


U.S. Geological Survey Global Seabed Mineral Resources

The U.S. Geological Survey (USGS) provides science and data on seabed mineral resources and ecosystems, as well as any potential hazards associated with extraction. The Nation relies on minerals for infrastructure, technology, manufacturing, and energy production. Critical minerals (USGS, 2022a) are essential to the economic and national security of the United States and have a supply chain vulnerable to disruption.

For decades, USGS scientific innovation has contributed to the delineation of seabed mineral resources, the mechanisms of seabed mineral formation, and the environmental impacts of resource extraction. Since 1962, the USGS has also led scientific inquiries into the potential for deep sea mining. By providing impartial science on seabed minerals and their environmental setting in the deep oceans, the USGS enables decision-makers to evaluate the best practices for mineral resource development.

What Is the Role of the USGS in Understanding Seabed Minerals?

In many regions of the global ocean, limited data are available regarding the abundance, composition, environmental setting, and associated ecology of seabed minerals. The USGS provides cutting-edge, impartial data on seabed minerals by creating prospective maps of the places where these minerals may occur, investigating the processes that lead to specific enrichments within these minerals, and studying the physical and chemical implications of potential commercial extraction. The USGS also conducts multidisciplinary studies of the marine and seabed environments where these minerals exist. Such investigations provide data and insights that are essential for decision-makers and the public to understand and make informed decisions regarding potential resource extraction.



Remotely operated vehicle collects a sulfide mineral sample from Escanaba Trough.

The USGS provides the Nation with expertise in many aspects of global seabed minerals through a collaboration of three Mission Areas:

- **The Coastal and Marine Hazards and Resources Program in the Natural Hazards Mission Area** (<https://www.usgs.gov/programs/cmhrp>) leads Federal scientific work on seabed minerals, which has included research into polymetallic nodules in the Clarion-Clipperton Zone, Cook Islands, and elsewhere; cobalt-rich ferromanganese crusts throughout the central and western Pacific Ocean, the Arctic Ocean and the Atlantic Ocean; and polymetallic sulfides in many locations globally, including most recently on an interagency research expedition to the Escanaba Trough off the shore of northern California (Pearsall, 2022).
- **The Land Management Research Program in the Ecosystems Mission Area** (<https://www.usgs.gov/programs/land-management-research-program>) characterizes seabed and water-column ecosystems and studies the potential environmental effects of disturbing habitats or ecosystems, including recent work on the Blake Plateau off the shore of South Carolina (USGS, 2024).
- **The Mineral Resources Program in the Energy and Minerals Mission Area** (<https://www.usgs.gov/programs/mineral-resources-program>) contributes expertise in natural resources, mineral lifecycles, and mineral supply chains. The Program's National Mineral Information Center (<https://www.usgs.gov/centers/national-minerals-information-center>) tracks mineral commodities, including any extracted seabed minerals.

USGS activities focused on seabed mineral studies complement the Survey's work on land-based minerals and mineral supply chains. USGS data collection and analysis are used to evaluate and identify minerals that are critical to the economic and national security interests of the United States. The USGS also analyzes mineral markets and provides statistics on mineral commodities in all sectors of the U.S. economy, including analysis in support of national security.

In addition to collaboration within the three Mission Areas, the USGS collaborates on targeted studies of seabed minerals and associated ecosystems with the Bureau of Ocean Energy Management, which has regulatory authority for mineral extraction on the U.S. Outer Continental Shelf, and the National Oceanic and Atmospheric Administration, which has regulatory authority for U.S. activities related to mineral extraction on the high seas. Such studies provide crucial data that inform the regulatory decisions of other agencies.

Which Minerals Are Found in Seabed Environments?

Heavy mineral sands.

Minerals can be found in every ocean basin, from the coastal zone to the deep ocean (USGS, 2022b). In the deep ocean, exploration is ongoing for polymetallic nodules, polymetallic sulfides, and cobalt-rich ferromanganese crusts. These minerals are considered a potential future source of many elements, including some elements that are designated as critical minerals (table 1). Critical minerals that are abundant in sea-floor deposits include nickel, cobalt, and manganese. These minerals are crucial components in stainless steel, superalloys, and batteries. The rare earth elements and yttrium, often abbreviated as REY, are a group of 17 elements. Two of these, neodymium and dysprosium, are used in permanent magnets and lasers.

Polymetallic nodules.



Cobalt-rich ferromanganese crust.



Phosphorite.



Polymetallic sulfide.



Table 1. Elements found in seabed minerals.

[The term “potential byproducts” indicates elements that are not a main product of a potential mining operation but could possibly be produced in addition to the main products. REY, rare earth elements including yttrium; —, not applicable]

Mineral type	Mineral setting	Minerals of interest	Potential byproducts
Polymetallic nodules	Found on sediment-covered abyssal plains with low particle flux at depths of 11,500–21,325 feet (3,500–6,500 meters) below sea level.	Nickel,* copper, cobalt,* and manganese*	REY* and lithium*
Polymetallic sulfides	Form at some hydrothermal vents, which occur where new sea floor is formed (spreading centers) and in the areas where sea floor is consumed at subduction zones (arcs and back arcs).	Copper, zinc,* gold, silver, and lead	Beryllium,* bismuth,* cadmium, cobalt,* chromium,* gallium,* germanium,* mercury, indium,* manganese,* molybdenum, nickel,* selenium, tin,* tellurium,* and platinum group elements*
Cobalt-rich ferro-manganese crusts	Form on rock surfaces at depths of 1,300–23,000 feet (400–7,000 meters) below sea level. They are often found on seamounts.	Manganese,* cobalt,* nickel,* and copper	REY, tellurium,* scandium,* and platinum*
REY-rich muds	Deep sea muds that can also occur in the deep ocean, usually several meters below the sediment surface.	REY*	—
Phosphorite minerals	Can be found in continental margins or further offshore on seamounts.	Phosphorus and REY*	—
Heavy mineral sands	Can accumulate in coastal environments as water transport sorts these sands from other sediments.	Titanium,* tin,* platinum,* gold, silver, and REY*	—

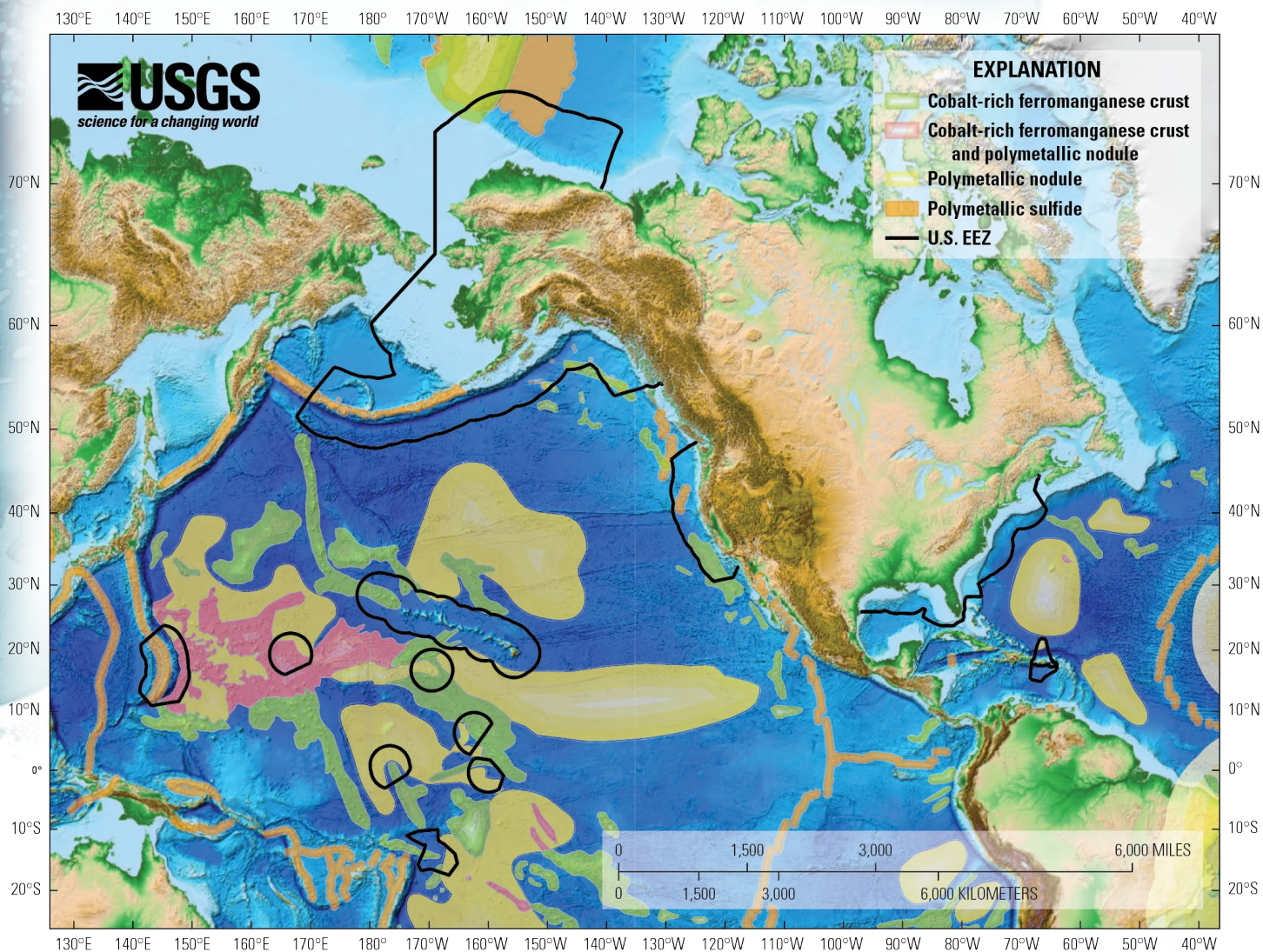
*Included in the 2022 list of critical minerals (USGS, 2022a).

Where Are Seabed Minerals Found?

Seabed minerals occur in every ocean basin, including within the U.S. Exclusive Economic Zone (Hein and others, 2005), which is larger than the land area of the United States, as well as the Extended Continental Shelf (U.S. Department of State, 2023). However, as of 2025, only a few of these locations have sufficient data to determine whether they have deposits, defined as mineral concentrations that could be viable for commercial production.

The map shows prospective regions, or regions where minerals may occur based on geological and oceanographic criteria, for polymetallic nodules and cobalt-rich ferromanganese crusts. The map also outlines mid-ocean ridges and back arc basins, which, along with volcanic arcs, are regions where hydrothermal vents form. Under certain conditions, hydrothermal vents can form polymetallic sulfide deposits. As of 2025, there are only a handful of locations where enough data have been collected on the grade and tonnage of these minerals for the term “deposit” to be used with confidence.

Seabed Mineral Prospective Regions



Global seabed mineral prospective regions, including those that occur within the U.S. Exclusive Economic Zone (U.S. EEZ). More information on these regions can be found in Mizell and others (2022) and Gartman and others (2022).

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Publishing support provided by the Moffett Field and
Pembroke Publishing Service Centers

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ISSN 2327-6916 (print)
ISSN 2327-6932 (online)
<https://doi.org/10.3133/fs20253017>