
Cover map: Significant critical mineral deposits in Idaho.
Critical Mineral Atlas of Idaho

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The Yellow Pine pit at Stibnite during 1943 wartime operations.
Photographer: George Nock
Bradley Mining Company Collection
Photo courtesy: Perpetua Resources Idaho, Inc.
Introduction

Critical minerals are non-fuel minerals essential to the economic or national security of the United States and which have a supply chain that is vulnerable to disruption. In close collaboration with the mining industry, state and federal governmental agencies are conducting research on critical mineral deposits to help improve the nation’s supply of domestically sourced critical minerals. According to the U.S. Geological Survey, the United States was 100 percent import reliant on 12 of the 50 listed critical minerals, and greater than 50 percent import reliant for an additional 31 critical minerals in 2022. These critical minerals are used in the manufacturing of products that are essential to the defense, energy, transportation, and consumer electronic industries.

Historically, Idaho has been a significant producer of many critical mineral commodities, including antimony, cobalt, niobium and tantalum, rare earth elements (REEs), zinc, and zirconium. Idaho has potential for deposits of other critical minerals, such as fluorine and vanadium, which have been produced in smaller amounts.

The Idaho Geological Survey (IGS), formerly the Idaho Bureau of Mines and Geology, has focused much of its geologic mapping and ore deposit research efforts on areas with potential for mineral production. This includes work in districts such as Stibnite and Lemhi Pass, which host deposits of critical minerals (Sb and REEs respectively). Recent U.S. Geological Survey funding to the Idaho Geological Survey as part of the Earth Mapping Resource Initiative program has broadened that effort to the Idaho cobalt belt and Mineral Hill district of Lemhi County and the Idaho Phosphate district in Caribou County. Additional support from industry and the Idaho Department of Commerce is focused on critical mineral systems in the Idaho cobalt belt and at the Diamond Creek property.

This atlas provides: 1) general geologic descriptions of the most important critical mineral deposits and occurrences in Idaho; 2) maps showing the locations of the larger deposits; and 3) photos of mineral specimens and historical mining activity associated with the respective critical mineral. Information on related critical mineral deposits across the world and the United States is provided for context.

The U.S. Geological Survey’s Special Report No. 1, Mineral and Water Resources of Idaho, which was published in 1964 in cooperation with the Idaho Bureau of Mines and Geology, was used extensively in the creation of this atlas. It remains an important resource for pre-1964 mining in Idaho. Key uses of critical minerals and data on import reliance were sourced from the U.S. Geological Survey’s National Mineral Information Center. Locations of mines, mineral deposits, and mineral occurrences were sourced from the IGS Mines and Prospects database, which is available online at idahogeology.org/WebMap. Additional references are listed following the respective critical mineral discussions.

The mill at the Triumph mine, Blaine County. Photo courtesy of the Idaho State Historical Society.
Antimony (Sb)

Overview:
- Antimony is used in the manufacture of ammunition, flame retardants, and lead-acid batteries.
- Globally, antimony is produced from epithermal veins, pegmatites, and replacement and hot-spring deposits.
- Tetrahedrite, \((\text{Cu,Fe,Zn,Ag})_{12}\text{Sb}_4\text{S}_{13}\), and stibnite, \(\text{Sb}_2\text{S}_3\), are the principal ore minerals of antimony in Idaho.
- Recoverable antimony has not been mined in the United States since 2000.
- Antimony has been mined at the Stibnite district of Valley County, at the Hermada mine of Elmore County, and, as a byproduct of silver mining, in the Coeur d’Alene district of Shoshone County.
- The Sunshine mine of the Coeur d’Alene mining district was the last mine to recover antimony in the United States.
- In 2022 the United States was 83 percent import reliant for antimony. Antimony was primarily imported to the United States from China, as well as from Italy, India, Belgium, and other countries.

Idaho deposits:
Between 1932 and 1952, the Stibnite mining district northeast of Cascade was a major source of antimony (Mitchell, 2000). The Yellow Pine, West End, and Meadow Creek deposits of the district are hosted primarily in granitic rocks. The deposits were mined intermittently from 1932 to 1991 for gold, tungsten, and antimony, producing 39,930 metric tons of antimony (Zimmerman and others, 2021). Recently, the Stibnite mining district has been the site of a major exploration effort, and a new gold-antimony mine proposal is in the permitting phase. The antimony is contained in the mineral stibnite.

Antimony has also been produced in Idaho from the Coeur d’Alene mining district (also known as the Silver Valley) of Shoshone County. The Coeur d’Alene mining district is one of the world’s top silver-producing districts (Gillerman, 2022). Antimony contained in the mineral tetrahedrite is a byproduct of the Cu, Pb, and Zn sulfide veins at several mines, including the Sunshine and Lucky Friday mines. The Sunshine mine had an ore to market complex containing a mill, refinery, mint, and antimony plant (Anderson and others, 1992).
Milled concentrates were cycled through the antimony plant, where metallic antimony and sodium antimonate (a flame retardant) were produced. The Lucky Friday mine sells ore concentrates to Teck Resources Limited, who refines Ag, Pb, and Zn at the Trail smelter in British Columbia. Although the Trail facility accepts antimony-bearing feed, it lacks an antimony plant, so it does not recover antimony from the concentrates.

The Hermada mine, northeast of Boise, produced antimony between 1947 and 1952. Stibnite mineralization is hosted in quartz veins along fault zones cutting Idaho batholith granitic rocks. Most antimony production at the Hermada mine was between 1947 and 1950, producing a relatively small 583 metric tons of antimony (Popoff, 1953).

Selected references:
Cobalt (Co)

Overview:

- Cobalt is used for cathodes of rechargeable batteries, superalloys in gas turbine engines, catalysts in the chemical and petroleum industries, and cemented carbides used in cutting tools and wear-resistant applications.

- Due to its use in rechargeable batteries used for wind and solar energy storage and in electric vehicles, demand for cobalt is expected to increase significantly.

- Economically important cobalt deposit types include sediment-hosted stratiform Cu, laterites, magmatic Ni-Cu sulfide, metasedimentary-hosted Co-Cu-Au deposits, and Co-Ag-Ni-As veins.

- Cobalt is primarily recovered from sulfide, arsenide, and sulfarsenide minerals, with some recovery from secondary weathering minerals.

- Cobalt is largely produced as a byproduct of copper or nickel mining. As a result, the supply of cobalt is contingent in part upon the demand for copper or nickel.

- Most of the world’s supply of cobalt is produced as a byproduct of copper mining in the Democratic Republic of the Congo (DRC).

- Most cobalt mined in the DRC is refined in China, which is both the world’s largest refiner and consumer of cobalt.

- The Eagle mine in Minnesota produces cobalt as a byproduct of its nickel and copper operations.

- During the 1950s and 1960s Idaho was a major producer of cobalt from the Blackbird district of Lemhi County.

- In 2022, the United States was 76 percent import reliant for cobalt, with cobalt contained in metal, oxide, and salts primarily imported from Norway, Canada, Finland, and Japan.

Above: Cobaltiferous pyrite from the Iron Creek deposit, Idaho cobalt belt, Lemhi County.

Left: Cobaltite from the Blackbird mine, Idaho cobalt belt, Lemhi County.
Idaho deposits:

The Idaho cobalt belt, which includes the Blackbird district and other deposits, is one of the most important cobalt endowments in the United States. The metasedimentary-hosted Co-Cu-Au deposits of the Idaho cobalt belt are the only domestic deposits that have produced cobalt as a primary product, rather than as a byproduct. From 1949 to 1960, operations in the Blackbird district produced approximately 30,000 metric tons of cobalt from 5 million metric tons of ore, both from the Blackbird underground mine and the Blacktail open pit mine (Slack, 2012). Other deposits within the Idaho cobalt belt that have recently been explored and/or developed include the Blackpine, Iron Creek, Ram, and Salmon Canyon deposits. The Ram deposit, which was discovered in 1997, is currently being developed as an underground mine. It opened partially in 2022 but was put on care and maintenance in 2023 due to low cobalt prices.

The mill at the Blackbird mine, Lemhi County, 1950s. Photo courtesy of the Lemhi County Historical Society.

Selected references:


Fluorine (F)

Overview:

- Important uses of fluorine include as a metallurgical flux and as hydrofluoric acid. Hydrofluoric acid is used in refining oil and aluminum, manufacturing semiconductors, and synthesizing fluorine compounds such as refrigerants.

- Fluorspar is a term for ore of the mineral fluorite, CaF$_2$, and is the principal source of fluorine worldwide. Fluorspar is categorized into acid-grade (> 97 percent CaF$_2$), ceramic grade (85 – 97 percent CaF$_2$), and metallurgical grade (60 – 84 percent CaF$_2$).

- Fluorspar is produced from multiple types of hydrothermal deposits, including from carbonatite-related, alkaline-related, and Mississippi Valley type, among others.

- Fluorspar was produced in Idaho from the Meyers Cove district and the Bayhorse district between 1947 and 1953.

- In 2022 the United States was 100 percent import reliant for fluorspar. Fluorspar was primarily imported to the United States from Mexico, Vietnam, South Africa, and Canada.

Colorless fluorite crystals from the Chalspar mine, Bayhorse district, Lemhi County.
Idaho deposits:

In Idaho, fluorspar is associated with Tertiary volcanic and granitic rocks of the Challis magmatic episode. Fluorspar was mined in Idaho during the late 1940s and early 1950s. Production from the Meyers Cove district between 1951-1953 totaled approximately 10,000 metric tons of acid-grade, 900 metric tons of ceramic grade, and 90 metric tons of metallurgical grade fluorspar (Anderson, 1954).

The Bayhorse district, although not a major producer, produced 431 metric tons of metallurgical-grade fluorspar from a stint of mining between 1947 and 1953 (Anderson, 1964). Drilling in the Bayhorse district was conducted in the 1980s but production was not restarted. The Phosphate district of southeastern Idaho could potentially produce fluorine as a byproduct of phosphate mining operations (Anderson, 1964).

Selected references:

Niobium (Nb) & Tantalum (Ta)

Overview:

- Niobium is used in high-strength steels and other specialty alloys. Tantalum is used in gas turbines, electronic capacitors, cell phones and computers, cemented carbides, and camera lenses.

- Niobium (historically known as columbium) and tantalum commonly occur together, with ore grades of niobium typically higher than of tantalum.

- The main ore minerals for niobium and tantalum are pyrochlore, \((Na,Ca)_2Nb_2O_6\), and columbite-tantalite, \((Fe,Mn)(Ta,Nb)_2O_6\), respectively.

- The niobium and tantalum bearing minerals euxenite, \((Y, Ca, Ce, U, Th)(Nb, Ta, Ti)_2O_6\), and columbite-tantalite are also mined from secondary heavy-mineral placer deposits.

- Primary mineral deposits for niobium and tantalum are hosted in three types of igneous intrusive rocks: carbonatites (Nb), alkaline to peralkaline granites and syenites (Nb), and granitic pegmatites (Nb and Ta).

- Brazil accounts for approximately 90 percent of global niobium production, largely from carbonatites.

- Niobium and tantalum have not been mined in the United States since 1959, when dredging operations at the Bear Valley placers in Valley County ceased.

- In 2022, the United States was 100 percent reliant on imports of niobium and tantalum, with niobium primarily imported from Brazil and Canada and tantalum primarily imported from Germany, Australia, and Indonesia.

Idaho deposits:

Production of niobium and tantalum occurred in Idaho during the mid to late 1950s from heavy-mineral placer deposits distributed throughout central Idaho. The greatest amount of niobium-tantalum production in Idaho was from the Bear Valley placer area. Dredging of heavy-mineral placers there from 1950-1959 produced 476 metric tons of niobium-tantalum oxide (Barton, 1962). Additional production of niobium from Idaho placers includes 2,000 pounds of columbite concentrates from the Dismal Swamp placer deposit in 1958 (Parker, 1964). An estimated 18,000 metric tons of niobium-tantalum oxides remain in Idaho placer deposits, most of which is in the Bear Valley placer area (Parker, 1964).

The carbonatite veins of the Mineral Hill district contain niobium-bearing rutile, although no published resources are available.

At the Diamond Creek REE-Th deposit in Lemhi County, a 2022 drilling program intercepted a 10.1-meter interval with a grade of at least 0.7 percent niobium, including a 0.5-meter interval with a grade of 1 percent niobium (Idaho Strategic Resources, 2023). Mineralization is hosted within highly oxidized veins which cut Precambrian metasedimentary rocks.

Selected references:

Idaho Strategic Resources, 2023, Idaho Strategic Releases First Results from Diamond Creek – Intercepts 11.3 meters of 1.3% REEs Including Intervals with 2.2% REEs and 1.0% Niobium. Available at: https://idahostrategic.com (accessed 9 January 2024).
Rare Earth Elements (REEs)

Overview:

- The rare earth elements (REEs) are used in permanent magnets, defense applications such as night vision goggles and guidance systems, catalytic converters, ceramics and glass, data storage devices, medical lasers, and nickel-hydride batteries, among many other specialty uses.

- REEs are the lanthanide group (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu). The transition metal yttrium (Y), while not actually a rare earth element, is commonly included in the rare earth element group due to its similarity to the lanthanides.

- The two principal ore minerals for REEs are monazite (Ce,La,Th)PO$_4$, and bastnäsite, (La,Ce,Y)CO$_3$F.

- The light rare earth elements (La, Ce, Pr, Nd, Pm, Sm, Eu) are primarily produced from carbonatites.

- The heavy rare earth elements (Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) are primarily produced from ion-absorption clays.

- Globally the vast majority of REEs are produced in China. During the 1960s-1980s Mountain Pass, California was a major producer of rare-earth elements.

- REEs were produced in the United States in 2022 from the Mountain Pass mine in California, as well as from heavy-mineral sand deposits in the southeastern United States.

- Idaho has four of the twenty-nine significant REE deposits in the United States.

- In 2022, the United States was greater than 95 percent import reliant on compounds and metals of the rare earth elements, which are primarily imported from China, Malaysia, Estonia, and Japan.

Carbonatite containing rare earth elements in monazite (red mineral), Mineral Hill district, Lemhi County.
**Idaho deposits:**

While not abundant, monazite is present as an accessory mineral in most granitic intrusions, including the Idaho batholith and other plutonic rocks that occupy large areas in central Idaho. Because of monazite’s high density, sediments derived from the weathering of intrusive and metasedimentary rocks can accumulate monazite placer deposits. Such placer deposits are found throughout central Idaho, but the most notable deposits are in the Bear Valley and Long Valley areas, where estimated monazite resources total 143,000 metric tons, equating to roughly 93,000 metric tons of rare earth oxides (Jackson and Christiansen, 1993).

Rare earth deposits in the Salmon area of Lemhi County include three groups of deposits, all of which have had recent exploration activity. These are the carbonatites of the Mineral Hill district, the REE-Th-Fe veins of the Lemhi Pass thorium district, and the REE-Th-Fe veins of the Diamond Creek deposit. Carbonatite occurrences of eastern Idaho and across the Montana border have garnered industry attention, with REE, Th, and Nb exploration campaigns beginning in the 1950s. For the Lemhi Pass thorium district, estimated resources from 1979 total approximately 369,000 metric tons of rare-earth oxides (Staatz and others, 1979).

The Hall Mountain group of Boundary County is a vein occurrence with anomalous thorium and REEs associated with Precambrian mafic intrusions. The Idaho Phosphate district in Caribou County is another potential source of REEs, as the phosphatic mudstones are enriched in REEs (Embso and others, 2015) and approximately four to five million metric tons of phosphate rocks are mined and processed annually (Gillerman, 2022).

**Selected references:**

Titanium (Ti), Zirconium (Zr), and Hafnium (Hf)

Overview:
- Titanium is primarily used as titanium dioxide and as titanium sponge metal.
- Uses of titanium sponge metal include aerospace applications, armor, chemical processing, and medical implants. Titanium dioxide is used in paint pigments, plastics, paper, catalysts, and ceramics.
- Economic sources of titanium include magmatic-hosted deposits and heavy-mineral placer deposits.
- The principal titanium ore minerals are ilmenite (FeTiO$_3$) and rutile (TiO$_2$).
- Ilmenite is mined from both magmatic and heavy-mineral placer deposits.
- Rutile is primarily mined from heavy-mineral placer deposits.
- Titanium mineral concentrates were mined from heavy-mineral placer deposits in Georgia and Florida in 2022.
- In 2022, the United States was 81 percent import reliant on imports of titanium sponge metal and a net exporter of titanium dioxide.
- Zirconium is used in nuclear fuel cladding, chemical piping, heat exchangers, and specialty alloys.
- Hafnium is used in nuclear control rods, superalloys, plasma cutting nozzles, and high temperature ceramics.
- The mineral zircon itself is also used in refractories, foundry sands, and ceramic opacification.
- Zircon is a coproduct or byproduct of titanium- and tin-bearing heavy-mineral placer deposits.
- Zirconium and hafnium are extracted from their primary ore mineral, zircon (ZrSiO$_4$).
- Zirconium and hafnium are contained in zircon at a ratio of approximately 36 to 1.
- In 2022, zircon was mined from heavy-mineral placer deposits in Georgia and Florida.
- Zircon was historically produced in Idaho from heavy-mineral placer operations.
- In 2022, the United States was less than 50 percent import reliant for zirconium. Import reliance data for hafnium are not available.

**Idaho deposits:**

Historic production of titanium and zircon occurred in Idaho during the 1940s and 1950s from heavy-mineral placer deposits. Most of the placer deposits are in central Idaho within the Idaho batholith. In the late 1940s, ilmenite and zircon were produced as by-products of gold dredging operations in the Boise Basin. Heavy-mineral placer dredging for monazite in the Long Valley and Bear Valley placer areas produced byproduct ilmenite and zircon during the 1950s (Savage, 1964).

In 1964, the U.S. Geological Survey and Idaho Bureau of Mines and Geology estimated the placer deposits in Long Valley contain approximately 460,000 metric tons of recoverable ilmenite. Numerous other heavy-mineral placer deposits are distributed throughout central Idaho. In addition to heavy-mineral placer deposits, the high-alumina clay deposits of Latah County are an unconventional potential resource of ilmenite (Savage, 1964).

**Selected references:**


Tungsten (W)

Overview:

- Important uses of tungsten include cemented carbides, electrical wires and components, high-temperature lubricants, superalloys, armaments and munitions, and light bulb filaments.
- Tungsten is primarily mined from skarn, vein, and porphyry deposits.
- Scheelite, CaWO$_4$, and wolframite, (Fe,Mn)WO$_4$, are the principal ore minerals of tungsten.
- The United States has not produced tungsten from a primary source since 2015.
- Historically, Idaho was a significant producer of tungsten, supplying ore during World War I, World War II, and the Korean War from the Yellow Pine mine of Valley County and the Ima mine of Lemhi County.
- In 2022, the United States was greater than 50 percent import reliant for tungsten, with the remainder sourced from recycling. Tungsten is imported from China, Germany, Bolivia, Vietnam, and other countries.

Scheelite from the Golden Chest mine, Shoshone County showing characteristic blue fluorescence under shortwave ultraviolet light. The Golden Chest mine, located north of the Silver Valley, produces gold as a primary commodity and contains scheelite in quartz veins. During World War I the Golden Chest mine produced minor amounts of scheelite.
Idaho deposits:

Idaho has historically been a leading producer of tungsten, supplying 40 percent of the total U.S. production from 1942 to 1944 (Hobbs, 1964). The two major tungsten producers in Idaho were the Ima mine of the Blue Wing district and the Yellow Pine mine of the Stibnite district.

Tungsten production at the Yellow Pine mine of the Stibnite district spanned from 1941 to 1945 and from 1950 to 1952 and totaled approximately 6,159 metric tons of tungsten (Zimmerman and others, 2020). The Yellow Pine mine is characterized as an intrusive-hosted ore deposit, with scheelite concentrated in veins and breccias in granitic rocks of the Idaho batholith.

Production of tungsten at the Ima mine began in 1911. Between 1937 and 1957 the Ima mine produced approximately 1,426 metric tons of tungsten (Mitchell, 1999). The Ima mine contains scheelite and hubnerite (MnWO₄) in veins emanating from granitic stocks.

Selected references:


Vanadium (V)

Overview:
- Uses of vanadium include steel alloys, chemical catalysts, ceramics, glasses, and pigments.
- Globally, sources of vanadium include vanadiferous titanomagnetite, sandstone-hosted vanadium, and vanadium-rich black shales.
- Vanadiferous titanomagnetite deposits are the primary source of vanadium from vanadium-bearing ilmenite, FeTiO$_3$, and magnetite, Fe$_3$O$_4$.
- The Meade Peak Member of the Phosphoria Formation in southeastern Idaho and western Wyoming is enriched in vanadium, among other critical minerals.
- No vanadium was mined in the United States in 2022. However, vanadium and vanadium-bearing chemicals and alloys were recovered from waste materials in Arkansas, Ohio, and Pennsylvania.
- In 2022 the United States was 54 percent import reliant for vanadium. Vanadium was primarily imported from Canada, China, Brazil, South Africa, and other countries.

*Phosphate mining operations in 2021 at the Rasmussen Valley mine, Caribou County. The black material is the phosphate ore, which is often enriched in vanadium.*
Idaho deposits:
Vanadium was first recognized in the Phosphoria Formation in 1911. Historic exploration for vanadium occurred in Idaho during the early 1940s as part of strategic wartime efforts. As a result, vanadium pentoxide was produced as a byproduct of phosphate mining from the Conda mine of the Phosphate district between 1941 and 1954 (Fischer, 1964). Vanadium was recovered from phosphate mining byproducts at the Kerr-McGee vanadium plant in Soda Springs, Idaho between 1963 and 1999 (EPA, 2022).

The Phosphate district, which is a major producer of phosphate, has substantial resources of vanadium and in the future, vanadium may potentially be produced as a byproduct of mining operations there. Other vanadium deposits in the Phosphoria Formation include those in the Paris-Bloomington area and Long Canyon.

Selected references:
Zinc (Zn)

Overview:
- Important uses of zinc include in galvanized steel and metal alloys such as brass and bronze.
- Zinc deposit types include sedimentary exhalative, Mississippi Valley-type lead-zinc, massive sulfide, skarns, and Coeur d’Alene-type polymetallic veins.
- Zinc is largely extracted from its primary ore mineral, sphalerite, ZnS.
- The United States is a major producer of zinc, especially from the Red Dog mine in Alaska.
- Idaho is among five U.S. states that currently produce zinc.
- The Coeur d’Alene mining district has the largest past production of zinc and has the greatest future potential for zinc mining in Idaho.
- In 2022, the United States was a net exporter of zinc ores and concentrates and 76 percent import reliant for refined zinc. Zinc is primarily imported from Canada, Mexico, Peru, and Spain.

Sphalerite from the Coeur d’Alene district, Shoshone County.

Idaho deposits:

Idaho actively produces zinc and has high potential for expanding zinc production. Zinc production in Idaho is in part contingent on the prices of other associated commodities, such as silver, copper, and lead, which are also present in the polymetallic veins throughout the state.

Ore deposits in the Silver Valley of the Coeur d’Alene mining district are within folded Belt Super-group metasediments. In 2022, two deep underground mines were operating with three other major exploration projects underway. Between 1884 and 2020, the Coeur d’Alene district produced 3,067,156 metric tons of zinc (Gillerman, 2022).

The greatest zinc production was from the Bunker Hill mine on the west side of the district. The Bunker Hill mine was the site of renewed exploration in 2022 and 2023. Currently, the Lucky Friday mine is the only active zinc producer in the state, though the Galena complex, which has only reported silver and lead production recently (2016 - 2022), could potentially yield zinc.

Outside of the Silver Valley, Idaho has many zinc occurrences and historic producers. Of the notable zinc producers, the Bayhorse district mines and the Triumph, South Mountain, and Red Ledge mines are the largest. The Triumph mine, a sedimentary exhalative Zn-Ag-As deposit near Hailey, produced 85,049 metric tons of zinc between 1916 and 1958 (Long and others, 1998). The Red Ledge mine, a volcanic massive sulfide deposit near the historic mining town of Cuprum, produced zinc, though cumulative production for the mine is poorly constrained from historic records. The South Mountain mine, a polymetallic replacement and skarn deposit, produced 5,726 metric tons of zinc between 1940 and 1965 (Choquette and others, 2019).

Selected references:


