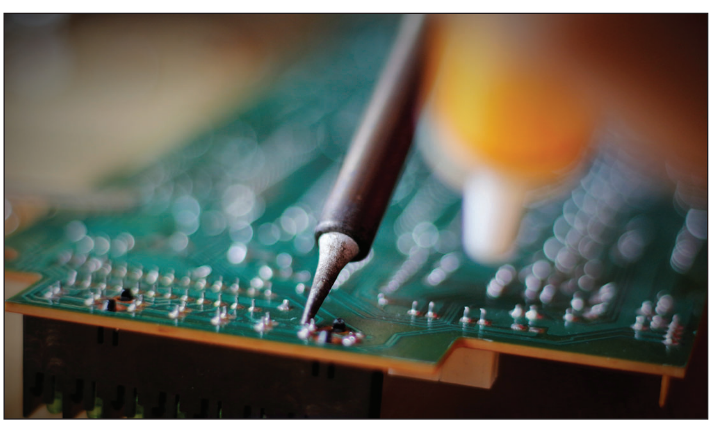

Figure 2. Electronic connections on a circuit board being soldered with Sn-based solder (CC0 1.0 Universal).

Supply

No significant Sn reserves exist in North America. Most reported domestic Sn mineralization is in Alaska. Sn ore has not been mined or smelted in the USA for over 30 years. Globally, China holds the highest reserves at 1,100 kt (thousand metric tonnes). Burma, Australia, Russia, Brazil, and Bolivia round out the top 6 with 700 kt, 620 kt, 460 kt, 420 kt, and 400 kt, respectively.

Production in 2023 was led by China at 68 kt of Sn metal, followed by Burma at 54 kt, Indonesia at 52 kt, and Peru at 23 kt. Sn exports in Burma, Indonesia, and Bolivia have fallen in recent years for political and logistical reasons.

U.S. domestic Sn consumption was 39 kt in 2023. Recycling accounts for about 17 kt (44%), with the remaining 22 kt as imports. Sn is considered a strategic mineral. The U.S. Department of Defense maintains a national stockpile of Sn. In July 2024, this stockpile contained 0.18 kt. In 2023, the average price of Sn was $25,938/t ($11.77/lb).

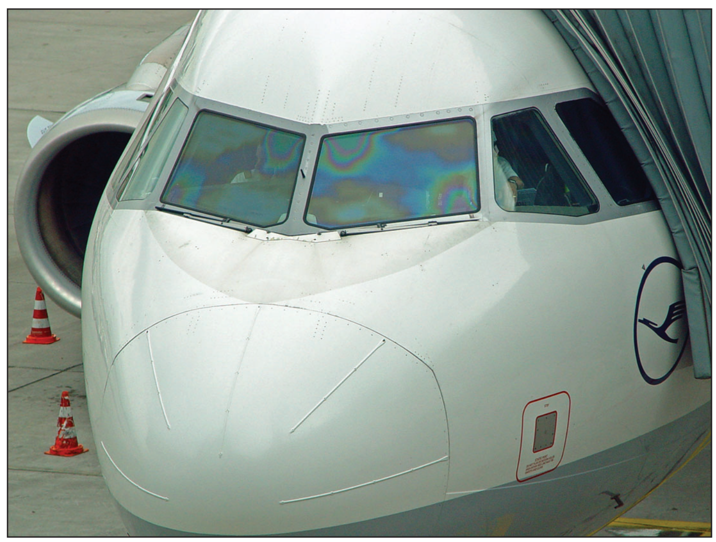

Figure 3. Optical fringes seen on the cockpit window of a commercial jetliner. The fringes are caused by an In-Sn-oxide coating that is electrically conductive to allow for controlled uniform defogging and defrosting. Photo by Etan J. Tal (CC-BY-SA-3.0).

Mineralogy

Cassiterite, a Sn oxide mineral, is the most common occurrence of Sn. Other possible ore minerals are the complex sulfides stannite, franckeite, and canfieldite. The zinc (Zn) sulfide mineral sphalerite can also have high levels of Sn as an impurity.

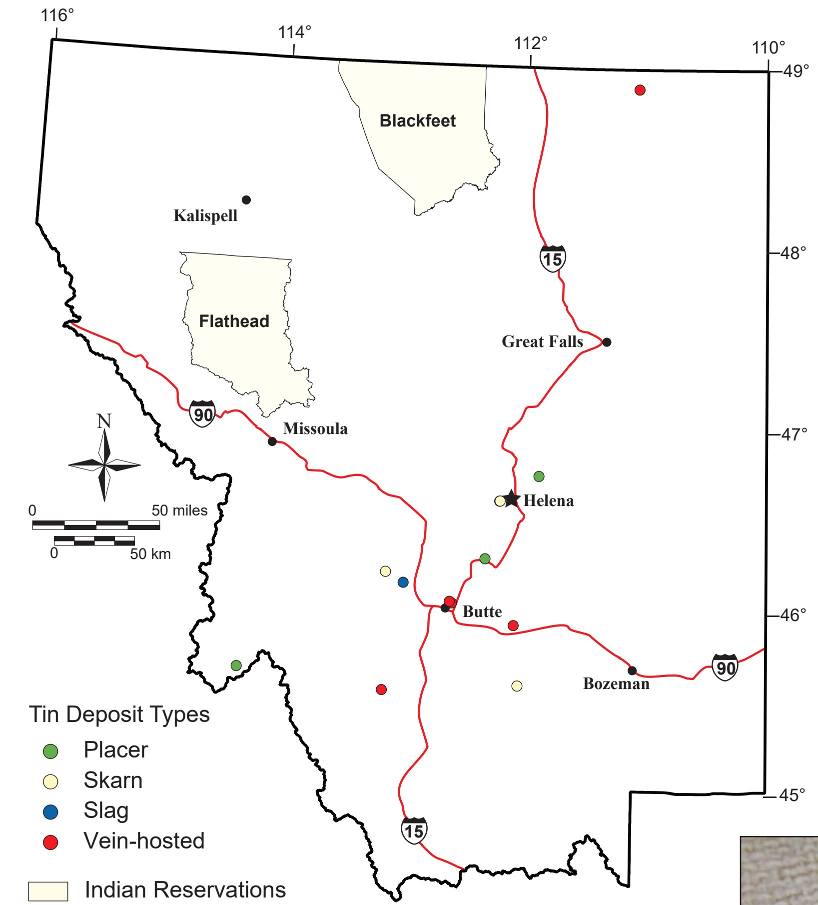

Figure 4. A map of Montana displaying known Sn occurrences.

Sn mineralization usually occurs in association with granitic intrusions as greisen (altered granite), skarn, and/or vein-hosted deposits. Such deposits containing cassiterite, a dense and weathering-resistant mineral, can erode to form placer deposits.

Aside from Zn, other critical minerals that can occur with Sn are In, fluorite (CaF_2), barite ($BaSO_4$), tungsten (W), germanium (Ge), gallium (Ga), antimony (Sb), bismuth (Bi), arsenic (As), manganese (Mn), tantalum (Ta), and/or beryllium (Be). Non-critical minerals that can be found with Sn are topaz, tourmaline, gold (Au), silver (Ag,), copper (Cu), and molybdenum (Mo). Sn deposits range in grade from about 0.1 to 1.1 wt.% Sn.

Deposits in Montana

All reported Sn mineralization is in western Montana. Most deposits are skarns or sulfide veins associated with granitic intrusions. Most of these intrusions are in the vicinity of Butte (Silver Bow, Madison, Beaverhead, Jefferson, Deer Lodge, and Lewis and Clark Counties). There is one report of vein-hosted Sn mineralization around the intrusions of the Sweet Grass Hills (Liberty County). In addition to placer deposits associated with intrusions around Butte, there is a noted placer deposit for cassiterite at Hughes Creek in Ravalli County.

Finally, slag piles around the decommissioned smelter in Anaconda (Deer Lodge County) are reported to contain up to 0.04 wt.% Sn.

Outlook in Montana

Active exploration targeting Sn is absent in Montana. Academic and MBMG research is focused on Sn potential in skarn and vein deposits, particularly the waste from past mining of such deposits: dumps, tailings piles, and slag heaps. This research could support further exploration and development.

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 domestic supply chains for critical minerals; (2) lower mining impacts on the landscape as the material is already fragmented and at the surface; (3) increased employment for legacy mining communities; and (4) rehabilitation of legacy mine sites that cause pollution.

Figure 5. Cassiterite ("wood tin" variety) pebbles from the Hughes Creek Placer, Ravalli County, Montana. Adult fingertip for scale. Photo by Adrian Van Rythoven (MBMG). Sample from the Montana Tech Mineral Museum collection.

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.