Contested Depths: Securing Arctic Seabed Minerals in an Era of Energy Transition and Strategic Competition

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INTRODUCTION

In its initial months, the second Trump Administration reignited controversy by proposing the annexation of Greenland, citing abundant critical mineral reserves and the strategic necessity to counter China's Arctic ambitions. This focus, however, overlooks a more immediate and sovereign opportunity: the vast marine mineral wealth within America's newly delineated Arctic continental shelf, unlocked by melting sea ice. As the nation looks to secure its critical mineral future, it should look North to the newest addition to the nation: a half million square kilometers of seabed.

Global demand for critical minerals is surging as Great and regional powers recognize their importance. Metals are essential for clean energy technologies, advanced defense systems, and other next generation technologies. The International Energy Agency estimates demand for these minerals, in aggregate, could rise by 600% by 2040, with demand for specific metals growing more than an order of magnitude. The United States Geological Service has published a list of 50 minerals considered strategic for economic or national security reasons – China has a stranglehold on supply for the vast majority. Simultaneously, expanded terrestrial mining faces resource constraints, environmental pushback, and human rights concerns.

Nations and companies are turning to seabed minerals as an alternative to terrestrial sources, particularly for cobalt, nickel, manganese, and rare earth elements (all of which are in high demand for the energy transition). Large scale production has yet to start but recent exploration activities indicate deep sea mining in equatorial regions may be economic. Regulatory gridlock over the international high seas, however, is compelling nations to examine domestic resources. Over the last fifteen years, Arctic nations have raced to survey and exert mineral jurisdiction over almost all of the Arctic seabed. Russia is particularly notable, claiming almost half of the Ocean's seabed minerals at the same time Russia and China explicitly oppose U.S. claims. This focus on domestic marine minerals culminated recently, with Norway first legalizing deep-sea mining before backtracking amidst objections from environmentalists. This reversal underscores the uncertainty around deep sea mining in the region, amidst broader environmental changes and geopolitical sensitives.

The Arctic is undergoing a profound transformation as climate change accelerates the retreat of sea ice, heating up geopolitical competition. Russia considers the Arctic a new mineral frontier, as do other states. China, despite lacking Arctic territory, has declared itself a "near-Arctic state," investing in research and infrastructure to position itself as a future player. Melting sea ice has spurred maritime traffic through the nascent Northern Sea Route and Northwest Passage, valuable corridors in future conflict scenarios. There are significant offshore oil and gas resources, as well as interest in submarine telecommunications cables to directly link countries across the pole, such as Japan and Norway.

While these new Arctic opportunities have engendered considerable attention, Arctic marine minerals have not. Similarly, deep sea mining research and governance debates almost exclusively focus on equatorial regions like the Clarion-Clipperton Zone (CCZ). Limited scholarly and policy attention to Arctic marine minerals portends governance gaps. Urgently, recent surveys unveiled unique resources and early legal scholarship has identified a complex legal dance of Arctic nations asserting seabed jurisdiction before the ice even fully melts.

This essay argues that emergent deep sea mining opportunities are poised to exacerbate the Arctic's role as a strategically vital intersection of critical mineral supply and geopolitics. As the West seeks to diversify from Chinese-controlled supply chains, Arctic marine minerals offer a solution. This essay makes three contributions. First, it identifies marine mineral resources opportunities in the Arctic, noting the lack of resource surveys but evidence of unique mineral types. Second, it synthesizes recent geopolitical developments, particularly the surge in Extended Continental Shelf (ECS) claims made by Arctic states, driven by receding ice and advancements in exploration technology. Finally, the article proposes a strategic roadmap for proactive U.S. leadership in Arctic seabed minerals.

MINERALS RESOURCES OF THE ARCTIC OCEAN

Generally, marine minerals are categorized into three principal types derived by their formation and incidence:

- Polymetallic nodules ("nodules") – Found on abyssal plains, these nodules are rich in manganese, nickel, copper, and cobalt.
- Ferromanganese crusts ("crusts") – Occurring on seamounts and ridges, these crusts contain cobalt, rare earth elements (REEs), and platinum-group metals.
- Seafloor massive sulfides – Associated with hydrothermal vents, SMS deposits can be enriched in copper, zinc, gold, and silver.

Seabed resources thus offer multiple types of critical minerals, with individual ore grades often matching or exceeding terrestrial resources. Nodules and crusts particularly can produce many metals as coproducts, improving economic yield and reducing the intensity of processing. The four primary metals of interest – cobalt, nickel, copper, and manganese – are all major inputs to renewable energy, batteries, nuclear power, and other energy infrastructure. All four targets, as well as trace but valuable REEs, are subject to complete or majority import dependence for the U.S. (mainly from China).

Limited oceanographic expeditions have found all three types of marine minerals in the Arctic, though data on resource occurrence, abundance, and distribution are extremely limited. Historically this was due to sea ice, challenging operating conditions, and the lack of an economic case absent strategic imperatives.

A pioneering 2017 study, however, revealed that the nature of Arctic marine minerals may be substantially different from other deep sea mineral deposits. American and Russian research programs, enabled by shrinking sea ice, began the first major mineralogical surveys in the late 2000s and early 2010s. Hein et. al. (2017) reported that this data indicates nodules and crusts in the Arctic Ocean are compositionally unique compared to other oceanic deposits. Although the primary metals targeted by conventional deep sea miners (Co, Ni, and Cu) had lower concentrations than equatorial regions, the Arctic samples had somewhat higher levels of the most valuable REEs and vanadium.

Most strikingly, samples of both nodules and crusts were found to possess unusually high levels of scandium – 50 ppm, approximately ten times higher than CCZ nodules. Scandium, an obscure REE, is potentially valuable for solid oxide fuel cells, renewable energy alloys, military aircraft, missile systems, and other applications. Listed by all three critical mineral lists in the United States (DOD, DOE, USGS), one analysis has additionally declared scandium as one of twelve "strategic defense critical minerals." Current global production is less than 25 tons annually, but projections indicate demand as high as 5,300 tons just for clean energy applications by 2030. There are no dedicated scandium mines (it is produced as a minor coproduct), and it is 100% imported by the U.S.

These early surveys underscore the Arctic marine minerals are largely uncharacterized, in part due to the mineral formation environment. The Arctic Ocean is bound by multiple continents, fed by large terrestrial basins, and subject to extreme weather conditions, creating unique geological conditions for mineral formation. A 2024 study found that Arctic basin has mineralization through fault-driven hydrothermal processes, a previously undocumented mechanism in the region. Such findings indicate that mineral deposit types in the Arctic could be greater than assumed, reinforcing the need for extensive seabed surveys.

As a brief aside, there may be an additional critical mineral source in the Arctic Ocean: oil and gas. Researchers are investigating critical mineral extraction from produced water during fossil development. Watson et. al. posit that the source rocks of Alaska's North Slope oil and gas fields contain high levels of REE and other valuable minerals, and that produced water extraction could enable mineral coproduction across future Arctic offshore oil and gas operations.

Economic viability will determine the Arctic's potential marine mineral resources – lacking survey data, it is unknown whether it can be feasible. Deep sea mining operations globally are in their infancy, although equatorial regions are on the verge of initial commercial mining. The mineral economics of equatorial seabed mining depend highly on commodity prices, which have been especially volatile since the COVID-19 supply disruptions.

Arctic deep sea mining operations will be more challenging than equatorial equivalents. Exploration and mining operations will have to contend with variable and retreating ice, needing both ice-class vessels and potential icebreaker support. Extreme weather conditions and cold may drive seasonal production. Arctic infrastructure is nascent and may need significant investment to support an influx of vessels, especially for mineral off-load and transport. Conversely, the Arctic Ocean features shallower depths than Pacific equivalents, potentially simplifying operations. Ultimately, the economics of the endeavor depend on broader infrastructure and geopolitical developments.

GOVERNANCE AND GEOPOLITICS IN THE ARCTIC CIRCLE

The legal landscape governing deep sea mining is shaped by the United Nations Convention on the Law of the Sea (UNCLOS), which divides jurisdiction:

- Coastal states have exclusive rights to seabed resources within their exclusive economic zones (EEZs), up to 200 nautical miles, and in their ECS, which states can claim up to 350 nautical miles if they demonstrate geological connectedness.
- The International Seabed Authority (ISA) regulates mining in "the Area," which is seabed beyond EEZs and ECS.

Critically, the United States has not ratified UNCLOS, largely due to objections to ISA jurisdiction. The most promising global marine mineral deposits are the nodules of the expansive CCZ, exclusively located in ISA jurisdiction. U.S. companies are thus unable to access the CCZ. The ISA is struggling to adopt a mining code to authorize commercial extraction in the CCZ, with nations turning to domestic deposits instead.

With this shift, and broader geopolitical tensions, marine minerals are now an important axis of strategic competition at the top of the world. All Arctic nations with major coastlines – Canada, Denmark/Greenland, Norway, Russia, and the United States – have claimed an ECS and submitted these to an advisory UNCLOS body for scientific validation. Collectively, these ECS claims are significant as they mean that most of the Arctic seabed falls under domestic regulation, as opposed to ISA.

In 2023, two decades of Russian work culminated in the advisory body embracing Russia's ECS claim in the Arctic Ocean. The claims' edges must be adjudicated with other Arctic ECS assertions, particularly around the North Pole. Still, Russia is now the dominant EEZ and ECS holder in the Arctic, cementing offshore fossil, military, and navigational interests. Although Russia's capability to independently develop marine mineral resources may be limited, it could lease resource rights to China, who has significant interests in the Arctic, in Arctic critical minerals, and in deep sea mining globally.

In 2024, the U.S. similarly made expansive ECS claims. Following the largest civilian offshore mapping project in U.S. history, the Department of State claimed over 1 million square kilometers of ECS in seven regions, half of which were in the Arctic Ocean north of Alaska. Another region included the near-Arctic Aleutian Islands. The region could pose the best opportunity for domestic marine minerals production. However, the U.S.'s non-ratification of UNCLOS hampers its ability to formalize ECS claims, thereby weakening its strategic position in the region.

As a governance note, regional deep sea mining is heading towards reality, as demonstrated by Norway, meaning the topic will have to be addressed in regional governance. Environmental and indigenous perspectives will play a major role alongside geopolitical interests in forums such as the Arctic Council.

A ROADMAP FOR U.S. LEADERSHIP IN ARCTIC MARINE MINERALS

As sea ice retreats over the next several decades, American marine mineral resources in the Arctic can become a pillar of the nation's critical mineral security. The nation can actualize this promise through the following actions:

1. Conduct extensive resource surveys of Arctic marine minerals in the U.S. ECS, as well as allied ECS.
2. Incorporate deep sea mining into the nation's Arctic and critical mineral policy, and promote domestic mineral interests in international fora such as the Arctic council.
3. Bolster the U.S. ECS claim by ratifying UNCLOS to enable formal adjudication or seek recognition of claim by Arctic allies.
4. Develop a program of integrated research and development, public private partnerships, and infrastructure development, capturing synergies with other Arctic seabed activities.

By shifting attention northward—beyond Greenland's allure—the United States can secure its strategic autonomy, lead in critical mineral production, and shape polar geopolitics.