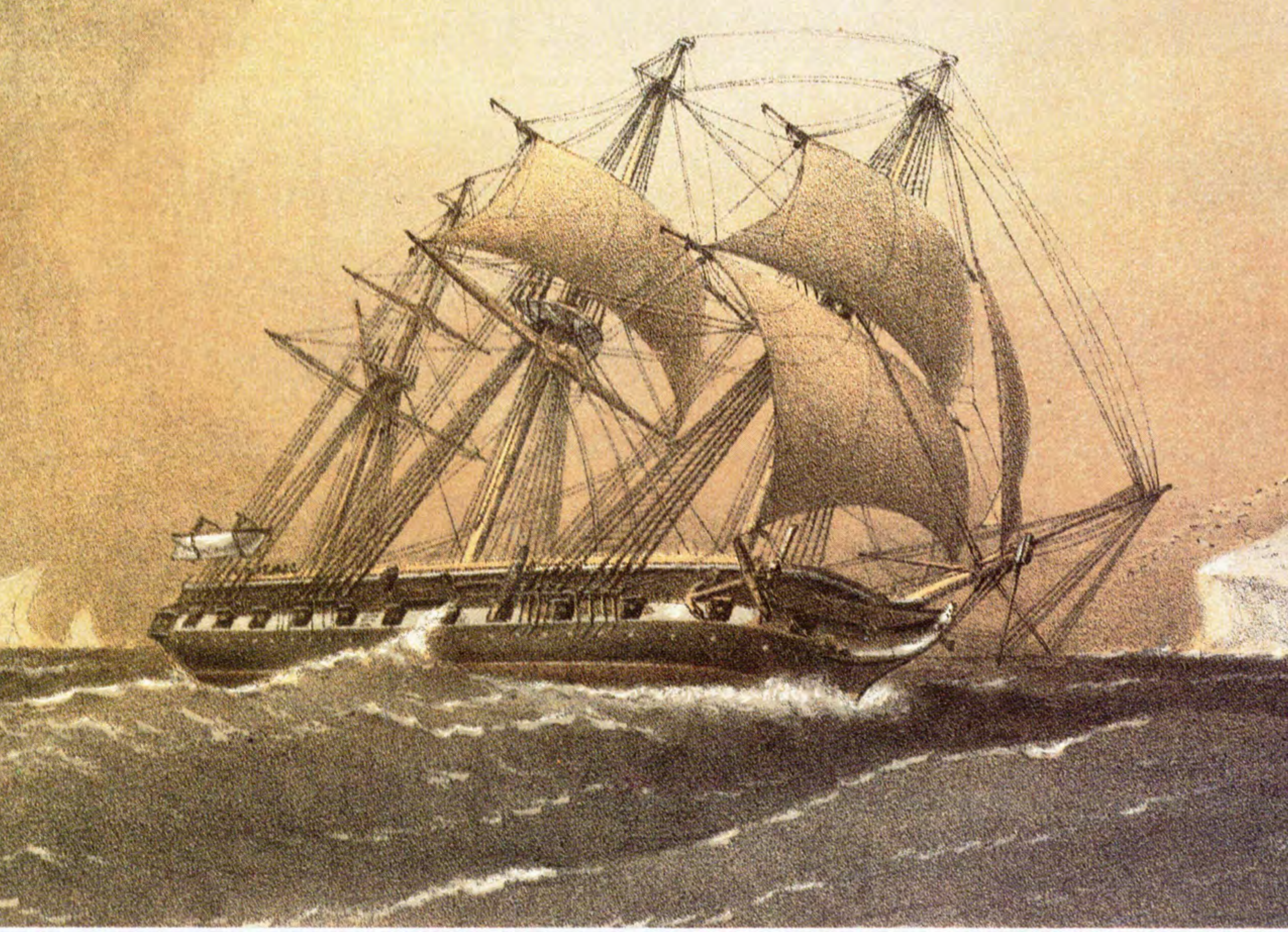
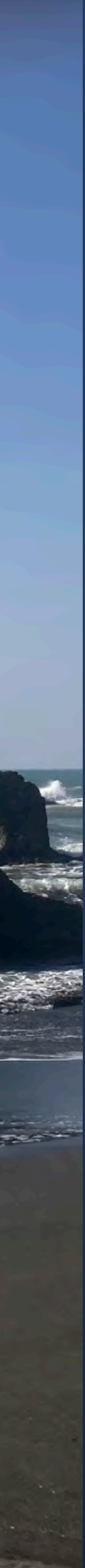
BARON



REPORT

DEEP-SEA MINERALS: THE NEXT ARENA OF U.S.-CHINA COMPETITION

MARCH 2024



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Cover: *The HMS* Challenger, *painted by William Frederick Mitchell in 1858. During a voyage from 1872 to 1876, the crew on the* Challenger *found that polymetallic nodules are present in most oceans of the world. (William Frederick Mitchell, 1858).*
Left*: Shipping in the Taiwan Strait outside Kaohsiung, Taiwan. The growth of the PLA Navy (PLAN) in the past few years ostensibly has been oriented toward Taiwan. Chinese dominance of the deep-sea minerals industry would serve as a significant boost to PLAN capabilities.*

About Baron

Baron has guided clients through the most challenging political terrain for almost two decades. Applying a methodology focused on mastering the strategic competition of interests, Baron advises some of the nation's most prominent organizations, including members of the *Fortune* 10 and the U.S. Department of Defense. Baron's client work includes the U.S.-China relationship, as well as the automotive, energy, and critical mineral sectors.

EXECUTIVE SUMMARY

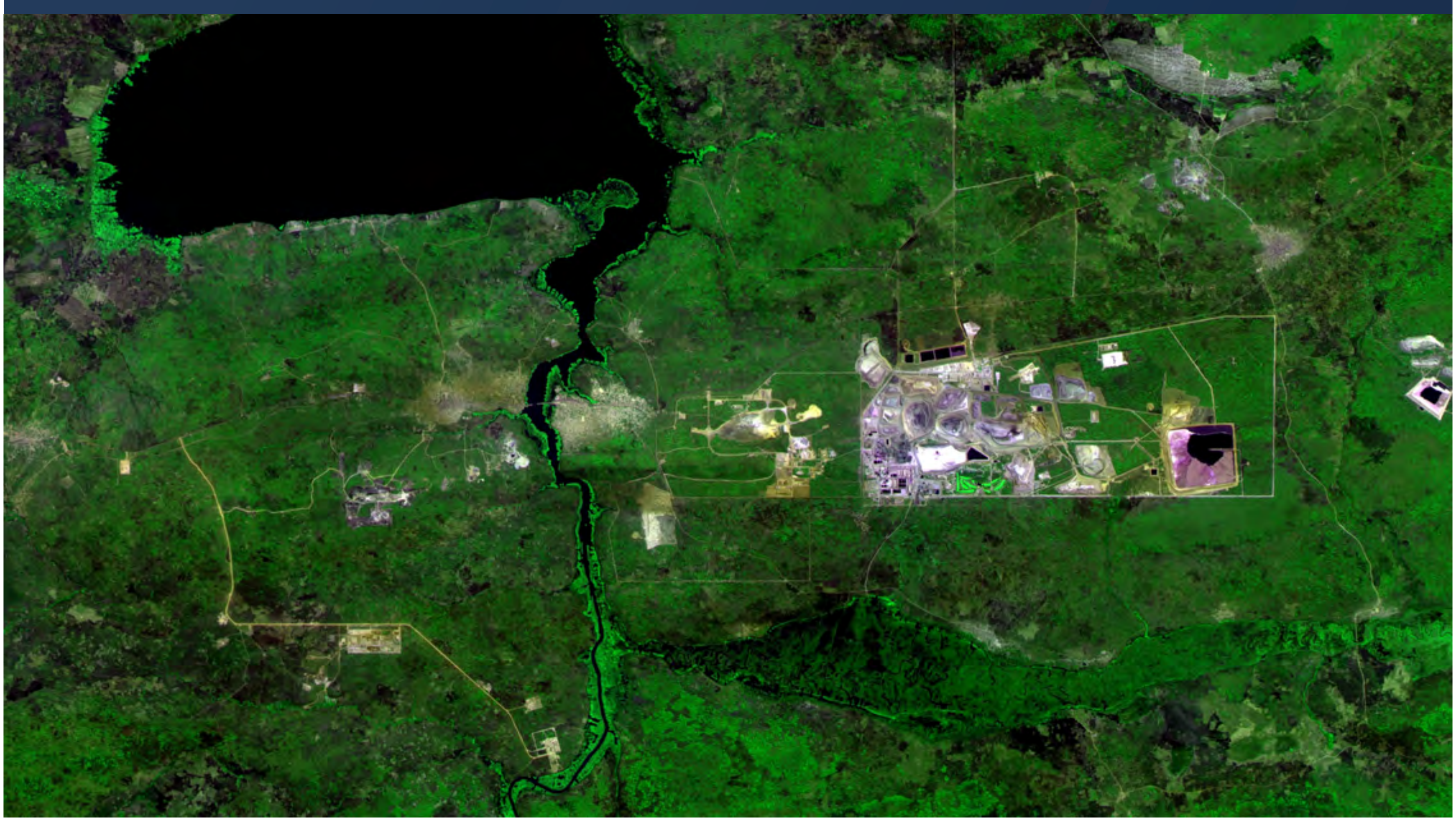
1. **China has implemented aggressive industrial policies to capture a leading position in deep-sea mining.** This report identifies 29 Chinese entities that are involved in a constellation of research institutes, universities, state-owned enterprises (SOEs), government agencies, and other entities dedicated to the development of China's deep-sea mining industry. These entities are securing contracts at the International Seabed Authority (ISA), developing advanced deep-sea technology, and executing extensive deep-sea operations.

2. **China's access to domestic deep-sea minerals is constrained by geography and international regulation.** While America has the world's largest Exclusive Economic Zone (EEZ), China's EEZ is only the 33rd largest. To address this disadvantage, China is heavily prioritizing efforts to shape debates at the ISA and expand its *de facto* EEZ through civilian and military infrastructure projects in the South and East China Seas.

3. **A Chinese-led deep-sea mining industry would threaten U.S. primacy in the Pacific.** A surge in deep-sea mineral extraction throughout the Pacific would pit the maritime capabilities of both countries against each other and open new theaters of economic and military competition. By weakening U.S partnerships with Pacific Island nations, disrupting maritime traffic, and exposing growing vulnerabilities in U.S. maritime power, expanded Chinese operations would signal the end of the post-World War Two status quo in the Pacific.

4. **U.S. leadership in deep-sea mining and mineral processing would boost America's industrial economy.** The looming gap between demand for critical minerals and the supply from terrestrial mines – compounded by global dependency on China – threatens American companies across a range of sectors. In response, the U.S. government can capitalize on the latent potential of deep-sea minerals to transform mineral supply chains and, in the process, enable U.S. firms to unlock opportunities that were not viable in the past.

An aerial view of the Mutanda open-pit copper and cobalt mine in the Democratic Republic of the Congo (DRC). Most of the world's cobalt is mined in the DRC, deep-sea minerals have the potential to open up new sources of cobalt and other critical minerals (Source: Coordenação-Geral de Observação da Terra/INPE, 2018, CC BY-SA 2.0).



The Hughes Glomar Explorer *at port in Long Beach, California in 1976, two years after the CIA successfully used her to recover parts of a sunken Soviet submarine under the guise of searching for polymetallic nodules on the ocean floor (Source: Tequask, 1976, CC BY-SA 3.0).*

INTRODUCTION

THE NEW OIL

Just as petroleum was central to the great power contests of the 20th century, the emerging deep-sea mineral industry has the potential to reshape the geopolitics of the rest of the 21st century.

As more countries pursue "clean energy transitions," the International Energy Agency (IEA) estimates that total demand for critical minerals could double by 2040.[1] As a result of this anticipated growth, it is possible that supplies of copper, lithium, and cobalt will be inadequate by 2030.[2] Companies and governments around the world are all faced with a common challenge: securing access to these minerals.

In the past 15 years, China has steadily established itself as the country best positioned to not only overcome these new challenges but to turn them into an advantage. Beyond domestic mining operations, Chinese companies have secured access to critical minerals *via* ownership of foreign mines and dominance over the global mineral processing industry.

China has been successful despite its limited domestic resources. For example, China controls an estimated 48 percent of global nickel and 47 percent of cobalt mining operations.[3] This is despite the United States Geological Survey ranking China eighth in nickel mine production and not even listing China as a major cobalt producer. Even when the largest repositories of minerals are far from China and are mined by non-Chinese entities, China's superior mineral processing industry forces large amounts of minerals to pass through

China before entering finished goods. Based on IEA data, China processes 42 percent of the world's copper, 56 percent of the world's nickel, 65 percent of the world's lithium, 74 percent of the world's cobalt, 90 percent of the world's rare earth elements (REEs), and 100 percent of the world's graphite – the most common anode material in lithium-ion batteries.[4] Consequently, electric vehicles (EVs), solar power, wind turbines, energy storage systems, personal electronics, and other critical mineral-dependent technologies cannot be built without China.

While the shale revolution is a case study of how the U.S. private sector can drive a rapid and massive increase in U.S. natural resource production – America became the world's largest oil producer, while China imports around 11 million barrels of oil per day – securing critical minerals presents additional obstacles for the United States.[5] One advantage China enjoys is being able to rapidly scale mining and processing operations. China reportedly can build profitable nickel processing plants in Indonesia in just two years, while it would take Western companies up to 15 years to do the same.[6] Moreover, while its geology is favorable for oil and gas production, the United States does not have significant reserves of cobalt (less than one percent of land reserves), copper (about five percent of land reserves), lithium (about four percent of land reserves), nickel (less than half a percent of land reserves), or manganese (no economically viable reserves).[7]

The emergence of deep-sea mining as an economically attractive alternative to conventional terrestrial mining creates an inflection point in U.S.-China competition for natural resources. The United States has the opportunity to reset the competition. Rather than trying to overcome China's entrenched advantages in terrestrial mining, the United States – with favorable policies from the federal government coupled with private-sector interest – could gain a leadership position in deep-sea mining.

Given the nascent nature of the industry, it is too early to tell whether the United States or China will become a leader in deep-sea mining in the long term, but enough early indicators have emerged to paint an initial picture of what might be possible. This report assesses publicly available information about Chinese activity in the deep-sea mining sector to help U.S. government and private-sector leaders understand how this new domain of competition is likely to develop.

This report explores the following topics:

Section I begins with an overview of deep-sea mining and the major asymmetries between the American and Chinese approaches to the industry.

Section II provides a comprehensive framework for understanding Chinese involvement in deep-sea mining and, based on research using Chinese sources, offers the most detailed English-language descriptions available of Chinese entities involved in deep-sea mineral research and exploration.

Section III explores the future risks and implications of Chinese engagement in deep-sea mining for U.S. economic and military interests to equip decision makers for the coming changes.

Conclusion compares the emerging competition for deep-sea minerals to fluctuations in U.S. oil independence and assesses the U.S. government's role in building out domestic and allied deep-sea mineral extraction and processing capabilities.

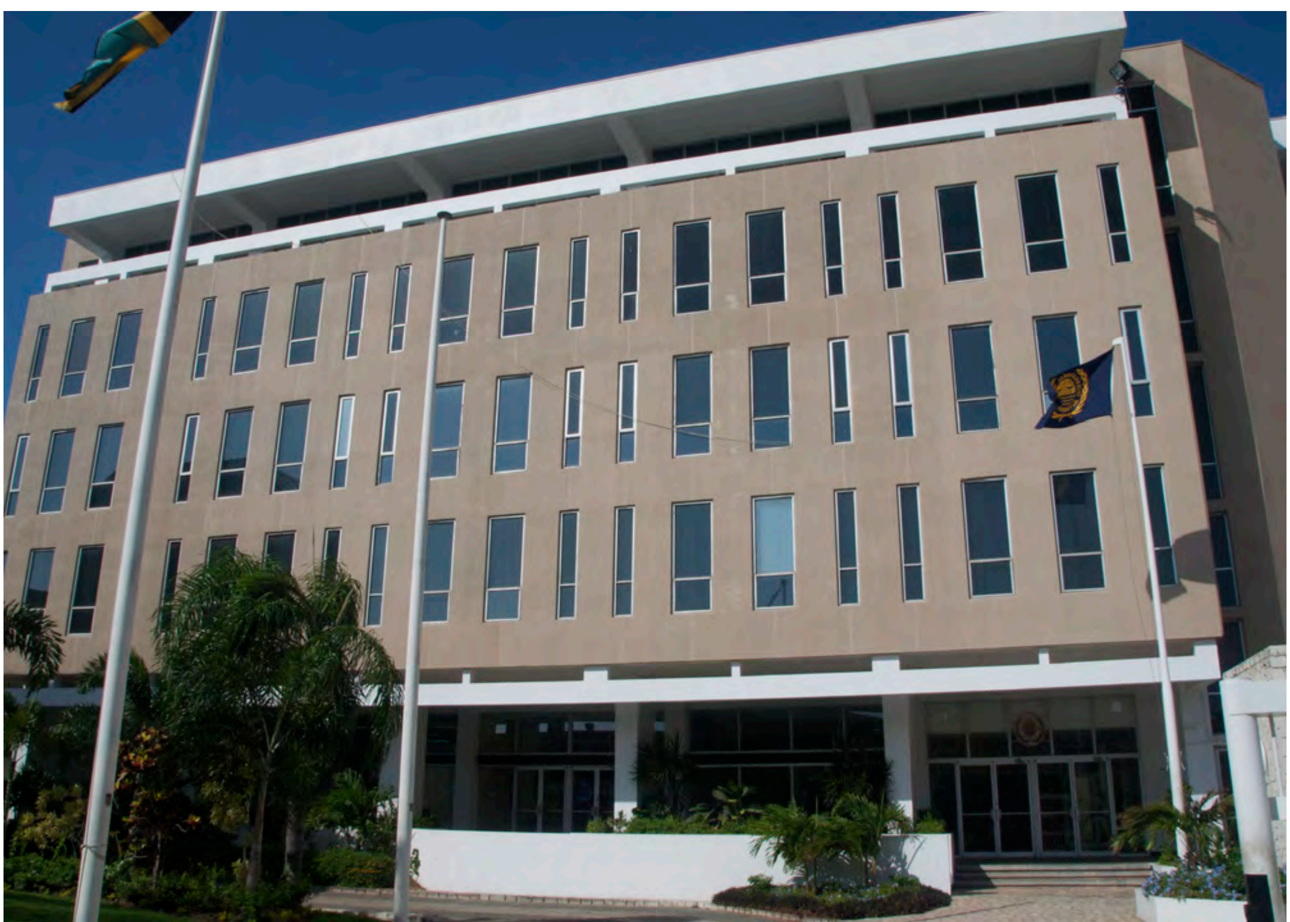
SECTION I

THE GROWING IMPORTANCE OF DEEP-SEA MINERALS

Collectively, deep-sea minerals constitute one of the greatest potential sources of wealth available anywhere on Earth. Estimates of the total value of global deep-sea mineral deposits vary widely due to the unprecedented nature of commercial deep-sea mining, variance in the economic viability of deposits, and volatility in mineral pricing. According to information published by the National Oceanic and Atmospheric Administration (NOAA), the amount of polymetallic nodules (commonly containing cobalt, manganese, copper, and nickel) in international waters may be as great as two trillion tonnes.[8] In a 2020 study commissioned by the International Seabed Authority (ISA) – the UN body tasked with administering exploration and mining of ocean regions beyond the boundaries of EEZs – the estimated gross value of the metals contained in polymetallic nodules fluctuated between $320/tonne and $1,100/tonne from 2000 to 2020.[9] The significant supply of minerals on the ocean floor, combined with growing demand, make this a valuable opportunity for companies and countries looking to diversify their critical mineral supply chains.

The following factors determine the economic viability of deep-sea mineral deposits in international waters: 1.) critical mineral processing fees, 2.) density and makeup of the mineral deposits, and 3.) royalties to the ISA. Beyond the common and significant cost of acquiring the requisite vessels and extraction equipment for deep-sea mining, these three factors are what will shape commercial mining efforts in the future. For example, The Metals Company – a Canadian multinational company then known as Deep Green Metals Inc. – conducted an "Initial Assessment" of the potential economic value in one of its contracted regions of the Clarion Clipperton Zone (CCZ) in 2021 and found billions of dollars of anticipated expenses from mineral processing fees and anticipated ISA royalties. Despite these significant costs, the assessment also found a net present value (NPV) of $6.8 billion due to the favorable density and makeup of the nodules in its contracted area.[10]

ISA headquarters in Kingston, Jamaica. With a 2025 deadline for approving deep-sea mining regulations, the next year of meetings at the ISA will significantly impact the future of deep-sea mining in international waters (Source: James A.R. McFarlane, 2009, CC BY-SA 3.0).



In recent years, technological advances have made deep-sea mining a viable alternative to terrestrial mining. Chinese organizations working on novel seafloor extraction methods, advanced submersible vehicles and conveyor systems, and topographical mapping techniques are setting industry standards for the rest of the world.[11] The progressive increase in surveys by Chinese deep-sea vessels and other ISA contractors has shown prospective mining areas with high nodule density on top of – not buried beneath – the seabed. With only limited biological activity on the seabed, deep sea mining is less environmentally disruptive to natural biomes than terrestrial mining and resource extraction projects. In fact, terrestrial mining projects cause up to $3 trillion in ecological damages annually, while deep-sea mining may reduce the lifetime carbon footprint by 38 percent.[12]

Three major types of mineral deposits exist on the seafloor: cobalt-rich ferromanganese crusts (CFC), polymetallic sulfides (PMS), and polymetallic nodules (PMN). Polymetallic nodules are the most abundant and, therefore, potentially most valuable source of critical minerals for the global economy.[13] These nodules primarily contain cobalt, manganese, copper, and nickel but can also hold ultra-rare minerals, such as tellurium, and rare-earth elements (REEs), such as yttrium.[14] The four most prominent minerals alone are essential components for important green technologies such as solar power, wind turbines, and batteries.

Many commercially viable deep-sea mineral deposits, particularly polymetallic nodules, are in international waters. Although mineral deposits can also be found in shallower, coastal areas, the CCZ is currently the most sought after region under ISA authority because of its high density of nodules. Countries with mineral deposits within their 200 nautical mile coastal EEZ are authorized by international law to mine those deposits, assuming compliance with pertinent environmental regulations.[15] EEZs are more likely to contain polymetallic sulfides and ferromanganese crusts than nodule fields due to the lower depths at which they naturally occur.

Deep-sea minerals found in EEZs have significant economic potential. Without the need to pay royalties to the ISA for extracting from international waters and a high nodule density in a field around twice the size of ISA contract areas, the Cook Islands has access to a lucrative deposit of nodules.[17] While they may not have the same ease of access and abundance as

Global distribution of three major types of deep-sea mineral resources (UNEP, adapted from ISA 2014).[16]

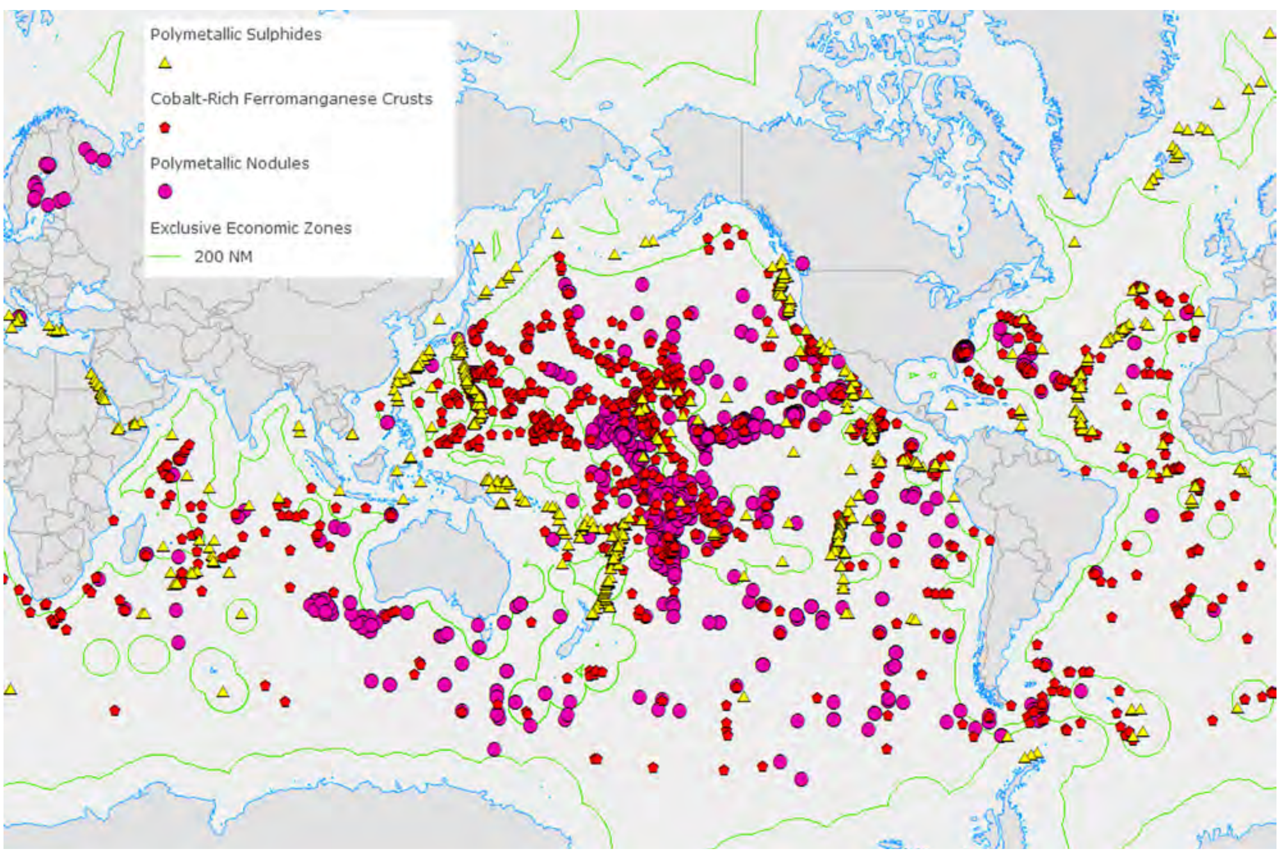


Table 1: Top 36 Countries by EEZ Size and Relationship with the United States.

Rank	Country	Status	Rank	Country	Status
1	United States		19	Marshall Islands	Major partner
2	France	Ally	20	Cook Islands	Major partner
3	Australia	Ally	21	Portugal	Ally
4	Russia	Competitor	22	Philippines	Ally
5	United Kingdom	Ally	23	Solomon Islands	Other
6	Indonesia	Other	24	South Africa	Other
7	Canada	Ally	25	Seychelles	Other
8	Japan	Ally	26	Mauritius	Other
9	New Zealand	Ally	27	Fiji	Other
10	Brazil	Ally	28	Madagascar	Other
11	Chile	Other	29	Argentina	Ally
12	Kiribati	Other	30	Ecuador	Other
13	Mexico	Other	31	Spain	Ally
14	Federated States of Micronesia	Major partner	32	The Maldives	Other
15	Denmark	Ally	33	Peru	Other
16	Papua New Guinea	Other	34	China	Competitor
17	Norway	Ally	35	Somalia	Other
18	India	Major partner	36	Colombia	Ally

Notes: The list of allies includes NATO members and major non-NATO allies while the list of major partners includes Quad members, Compacts of Free Association (COFA), and the Cook Islands - which is in free association with New Zealand.[18]

the Cook Islands, other viable deep-sea mineral deposits likely exist in the extensive EEZs of the United States and its strategic partners. Although deep-sea mining may distort markets for critical minerals, current extraction speeds and rapidly increasing demand from the renewable energy sector and EVs mean that such minerals will likely remain profitable for years to come. As such, identifying economically viable deposits in EEZs will become increasingly important for the United States and its strategic partners.

The ISA was established by the UN Convention on the Law of the Sea (UNCLOS) to administer the contract approval system for prospecting and mining these mineral deposits.[19] Notably, the United States is not a party to the ISA due to its unwillingness to ratify UNCLOS, which is in part due to the Convention's insufficient attention to U.S. interests in deep-sea minerals. In particular, U.S. disagreements have centered on the UN decision to empower the ISA to control seabed mining royalties and contracting areas.[20] As of 2024, 31 contracts have been awarded to a variety of research institutes and companies vying for control of the richest deposits. Many of these contracts are located within the CCZ, to the east of Hawaii, which has become an area of considerable interest for deep-sea mineral contractors. Polymetallic nodule fields in the CCZ are estimated to contain more nickel, cobalt, and manganese than all land-based deposits of those three minerals combined.[21]

U.S. entities account for zero of 31 contracts granted by the ISA.[22] Although the ISA requires all potential contractors to attain sponsorship from an UNCLOS state, this does not preclude U.S. companies from attaining ISA contracts.[23] Additionally, Lockheed Martin previously owned UK Seabed Resources Ltd. (UKSR), a former subsidiary that secured two ISA contracts in the CCZ *via* the United Kingdom's sponsorship.[24] Lockheed sold UKSR to Norway's Loke Marine Minerals in 2023, thus ending Lockheed's indirect control over two ISA contracts.

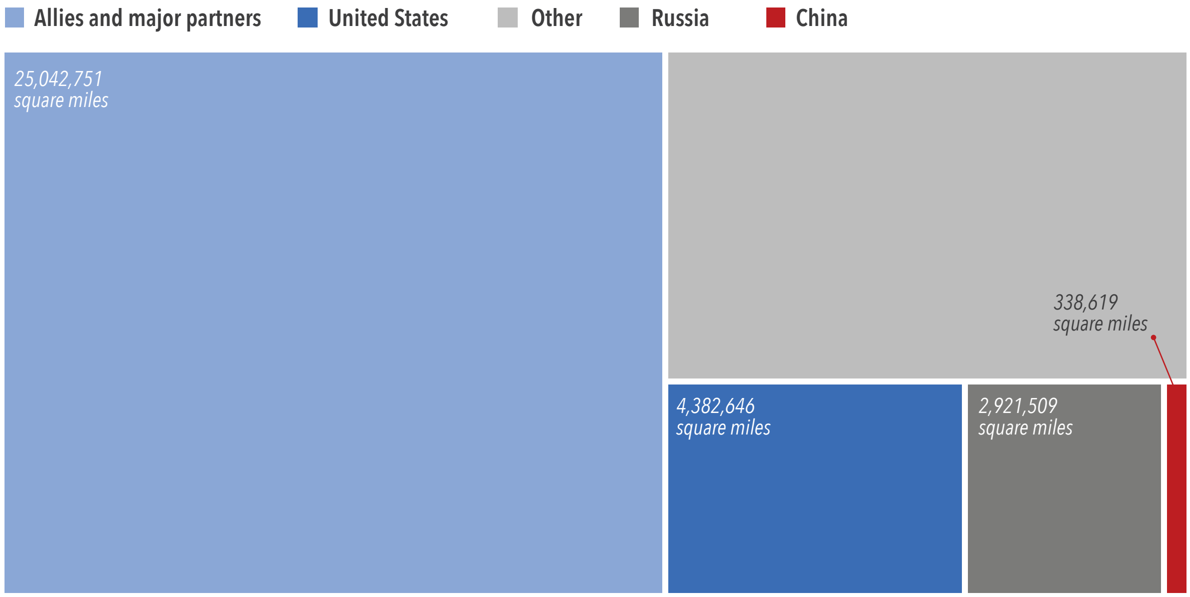
The ISA has awarded five of its 31 total tendered contracts to Chinese deep-sea mineral contractors. The details of the five contracts are displayed in Table 2, along with other sponsoring states' ISA contracts.

Table 2: ISA exploration contracts (Adapted from ISA, undated).

Sponsor	Contracts	Contractor	Contractor Type	Location	Nodule Type
China	5	China Minmetals Corporation	SOE	CCZ	Polymetallic Nodules
		Beijing Pioneer Hi-Tech Development Corporation	SOE	Western Pacific	Polymetallic Nodules
		COMRA	Government	CCZ	Polymetallic Nodules
		COMRA	Government	SW Indian Ridge	Polymetallic Sulfides
		COMRA	Government	Western Pacific	Cobalt-Rich Ferromanganese Crusts
South Korea	3	Government of the Republic of Korea	Government	CCZ	Polymetallic Nodules
		Government of the Republic of Korea	Government	Central Indian Ocean	Polymetallic Sulfides
		Government of the Republic of Korea	Government	Western Pacific	Cobalt-Rich Ferromanganese Crusts
Russia	3	JSC Yuzhmorgeologiya	Private*	CCZ	Polymetallic Nodules
		Government of the Russian Federation	Government	Mid-Atlantic Ridge	Polymetallic Sulfides
		Government of the Russian Federation	Government	Magellan Mtns, Pacific Ocean	Cobalt-Rich Ferromanganese Crusts
Japan	2	Deep Ocean Resources Development Co. Ltd.	Government/ Private*	CCZ	Polymetallic Nodules
		Japan Organization for Metals and Energy (JOGMEC)	Government	Western Pacific	Cobalt-Rich Ferromanganese Crusts
Germany	2	Federal Institute for Geosciences and Natural Resources of Germany	Government	CCZ	Polymetallic Nodules
		Federal Institute for Geosciences and Natural Resources of Germany	Government	Central Indian Ocean	Polymetallic Sulfides
India	2	Government of India	Government	Indian Ocean	Polymetallic Nodules
		Government of India	Government	Central Indian Ocean	Polymetallic Sulfides
UK	2	UK Seabed Resources Ltd.	Private*	CCZ	Polymetallic Nodules
		UK Seabed Resources Ltd.	Private	CCZ	Polymetallic Nodules
France	2	French Research Institute for Exploitation of the Sea	Government	Mid-Atlantic Ridge	Polymetallic Sulfides
		French Research Institute for Exploitation of the Sea	Government	CCZ	Polymetallic Nodules
Poland	1	Government of the Republic of Poland	Government	Mid-Atlantic Ridge	Polymetallic Sulfides
Nauru	1	Nauru Ocean Resources Inc.	Private*	CCZ	Polymetallic Nodules
Tonga	1	Tonga Offshore Mining Limited	Private*	CCZ	Polymetallic Nodules
Belgium	1	Global Sea Mineral Resources NV	Private*	CCZ	Polymetallic Nodules
Kiribati	1	Marawa Research and Exploration Ltd.	Private*	CCZ	Polymetallic Nodules
Singapore	1	Ocean Mineral Singapore Pte Ltd.	Private*	CCZ	Polymetallic Nodules
Cook Islands	1	Cook Islands Investment Corporation	Government/ Private*	CCZ	Polymetallic Nodules
Jamaica	1	Blue Minerals Jamaica Ltd	Private*	CCZ	Polymetallic Nodules
Multiple^	1	Interoceanmetal Joint Organization	Intergovern-mental	CCZ	Polymetallic Nodules

Note: COMRA stands for China Ocean Minerals Resources Research and Development Association
** Citation included in footnote.*[25]
^ Bulgaria, Cuba, Czech Republic, Poland, Russia, and Slovakia are the joint-sponsors of the Interoceanmetal Joint Organization's ISA contract

Chart 1: China's EEZ is marginal compared to those of the United States, U.S. allies and major partners, and Russia.



Note: Other represents the cumulative EEZ of the remaining countries in the top 36.

China's rush to obtain ISA contracts is likely shaped by continued frustrations over its relatively small EEZ. Due to its coastline's proximity to South Korea, Japan, Vietnam, and the Philippines, China's EEZ is only the 33rd largest in the world, behind Peru, Maldives, and Spain.[26] For comparison, the United States' EEZ is 12 times the size of China's.[27] These natural constraints make ISA contracts even more attractive for China because they grant access to large swaths of resource-rich regions of the ocean.[28] In part due to its notably small EEZ (see Chart 1), there are persistent tensions between China's formal ratification of UNCLOS and its disregard for how UNCLOS defines China's EEZ.

Beijing may view deep-sea minerals as a contingency plan in the event of disruptions to its sourcing of minerals from Africa. China's extensive loans to African countries have fallen precipitously from a peak of almost $28 billion in 2016 to less than $1 billion in 2022.[29] Over time, this reduced commitment to the region could erode China's primacy over Africa's mining industry. The world's oceans offer China the opportunity to lock in mineral stores without the risks posed by political instability and fraught financial entanglements.

Deep-sea minerals need to be processed. Today, China dominates global mineral processing capacity while the sector is almost nonexistent in the United States. China is the world's leading processor of critical minerals and REEs.[30] In contrast, the United States "lacks domestic processing and manufacturing capabilities for some critical minerals, which results in the export of domestically produced ores and concentrates for further processing into more value-added products" according to a 2020 Department of Commerce report.[31] Further, in Executive Order 13953 signed by former President Trump in 2020: "Our country needs critical minerals to make airplanes, computers, cell phones, electricity generation and transmission systems, and advanced electronics. Though these minerals are indispensable to our country, we presently lack the capacity to produce them in processed form in the quantities we need. American producers depend on foreign countries to supply and process them. For 31 of the 35 critical minerals, the United States imports more than half of its annual consumption. The United States has no domestic production for 14 of the critical minerals and is completely dependent on imports to supply its demand."[32]

Non-Chinese deep-sea mining entities confront difficult choices about partnering with Chinese contractors for transport, extraction, and processing. China's geographic proximity to many of the richest deposits may make it the logical choice for interim processing and end-user manufacturing. Early entrants into the deep-sea mining industry have reported extensive efforts by Chinese companies to secure advance mineral processing agreements before mining begins.[33] These overtures are not without basis as China's nickel processing capacities in Indonesia are the most profitable in the world.[34]

The Tan Suo Yi Hao (探索一号) *, a deep-sea research vessel owned by the Institute of Deep Sea Science and Engineering (IDSSE). In the past 10 years, China has rapidly increased its deep-sea mining efforts, with vessels like the* Tan Suo Yi Hao *and the submersibles they support leading the way (Source: IDSSE).*

SECTION II

THE SOURCES OF CHINA'S SUCCESS

China's established position is a result of its concerted strategy to galvanize public and private sector actors around a vibrant "blue economy" (蓝色经济, *lanse jingji*).[35] The roots of China's quest to dominate deep-sea minerals extend back at least a decade. The 18th Party Congress Political Work Report published in 2012, the same year as China's President Xi Jinping took office, was the first government document to refer to the goal of making China into a "maritime great power" (海洋强国, *haiyang qiangguo*).[36] This strategic objective provided the official motivation for China's buildup of maritime capabilities.

Investments in deep-sea research and technology are a central element of China's maritime great power strategy. Occurring around the time that China's new strategic guidance was being formulated, the successful sea trials of the 7,000-meter *Dragon* (蛟龙, *jiaolong*) manned submersible between 2009 and 2012 played a crucial role in encouraging greater investment in the deep-sea mining industry.[37] While the China Ocean Minerals Resources Research and Development Association (COMRA) has maintained a leading role in shaping the frontier of deep-sea investments, research institutes represented by the Chinese Academy of Science (CAS), SOEs including China Minmetals Corporation (CMC), and satellite entities such as the Changsha Research Institute of Metallurgy and Mining (CRIMM) seized the occasion of Xi's ascent to advance their own deep-sea exploration and technology development capabilities.

China is increasing the frequency and scale of its deep-sea exploration campaigns. COMRA has spearheaded around 80 deep-sea voyages between 1992 and today.[38] More than half of these (around 50) occurred in the last 10 years, with at least 29 of them dedicated to polymetallic nodule-rich regions of the Pacific and Indian Oceans.[39] Beijing bookended this increase in deep-sea campaigns by becoming the first state to acquire ISA contracts in all three types of exploration areas, adding to its May 2001 polymetallic nodule contract with a polymetallic sulfide contract in November 2011 and a cobalt-rich ferromanganese crust contract in April 2014.[40]

China is a leader in the technologies necessary to enable deep-sea mining at the greatest scope and scale. In 2022, the China State Shipbuilding Corporation (CSSC), a SOE hosting multiple deep-sea research institutes, unveiled the country's first oceanographic drilling ship: *Dream* (梦想, *mengxiang*).[41] The ship can drill at depths exceeding 10,000 meters below sea level, surpassing the drilling depths of similar ships owned and operated by the United States, Japan, and the United Kingdom.

A news report from *Xinhua* on the unveiling ceremony for the ship invoked the language of maritime great power (海洋强国).[42] As China continues to set new benchmarks in deep-sea mining capabilities, it will likely further integrate its large military and non-military SOEs into the nascent industry as both stand to benefit from access to the world's richest supply of critical minerals.

While COMRA is still the leading organization in China's deep-sea mining efforts, a more diverse group of deep-sea-related entities is starting to emerge. Universities like Shanghai Jiaotong University, Dalian Maritime University, and China Ocean University in Qingdao have also developed and tested the types of collectors and risers used to dig and transport deep-sea minerals underwater.[43] Chinese research institutions are also indigenously developing and commercializing several advanced autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) currently in use in early tests of mineral-rich zones in the CCZ and Western Pacific.[44] The combined involvement of the public and private sectors, universities, and research institutes suggests that Chinese investors and grantmaking institutions are confident in the government's future support of deep-sea mining.

PLA interest in deep-sea mining is driven by innovations in dual-use ocean technologies such as submersibles and mapping techniques. As China seeks to gain a greater foothold in the Arctic regions, the South China Sea, and the Taiwan Strait, advances in deep-sea exploration can result in tangible military benefits. For example, improved ocean floor mapping by a civilian entity engaged in mining operations could offer the military an edge in designing submarine warfare battle plans. Xi's efforts to amplify the importance of military-civil fusion (军民融合, *junmin ronghe*), which date back to the 12th National People's Congress in 2015, increase the potential for collaboration between China's deep-sea mining industry and the PLAN.[45] Although military-civil fusion is largely aspirational, Beijing has promoted the city of Qingdao – the largest hub for deep-sea mining affiliates – as a military-civil fusion success story.[46] This suggests submersibles, mapping technologies, or permanent installations connected to Chinese deep-sea mining entities will likely be repurposed for use by the PLAN in crisis scenarios and beyond.

When innovating, refining, and adopting new technologies, China has often taken the approach of placing many bets and hoping for a few big payoffs. The sector that most clearly demonstrates this strategy is the Chinese EV industry. During the 2010s, dozens of Chinese car companies emerged in the early EV boom. Many of the companies that spawned the EV boom have now folded or been consolidated into the smaller cohort of national champions that now dominate China's EV marketplace, including BYD, Geely, Nio, Xpeng, and Wuling.[47] China's EV industry is now poised to dominate the global market as demand for zero-emissions vehicles increases.[48]

China's EV approach stimulated competition through state-led subsidization. By supporting multiple entities conducting the same R&D, manufacturing, and with the same goals of creating a go-to-market product, China can simulate free-market competition through state action. Those companies that best combine manufacturing, marketing, and technology

A BYD Seal – an electric vehicle described by BYD as "a true masterpiece of ocean inspired design" – on display in Munich, Germany. After BYD's rise to dominance within China, it is now competing with Western automakers in their home markets. Many Western automakers are struggling to delink their EV supply chains from China.

in their product will rise above the rest and become the titans of the sector. Still, this approach also has certain limitations. For example, the proliferation of companies within China's EV industry led many international investors to withdraw capital as they saw many once-promising EV companies declare bankruptcy or merge with competitors.[49]

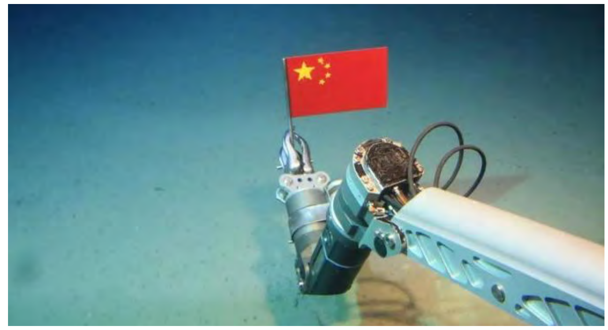
In deep-sea mining, China's strategy of promoting institutional repetition or duplication – in the mold of its EV industry – to spur competition seems to be in full effect. Several important trends emerge from a study of the various institutions involved in China's nascent deep-sea mineral industry:

1. Geographic diversity

Much of China's urban coastline enjoys unimpeded access to coastal waters rich in biodiversity and offering easy connections for outbound vessels to international shipping lanes. Instead of concentrating R&D activity in one area where researchers can gather, share knowledge, and accelerate the national deployment of deep-sea mineral extraction systems, China has fostered competition by distributing deep-sea mineral research activities into several key areas. Hubs in Beijing, Xiamen, Shanghai, and Qingdao emerge from a study of participating entities. Beijing-based entities are connected to government bodies such as the Ministry of Natural Resources. The remaining hubs all contain major ports and marine infrastructure that are used for building or launching large military and commercial vessels. In particular, Qingdao and Sanya are home to major naval bases that support PLAN units in the East and South China Seas, respectively. Significant activity in Qingdao is also unsurprising considering the regional origins of CCP leadership: Shandong comprises the majority of contemporary PLA and CCP elites' regional backgrounds.[50] The heat map on the right shows the degree of geographical diversity and Qingdao's role as the most significant hub for China's deep-sea mining operations (Baron identified six entities there). Please refer to the Appendix for a full list.

2. Limited private sector engagement

Among the 40 entities that Baron assessed as being involved in deep-sea mining activities, only one – Changsha Research Institute of Metallurgy and Mining (CRIMM) – could potentially be classified as a private company. Even this possible exception is ambiguous, with its history as a government enterprise from 1955 to 2009 and as a wholly-owned subsidiary of a SOE – China Minmetals Corporation – since then.[51] The lack of private sector entities with a stake in deep-sea mineral exploration may suggest that China does not want private sector actors too far outside of Beijing's influence to control deep-sea mineral supply chains. Conversely, China's major shipbuilding and oil and gas SOEs possess the human and physical capital required for seabed mining. The capital-intensive nature of the deep-sea mineral industry means that China likely prefers to manage its activities and priorities through an organizational structure that has proven successful in the past.



The Dragon *(*蛟龙*,* jiaolong*) submersible plants the PRC flag on the seabed of the South China Sea (Source:* Ministry of Natural Resources*).*

Heat map of entities Baron identified in China's deep-sea mining industry.

The ROCN Zhongqi *operating near the Matsu Islands. The ROCN* Zhongqi *was originally built by American Bridge Company in 1943 as the USS* Berkley County *and was transferred to Taiwan after the 1955 Mutual Defense Treaty between the United States and Taiwan (Republic of China). CSSC now outpaces U.S. domestic shipbuilding by itself, with the* Zhongqi *a reminder of an era when American shipbuilding helped the Allies defeat the Empire of Japan in the Pacific.*

3. Overlap with PLA affiliates

Given Beijing's growing emphasis on its military-civil fusion approach to developing and scaling new technologies, it is not a surprise that some key entities are linked to the PLA. CSSC, one of the country's largest industrial sector SOEs and a sponsor of several research institutes involved in the design and manufacture of both aircraft carriers like the *Shandong* and deep-sea mining research vessels, is poised to play a significant role in building the maritime fleets required for sustaining deep-sea mineral extraction far from China's borders. Since PLA-linked entities often receive proportionally larger subsidies and enjoy lesser scrutiny by financial regulators, they are permitted to take on more risk in their projects and investments. PLA-affiliated SOEs benefit from reduced financial and other risk due to their status as a suppliers of parts, vessels, or equipment to PLAN units.

The following section lists and describes the activities of major entities from four major categories: 1) Universities, 2) Government, 3) Research Institutes, 4) SOEs and subsidiaries. All entities are assessed in terms of their relative importance to the Chinese deep-sea mineral ecosystem. For a complete list of all entities known to be engaged in deep-sea mineral research, exploration, and extraction, as well as entities that participate in the design and construction of the equipment and technology required for scalable deep-sea mineral campaigns, please refer to the Appendix.

UNIVERSITIES

Dalian Maritime University (DLMU)

DLMU was founded as a shipping management university but has since grown to encompass a variety of maritime disciplines, including deep sea engineering, naval architecture, and nautical transportation engineering. It is located in Dalian, the capital of Liaoning and a strategic port city that provides a launching point for maritime traffic into the North China and Yellow Seas. Also located in Dalian are the Dalian Naval Academy and a People's Liberation Army Navy Air Force (PLANAF) base. Together with Xiamen University, DLMU sponsors the Zheng He Academy of International Oceans Law and Policy, which brings students from developing countries to China to study ocean governance. The Academy is partially supported with funds from the ISA Endowment Fund.[52] Although DLMU does not own or operate AUVs or ROVs, researchers have worked on submersible vehicle applications for deep-sea infrastructure using the university's water tunnel for testing purposes.[53]

Ocean University of China

Located in Qingdao, a port city with dual use as a commercial trading and military logistics node, Ocean University of China is the country's premier institution for oceanographic studies and marine engineering. The university owns a 3,500-ton marine research vessel, the *Dong Fang Hong 2* (东方红2号) and has pledged support toward the construction of Yazhou Bay Science and Technology City, an infrastructure project at the southern tip of Hainan intended to expand China's deep-sea mining operations and serve as a hub for mining operations in and around the South China Sea.[54]

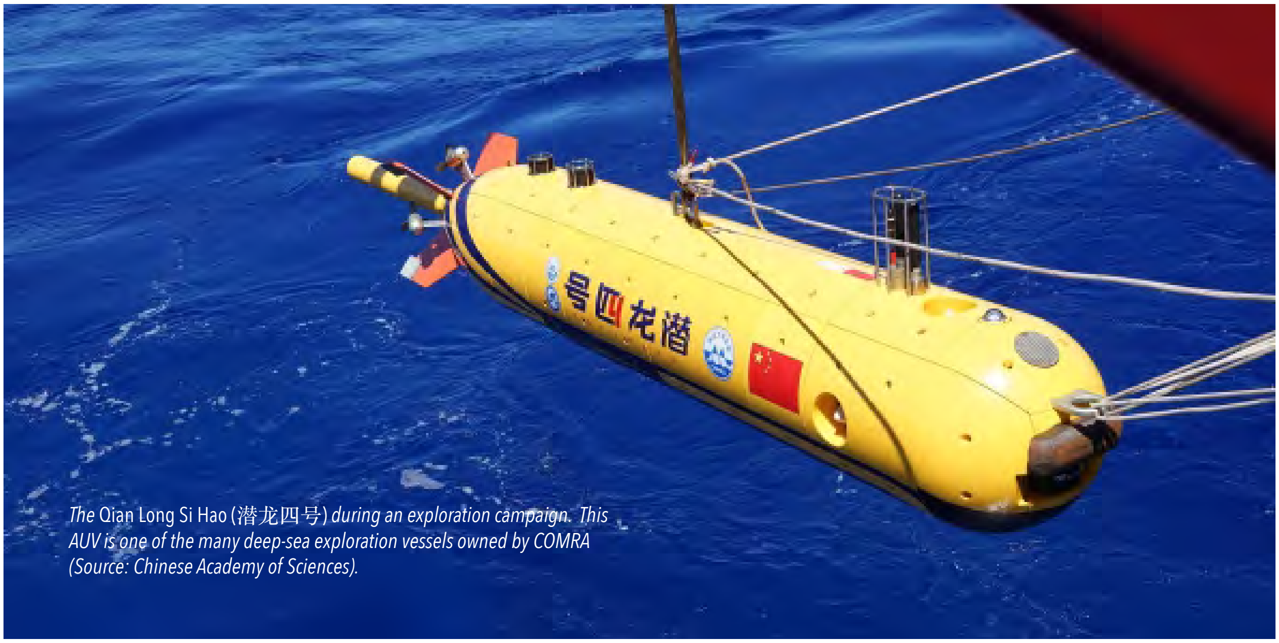
School of Ocean and Earth Science, Tongji University

The School of Ocean and Earth Science at Tongji University was founded in 2002 as a successor to the former Department of Marine Geology and Geophysics, which was established in 1975. When the academic degree system was restored in 1982, Tongji University was then the only doctoral program in marine geology.[55] Scholars from Tongji have participated in major national and international marine geological projects, such as the International Ocean Discovery Program (IODP), the National Long-term Seafloor Scientific Observation System, and the South China Sea Deep Project.[56]

Shanghai Jiaotong University Institute of Oceanography

SJTU is ranked among the top five marine engineering universities worldwide, partly due to its demonstrated history of investment in R&D. The university's scientists are currently developing deep-sea minerals collector systems and searching for partnerships with deep-sea minerals license holders.[57]

PLAN Marines in the Qingdao railway station. Qingdao is the hub of China's deep-sea operations. Since the 1980s, a disproportionately high number of CCP leaders and PLA generals have been from Shandong Province.



The Qian Long Si Hao (潜龙四号) *during an exploration campaign. This AUV is one of the many deep-sea exploration vessels owned by COMRA (Source: Chinese Academy of Sciences).*

GOVERNMENT

China Ocean Minerals Research and Development Association (COMRA)

COMRA was established in 1991 and registered as one of seven pioneer investors in the Preparatory Committee for the ISA and the International Tribunal for the Law of the Sea in 1991. As an ISA contractor, COMRA holds three exploration licenses (of the five that China-based entities have been awarded) encompassing the three primary types of deep-sea minerals (See Table 2). Since its founding, COMRA has served as the leading organization in China's state-backed deep-sea mineral industry. As a quasi-governmental organization, COMRA embodies Beijing's Made in China 2025 initiative by investing in Chinese-made exploration equipment. COMRA's most recent display of its technological prowess was a 2021 nodule collection sea trial in the South China Sea, which was the first of its kind since the trials by Western states in the 1970s that spurred the creation of the ISA.[58] As it has been for most of its history, COMRA remains the go-to institution for deep-sea mineral contractors. In addition to conducting research on the law, policy, technology, and economic dimensions of deep-sea minerals, COMRA is empowered to operate ocean campaigns in China's five ISA-designated license areas.

Guangzhou Marine Geological Survey (GMGS)

Guangzhou Marine Geological Survey (GMGS) is a regional branch of the China Geological Survey, a department of the Ministry of Natural Resources. Its predecessor was the Marine Geological Scientific Research Institute of the Geological Ministry, which was founded in December 1963 in Nanjing.[59]

GMGS has found and demarcated a batch of large-scale petroliferous basins in the Beibu Gulf, the Pear River Estuary, Wan'an, and Zengmu. GMGS has over 800 staff members, including more than 500 researchers with 147 holding doctorate degrees.[60] GMGS operates a fleet of seven research vessels, including the *Hai Yang Liu Hao* (海洋六号), which has been used for deep-sea mineral exploration and evaluation.[61]

GMGS also has established working relationships with twelve countries, including the United States, Germany, and Russia.[62] GMGS owns and operates marine survey equipment and maintains relationships with low-cost manufacturers in the Chinese ocean industry. Along with several other research institutes on this list, GMGS has shown interest in partnering with private deep-sea mineral contractors from both China and other countries. Also located in Guangzhou is CSSC Guangzhou Huangpu Shipbuilding, one of the major hubs of CSSC, China's largest shipbuilder. Guangzhou-based GMGS' connectivity with international partners is in some ways unsurprising: Guangdong has a long tradition of deep commercial and cultural exchanges with the outside world.

RESEARCH INSTITUTES

Institute of Deep Sea Science and Engineering (IDSSE), Chinese Academy of Sciences

IDSSE is a scientific institute located within the Guangzhou Branch of the Chinese Academy of Sciences. Established in 2016, IDSSE is China's frontier institution for deep-sea mining activities. IDSSE is designed to engage with both government and private sector entities to galvanize research activity supporting deep-sea mineral exploration campaigns, especially in the South China

An exhibit in the Military Museum of the Chinese People's Revolution depicting the PLAN assets that embody China's "maritime great power, (海洋强国, haiyang qiangguo)" aspirations. The display includes the Shandong *and* Liaoning *aircraft carriers, likely named due to the close relationship between Shandong and Liaoning as well as the CCP elite's ties to both provinces.*

Sea. IDSSE consists of three primary research units: deep-sea science and research, deep-sea engineering and exploration campaign support, and deep-sea operational management and maintenance of wharves, AUVs, ROVs, and research vessels.[63]

250 full-time staff work at IDSSE, including 204 technical personnel.[64] IDSSE owns two 100-meter long research vessels, the *Tan Suo Yi Hao* (探索一号) and *Tan Suo Er Hao* (探索二号), as well as two human-occupied vehicles (HOVs), the *Shen Hai Yong Shi* (深海勇士) and the *Striver* (奋斗者). The *Striver* is China's only full-ocean capable vessel, meaning it can reach the seafloor even at the deepest parts of the world's oceans.[65] IDSSE also owns multiple unnamed ROVs and AUVs. In 2020, IDSSE and China Merchants Industry (CMI) participated in a joint mission that tested a cobalt-rich crust collector at more than 1,300 meters.[66]

IDSSE is known for its capabilities in fielding manned and unmanned vessels for deep-sea exploration, and for its researchers who focus on deep-sea biology and geology. Among research institutes that are adjacent to the deep-sea mining industry in China, IDSSE has potentially the richest experience working with international partners, having expressed interest in deepening its ties with international organizations that could provide logistical support for deep-sea exploration campaigns.

In 2022, IDSSE worked with the New Zealand-based National Institute of Water and Atmospheric Research (NIWA) on a joint research program to explore the Kermadec Trench in the southern Pacific Ocean. Scientists from IDSSE and NIWA dived multiple times in the *Striver* to explore the Kermadec Trench.[67]

First Institute of Oceanography (FIO), Ministry of Natural Resources

The First Institute of Oceanography, established in 1958, is a non-profit marine research institute overseen by the MNR. Scientists in FIO conduct research on marine environmental geology, climate change, and coastal sustainability. FIO spreads its operations across two campuses: Laoshan, a district of Qingdao, and Aoshan, an island in Zhejiang near the city of Ningbo. The institute has more than 520 permanent staff, including 470 researchers.[68] FIO operates two out of eight functional units of the Qingdao National Laboratory for Marine Science and Technology and five MNR key laboratories.[69] The Institute also owns two research vessels (these vessels are 4,813 and 2,184 tons respectively).[70]

The annual budget of FIO averaged 650 million RMB ($100 million) over the past five years.[71] Additionally, FIO has received over 260 national and ministerial science and technology awards and filed more than 1,000 national and international patents.[72] FIO is also home to the China Ocean Sample Repository, the largest single collection of samples collected by any research institute in the country during China's deep-sea mineral exploration campaigns.[73]

Second Institute of Oceanography (SIO), Ministry of Natural Resources

The Second Institute of Oceanography operates the only state key laboratory within the MNR system, the State Key Laboratory of Satellite Ocean Environment Dynamics. SIO also oversees three key laboratories funded by the MNR: the Marine Academy of Zhejiang Province, the School of Oceanography at Shanghai Jiaotong University, and the Institute for Polar and Deep Ocean Technology at Shanghai Jiaotong University.[74]

SIO also co-built the 4,500 tonne marine scientific research vessel *Xiang Yang Hong 10* (向阳红10号) and maintains the *Dayang* (大洋) "Oceanic Integrated Resources Research Vessel," which are both listed in the National Oceanographic Research Fleet. SIO also maintains an equipment research base in Changzhi Island of Zhoushan, Zhejiang. In recent years, SIO has become the most active institute in China for conducting exploration campaigns and studies in deep sea minerals, especially for polymetallic nodules and sulfides and is recognized for its experience and resources in conducting deep-sea minerals exploration and environmental surveys in international waters.[75] The success of SIO is based on Chinese government research funds and its connections to manufacturers with low-cost deep-sea mining equipment.

Third Institute of Oceanography (TIO), Ministry of Natural Resources

Founded in 1959, the Third Institute of Oceanography has 427 employees. In 1984, the institute was approved by the Academic Degrees Committee of the State Council to confer master's degrees in oceanography, microbiology, and environmental science. Domestically, TIO participates in joint doctoral programs in collaboration with Tsinghua University and the University of Science and Technology of China and publishes in the *Journal of Applied Oceanography*. TIO also administers exchanges with universities in 30 countries, including the United States, Germany, France, and Japan.[76] Additionally, TIO is the leading institute for environmental studies, especially biological studies related to mineral development and owns a 4,500-ton marine research vessel, the *Xiang Yang Hong 3* (向阳红3号).[77]

SOEs AND SUBSIDIARIES

Beijing Pioneer High-Tech Development Corporation (Beijing Pioneer)

Beijing Pioneer is a SOE established in 1993 and now wholly owned by COMRA. Before becoming an ISA contractor, Beijing Pioneer developed deep-sea exploration tools and provided offshore services to COMRA and other Chinese marine research institutes, as well as equipment including AUVs, ROVs, telescopic grab arms, shallow drills, towed transient electromagnetic systems, and deep tow systems.[78] Beijing Pioneer personnel have participated in a majority of Chinese deep-sea minerals exploration campaigns, primarily to assist with the operation of Pioneer-developed equipment. Since acquiring an ISA exploration license for the Western Pacific in July 2019, Beijing Pioneer has conducted four exploration campaigns.[79] During Pioneer's campaign in late 2022, company engineers tested a 4.2-ton ROV collector named *Manta* (曼塔). *Manta* worked in areas as deep as 5,600 meters, with a total collecting distance of over 300 meters and a demonstrated collection rate of 20 tons of polymetallic nodules per hour.[80]

Beijing Pioneer is notable for its deep ties with COMRA and its in-house exploration equipment. Pioneer is likely interested in providing mineral and environmental surveys as well as monitoring services to license-holders in China and other foreign countries with a growing deep-sea mineral industry.

The China Minmetals Development Office in Beijing (Source: Bjoertvedt, 2017, CC BY-SA 4.0).

China Minmetals Corporation (CMC)

China Minmetals Corporation is a metals and mineral trading SOE headquartered in Beijing and administered by the State Assets Supervision and Administration Commission (SASAC). China Minmetals produces and trades metals and minerals, including copper, aluminum, nickel, cobalt, zinc, tin, and tungsten. Notably, one of China's most influential and richest businessmen – Zhang Lei, founder of private equity firm Hillhouse Capital – was employed by CMC shortly after he graduated from Yale University.[81]

CMC is one of the world's largest metals and minerals trading companies, ranked 65th in the global *Fortune* 500.[82] The SOE processes and, since 2020, has traded an average of 14 million tons of steel annually.[83] CMC also trades electrical products and operates subsidiary entities focused on real estate development, marine shipping, and mining operations. The company operates in the United States as Minmetals Inc., with its North American headquarters located in Weehawken, New Jersey.

CMC is a partner to various research institutes, aiding with mining engineering and processing for the ongoing exploration campaigns in China's contract areas in the CCZ and Western Pacific.[84] Given its ongoing mineral processing ventures in countries such as Russia and the recent consolidation of two rival rare earth SOEs (Chinalco Rare Earth & Metals and China Southern Rare Earth Group) into Minmetals' rare earth division, CMC is poised to control an even greater portion of the deep-sea mining supply chain.[85] This makes CMC a potential threat to U.S. commercial and national security interests that hope to diversify their critical mineral supply chain away from China.

Changsha Research Institute of Mining and Metallurgy Co., Ltd. (CRIMM)

CRIMM was established in 1955 as a research institute under the control of the Chinese Academy of Sciences before becoming a subsidiary of CMC. It has since taken on a dual identity as a for-profit R&D company and a SOE subsidiary. On the research side, it undertakes mining and metallurgical R&D projects funded by public and private entities. CRIMM also provides a range of engineering and consulting services for commercial entities and is the controlling shareholder of over ten companies focusing on metallurgical testing, mineral sales, and metal recycling.[86]

Prior to its merger with CMC, CRIMM was an early mover in China's deep-sea mining industry. CRIMM has been developing deep-sea mining technologies through its wholly owned subsidiary, the Ocean Mineral Resource & Technology Development Research Institute, since 1983.[87] CRIMM's participation in deep sea mining led to its partnership with CMC. Since 2017, CRIMM has conducted at least four exploration campaigns in its contracted area for a minimum of 377 days of offshore operating time.[88]

CRIMM is a prolific R&D institution with particular experience in designing collectors and transport systems, both essential technologies for deep-sea mineral extraction. CRIMM researchers are strong in the fields of mineralogy and mineral processing and refining operations, and the institute is noted as a prolific developer and prototype shop for nodule harvesting technology. Of all the institutions surveyed, CRIMM is the non-governmental entity with the strongest relationship to the ISA, having collaborated on knowledge-sharing initiatives in the deep-sea mining industry. For example, in tandem with CMC, CRIMM convened a workshop for foreign national researchers on "The Law of the Seabed Workshop – Polymetallic Nodules" in 2022. The workshop featured a case study on the legal status of the CCZ and mining activities planned to occur within it.[89]

China Merchants Industry (CMI)

China Merchants Industry is one of the world's largest shipbuilding conglomerates. CMI has shown strong interest in developing specialized vessels for deep-sea mining activities through its partnerships and strategic investments. CMI intends to play a similar role to Allseas – a Swiss offshore contractor – in managing the expansion of the deep-sea mining industry and plans to become an integrated subsea mining operator by 2030. With financial backing from one of China's largest SOEs, China Merchants Group (CMG), CMI has access to the capital required for deep-sea mining projects and is pursuing partnerships with other potential investor companies.[90]

China State Shipbuilding Corporation (CSSC)

Since the 2019 merger with China Shipbuilding Industry Corporation (CSIC), CSSC has been the largest shipbuilding conglomerate in the world.[91] In the past, CSSC has helped build major offshore oil and gas platforms and is now helping construct vessels for China's deep-sea exploration campaigns.

Mixture of traditional and modern architecture styles in Changsha, Hunan Province. CRIMM has played a key role in China's deep-sea mining industry since 1983, in spite of its landlocked headquarters. Its curious geographic location is an artifact of the distribution of political and military power in China decades ago. Hunan, Mao Zedong's home province, had an outsized level of importance in China's political and military life from the PRC's founding until the mid-1980s.

KEY STRATEGIES

China's approach to deep-sea mineral exploration is guided by three major strategies: standards-setting, incentivizing simultaneous collaboration and competition, and overseas infrastructure buildouts. Each principle serves Chinese interests in a different domain: international law, domestic industry, and the physical geography of deep-sea mineral competition on the high seas.

1. Engage in Regulatory Capture and Standards-Setting to Box Out External Competition

China has consistently used its ISA membership to advance its interests in deep-sea mining. During the 28th Session of the ISA Assembly and Council in July 2023, China fervently opposed efforts to establish a general policy "related to the conservation of the marine environment" in the meeting agenda.[92] While countries like France and Chile are seeking to delay the adoption of a "Mining Code" – the ISA-approved regulations for mineral extraction in international waters – China is playing a notable role in pushing the agenda forward. Domestically, China has already laid the foundation for future mineral extraction through the 2016 "Law of the People's Republic of China on Exploration for and Exploitation of Resources in the Deep Seabed Area" (Deep Seabed Law).[93] China also includes the deep-sea in its national security documents as a theater of strategic priority for PLA operational planners.[94]

Through COMRA, China is the largest financial contributor to the ISA and is accordingly well-positioned to spearhead the ISA's drafting of new regulations governing deep-sea mining ahead of the anticipated 2025 deadline for approving deep-sea mining regulations.[95] In coordination with the ISA and the United Nations Department of Economic and Social Affairs, China is also setting up a training program for deep-sea mining personnel from developing countries. According to UN sources, training activities for these personnel will be "jointly managed by the Ministry of Natural Resources of China and the International Seabed Authority."[96] As its influence at the ISA expands, China has coopted the perspectives of developing countries on the frontier of the deep-sea mining industry to ensure that it becomes a leader in setting global industry standards. China is showing the world what a multilateral, multipolar future could look like in international waters.

2. Incentivize both Collaboration and Competition to Fuel Innovation

China's approach to military-civil fusion relies on knowledge and resource-sharing between public and private institutions. Much of Chia's deep-sea mining ecosystem follows this same logic. Universities, government-funded research institutes, and quasi-governmental institutions like SOEs are all interconnected, with many co-sponsoring some of the country's recent ocean exploration campaigns. Although China has not explicitly encouraged competition between the domestic public and private sectors on the issue of deep-sea minerals, the web of relationships between contractors, researchers, and government agencies suggests that there will be multiple entities working to develop the same AUVs, ROVs, and transportation platforms required for deep-sea mining. In many cases, Beijing draws upon institutions with prior experience in a related area that can be transferred to deep-sea mining. For example, the 708th Research Institute of CSSC, which was previously charged with designing the *Liaoning* aircraft carrier, helped to design the *Xiang Yang Hong 3*.

3. Build Extensive Overseas Infrastructure to Strengthen Supply Chains

When Chinese entities set up mining operations in foreign countries, especially in undeveloped regions of Latin America and Africa, they often request government support for infrastructure projects such as ports, airports, hospitals, and highways. These requests have the twofold effect of currying favor with local governments and reducing long-term transportation and logistics costs for the miners themselves. China will likely employ a similar investment strategy as it seeks to direct capital into the deep-sea minerals industry. This approach may also be deployed in the Pacific Islands, where new infrastructure that can support deep-sea miners may also benefit Pacific governments and open the possibility of PLAN base expansion or the establishment of deeper economic partnerships. All of which could lead to stronger Chinese influence in the region at the expense of the United States.

SECTION III

IMPLICATIONS FOR U.S. ECONOMIC AND MILITARY INTERESTS

Deep-sea minerals are a compelling alternative for imperiled supply chains

China's dominance of critical mineral supply chains is a serious vulnerability for the U.S. economy. Beijing's export restrictions on gallium and germanium in response to the Biden administration's efforts to constrain China's semiconductor industry is just one example of how the fraught bilateral relationship can harm U.S. companies.[97]

Deep-sea minerals are vital for industries faced with a growing gap between critical mineral supply and demand. To meet global demand for EV batteries in 2035, 384 new mines for metals including graphite, lithium, nickel, and cobalt will need to be constructed.[98] Notably, two of these minerals – nickel and cobalt – are commonly found in polymetallic nodules.

Currently, American companies that depend on critical minerals are more exposed to sanctions and tariffs as U.S.-China competition intensifies. China's dominant position in the global mineral supply chain, the state-led structure of its economy, and the degree of military-civil fusion in its economy all increase the risk that unexpected sanctions could disrupt partnerships between American companies and their Chinese suppliers. In sanctioning individuals connected to China's mineral industry, the United States can, in effect, set tariffs on any mineral passing through the Chinese industrial ecosystem, using the increased price and risk of these minerals to push companies headquartered in the United States and other allied nations to source their minerals elsewhere. This would amount to a state-led reorientation of the entire Western mineral, technological, and green energy economies based on the interests of American statecraft rather than market fundamentals.

Deep-sea minerals could prove to be a valuable hedge against worsening relations between Washington and Beijing. As economic competition in other sectors intensifies, China can exploit America's critical mineral dependence through any of the following minerals: nickel, cobalt, copper, lithium, graphite, and REEs.[99] These vulnerabilities will only grow over time as U.S. demand for these materials increases. Deep-sea minerals, however, are a clear opportunity for American companies to strengthen U.S. economic security by shifting mineral supply chains away from China.

The airstrip on Nangan Island, Taiwan. Nangan, one of Taiwan's Matsu Islands, is one of many potential flashpoints between Taiwan and China that could destabilize global supply chains.

View of Xiamen, China from an old military bunker on Kinmen Island, Taiwan. Kinmen's proximity to China has long been a source of tension. In 1958, Kinmen was bombarded by the PLA during the Second Taiwan Strait Crisis; eventually the PRC and ROC agreed to bomb the other side on alternating days until 1979, when the United States and the PRC normalized relations.

The importance of U.S. government support for deep-sea mining and processing

Washington can tap into the immense potential of deep-sea minerals to fuel American reindustrialization. U.S. companies need government support to benefit from deep-sea mining. The U.S. government can unlock deep-sea mining's potential in the following ways: encouraging private investments in domestic and allied deep-sea mining projects, facilitating research into the most economically viable EEZ deposits, expediting common-sense regulations for extracting EEZ resources, and investing in American processing capabilities.[100]

U.S. efforts to court the Taiwanese semiconductor giant TSMC provide a glimpse into how America may try to reinvigorate its mining and mineral processing capacities. Just as America's inability to produce semiconductor chips motivated the Biden administration to allocate billions of dollars in loans, grants, incentives, and tax credits to lure TSMC to America, future administrations may emulate this model to bring firms with mineral processing expertise to the United States. Though it may prove expensive in the near term, in the long run it will prove less costly than continuing to cede key resource supply chains to China.

Investments in deep-sea mining can integrate industrial supply chains and strengthen domestic manufacturing. Fueled by immediate demand for critical minerals, further investments in domestic refining capacity would only increase the profitability and efficiency of deep-sea mining efforts by enabling the extraction of more valuable metals. Lower costs for metal production inputs such as manganese, nickel, and cobalt would lower the overall cost of U.S. manufacturing of corresponding outputs (EVs, energy storage systems, electronics, superalloys, and more). In turn, deep-sea mining presents an opportunity to help American enterprises access new markets and greater profits while rebuilding critical segments of the national industrial base.

U.S. access to deep-sea minerals in its EEZ and the EEZs of allies and partners can mitigate the challenges posed by a more militarized maritime domain. For companies whose assets regularly transit the increasingly tense areas of the South China Sea, Straits of Malacca, Taiwan Strait, and Bashi Channel, militarization in these disputed areas poses significant risks. Fluctuations in the U.S.-China relationship are more likely to affect input prices for manufactured goods, as displays of force have become Beijing's standard response to American, Taiwanese, Japanese, or Filipino actions it interprets as hostile.

Overhead view of Eternal Tsingshan Group's nickel processing facility at the Morowali Industrial Park in Central Sulawesi Province, Indonesia. Eternal Tsingshan and other Chinese companies have helped Indonesia become the global nickel processing juggernaut. Reshoring nickel processing away from Indonesia will require significant U.S. government support (Source: Eternal Tsingshan Group).

Although polymetallic nodules are less common in EEZs, polymetallic sulfides and ferromanganese crusts have their own economic value and are often present. Some deposits of critical minerals could be vulnerable to increased militarization. However, potential deposit areas around Alaska, the West Coast, Hawaii, and Wake Island are relatively removed from flashpoints around China's periphery.[101] Furthermore, the Cook Islands has engaged in more extensive prospecting campaigns in its EEZ and is far past the Second Island Chain, geographically close to NATO and major non-NATO allies, including Australia, New Zealand, and France (French Polynesia). Collaboration with existing deep-sea mining projects by friendly nations, while developing America's own capacity, can avoid areas of increased militarization.

U.S. government investment in domestic mineral processing facilities is a clear opportunity to revitalize America's industrial base. Although costly and time-intensive, building out U.S. mineral processing capacity could pay significant dividends in the long term. More than just securing the U.S. economy and military from punitive actions by China, this could promote onshoring efforts by downstream sectors and create opportunities for the United States to become a key node in global mineral supply chains.

Numerous industries stand to benefit from greater U.S. influence over critical mineral supply chains

While America lags behind China in mineral processing, deep-sea mining in the EEZ and beyond could create an economically viable source of manganese for the U.S. steel industry. American firms rely on foreign refiners for many critical metal products, such as nickel alloys; however, American firms consume less-processed forms of manganese, which is often the most abundant metal found in nodules. Though relatively abundant and inexpensive, manganese is an irreplaceable input, necessary for both refining iron ore and alloying steel, yet America is totally reliant on imports.[102] Each year, American firms import roughly 500,000 metric tons of manganese ore for direct industrial applications, specifically steelmaking.[103] Manganese-rich nodules could be crushed, separated, and concentrated to produce smeltable manganese ore, which domestic firms are already able to process. At scale, this less-intensive form of manganese processing would provide a secure and reliable source of ferromanganese – the most critical input for steelmaking – for immediate use by American producers.

Deep-sea mining would liberate American producers from insecure manganese supply chains. Most manganese ore used in steel production comes from Gabon (62 percent) and South Africa (24 percent).[104] American enterprises may not be able to rely on imports from either country in an era of increasing global complexity: a military coup recently toppled Gabon's long-time ruler and ended a long era of stability, and South Africa is increasingly aligned with Beijing and Iran. Meanwhile, the United States depends on China, as well as producers in Malaysia and Indonesia, for more-refined manganese metal products, including the electrolytic manganese flake used in the production of more advanced alloys and non-metallurgical products such as batteries.[105] Some of these suppliers are also likely to be affected by foreign entity of concern guidance.[106] Using deep-sea mining to shift American manganese supply chains away from insecure partners can lower costs and limit supply chain disruptions for steelmakers and other industrial consumers.

A stronger domestic steel industry would help drive American reindustrialization in other sectors. Secure and affordable access to steel and other metals would greatly increase the incentives for American companies to onshore manufacturing capabilities. Projects to maintain, renew, and expand America's infrastructure require reliable supplies of steel, ideally produced as close to consumers as possible. Deep-sea mining can shift American manganese supply chains away from insecure partners and produce positive downstream effects.

Consumer electronics have long been exposed to supply chain risks but investments in deep-sea mining can onshore vital inputs. Established consumer electronics companies will face increased competition for access to critical minerals due to subsidies and incentives favoring EVs, batteries, and renewable energy sources. Electronics companies will likely be squeezed by growing demand from other sectors dependent on the same mineral resources. Companies looking to outcompete other actors in this increasingly crowded sector would benefit from more robust supply chains that can mitigate geopolitical risk and price volatility.[107] Domestic access to the necessary inputs *via* deep-sea mining and, eventually, domestic processing facilities, would increase the economically viable options for leading consumer electronics companies.

EV makers can leverage deep-sea minerals to minimize dependence on China and catalyze a homegrown resurgence in U.S. automotive productivity. Ford's now dormant partnership with Chinese battery juggernaut, CATL, to produce EV batteries at a plant in Michigan is illustrative of the significant challenges automakers face. Despite Ford emphasizing how the partnership would create new jobs, Washington was quick to criticize the deal, with the U.S. House Select Committee on the CCP opening an extensive investigation into Ford.[108] Although the battery plant was put on hold in September 2023, the scrutiny continued. In January 2024, the U.S. House Select Committee's investigation found that four of Ford's Chinese partners were linked to the PLA, provided

View of Bath Iron Works, the home of the Zumwalt Class destroyer program, in Bath, Maine. American leadership in deep-sea mining could have positive downstream effects on domestic shipbuilding and port infrastructure (Source: Jacklee, 2013, CC BY-SA 3.0).

Shell's floating production, storage and offloading (FPSO) vessel, the Turritella*, underway in the Gulf of Mexico.* Turritella *is the world's deepest oil and gas project, capable of producing oil at depths of 9,500 feet (about 2,896 meters). It is possible that offshore oil and gas expertise could be leveraged for deep-sea mining (Source: Shell).*

software to the government of North Korea, and abetted human rights abuses in Xinjiang.[109] The government's sharp rebuke of Ford is a warning to EV makers. Faced with Chinese dominance over every node of the EV battery supply chain, there are very few cost-effective options that avoid China's battery manufacturing and mineral industries. Deep-sea mining has the potential to finally provide U.S. and allied-sourced minerals to U.S. battery manufacturers and mitigate the perils posed by China-centric EV supply chains.

Renewable energy industries, particularly solar, would also benefit from deep-sea minerals. Just as CATL and BYD dominate the EV battery industry, Chinese firms also dominate the solar market. For example, as recent as March 2023, seven of the ten largest commercial solar companies by U.S. market share were Chinese.[110] In the U.S. residential solar market, the American firm SolarEdge Technologies reported "fluctuating prices of…Copper, Lithium, Nickel and Cobalt" as risks to its business.[111] Although scrutiny of U.S. solar companies has attracted less attention than that of EV makers, China's control over mineral supply chains means that changes in Chinese policy can result in destabilizing price fluctuations for American firms. Alternative mineral sources would be a benefit not only to American solar but also American wind, nuclear, and geothermal companies.[112]

Companies with expertise in offshore oil and gas could leverage their existing expertise. The United States is one of the global leaders in offshore hydrocarbon exploration and production. While deep-sea mining will require technologies and capabilities that are not identical to those of the oil and gas industry, there will be opportunities for companies to make efficient pivots into the deep-sea mineral sector. Amid U.S. government and shareholder pressure on oil and gas companies to diversify their business models, several leading oil and gas companies already have started moving into the mineral sector.

Future growth in the deep-sea mining sector may generate both the financial and political resources necessary for new investments in maritime infrastructure. A significant consequence for U.S. maritime commerce may be increased congestion in the West Coast's dry bulk ports where nodules would be unloaded for domestic consumption. Only five of the top twenty-five largest dry bulk ports by tonnage are located on the West Coast.[113] How these ports would handle large nodule shipments cannot be reliably foreseen because of broader fluctuations in global shipping volume. Reducing congestion at these ports would likely require regulatory changes enabling port expansion and increased investment in dry bulk terminals. Intermodal terminals at major dry-bulk ports may also see increased demand and traffic as these facilities would enable rail transport of deep-sea mineral shipments to inland industrial consumers.

CHINA IN THE PACIFIC: A THREAT TO AMERICAN PRIMACY

Deep-sea mining will transform critical mineral supply chains, but the industry's growth will add new dimensions to American security interests in the Pacific. The proliferation of deep-sea mining surveying and extraction operations in the Pacific will likely impact U.S. naval operations in the primary theater of U.S.-China strategic competition.

China's interest is similar to Japan's in the 1940s: separate the United States from its allies and expand its defensive perimeter. Indeed, a more subtle, and therefore more insidious, implication of China's deep-sea exploration has less to do with extracting and transporting critical minerals than it does with diplomacy. China's diplomatic offensive in the South Pacific – namely with the Solomon Islands, Nauru, and Kiribati – raises the prospect of China developing the means to weaken American and allied sea lines of communication. It is no coincidence that these locations were the focus of major clashes between Allied and Imperial Japanese forces during the Second World War.

Like critical minerals, the Pacific Islands are another issue that Washington D.C. has overlooked until China has established a foothold. Without pledging its own economic and diplomatic support, U.S. warnings to Pacific governments of the dangers posed by China's generosity are likely to ring hollow. Consequently, Beijing may expand its commercial and cultural exchanges as the foundation for building out a forward military presence. China's relative proximity, its willingness to offer financial inducements that the United States tends to be unwilling or unable to match, and the continued presence of states who diplomatically recognize Taiwan (Republic of China) provide China with strong advantages and incentives to continue building influence in Oceania.

The Haima (海马) ROV is owned by the GMGS (see Section II) and is one of many deep-sea submersibles that has the potential to gather bathymetric data for the PLAN's submarine fleet (Source: Shanghai Jiaotong University).

A more active American presence in the Pacific Islands can effectively counter Beijing. Renewing COFA agreements with the Federated States of Micronesia, Palau, and the Republic of the Marshall Islands is a crucial opportunity to signal America's national interest in the region. These three countries used to be a part of the United States Trust Territory of the Pacific Islands that the U.S. government controlled from the end of World War Two until 1994 when the last member, Palau, gained independence. By replacing the Trust Territory, COFA agreements with these nations grant the U.S. military significant privileges for basing military assets while denying those of other countries without U.S. approval. Beyond the COFA states, other countries are critical partners. For example, the United States stands to benefit from closer ties with the Cook Islands, which controls the largest commercially viable polymetallic nodule deposit of any nation on earth.[114] For example, access to the Cook Island nodules alone would limit China's market share and hedge against Chinese dominance of the global deep-sea mineral supply chain.[115]

In the event deep-sea mineral extraction proliferates in the Pacific, the U.S. military will have to revise certain strategic principles and adapt to new drivers of global conflict. Since the latter half of the 20th century, U.S. military strategy has been reliant on oil from the Middle East. Operations in support of defending and securing oil-rich regions depended on a combination of land, air, and sea assets. The United States is estimated to spend approximately $81 billion per year protecting global oil supplies.[116] The ongoing shift to renewable energy sources that are dependent on critical minerals will also necessitate military expenditures to accomplish these shifts in U.S. priorities. Specifically, the U.S. Navy and Coast Guard are likely to face six primary challenges to their ability to protect vital trans-Pacific shipping lanes, ensure the security of critical maritime infrastructure, and maintain an operational advantage *vis-à-vis* PLA units in a potential crisis scenario.

COUNTERING THE CHALLENGES POSED BY DEEP-SEA MINING AND CHINA'S AMBITIONS

1. China's dual-use technologies

China's advanced deep-sea exploration technologies are inherently dual-use. What is useful for commercial purposes can and often does have military applications in the deep sea. For example, a fleet of AUVs and ROVs developed in tandem with deep-sea mineral contractors will give PLA military planners access to troves of data on barometric pressure, distance, depths, and underwater topography which could potentially aid in battle planning for a naval conflict between the United States and China. The oceanographic research in which China is beginning to excel is particularly vital for undersea submarine routes. Analysis of the ocean floor produces bathymetric maps – topographic maps of the ocean floor – that promise to offer advantages in submarine warfare and planting undersea mines.[117] Such bathymetric data can also support the implementation of sonar and other detection devices, aiding anti-submarine warfare (ASW).[118] While China has advantages in its domestic deep-sea exploration industry, the United States can partner with major non-NATO treaty allies like Japan and South Korea to share bathymetric data throughout international waters and Pacific EEZs.

Japanese Coast Guard vessels patrolling waters off the coast of the disputed Senkaku/Diaoyu Islands. Japanese and Chinese Coast Guard operations around the Senkaku/Diaoyu Islands point to the increased importance coast guards will have in potential disputes over resource rich areas of the Pacific (Source: Al Jazeera English, 2012, CC BY-SA 2.0).

2. China's inroads with the Pacific Islands

China is attempting to build out its network of Pacific partners, but the United States' extensive and well-established ties in the region mean China is facing an uphill battle. Beijing's efforts to expand its *de facto* EEZ through ISA contracts and agreements with Pacific Island nations would provide greater operating freedom for PLAN vessels in the Pacific. Already, agreements with Pacific Island nations such as the Solomon Islands have given the PLAN access to new ports through security agreements that could prove decisive in a conflict with the United States and its allies in the region.[119] Similar agreements would multiply the chances of Chinese military bases appearing on other strategically located islands throughout the Pacific. Gaining access to deep-sea minerals will likely become an increasingly powerful motivator for China's diplomatic offensive in the Pacific. Not only technology, but also diplomacy has dual-use applications in the context of deep-sea exploration. The United States benefits, however, from being the established power in the region. Although the U.S. Navy is confronting significant challenges from a diminished shipbuilding industry and an ascendant PLAN, the United States can leverage existing and new partnerships with Pacific Islands in deep-sea minerals to strengthen economic ties. This could include U.S. government support for companies that have already partnered with Pacific Island nations on prospective deep-sea mining projects.

3. Chinese deep-sea infrastructure

Countering the presence of a Chinese early detection system in international waters could prove decisive in preserving America's traditional advantage in naval warfare. Although not part of China's deep-sea infrastructure, China has flexed its maritime infrastructure muscles by finishing construction on the world's largest offshore wind farm in terms of single-unit capacity (16-megawatt) in the Taiwan Strait off the coast of Fujian Province.[120] China has historically used infrastructure construction to enable its expansionist strategies, including its absorption of both Tibet and Manchuria in the 19th and 20th centuries.[121] Coordination with American partners in the Pacific and increased resources for the U.S. Navy and Coast Guard once again will be crucial to monitor and, if necessary, undermine such projects.

4. New hazards for submarine warfare

Dual-purpose vessels and infrastructure linked to deep-sea mining threaten one of the U.S. Navy's greatest advantages: its all-nuclear fleet of submarines. Though China operates the world's second-largest submarine fleet after the United States, the Chinese fleet still relies on diesel to power 80 percent of its submarines.[122] Beijing is making considerable efforts to remedy its disadvantages in ASW, likely by using data collected by Chinese deep-sea mining and exploration operations to improve guidance systems for PLAN submarines attempting to evade U.S. ASW capabilities. Deep-sea mining vessels would allow China to install more anti-submarine equipment throughout international waters. Obstacles attached to the seabed can range from simple physical snares to more advanced electronic warfare instruments that could hamper a vessel's navigation or sonar systems. Additionally, AUVs and ROVs intended for nodule collection could be used to install, repair, and upgrade anti-submarine defenses that may reduce the U.S. Navy's underwater advantages. By establishing what appear to be commercial or scientific fixtures, the PRC also gives itself a potential resource in any kinetic engagement.

5. An expanded role for coast guards

Although navies will be crucial, coast guards could prove more critical than navies. The China Coast Guard (CCG) is well versed in asserting Chinese claims in the South China Sea as well as running interference for its large and often illegal fishing fleets. Mining operations in the CCZ could bring the CCG and its approach to safeguarding Chinese claims closer to the Hawaiian Islands and the critical U.S. military infrastructure there. Consequently, the U.S. Coast Guard will prove vital for protecting American interests near the CCZ as well as monitoring and countering Chinese behavior. Although the U.S. Coast Guard is chronically overworked and under-resourced, it will likely need to take on a more significant role to protect U.S. commercial and security interests.

Just like fisheries, backing American interests in deep-sea mining within and beyond the EEZ falls under the purview of the Coast Guard. Beijing's decision to relocate the CCG from the State Oceanic Administration (SOA) to the People's Armed Police Force – and into the Central Military Commission's purview – shows China is already bringing the CCG into closer contact with its armed forces.[123] The U.S. government would also benefit from reassessing and reprioritizing the Coast Guard's role within the defense establishment so that the United States can secure its deep-sea mineral interests in domestic and allied EEZs.

6. Potential militarization of maritime shipping

China has an interest in acquiring the ability to hold other nations hostage by way of threatening maritime traffic. As more countries invest in deep-sea mineral exploration, currently calm areas of the Pacific Ocean will receive higher amounts of maritime traffic. Acquiring extensive knowledge of the ocean's depths will help China target opposing navies *via* more effective submarine warfare and underwater blockades of commercial shipping. Furthermore, China is known to use naval diplomacy as a coercive tool to lock in territorial gains while securing fishing and resource rights in its maritime near-abroad. As shipping networks change and maritime traffic related to deep-sea mining grows, China may selectively discourage foreign companies from operating in its sphere of influence, thus limiting U.S. and allied access to deep-sea minerals.[124] The United States will also have to balance its duty to protect critical infrastructure related to deep-sea mining and cargo ships belonging to allied nations with its interest in avoiding a sudden outbreak of conflict with China in the open ocean.

Overhead view of Wake Island. The U.S. EEZ around Wake Island is one of many underexplored and potentially profitable regions for deep-sea mining throughout the Pacific. It has been highlighted by the U.S. government as a priority area for future deep-sea research.

The USS America transiting the Suez Canal in 1981. U.S. oil supply chains benefitted greatly from the U.S. Navy's dominant position. The PLAN is now calling into question the U.S. Navy's ability to protect maritime shipping lanes in the Pacific.

EXCLUSIVE ECONOMIC ZONES: DEFINING, DEFENDING, AND CAPITALIZING ON MARITIME TERRITORY

The discovery of deep-sea minerals in contested EEZs would produce new legal claims to previously undisputed maritime areas. While most EEZ areas lie in coastal waters where few deep-sea minerals are to be found, some nations have expansive EEZs covering mineral-rich areas of the Pacific where future mining is a near certainty. China, which has a small undisputed EEZ, is likely to place a premium on mineral-rich areas of its disputed EEZ, including in the South and East China Seas. These regions are already geopolitical hotspots and have witnessed multiple near-misses with foreign militaries in recent years. Greater Chinese maritime activity in support of deep-sea mining is sure to rankle Vietnam and the Philippines, both of which have attempted to police PLAN incursions in their EEZs.

Major unresolved EEZ disputes could become flashpoints for further revanchism if deep-sea minerals are discovered within claimed areas. For example, mineral deposits around the Sea of Japan and East China Sea could implicate a host of actors including China, Japan, South Korea, Russia, and Taiwan. Discovering minerals in disputed EEZs may provide the spark that sets off a geopolitical chain reaction and escalates to the kind of diplomatic tit-for-tat that China and Japan engaged in during the Senkaku/Diaoyu Islands dispute. Those islands first came to the attention of strategists in Beijing and Tokyo when substantial oil reserves were discovered in 1969 on the continental shelf between Taiwan and Japan.[125]

Although it is currently opposed to deep-sea mining on environmental grounds, France and other countries with pre-existing EEZs in the Indo-Pacific may seek to expand their legal claims to access deep-sea minerals. Owing to its numerous overseas departments, France has the second largest EEZ in the world at around eleven million square kilometers.[126] The Indo-Pacific EEZ of France is the largest of its overseas EEZs and totals 90 percent of the entire French EEZ.[127] As recently as 2020, France expanded its Indo-Pacific EEZ, adding more than 150,000 square kilometers of extended continental shelf area around Reunion Island and the Saint-Paul and Amsterdam Islands.[128]

Competition around ISA contracted areas or expanded EEZs could lead to additional militarization of the Pacific. As EEZs increase in economic value, they will require increased military protection. For China, EEZ expansion in the name of deep-sea mining is a convenient excuse for further militarizing the Pacific. For the United States, increased Chinese investment in Pacific military infrastructure will necessitate more frequent patrols and joint military exercises with regional allies and partners.

CONCLUSION

RESTORING AMERICAN SUPPLY CHAIN SECURITY

Restoring supply chain strength will require reflection on why, where, and how the United States went wrong. A proximate historical analogy for the emerging competition for deep-sea minerals is the approach the United States has taken toward oil deposits in the Middle East and within its own borders since the latter half of the 20th century. Following the Suez Crisis, the United States assumed the role of Middle East mediator and ultimate guarantor of the region's stability, including through its proxy relationship with Israel. When Saddam Hussein invaded Kuwait in the hopes of widening Iraqi access to the Persian Gulf and seizing the country's oilfields, the United States embarked on a military intervention that showed the world what a unipolar power could do when means aligned with ends.

America's infrastructure for global resource extraction relied on a peaceful geopolitical environment and a military that could be rapidly deployed to confront threats to resource-rich regions. That peaceful geopolitical environment is gone. In its place, competitor states have emerged with the means and ambitions to shape global resource flows in directions that are not favorable to American interests.

Today, the U.S. lacks a coherent strategy for acquiring, securing, and exploiting key resources on a global scale. With the exception of the strategic petroleum reserve and similar stockpiles, critical resource flows – drilling, purchasing orders from foreign entities, and cargo transfer to American ports – are all the work of private sector entities. Regarding oil in particular, one might wonder why the United States – which produces sufficient oil to meet its own needs – persists in importing oil from abroad. One explanation lies in the fact that maritime transportation costs have decreased markedly in recent decades, making imports more affordable. Additionally, the oil that the United States extracts from its own soil is unusable for most domestic purposes. While U.S. refineries process both heavy and light crude oil, without heavy crude imports from abroad, these refineries would be unable to maximize capacity and may not be able to maintain operational viability.[129] This is hardly a new problem, nor one owing entirely to chemical differences between heavy and light crude oil.

A bias towards market-oriented approaches is predicated on enduring American dominance of the high seas. Though often glossed over, sea control should be defined not only as the ability to protect one's own commerce, but also as the ability to interrupt that of an opposing nation, thereby leaving its internal system "deranged," in the words of renowned naval theorist Alfred Thayer Mahan.[130] There is as much of a peacetime element as there is a military element to sea control. Sea control – a temporary military condition – nonetheless assures friendly maritime vessels access to the sea while denying adversaries that same access. America's private sector-centric approach to securing resources – as well as its reliance on widely dispersed supply chains for strategically important goods – presumes a level of sea control that no longer exists.

Since World War Two, both the global economy and American power have depended on American sea control. During this period, the United States faced no serious challenge to its maritime dominance, with the Pacific Ocean functionally serving as an American lake. As such, the U.S. Navy shouldered the burden of upholding freedom of the seas to ensure the safety of all maritime commerce. To the extent that the United States has a resource strategy, it is vested in its ability to guarantee that U.S. resources – all privately extracted and transferred – move where the market demands that they go. U.S. energy and resource policy, therefore, is indistinguishable from its maritime policy.

In recent years, however, China has become capable of challenging U.S. maritime dominance. The PLA Navy is growing rapidly while the U.S. Navy shrinks. Furthermore, China is in the process of establishing port projects along the world's most heavily trafficked shipping lanes, from Cambodia, to Pakistan, and even as far afield as the Persian Gulf, Europe, and Africa.[131] Some of these port projects – as in Cambodia – are already slated to become fully-fledged military bases, while others can berth Chinese warships. This means that the PLAN is increasingly capable of threatening U.S. sea control, and thus American access to the resources it needs.

Chinese activity in other domains - including fisheries and terrestrial mining - raises the prospect of illegal deep-sea mining. It is quite possible that the United States, along with allies and partners, will therefore confront a double challenge: legal Chinese deep-sea mining that poses strategic risks, and illegal deep-sea mining that coast guards will have a difficult time policing. The U.S. Navy and Coast Guard will likely face challenging circumstances involving illegal Chinese mining supported by the PLAN or CCG.

The Houthis' ability to shut down virtually all Red Sea maritime traffic points to the PLAN's destructive potential. With a fraction of the resources of the PLAN, the Houthis have severely disrupted shipping patterns in the Red Sea. China's vast resources and sophisticated navy make it a far more formidable threat than the Houthis. As such, if the PLAN deliberately targets American economic – and therefore political and strategic – interests, it would be able to wreak havoc. It is likely that the ensuing naval clash would impact global commerce, even if disrupting commerce is not the deliberate goal.

The purpose of navies is to protect friendly access to the global commons while remaining capable of systematically disrupting the ability of an adversary to sustain war, primarily by way of a blockade. If the U.S. Navy is unable to fulfill this role, then a *laissez-faire* resource strategy will almost certainly become a serious vulnerability. The global market, and with it, U.S. resource security, relies on the dominance of the U.S. Navy. Without it, the United States could be held hostage in a time of war.

Furthermore, the lack of a strategy for securing resources extends to the practical matter of shipping. The U.S. Merchant Marine is virtually nonexistent. Less than two percent of U.S. trade is carried by U.S.-flagged vessels.[132] The United States relies on other countries not only for production but also for transportation of its goods – including strategic resources like oil and critical minerals. The global economy, especially the United States, is reliant on maritime commerce. As such, any interruption of maritime transport is a national security threat.

Many U.S. imports by sea are carried in Chinese vessels. The United States saw its merchant fleet reduced from 1,288 ships in 1951 to 282 by 2000.[133] Since then, the size of the fleet has withered to under 180 hulls, with the average age of each ship eclipsing 45 years.[134] The dire condition of the U.S. shipbuilding industry is just one example of the pervasive offshoring of U.S. production. Even if the United States were to attempt to rebuild this industry, the factors of cost, time, and manpower – not to speak of political will – make such an endeavor an enormous challenge.

A U.S. Navy Sikorsky MH-60S Seahawk helicopter lifts pallets of supplies from the flight deck of the Military Sealift Command fleet replenishment oiler USNS Walter S. Diehl *in the South China Sea.*

Polymetallic nodules in the Pacific Ocean observed by the French Research Institute for Exploitation of the Sea's Nautile *submersible in 2004 (Source: Philweb, 2004, CC-BY-3.0).*

Foreign-flagged vessels utilized by U.S. firms are often reliant on data flows controlled by Beijing. China's National Public Information Platform for Transportation and Logistics, known as LOGINK, serves as "a single-window logistics management system that aggregates a vast array of logistics data, including information from domestic and foreign ports, foreign logistics networks, and hundreds of thousands of users within the PRC, as well as other public databases."[135] In September 2022, the U.S.-China Economic and Security Review Commission (USCC) warned that a forthcoming second-generation LOGINK will introduce a cloud-based suite of software applications including advanced data analytics that may be appealing to carriers and logistics firms.[136] This would provide LOGINK with even deeper insights into global trade patterns, potentially offering Beijing an unmatched perspective on commercial transactions and relationships. China now has a virtual monopoly on global shipping data – the same type of data the Royal Navy went to great lengths to acquire during the First World War. This success happened with the consent of global shipping firms, including those that carry the resources upon which the U.S. economy depends.

Ultimately, U.S. policy has produced a vast, complex, and fragile supply chain. For nearly 80 years, the United States has taken secure maritime routes for granted. As a result, the United States has no clear strategy for securing vital resources. Instead, it has a naval strategy that presumes a level of dominance and tranquility that no longer exists, leaving the American economy and its industries vulnerable for the foreseeable future.

A private sector led approach to resource acquisition is insufficient for the critical mineral challenge. America's oil security is a not a result of U.S. policy but private companies leveraging geographic advantages, game changing innovations, and existing capital to revitalize domestic oil production. In the case of critical minerals, the United States lacks developed terrestrial mines and processing capabilities. The geographic advantage provided by the U.S. and allied EEZs will remain underutilized without government action to assist the private sector in building out a domestic mineral processing industry.

Deep-sea minerals are an opportunity for U.S. policy to proactively secure America's supply chains. So long as China remains unchallenged as the leader of critical mineral supply chains, American economic security will be at risk. Moreover, these risks will become even more perilous as demand for critical minerals outpaces terrestrial mining production in the next ten years.[137] Deep-sea minerals are a promising solution. However, searching for and extracting viable deposits in EEZs and international waters will not be a purely private-sector endeavor. An evaluation from the U.S. Congress Office of Technology Assessment in 1987 – deep-sea mining "is not an activity that is likely to be undertaken by the private sector in response to market forces" – still rings true today.[138] Creating domestic mineral processing facilities to challenge China's dominance will also require significant government support. If the U.S. government does take the initiative, America can leverage its EEZ, those of strategic partners, and – eventually – partners' ISA contracts to unlock an abundant source of critical minerals. Coupled with government support for onshore mineral processing capabilities, the United States can transform global supply chains, revitalize its industrial base, and counter China's ambitions.

APPENDIX

SUMMARY LIST OF SURVEYED CHINESE DEEP-SEA MINING ENTITIES

Name	Abbreviation	Location	Affiliated Institution	Category
Beijing Pioneer Hi-tech Development Corporation	N/A	Beijing	COMRA	SOE
China Minmetals Corporation	CMC	Beijing	State Assets Supervision and Administration Commission	SOE
China Ocean Mineral Resources Research and Development Association	COMRA	Beijing	Ministry of Natural Resources (MNR)	Government
Ministry of Natural Resources	MNR	Beijing	State Council	Government
Changsha Mining Research Institute of Mining and Metallurgy Co., Ltd.	CRIMM	Changsha, Hunan	CMC	SOE Subsidiary
Dalian Maritime University	DLMU	Dalian City, Liaoning	Chinese Ministry of Transport	University
Shenyang Institute of Automation	SIA	Shenyang, Liaoning	Chinese Academy of Sciences (CAS)	Research
Guangzhou Marine Geological Survey	GMGS	Guangzhou, Guangdong	China Geological Survey of the MNR	Government
Deep Sea Technology Research Center	DSTRC	Hangzhou, Zhejiang	Westlake University	Research
Second Institute of Oceanography	SIO	Hangzhou, Zhejiang	MNR	Research
Zhejiang University Ocean College	ZJU	Hangzhou, Zhejiang	N/A	University
China Merchants Group (China Merchant Industry)	CMG/CMI	Hong Kong	Chinese Ministry of Transport	SOE
National Deep Sea Center	NDSC	Qingdao, Shandong	MNR	Research
First Institute of Oceanography	FIO	Qingdao, Shandong	MNR	Research
Ocean University of China	OUC	Qingdao, Shandong	N/A	University
North China Sea Branch of State Oceanic Administration	NCSB	Qingdao, Shandong	MNR	Government
Pengpai Ocean (Qingdao Bi G Brand Ocean Exploration Technology Co., Ltd.)	N/A	Qingdao, Shandong	Ocean University of China	Research
Qingdao National Laboratory for Marine Science and Technology	N/A	Qingdao, Shandong	Ocean University of China	Research
Lanzhou University	LZU	Lanzhou, Gansu	N/A	University
Institute of Deep Sea Science and Engineering	IDSSE	Sanya City, Hainan	CAS	Research
China State Shipbuilding Corporation	CSSC	Shanghai	State Assets Supervision and Administration Commission	SOE
708th Research Institute (Marine Design and Research Institute of China)	MARIC	Shanghai	CSSC	Research
Shanghai Jiaotong University Institute of Oceanography	SJU	Shanghai	SIO/CAS	University
Tongji University School of Ocean and Earth Science	TJU	Shanghai	N/A	Research
701st Research Institute (China Ship Research and Design Center)	N/A	Wuhan, Hubei	CSSC	Research
702nd Research Institute (China Shipbuilding Research Center)	CSRC	Wuxi City, Jiangsu	CSSC (formerly China Shipbuilding Industry Corporation)	Research
Coastal and Ocean Management Institute	COMI	Xiamen, Fujian	Xiamen University	University
Third Institute of Oceanography	TIO	Xiamen, Fujian	Ministry of Natural Resources	Research
Key Laboratory of Marine Biogenetic Resources	KLMBR	Xiamen, Fujian	TIO	Research

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