



Critical Mineral: Phosphorous

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Overview

Phosphorous (P) is a chemical element included on the United States Geological Survey's 2025 Final List of Critical Minerals. P is a non-metallic element. As a commodity, it is sometimes referred to as "phosphate" (when chemically bound to oxygen) or "phosphate rock" (phosphate minerals when including some other minerals).

This element is highly reactive, especially with oxygen in the atmosphere. It forms stable compounds with oxygen as phosphate. As phosphate, the main use is as fertilizer. Other applications for P are chemicals, munitions, matches, and semiconductors. Organisms require P. Teeth in particular contain apatite, a calcium phosphate mineral. All DNA incorporates some P into its structure.



Figure 1. A vial of red P, one of the four varieties of elemental P. Red P is used for safety matches. Photo by Tomihahndorf (public domain).

Supply

China produces the most phosphate rock, with 110 million metric tonnes (Mt) in 2025. Morocco and the United States follow with 36 Mt and 20 Mt, respectively. Morocco holds the most reserves at 50,000 Mt, followed by China at 3,400 Mt, and Egypt at 2,800 Mt. The United States has only 1,000 Mt of reserves.

Most of these domestic reserves are in the Western Phosphate Field (Idaho, Utah, Montana, and Wyoming), Florida, or the Carolinas. Current domestic production is limited to Idaho, Utah, Florida, and North Carolina. The current American phosphate industry directly employs about 2,000 people and is far smaller than in previous generations. Currently, the U.S. is reliant on imports for 16% of its P needs. Ore grades of typical phosphate rock are typically 20–38 wt.% P_2O_5 , although unconventional sources could have lower grades if the P production is a byproduct. Pricing for typical phosphate rock was ~\$100/t in 2025.



Figure 2. A sample of small diammonium phosphate granules. These water-soluble granules are used as fertilizer to add P and nitrogen to soil depleted by extensive cultivation. Photo by Suyash Dwivedi (CC-BY-SA-4.0)

Mineralogy

Most domestic and global P reserves and production are from phosphorite, a sedimentary rock formed in ancient marine environments from the remains of organisms. P from the organisms collected on the seafloor over time and later was incorporated into the sediments that formed phosphorite. The P content in phosphorite is held in an impurity-rich variety of apatite called francolite. Apatite can also occur in igneous rocks such as carbonatite or silicate rocks.

Other critical minerals that can occur with P in phosphorite are rare earth elements (particularly heavy REEs), vanadium (V), zinc (Zn), uranium (U), and chromium (Cr). P in igneous rocks can be associated with REEs, zirconium (Zr), hafnium (Hf), rubidium (Rb), U, tantalum (Ta), niobium (Nb), barite ($BaSO_4$), scandium (Sc), titanium (Ti), and fluorapatite (CaF_2). In addition to apatite, igneous rocks may host P in other minerals such as monazite and xenotime.



Figure 3. A sample of phosphorite with 32 wt.% P_2O_5 and ~0.3 wt.% REEs from Granite County, Montana. Photo by Adrian Van Rythoven (MBMG).

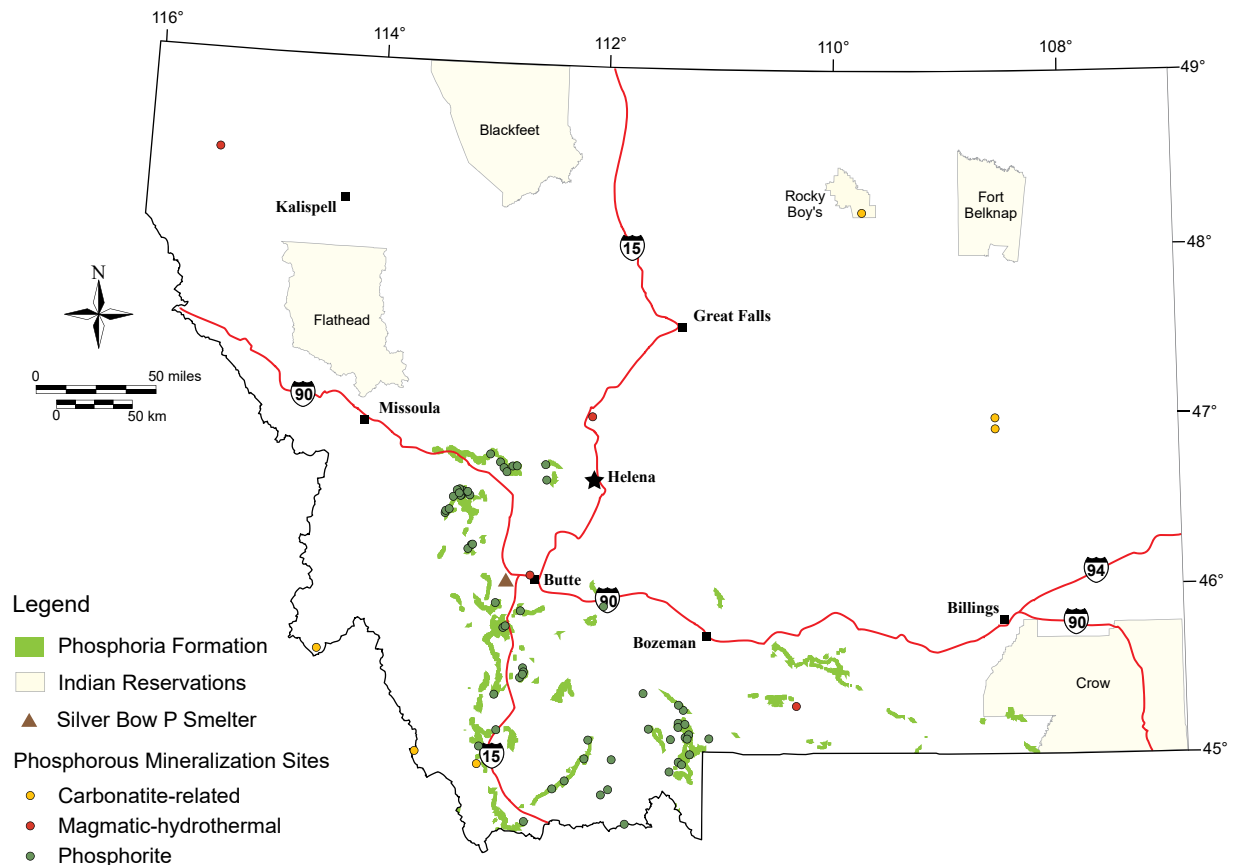


Figure 4. A map of western Montana displaying known P occurrences by geologic setting, mapped Phosphoria Formation, and the closed Silver Bow P smelter (plant).

Deposits in Montana

Most P deposits in Montana are in phosphorite of the Phosphoria Formation, the ~285 million-year-old unit of sedimentary rocks that make up the Western Phosphate Field. Phosphorite in Montana is restricted to the southwest in Beaverhead, Madison, Silver Bow, Granite, Powell, Gallatin, Deer Lodge, Park, Sweet Grass, Stillwater, and Carbon Counties.

Igneous-related P mineralization occurs in carbonatite from Petroleum, Beaverhead, Ravalli, and Hill Counties. Other silicate rock (magmatic-hydrothermal) P occurrences are in Silver Bow, Lewis and Clark, Lincoln, and Park Counties.

Outlook in Montana

P was mined from phosphorite in Montana from 1921 to 1993. Smelting of P continued at a plant in Silver Bow County using ore from Idaho until 1997. It is estimated that ~1,500 Mt of phosphate rock resource remains within shallow deposits in Montana. Currently, there is some exploration and development activity for P and other associated critical minerals in Powell, Granite, and Deer Lodge Counties.

Researchers at the MBMG sampled phosphorite across the State in order to assess the Formation's economic potential for critical minerals, including P and REEs. Compared to actively mined orebodies in Idaho, phosphorite from Montana appears to have a higher potential for byproduct REEs.



Figure 5. Phosphorite beds weathered white at Daly's Spur, Beaverhead County, Montana. I-15 is visible to the south. Photo by Adrian Van Rythoven (MBMG).

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.