BARON

Testimony Before the U.S.-China Economic and Security Review Commission

Hearing on "Part of Your World: U.S.-China Competition Under the Sea"

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Hearing co-chairs Schriver and Kuiken, distinguished commissioners and staff of the U.S.-China Economic and Security Review Commission, thank you for the invitation to testify. I am honored to support this important hearing.

As a disclosure, Baron has not had any clients in the seabed mining industry, but we have been in touch with several companies. We have provided them with informal, *ad hoc* advice, and we have discussed potential advisory relationships with them.

Recognizing the growing importance of seabed minerals for U.S.-China competition and the lack of in-depth analysis, I worked with my colleagues at Baron to publish "Deep-Sea Minerals: The Next Arena of U.S.-China Competition" in March 2024.[1] The report contains novel analysis of Chinese-language sources and explores the implications of a Chinese-led seabed mineral industry for the United States. Over the course of our research, it became evident that seabed minerals have the potential to transform mineral supply chains, naval warfare and strategy, and the global balance of power.

Why Seabed Minerals Matter

Secure access to mineral resources is essential for national security. Months after the United States entered World War I, American geologist Joseph E. Pogue summarized this dynamic:

> War has changed from an art to a science. It has come to be a large-scale engineering operation – a conflict of vast quantities of materials, handled by skilled labor, directed by expert knowledge. It is now a matter fundamentally of applied physics, chemistry and geology.[2]

Ten years before Japan bombed Pearl Harbor, American geologist Charles Kenneth Leith explored the ramifications of mineral production concentrating in a small number of sites. In his words, "surprisingly few mineral districts really figure largely in meeting modern requirements."[3] Today, the outsized influence of nickel mines in Indonesia (67 percent of global production in 2025), cobalt mines in the Democratic Republic of the Congo (74 percent of global production in 2025), and rare earth mines in China (69 percent of global production in 2025) show this feature of mineral supply chains has not changed since 1931.[4]

Japan is a useful case study. In 1917, Pogue saw the limited mineral resources of the Empire of Japan as a potential catalyst for further expansions into China.[5] Japan's eventual invasion of China, attack on Pearl Harbor, and its attempted Greater East Asia Co-Prosperity Sphere were all shaped by its lack of mineral resources.

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[1] "Deep-Sea Minerals: The Next Arena of U.S.-China Competition," Baron, Winter 2024, https://www.baronpa.com/library/deep-sea-minerals-the-next-arena-of-u-s-china-competition.

[2] Joseph E. Pogue, "Mineral Resources in War and Their Bearing on Preparedness," *The Scientific Monthly* Vol. 5, No. 2 (1917): page 120, https://www.jstor.org/stable/22641.

[3] C.K. Leith, *World Minerals and World Politics* (New York: Whittlesey House, 1931), vi.

[4] "Mineral Commodity Summaries," U.S. Geological Survey, January 2026, page 30, https://pubs.usgs.gov/periodicals/mcs2026/mcs2026.pdf.

[5] Pogue, "Mineral Resources in War," page 123.

Still subject to its unfavorable terrestrial deposits and frequently affected by Chinese export controls, Japan is now looking to the Pacific. Since 2007, the Japanese government has formally prioritized the development of its seabed mineral sector. As evidenced by its ongoing effort to extract rare earth rich mud in the waters surrounding Minamitorishima, it is one of the pioneering nations in this nascent industry.[6]

Japan is not alone; China is also investing heavily in its seabed mineral sector. China has the most exploration contracts at the International Seabed Authority (ISA) and is cultivating a constellation of research institutions, universities, state-owned enterprises (SOEs), and government agencies to support its ambitions.[7]

I believe three factors will contribute to commercial extraction of seabed minerals by China, Japan, and other nations within a decade:

1. **The potential gap between mineral supply and demand in the next 20 years.** Growing adoption of mineral intensive energy sources and increased electricity needs for artificial intelligence (AI) will cause the demand for critical minerals to expand over the coming decade.[8] While coal, oil, and natural gas will remain important, even moderate increases in the production of batteries, grid infrastructure, as well as nuclear, solar, and wind power could cause mineral demand to outpace current investments in terrestrial mining, particularly copper and lithium.[9] According to S&P Global, mines that transitioned from discovery to production in 2020-2023 took an average of 18 years to get there, compared to around 13 years for mines that came online from 2005-2009.[10] Ramping up terrestrial mining will take time and likely will occur in a similar concentration of jurisdictions. Seabed minerals offer an abundant alternative that, with the right support, could scale quickly and bring mineral deposits under U.S. and allied control.[11]

2. **Global dependence on a relatively small group of critical mineral sources.** Terrestrial mining depends on geography, capital, and skilled labor to become commercially viable. The complex convergence of these factors results in the dangerous concentration of mineral supply chains.

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[6] "Basic Act on Ocean Policy," Government of Japan, April 27, 2007, https://www8.cao.go.jp/ocean/english/act/pdf/law_e.pdf; Yutaro Takaya, Kazutaka Yasukawa, Takehiro Kawasaki, *et al*., "The tremendous potential of deep-sea mud as a source of rare-earth elements," *Scientific Reports*, Vol. 8, No. 5763 (2018): page 1, https://doi.org/10.1038/s41598-018-23948-5; Press release, "JOGMEC Conducts World's First Successful Excavation of Cobalt-Rich Seabed in the Deep Ocean; Excavation Test Seeks to Identify Best Practices to Access Essential Green Technology Ingredients While Minimizing Environmental Impact," Japan Organization for Metals and Energy Security, August 21, 2020, https://www.jogmec.go.jp/english/news/release/news_01_000033.html; and Harry Dempsey and Ian Bott, "Japan mines for deep sea rare earths to counter China's chokehold," *Financial Times*, February 23, 2026, https://www.ft.com/content/a811c4dc-bb93-42aa-983a-4c0363073e37.

[7] "Deep-Sea Minerals: The Next Arena of U.S.-China Competition," Baron, March 2024, https://www.baronpa.com/library/deep-sea-minerals-the-next-arena-of-u-s-china-competition.

[8] "Overview of outlook for key minerals," International Energy Agency, revised June 2025, https://www.iea.org/reports/global-critical-minerals-outlook-2025/overview-of-outlook-for-key-minerals.

[9] Ibid.

[10] Paul Manalo, "Average lead time almost 18 years for mines started in 2020–23," S&P Global, April 10, 2024, https://www.spglobal.com/market-intelligence/en/news-insights/research/average-lead-time-almost-18-years-for-mines-started-in-2020-23.

[11] Wolfgang Bernhart, Dominique Gautier, and François Castelein, "Deep-sea mining: a promising critical mineral solution," March 31, 2025, https://www.rolandberger.com/en/Insights/Publications/Deep-sea-mining-a-promising-critical-mineral-solution.html.

Furthermore, Chinese companies have acquired leading positions in the most prominent sources of minerals through investments in the mines themselves and the surrounding infrastructure.[12] Any state that capitalizes on the untapped potential of seabed minerals can mitigate the risks posed by this precarious *status quo*. Moreover, China sees its import reliance on countries like the Democratic Republic of Congo and Indonesia for cobalt and nickel as a strategic vulnerability.[13] China also wants a greater level of mineral security.[14]

3. **The quantity and quality of seabed mineral deposits.** Unlike terrestrial mining operations that must account for declining ore grades and process significant waste, promising seabed mineral deposits typically have higher ore grades.[15] In addition, multiple seabed mineral deposits have more reserves of some minerals than all terrestrial reserves combined. For example, the Clarion-Clipperton Zone (CCZ), a relatively well-explored region of the Pacific Ocean with an abundance of polymetallic nodules, is estimated to have more manganese, tellurium, nickel, cobalt, and yttrium than terrestrial reserves combined.[16] In addition, the Pacific Prime Crust Zone (PCZ), despite its much smaller size compared to the CCZ, also contains more tellurium, cobalt, and yttrium than terrestrial reserves combined.[17] Collectively, seabed minerals constitute one of the greatest untapped resource deposits on Earth. Estimates of the total value of global seabed mineral deposits vary widely due to the lack of commercial extraction, variance in the economic viability of nodule fields, and volatility in mineral pricing. According to information published by the National Oceanic and Atmospheric Administration (NOAA), the number of polymetallic nodules (commonly containing cobalt, manganese, copper, and nickel) in international waters may be as great as 2 trillion tonnes. In a 2020 ISA study the estimated gross value of the metals contained in polymetallic nodules fluctuated between $320/tonne and $1,100/tonne from 2000 to 2020. Nations capable of capitalizing on these untapped deposits, or others located inside and outside of exclusive economic zones (EEZs), will be able to rapidly derisk their supply chains.

Although there is considerable discussion about the specific commercial and military applications of seabed minerals, the diverse supply of minerals in the deep sea has inherent significance for U.S. and allied industry. This is especially true given the well-reported deficiencies in U.S. mining, processing, and mineral stockpiles.

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[12] Gusty da Costa, "China controls Indonesia's nickel industry," *Indonesia Business Post*, November 30, 2022, https://indonesiabusinesspost.com/insider/china-controls-indonesias-nickel-industry; and for Chinese ownership of cobalt mining in the Democratic Republic of the Congo refer to "STATISTIQUES MINIERES EXERCICE 2024," Republique Democratique du Congo Ministere des Mines, January 2025, https://mines.gouv.cd/fr/wp-content/uploads/simple-file-list/statistiques/STATISTIQUES-MINIERES-EXERCICE-2024.pdf.

[13] Wang Xing, Gao Mingyao, Wang Ke, Chen Yuexi, and Tang Panyao, "深海科技：万亿新兴产业的底层逻辑与发展路径思考," Huatai Securities, April 22, 2025, page 7, https://www.vzkoo.com/document/2025042344084028314c66156cb3407d.html (PDF available upon request).

[14] Li Zhijun, "李志军：应抓紧研究制定和实施我国深远海战略," *China Economic Times*, June 4, 2025, https://www.163.com/dy/article/K17KC3I90512D71I.html.

[15] Koichi Iijima, Kazutaka Yasukawa, Koichiro Fujinaga, *et al.*, "Discovery of extremely REY-rich mud in the western North Pacific Ocean," *Geochemical Journal*, Vol. 50, No. 6 (2016): pages 557-573, https://doi.org/10.2343/geochemj.2.0431; and Daina Paulikas, Steven Katona, Erika Ilves, and Saleem H. Ali, "Deep-sea nodules versus land ores: A comparative systems analysis of mining and processing wastes for battery-metal supply chains," *Journal of Industrial Ecology*, Vol. 26 (2022): page 2168, https://doi.org/10.1111/jiec.13225.

[16] James R. Hein, Kira Mizell, Andrea Koschinsky, and Tracey A. Conrad, "Deep-ocean mineral deposits as a source of critical metals for high- and green-technology applications: Comparison with land-based resources," *Ore Geology Reviews*, Vol. 51 (2013): page 1, http://dx.doi.org/10.1016/j.oregeorev.2012.12.001.

[17] Ibid.

Today, semiconductors, permanent magnets, clean energy sources, and fundamental manufacturing materials all require large quantities of critical minerals. As a result, the well-known challenges of mineral supply chains are only growing. These include identifying viable mineral deposits, securing complex and extensive supply chains, and developing mining, extraction, and refining operations at scale. America's reliance on a small number of mineral sources is a threat to U.S. economic and national security.

Today, unlike its position during World War I and World War II, the United States lacks mineral security while its primary adversary has established itself as the world leader. President Trump's 2020 executive order summarizes the challenge:

> 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.[18]

The Biden Administration was also vocal about vulnerabilities in U.S. mineral supply chains. It identified common weaknesses of U.S. supply chains as including "insufficient U.S. manufacturing capacity; misaligned incentives and short-termism in private markets; industrial policies adopted by allied, partner, and competitor nations; geographic concentration in global sourcing; and limited international coordination."[19]

Access to critical minerals is clearly vital for U.S. economic and national security. If China can secure a leading position in the nascent seabed mineral sector, it will make America more vulnerable. Moreover, an active seabed mineral industry will elevate the importance of maritime regions that, to date, have had minimal strategic importance. The winners and losers of the competition for seabed minerals will reshape the geopolitical landscape.

The Heightened Importance of EEZs and Areas Beyond National Jurisdiction

One important conclusion of Baron's March 2024 report was that seabed mineral deposits could revolutionize the importance of maritime borders.

Three major types of mineral deposits exist on the seafloor: cobalt-rich ferromanganese crusts, polymetallic sulfides, and polymetallic nodules. Polymetallic nodules are the most abundant and, therefore, potentially most valuable source of critical minerals for the global economy.[20] These

[18] Donald J. Trump, "Executive Order 13953: Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries," Executive Office of the President, October 5, 2020, https://www.federalregister.gov/documents/2020/10/05/2020-22064/addressing-the-threat-to-the-domestic-supply-chain-from-reliance-on-critical-minerals-from-foreign.

[19] "Executive Order on America's Supply Chains: A Year of Action and Progress," The White House, February 24, 2022, page 4, https://www.whitehouse.gov/wp-content/uploads/2022/02/Capstone-Report-Biden.pdf.

[20] "Exploration Contracts," International Seabed Authority, https://www.isa.org.jm/exploration-contracts.

nodules primarily contain cobalt, manganese, copper, nickel, rare-earth elements (REEs), yttrium, and other minerals.[21]

Many promising seabed mineral deposits, particularly polymetallic nodules, are in international waters. Although mineral deposits also can be found in shallower, coastal areas, the CCZ is currently the most sought-after region under the jurisdiction of the ISA. Countries with mineral deposits within their 200 nautical mile coastal EEZ are authorized by international law to mine those deposits in accordance with pertinent environmental regulations.[22] EEZs are more likely to contain polymetallic sulfides and ferromanganese crusts due to the lower depths at which they occur. As a result, analysts in China have expressed optimism about polymetallic sulfides and China has tested collector vehicle tests capable of collecting minerals from all three types of deposits (see Appendix C).

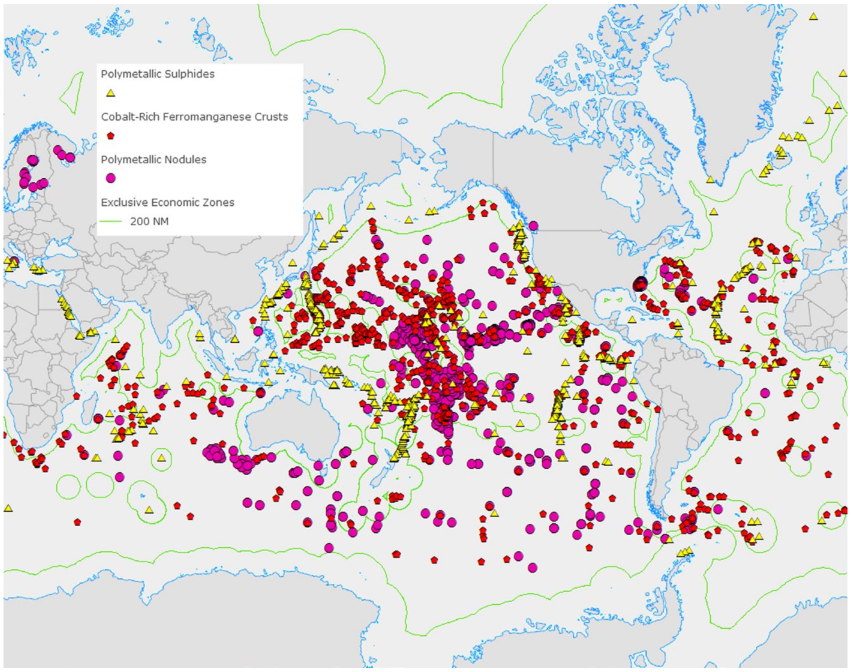

Image 1: Global distribution of three major types of seabed mineral resources (UNEP, adapted from ISA 2014).[23]

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[21] James R. Hein and Kira Mizell, "Deep-ocean polymetallic nodules and cobalt-rich ferromanganese crusts in the global ocean: New sources for critical metals," USGS Pacific Coastal and Marine Science Center, https://www.usgs.gov/publications/deep-ocean-polymetallic-nodules-and-cobalt-rich-ferromanganese-crusts-global-ocean-new.

[22] "Seabed Activities," NOAA, https://www.noaa.gov/seabed-activities; Exceptions to this rule are governed by the United Nations Commission on the Limits of the Continental Shelf (CLCS) within the Division for Ocean Affairs and the Law of the Sea. This body permits countries with a natural prolongation of land territory onto the continental shelf to claim ocean areas up to 350 nautical miles off their coasts. "Commission on the Limits of the Continental Shelf (CLCS)," Oceans & Law of the Sea: United Nations, https://www.un.org/Depts/los/clcs_new/clcs_home.htm; and because the United States is not a member of UNCLOS, the United States administers its own continental shelf mapping initiative, the U.S. Extended Continental Shelf (ECS) Project. "About the U.S. ECS Project," U.S. Department of State, https://www.state.gov/about-the-us-ecs-project.

[23] Yannick Beaudoin, Allison Bredbenner, Elaine Baker, Charles Roche, Sara Rice, and Linwood Pendleton, "Wealth in the Oceans: Deep sea mining on the horizon?" United Nations Environment Programme, May 2014, https://na.unep.net/api/geas/articles/getArticleHtmlWithArticleIDScript.php?article_id=112.

Seabed minerals found in EEZs have significant potential. The Cook Islands, for example, has a lucrative deposit of nodules.[24] Without the same regulatory hurdles at the ISA and a nodule field around twice the size of ISA contract areas, the Cook Islands is becoming a leading candidate to oversee commercial extraction in an EEZ.[25] While they may not have the same abundance as the Cook Islands, other promising seabed mineral deposits undoubtedly exist in the extensive EEZs of the United States and its strategic partners. Current constraints on the build out of non-Chinese mining projects and the rising demand for alternative mineral sources make EEZs a compelling option. Identifying abundant deposits in EEZs will become increasingly important for the United States and its strategic partners in the years ahead.

China's efforts to secure ISA contracts and win the "land rush" is shaped by its relatively small EEZ.[26] 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 smaller countries.[27] For comparison, the United States' EEZ is 12 times the size of China's.[28] In part due to its notably small EEZ (see **Table 1** and **Chart 1**), there are persistent tensions between China's formal ratification of the UN Convention on the Law of the Sea (UNCLOS) and its disregard for how UNCLOS defines China's EEZ.[29] These constraints make ISA contracts even more attractive for China because they could grant access to resource-rich areas of the ocean.[30] Just in the past year, a team of researchers affiliated with the Guangzhou Marine Geological Survey – one key body under China's Ministry of Natural Resources supporting China's seabed mineral sector – published a paper on promising polymetallic nodule deposits in the South China Sea. The team surveyed 72,000 square kilometers, the equivalent of an ISA exploration license, and produced an estimated resource range of 144,000-720,000 tonnes.[31]

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[24] James R. Hein, Francesca Spinardi, Nobuyuki Okamoto, Kira Mizell, Darryl Thorburn, and Akuila Tawake, "Critical metals in manganese nodules from the Cook Islands EEZ, abundances and distributions," *Ore Geology Reviews* Vol. 68 (2015): pages 97-116, https://www.sciencedirect.com/science/article/abs/pii/S0169136814003679.

[25] Press release, "Cook Islands and United States Establish Strategic Framework for Critical Minerals Research and Supply Chain Security," Ministry of Foreign Affairs and Immigration Government of the Cook Islands, February 5, 2026, https://mfai.gov.ck/news-updates/cook-islands-and-united-states-establish-strategic-framework-critical-minerals.

[26] Dai Mingyu, Wang Binpeng, Zhao Mengni, Li Yuexuan, and Tang Zhiwei, "深海科技，下一个国家级战略主线," Huayuan Securities, August 20, 2025, page 2, https://pdf.dfcfw.com/pdf/H3_AP202508201731246752_1.pdf?1755760048000.pdf.

[27] "Exclusive Economic Zone (EEZ) Map of the World," International Institute for Law of the Sea Studies, May 23, 2021, https://iilss.net/exclusive-economic-zoneeez-map-of-the-world.

[28] The U.S. EEZ is 11,661,674 square kilometers while China's is 963,556 square kilometers. "The United States is an Ocean Nation," National Oceanic and Atmospheric Administration, https://www.gc.noaa.gov/documents/2011/012711_gcil_maritime_eez_map.pdf; and "China," Marineregions.org, https://www.marineregions.org/eezdetails.php?mrgid=8486.

[29] *The South China Sea Arbitration (The Republic of Philippines v. The People's Republic of China)*, No. 2013-19, (Permanent Court of Arbitration (PCA). July 12, 2016).

[30] Contracted areas for polymetallic nodules are as large as 75,000 square kilometers, almost nine percent of China's current EEZ. "Exploration areas," International Seabed Authority, https://www.isa.org.jm/exploration-contracts/exploration-areas.

[31] Ren Jiangbo, Yang Yong, Zhang Lixue, Zhang Limin, Deng Yinan, *et al.*, "Discovery of Dense Ferromanganese Nodules in the Central Basin of the South China Sea: Insights Into Metallogenesis Processes and Resource Potential," *Geophysical Research Letters* Vol. 52, No. 9 (2025): pages 7-8, 10.1029/2025GL115849.

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

Table 1: Top 35 Countries by EEZ Size and Relationship with the United States
Note: "Strategic Partner" includes NATO allies, major non-NATO allies, Quad members, Compacts of Free Association (COFA), and the Cook Islands.[32]

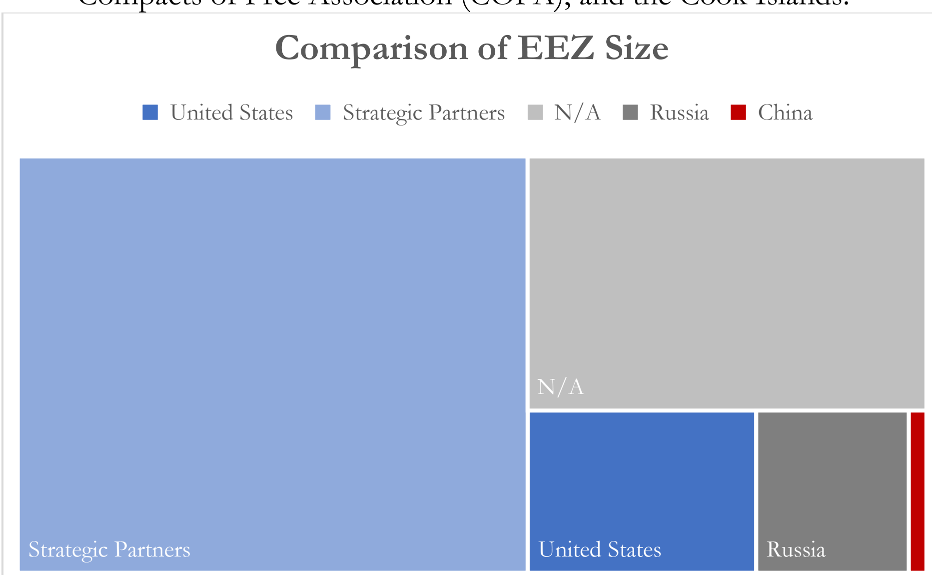

Chart 1: China's EEZ (338,619 square miles), denoted in red, is marginal compared to the United States (4,382,646 square miles), U.S. strategic partners (25,042,751 square miles), and Russia (2,921,509 square miles).
Note: "N/A" represents the cumulative EEZ of the remaining countries in the top 35.

[32] The Cook Islands is independent and self-governing but is in free association with major non-NATO ally, New Zealand.

Seabed Minerals and China's Ambition to Become a "Maritime Power, 海洋强国"

China's campaign to influence the ISA and efforts to solidify its unrecognized claims in the South China Sea are all components of a broader strategy to galvanize public and private sector actors around a vibrant "blue economy" (蓝色经济, *lanse jingji*).[33] Since the establishment of the ISA, China has sought a seat at the table, but it was only in the past 15 years that it accelerated efforts to develop the technological capabilities to extract seabed minerals (see Appendix D). The 18th Party Congress Political Work Report published in 2012, the same year as Xi Jinping took office, was the first government document to refer to the goal of making China into a "maritime power" (海洋强国, *haiyang qiangguo*).[34] This strategic objective has launched a mandate to build new commercial undersea capabilities.

This state-led initiative to benefit from seabed minerals was summarized by Hu Zhenyu, a director of the Institute for Sustainable Development and Marine Economy at the China Development Institute in Shenzhen, in a June 2025 op-ed in state-owned outlet *The Paper*:

> While land-based resources underpinned the dramatic transformations of modern society, rapid technological progress in the oceanic era is driving a shift in the historical geographical pivot toward the deep sea. … the advent of deep-sea mining is inevitable.[35]

China's Moves Before the April 2025 Executive Order

When it comes to prioritizing the development of a domestic seabed mineral sector, China stands alone. Well before President Trump signed the Executive Order (EO), "Securing America's Offshore Critical Minerals and Resources," on April 24, Beijing was already accelerating its efforts to develop a "Made in China" seabed minerals industry. One month prior, China's 2025 "Government Work Report," labeled "deep-sea technology (深海科技)" a "strategic emerging industry (战略性新兴产业)."[36] In the weeks between the "Government Work Report" and before the April 2025 executive order, Chinese provinces and municipalities promulgated plans to develop their "blue economies," Chinese advisory firms published forecasts for the sector, and companies directly or peripherally involved in undersea technology fielded questions during earnings calls about their plans to enhance their undersea capabilities.[37]

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[33] "中共中央关于制定国民经济和社会发展第十三个五年规划的建议," *People's Daily*, November 3, 2015, http://cpc.people.com.cn/n/2015/1103/c399243-27772351-3.html.

[34] Hu Jintao, "胡锦涛在中国共产党第十八次全国代表大会上的报告," *People's Daily*, November 8, 2012, http://cpc.people.com.cn/n/2012/1118/c64094-19612151-8.html.

[35] Hu Zhenyu, "聚焦深海采矿，抢占时代高点," *The Paper*, June 16, 2025, https://web.archive.org/web/20260129195420/https://m.thepaper.cn/newsDetail_forward_30989940.

[36] Li Qiang, "政府工作报告," *Xinhua*, March 12, 2025, https://www.gov.cn/yaowen/liebiao/202503/content_7013163.htm.

[37] Su Lizan, Xu Mu, Gao Zhengtai, "国防军工行业深度报告：深海科技六问六答，深海开发始于海洋探测， 信息化与工具载体先行," Soochow Securities, March 31, 2025, page 13, https://web.archive.org/web/20250616150523/https://pdf.dfcfw.com/pdf/H3_AP202504011649849372_1.pdf?1743506995000.pdf; and "株洲中车时代电气股份有限公司投资者关系活动记录表," Times Electric, March 28, 2025, pages 1-2, https://web.archive.org/web/20250620181746/https://pdf.dfcfw.com/pdf/H2_AN202503311649635800_1.pdf.

Although this sector remains fragmented and faces technological gaps to compete with the most advanced Western technologies, Beijing and a group of provinces and municipalities are mobilizing universities and SOEs to ensure China benefits from the abundant resources in the world's oceans. Moreover, analysts in China recognize that Chinese leadership in seabed minerals would enhance its subsea mapping and warfare capabilities and mitigate perceived supply chain vulnerabilities.[38] The success of China's enterprise would further endanger U.S. supply chains, cause U.S. companies to, once again, compete with non-market actors in a critical industry, and erode the U.S. Navy's advantages in undersea warfare. Understanding the progress, weaknesses, strengths, and ambitions of China's seabed mineral sector is vital for American policy makers looking to protect American interests in maritime and supply chain security.

China's Seabed Mineral Industry

Baron's March 2024 report was an initial effort to address the lack of English-language information on China's seabed mineral sector.[39] This lack of coverage largely has continued. For example, English-language media has discussed the reported acquisition of Beijing Pioneer by Global *Fortune* 500 member China Merchants Group (CMG), and rarely mentioned CMG's established role in China's seabed mineral sector.[40] Moreover, no English-language media has examined the October 2025 strategic cooperation agreement signed by Ningbo Fangzheng Automobile Mould Co., Ltd. (Fangzheng Tool, 宁波方正汽车模具股份有限公司) – an automotive parts manufacturer – and Shandong Future Robot (VVLAI, 山东未来机器 人有限公司) – an undersea robotics manufacturer that claims to be the first "high-tech enterprise in China to achieve independent domestic production of deep-sea robots."[41] The only English-language coverage of VVLAI's extensive deep-sea capabilities comes from the company's English website and Chinese state media.[42]

On the surface, China Ocean Mineral Resources R&D Association (COMRA) appears to play a leading role due to its three exploration licenses with the ISA. In reality, it is primarily an organizing body with relatively minimal funding of its own. It is not a behemoth. **Chart 2** compares COMRA and the Institute for Deep Sea Science and Engineering's (IDSSE) budgets since 2021. IDSSE is a unit of the Chinese Academy of Sciences strategically located in Sanya, Hainan. It is worth noting that IDSSE claims to have "an expert from the Woods Hole Oceanographic Institution of the United States" at its "Deep-Sea Resources Development Laboratory."[43] IDSSE was the leading entity behind 2019 and 2020 tests of cobalt-rich ferromanganese crust collector vehicles (see Appendix C) and partnered with CMG in the latter project. The disparity between the two reflects a

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[38] Wang Xing, Gao Mingyao, Wang Ke, Chen Yuexi, and Tang Panyao, "深海科技：万亿新兴产业的底层逻辑与发展路径思考," Huatai Securities, April 22, 2025, page 7, https://www.vzkoo.com/document/2025042344084028314c66156cb3407d.html (PDF available upon request).

[39] Tom LaTourrette, Fabian Villalobos, Elisha Yoshiara, and Zohan Hasan Tariq, "The Potential Impact of Seabed Mining on Critical Mineral Supply Chains and Global Geopolitics," RAND Corporation, April 9, 2025, page 4, https://www.rand.org/pubs/research_reports/RRA3560-1.html.

[40] Hu, "聚焦深海采矿，抢占时代高点;" and an exception is the interview Phillip Gales conducted with Andrew Lipman – a Shenzhen-based representative of the American Bureau of Shipping (ABS) who has observed China Merchants Group's seabed mineral activities firsthand. Phillip Gales, "Expert Series: Andrew Lipman on Vessel Classifications, Stars and DSM in China," Deep Sea Mining, May 11, 2024, https://deepseamining.ac/article/45#gsc.tab=0.

[41] "宁波方正：将与山东未来机器人在深海机器人机械零部件研发生产等方面开展合作," *Jiemian News*, October 26, 2025, https://web.archive.org/web/20260129195244/https://finance.eastmoney.com/a/202510263544441873.html.

[42] "Deep-Sea Exploration," VVLAI, https://vvlai.com/services-details/Deep-Sea-Exploration.

[43] "About us," Institute of Deep-sea Science and Engineering, https://english.idsse.cas.cn/research/dset/drd/about_us.

separation of responsibilities within China's seabed mineral industry today, with COMRA's organizing role not coinciding with internal technological capacity. Every noteworthy seabed mineral extraction test typically attributed to COMRA was primarily supported by other entities (Appendix C).

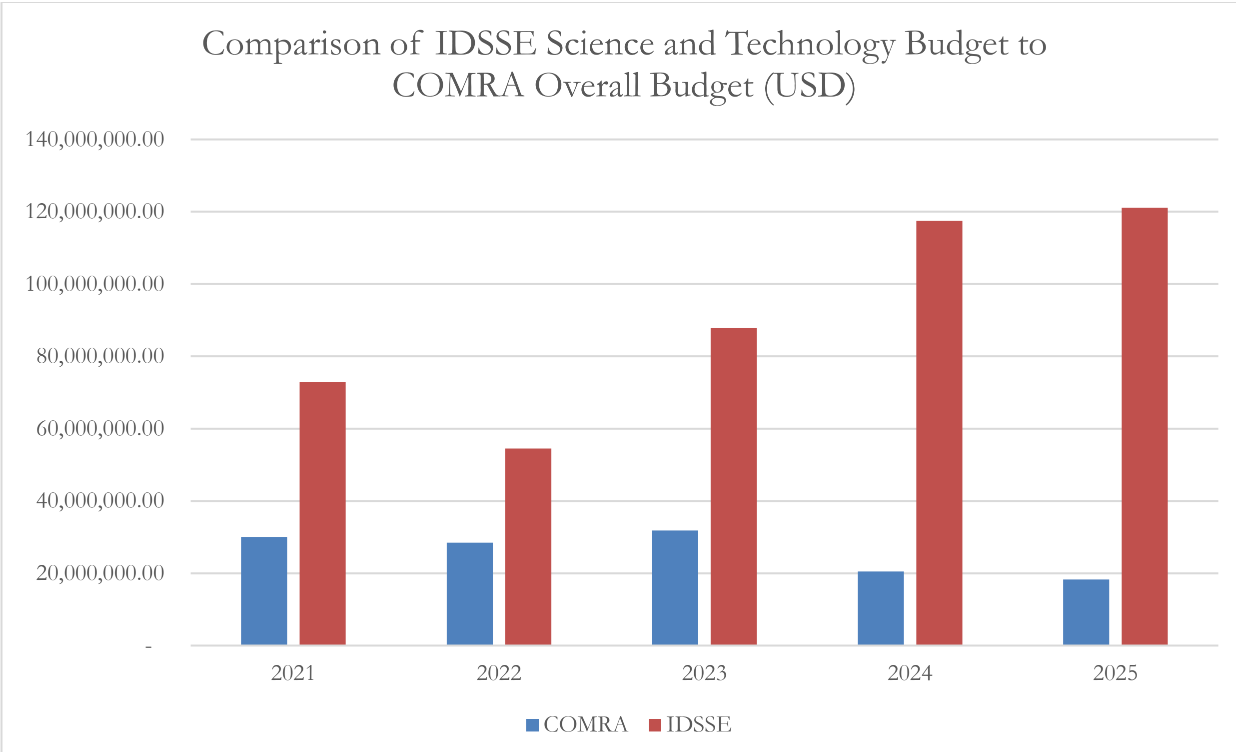

Chart 2: IDSSE's science and technology budget (科学技术支出) was more than double COMRA's total budget in 2021 and was over six times as large in 2025.[44]

Universities like Shanghai Jiao Tong University and Ocean University of China, research institutes like IDSSE, and SOEs play demonstrably larger roles in developing China's technological capabilities and conducting tests. In addition, VVLAI, while ostensibly a private company, has a

[44] "中国科学院深海科学与工程 研究所 2021 年度部门决算," IDSSE, https://web.archive.org/web/20250502002158/http://idsse.cas.cn//xxgk/xxgkml/201711/P020220825384794642643.pdf; "中国科学院 深海科学与工程研究所 2022 年度部门决算," IDSSE, https://web.archive.org/web/20250620214704/https://idsse.cas.cn//xxgk/xxgkml/201711/P020230822572518693093.pdf; "中国科学院 深海科学与工程研究所 2023 年度部门决算," IDSSE, https://web.archive.org/web/20250620212544/https://idsse.cas.cn/xxgk/202408/P020240829537847885144.pdf; "中国科学院深海科学与工程研究所 2024 年部门预算," IDSSE, https://web.archive.org/web/20250502011930/http://idsse.cas.cn/xxgk/202405/P020240520394568369688.pdf; "中国科学院深海科学与工程研究所 2025 年部门预算," IDSSE, https://web.archive.org/web/20250620213915/https://idsse.cas.cn/xxgk/202504/P020250418797146684019.pdf; "中国大洋事务管理局 2021 年预算," COMRA, December 26, 2020, http://download.china.cn/ch/ocean/20201226/newocean5.pdf; "中国大洋事务管理局 2021 年预算,"COMRA, April 28, 2022, http://download.china.cn/ch/ocean/20220428/newocean29.pdf; "中国大洋事务管理局 2023 年预算," COMRA, June 19, 2023, http://download.china.cn/ch/ocean/20230619/newocean47.pdf; "中国大洋事务管理局 2024 年预算，" COMRA, April 28, 2024, http://www.comra.org/2024-04/28/content_42773470.htm; and "中国大洋事务管理局 2025 年预算," COMRA, April 27, 2025, http://download.china.cn/ch/ocean/20250427/newocean68.pdf.

strategic investment agreement with Global *Fortune* 10 member and SOE China National Petroleum Corporation's (CNPC) subsidiary, CNPC Kunlun Capital (中石油昆仑资本).[45] The extensive role of government-backed institutions reflects the strategic significance of the industry and also provides substantive pathways for China to fund undersea research and development (R&D), even though it lacks an immediate regulatory pathway to seabed mineral extraction.

SOEs, unsurprisingly, have a significant role. In addition to holding exploration licenses at the ISA (China Minmetals and Beijing Pioneer – CMG) SOEs are supporting extensive R&D work. Minmetals' subsidiary Changsha Research Institute of Mining and Metallurgy (CRIMM) is the most prominent example. CRIMM is a formerly government-backed research institute that secured China's first patent related to seabed minerals in 1996 and has played an integral role in almost half of China's major seabed mining tests.[46] Since Minmetals gained control of CRIMM in 2009, it has become a key mechanism for Minmetals to develop undersea technologies for seabed mineral extraction. Major SOEs have also published investment reports praising the potential of the undersea technology sector. These include China Merchants Bank, a subsidiary of CMG, Global *Fortune* 500 member China Post, and Global *Fortune* 500 member China International Trust Investment Corporation (CITIC Group).[47]

Technological Gaps

China's investments in undersea technologies are attempting to address its only potential area of disadvantage in this nascent industry – besides its uncertain path to regulatory approval. Han Xiqiu (韩喜球), an experienced deep-sea researcher at the Second Institute of Oceanography – another key body under China's Ministry of Natural Resources supporting China's seabed mineral sector – claimed in 2024 that China suffers from an overreliance on foreign imports and described the prevailing mindset as "buying is better than making."[48] In part to address these gaps, the Ministry of Science and Technology (科学技术部) has reportedly dedicated around $700 million to the development of seabed mineral extraction technologies and subsea data centers.[49]

From the outset of China's seabed mineral R&D it has relied on Western partners. Between 1996 and 2000, Cybernetix – a French company with a specialization in undersea robotics – worked with

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45 "中石油昆仑资本与山东未来机器人投资签约仪式在山东威海隆重举行," VVLAI, May 8, 2025, https://vvlai.cn/news-details/1769129522529.

46 "Environmental Impact Statement Testing of Polymetallic Nodule Collector Vehicle in the Block A-5 of the Minmetals Contract Area," China Minmetals, March 2024, pages III and 9-10, https://www.minmetals.com/xxgk/qygg/202404/P020240407410576337793.pdf.

47 "深海科技专题报告：深蓝之钥，解锁海洋未来，布局深海科技核心资产," China Merchants Securities, June 9, 2025, https://www.vzkoo.com/document/202506106dd7cd569ecade5562643b16.html?keyword=%E6%B7%B1%E6%B5%B7%E7%A7%91%E6%8A%80; Bao Xuebo, Ma Qiang, and Wang Yutong, "深海科技 深海资源开发潜力巨大，攻防体系建设保障制海权," China Post Securities, April 2, 2025, https://finance.sina.com.cn/stock/stockzmt/2025-04-03/doc-inervzcy8477363.shtml; and Zheng Zaojin, "中信证券：深海科技主题后市有望持续演绎," https://finance.eastmoney.com/a/202503253354865395.html.

48 "高质量发展海洋经济 高水平建设海洋强国——访全国人大代表韩喜球," COMRA, March 19, 2024, https://web.archive.org/web/20240712170822/http://www.comra.org/2024-03/19/content_42728713.htm.

49 Man Zaipeng and Fang Lingcong, "海洋经济风起，关注海洋高端装备制造," Sinolink Securities, March 31, 2025, https://web.archive.org/web/20250616145159/https://pdf.dfcfw.com/pdf/H3_AP202504011649808724_1.pdf.

CRIMM to create the 2001 collector vehicle (see Appendix A).[50] A more recent example of China's efforts to overcome these gaps with Western expertise is Global *Fortune* 500 member China Railway Rolling Stock (CRRC) Group's subsidiary, Zhuzhou CRRC Times Electric (Times Electric). CRRC Group's is one of the largest railway manufacturers in the world and is attempting to leverage Western expertise to support China's undersea technology. In 2015, Times Electric acquired a United Kingdom company called Soil Machine Dynamics (SMD).[51] SMD built the collector vehicle for Nautilus Minerals' Solwara-1 project to extract seabed minerals from a polymetallic sulfide deposit in Papua New Guinea's EEZ. Times Electric is actively repurposing and expanding upon the technologies acquired from SMD to support China's seabed mineral industry, including an electric collector vehicle rated for depths of 6,000 meters that it built with CRIMM.[52]

Ability to Leverage Processing and Shipbuilding Advantages

Seabed mineral extraction requires modified surface vessels to support remotely operated vehicles (ROVs), unmanned underwater vehicles (UUVs), collector vehicles, and riser systems. China State Shipbuilding Corporation (CSSC) led the world in new surface vessel orders in 2025 and is playing an active role in China's nascent seabed mineral industry, primarily through its subsidiary China Ship Scientific Research Center's (中国船舶科学研究中心) Taihu Laboratory of Deepsea Technological Science (深海技术科学太湖实验室).[53] With CSSC and its Chinese peers possessing 232 times the shipbuilding capacity of the United States, it is not even close in terms of who is more prepared to construct new surface vessels.[54]

Seabed minerals will 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.[55] 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.[56]

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[50] Dai Yu and Liu Shaojun, "Researches on Deep Ocean Mining Robots: Status and Development," *Robot* Vol. 35, No. 3 (2013): page 367, 10.3724/SP.J.1218.2013.00363.

[51] Tom LaTourrette, Todd C. Helmus, and Irina A. Chindea, "China's Role in the Global Development of Critical Resources," RAND Corporation, November 7, 2022, https://www.rand.org/pubs/research_reports/RRA2096-1.html.

[52] Press release, "湖南省科技重大专项"深海矿产资源开采关键装备技术研究与示范应用"项目通过专家组验收," CRIMM, June 19, 2024, https://www.crimm.com.cn/xwzx/qyxw/202406/t20240619_304166.html.

[53] "七〇二所研发深海采矿关键设备取得阶段性进展," CSSRC, December 9, 2021, http://www.cssrc.com.cn/wnewsx/wdetail/1292.html.

[54] "China Continued Shipbuilding Dominance in 2025, Raking In Most Orders," *The Maritime Executive*, February 4, 2026, https://maritime-executive.com/article/china-continued-shipbuilding-dominance-in-2025-raking-in-most-orders; Joseph Trevithick, "Alarming Navy Intel Slide Warns Of China's 200 Times Greater Shipbuilding Capacity," *TWZ*, July 11, 2023, https://www.twz.com/alarming-navy-intel-slide-warns-of-chinas-200-times-greater-shipbuilding-capacity.

[55] Tae-Yoon Kim, Shobhan Dhir, Amrita Dasgupta, and Alessio Scanziani, "With new export controls on critical minerals, supply concentration risks become reality," International Energy Agency, October 23, 2025, https://www.iea.org/commentaries/with-new-export-controls-on-critical-minerals-supply-concentration-risks-become-reality.

[56] "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," U.S. Department of Commerce, Page 9, January 2020, https://www.commerce.gov/sites/default/files/2020-01/Critical_Minerals_Strategy_Final.pdf.

As a result, non-Chinese firms confront difficult choices about partnering with Chinese entities for transportation, 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. According to a 2022 RAND Corporation report, leaders of Western entrants into the seabed mineral sector have faced extensive efforts by Chinese processors to secure advance mineral processing agreements.[57] The shipbuilding and processing constraints increase the risks of potential investments by Americans in the seabed mineral sector and pose challenges for future efforts to compete with China.

Five Noteworthy Trends Since Baron's March 2024 Report

1. **Chinese provincial and municipal governments are attempting to lay strong foundations for future seabed mineral industrial hubs.** Notable collaboration exists across China and within the constellation of entities, but this is overshadowed by provincial and municipal governments aiming to align with Beijing's direction and to lead China's future seabed mineral industry.

2. **Changsha, in the landlocked Hunan Province, has both the longest and most active history of technological innovation in China's seabed mineral sector.** Led principally by two subsidiaries of the *Fortune* Global 100 state-owned enterprise (SOE) China Minmetals: CRIMM and the Changsha Institute of Mining Research (CIMR), Hunan has long sought to foster its technological leadership within China's seabed mineral research and development ecosystem. One peer to Hunan is Shanghai, where Shanghai Jiao Tong University's Changxing Ocean Laboratory, in conjunction with the Shanghai government-backed Grand Neobay Development Zone, has become a driving force for the other active Chinese contractor at the ISA, Beijing Pioneer, which is now reportedly controlled by CMG.[58] Shandong Province, Sanya, Hainan, and Shenzhen are other important hubs worth monitoring.

3. **China believes it can catch up to and surpass the West.** Like other industries, China believes it can leapfrog its rivals' undersea technology capabilities. An internal Baron estimate shows China has well over 1,000 seabed mining-related patents compared to less than 100 for U.S. entities. Some leaders in China's seabed mineral sector recognize they remain behind Western standards by "five to 10 years."[59] Challenges remain in localizing production of key deep-sea materials, transporting minerals from the seabed to surface vessels, and conducting integrated operations. The patent data suggests that government funded research is aggressively looking for solutions to these remaining obstacles. However, the founder and controlling shareholder of VVLAI claimed in an August 2025 interview that China's ROVs are already at the same level as Western competitors.[60]

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[57] A representative of a deep-sea mining operation interviewed for a 2022 RAND Corporation report said, "I don't know of a single seabed mining contractor that hasn't been approached by the Chinese." See Latourrette *et al.*, "China's Role in the Global Development of Critical Resources," page 49.

[58] "深海重载作业装备研究中心," Shanghai Jiao Tong University Changxing Ocean Laboratory, https://ime.sjtu.edu.cn/kjgg/jctd/shzzzyzbyjzx.htm.

[59] Wang Haohao, "深海矿产资源开采关键装备技术实现重大突破," *China Science Daily*, June 17, 2024, https://web.archive.org/web/20250625143410/https://rmtzx.sciencenet.cn/mixmedia/a/202406/17/WS666ffc3de4b0f632f266f533.html.

[60] Guo Hongyun, "未来机器人陶泽文：中国深海机器人的逆袭之路丨50x50," *TMT Post*, August 18, 2025, https://finance.ifeng.com/c/8lvLsDV0lTX.

4. **Analysts in China are increasingly aware of the strategic significance of seabed minerals and could spur investments beyond traditional government sources.** Since the release of the 2025 Government Work Report, investment analysts at SOEs and private firms have explored the prospects of China's seabed mineral sector.[61] Most reports reviewed by Baron identified the national security importance of seabed minerals as a reason to invest in the dual-use technologies and materials that will make seabed mining possible. They notably describe China as overly dependent on foreign sources of critical minerals but harp on the national security ramifications of the sector, predicting a "blue land rush."[62]

5. **Chinese analysts worry about China's critical mineral vulnerabilities.** Contrary to American perceptions of dominance, Chinese think tank scholars, academics, and analysts all have expressed concerns about China's reliance on foreign sources of critical minerals. These concerns provide Beijing a powerful incentive to secure its access to seabed minerals in the South China Sea, through the ISA, and – if necessary – in the EEZs of Pacific Island nations. The following image from a Huatai Securities report on undersea technology depicts China's import reliance for petroleum, natural gas, copper, nickel, manganese, diamond, chromite, and iron as a justification for investing in seabed minerals.[63]

Image 2: Chart produced by Huatai Securities showing China's import reliance for strategic resources.

Policy Recommendations

1. **Monitor:** China's ambitions in the South China Sea and international waters merit close scrutiny as they have direct impacts on United States and its allies. The United States Geological Survey (USGS) has not produced a country report for China since 2023. Resuming these critical reports on China's mineral sector will provide vital insights for U.S. business leaders and policy makers. In addition, from 1977 to 1979 the U.S. Bureau of Mines included "Ocean minerals" in its annual

[61] Su Lizan, Xu Mu, and Gao Zhengtai, "深海科技六问六答，深海开发始于海洋探测，信息化与工具载体先行," Soochow Securities, March 31, 2025, https://web.archive.org/web/20250616150523/https://pdf.dfcfw.com/pdf/H3_AP202504011649849372_1.pdf?1743506995000.pdf; and Wang Xing, Gao Mingyao, Wang Ke, Chen Yuexi, and Tang Panyao, "深海科技：万亿新兴产业的底层逻辑与发展路径思考," Huatai Securities, April 22, 2025, https://web.archive.org/web/20250616152116/https://www.vzkoo.com/document/2025042344084028314c66156cb3407d.html.

[62] Man and Fang, "海洋经济风起," page 10.

[63] Wang, *et al.*, "深海科技," page 7.

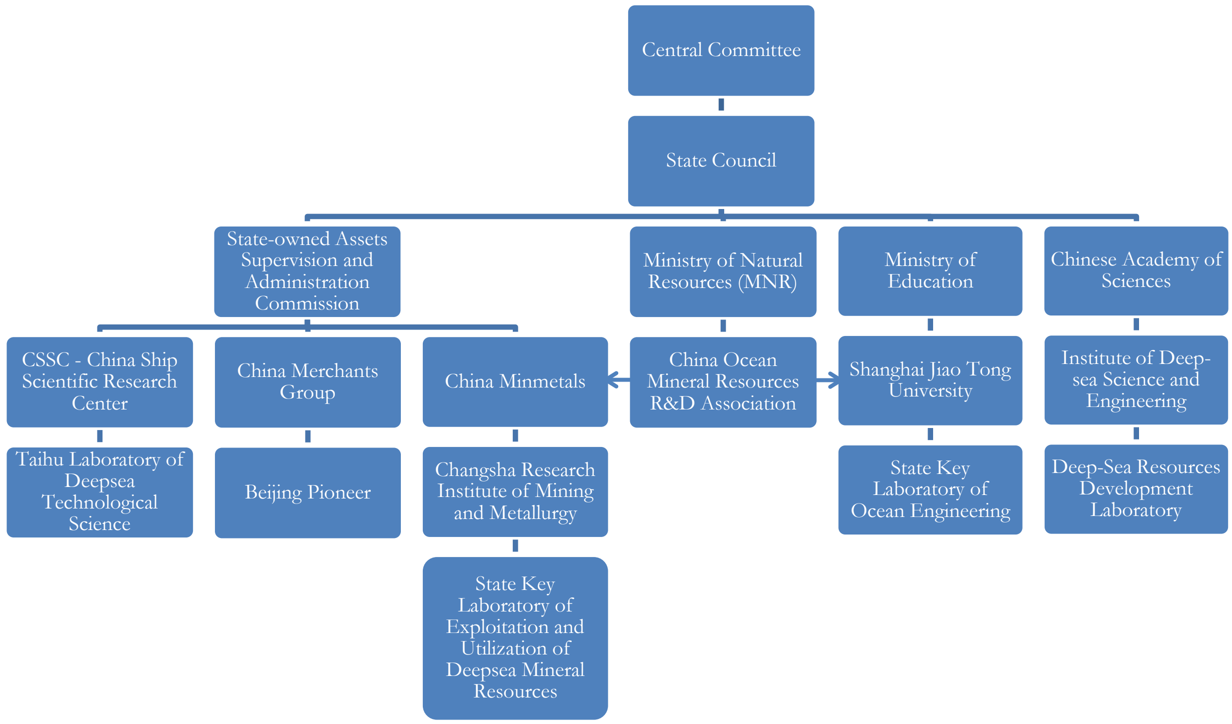
"Minerals Yearbook."[64] Including a section in the annual "Mineral Commodity Summaries" on seabed minerals would help decision makers advance U.S. interests. Producing a true estimate of China's investments in its seabed mineral sector in the past 10 years would also help policy makers assess the true extent of China's ambitions.

2. **Explore:** Seabed minerals have the potential to support economic diversification and infrastructure revitalization throughout the Pacific. As a result, identifying abundant deposits in Pacific EEZs is increasingly important for the United States and its strategic partners. In the past months, NOAA research vessels have already built scientific partnerships with the Cook Islands.[65] These voyages provide a model for future U.S. efforts to strengthen its network of alliances in the Pacific and ensure the peoples of the Cook Islands, other Pacific Island states, and U.S. Pacific Island territories have the information needed to support responsible extraction operations. Updated resource assessments will also encourage the flow of U.S. capital to promising projects.
3. **Build:** The heavy involvement of SOEs and state-funded institutions in China's build out insulates Chinese entrants from the regulatory and financial risks facing American firms. For Minmetals, CMG, CSSC, CRRC Group, and others, long-term strategic gains can outweigh short-term losses. America's moribund mineral processing and shipbuilding industries are also constraints. The Administration and Congress are focusing on these challenges, but more can be done to incentivize U.S. companies to invest in these industries. Advancing and scaling U.S. seafloor mapping, environmental monitoring, seabed mineral extraction, shipping, and processing will also not happen overnight. The highest value investment would be a government funded first of its kind nodule-specific processing facility in the United States, potentially on the Gulf Coast.[66] Such a facility would help shift the center of gravity of critical mineral supply chains away from China and back toward the United States.

Hearing co-chairs Schriver and Kuiken and distinguished commissioners, thank you again for the opportunity to testify.

[64] National Minerals Information Center, "Bureau of Mines Minerals Yearbook (1932-1993)," U.S. Geological Survey, https://www.usgs.gov/centers/national-minerals-information-center/bureau-mines-minerals-yearbook-1932-1993.
[65] "NOAA-Supported Expedition on E/V *Nautilus* to Explore Deep Waters of the Cook Islands," NOAA, September 29, 2025, https://oceanexplorer.noaa.gov/news/nautilus-cook-islands; and "Call for Input: NOAA Ship *Okeanos Explorer* 2026 Proposed Pacific Island Operating Areas," NOAA, September 17, 2025, https://oceanexplorer.noaa.gov/news/call-for-input-noaa-ship-okeanos-explorer-2026-proposed-pacific-island-operating-areas.
[66] Letter to Laura D. Taylor-Kale from Representative Wesley P. Hunt, *et al.*, November 8, 2023, https://x.com/RepWPH/status/1723048494833787377/photo/1.

Appendix A: Organizational Structure of China's Seabed Mineral Industry[67]



[67] Note: Beijing Pioneer is listed as a subsidiary based on Hu Zhenyu's list of China's ISA contractors proceeding as follows "先驱集团 (后被招商集团收购)." Hu, "聚焦深海采矿，抢占时代高点;" and COMRA previously listed Beijing Pioneer as a subsidiary entity in August 2023. Beijing Pioneer likely was guided by COMRA until the right SOE partner, CMG, took ownership. "全级次企业名单," COMRA, August 24, 2023, http://www.comra.org/2023-08/24/content_42494807.htm.

Appendix B: Timeline of Legal, Regulatory, and ISA Developments (before June 2025)

Year	Organization(s)	Description
1991	COMRA	China joins India, France, Japan, and the Soviet Union as one of five founding investors in the ISA and establishes COMRA in the same year to advance China's interests in deep-sea minerals.[68]
2001	COMRA	Secures first ISA contract for China, one of six polymetallic nodule exploration contracts awarded that year. The first year the ISA awarded exploration contracts.
2011	COMRA	Acquires the first polymetallic sulfide exploration contract ever granted by the ISA.
2013	COMRA	After ISA invitation for contractors to share progress on domestic deep-sea mining legislation, COMRA notifies the Ministry of Foreign Affairs of its preliminary progress.[69]
2014	COMRA	Secures China's first cobalt-rich ferromanganese crust exploration contract.
2016	National People's Congress	Deep-Sea Mining Law goes into effect and establishes framework for Chinese entities to formally participate in deep-sea mining activities.[70]
2016	SOA, COMRA, CRIMM, CSSC	Inaugural meeting of the "General Coordination Group" for the "National Key R&D Program Deep-Sea Polymetallic Nodule Mining Test Engineering Project" held in Changsha.[71]
2017	CRIMM	China Minmetals secures China's first non-COMRA ISA exploration contract in CCZ.
2018	CRIMM	China Minmetals formally establishes the "International Joint Research Center for Seafloor Mineral Resource Development" to facilitate ISA-related development projects.[72] In 2020, CRIMM states their goal is to use the center to support industrial mining within 5-10 years.[73]
2018	State Council	The State Oceanic Administration is dissolved, and its responsibilities are absorbed into the newly created Ministry of Natural Resources (MNR).[74] MNR is now responsible for natural resource ownership, evaluation, protection, and extraction, including deep-sea resources.
2019	Beijing Pioneer	Secures polymetallic exploration contract in the Western Pacific, only the second polymetallic nodule exploration contract outside the CCZ.
2021	COMRA	Begins drafting "Technical Guidelines for Deep-Sea Mineral Resource Extraction Systems" with the support of CRIMM, Beijing Pioneer, and Shanghai Jiao Tong University.[75]
2024	State Council	Ministry of Industry and Information Technology leads seven other agencies in formally promoting deep-sea development.[76]
2025	State Council	Annual "Government Work Report" lists "deep-sea technology" as a priority area for development.[77]

[68] Feng Ni and Yang Jianmin, "Development of Equipment Technology for Exploitation of Marine Mineral Resources," *Pacific Journal* Vol. 32, No. 8, page 73, http://www.pacificjournal.com.cn/CN/abstract/abstract367.shtml.
[69] "国际海底管理局秘书处照会各成员国邀请提供关于"区域"内活动的国内立法、规章和行政措施的文本," COMRA, October 13, 2013, http://www.comra.org/2013-10/16/content_6378722.htm; and "2014 年深海海底区域资源勘探开发法立法工作进展," COMRA, July 21, 2015, http://www.comra.org/2015-07/21/content_8089371.htm.
[70] "中华人民共和国深海海底区域资源勘探开发法," Government of the People's Republic of China, February 26, 2016, https://www.gov.cn/zhengce/2016-02/27/content_5046853.htm.
[71] "十三五"国家重点研发计划深海多金属结核采矿试验工程项目总体组及总师组成立大会在湖南省长沙市召开," COMRA, December 9, 2016, http://www.comra.org/2016-12/09/content_9212257.htm.
[72] "中国五矿成立海底矿产资源开发国际联合研究中心," China Minmetals, April 9, 2018, http://www.sasac.gov.cn/n2588025/n2588124/c8836208/content.html.
[73] "打造国际合作新平台 抢占科技战略制高点," CRIMM, January 16, 2020, http://www.crimm.com.cn/kjcx/kjdt/202303/t20230316_298694.html.
[74] "自然资源部职能配置、内设机构和人员编制规定," Government of the People's Republic of China, September 11, 2018, https://www.gov.cn/zhengce/2018-09/11/content_5320987.htm.
[75] "2021 年度自然资源标准制修订工作计划," Ministry of Natural Resources, October 2021, https://www.gov.cn/zhengce/zhengceku/2021-10/28/5647312/files/1d89127db18e43fb9cc6074f9e7423a6.doc.
[76] "工业和信息化部等七部门关于推动未来产业创新发展的实施意见," Ministry of Industry and Information Technology, January 29, 2024, https://www.mct.gov.cn/preview/whhlyqyzcxxfw/zhgl/202402/t20240204_951177.html.
[77] Li Qiang, "政府工作报告," *Xinhua*, March 12, 2025, https://www.gov.cn/yaowen/liebiao/202503/content_7013163.htm.

Appendix C: Timeline of Major Tests (before June 2025)

Year	Leading Organization	Water Depth (m)	Test Content	Remarks
2001	COMRA (CRIMM)	135	Prototype sea trial of polymetallic nodule mining vehicle (single unit)[78]	Prototype
2016	CRIMM	304	Prototype sea trial of polymetallic nodule conveying system (single unit)[79]	Prototype
2018	CRIMM	514	Prototype sea trial of polymetallic nodule mining vehicle (single unit)[80]	Prototype
2018	CRIMM	2,019	Sampling and testing equipment for cobalt-rich crusts (single unit)[81]	Prototype
2019	IDSSE	2,498	Prototype sea trial of track-type cobalt-rich crust mining vehicle (single unit)[82]	Prototype
2020	IDSSE	1,300	Prototype sea trial of track-type cobalt-rich crust mining vehicle (single unit)[83]	Prototype
2021	Dalian University of Technology	500	Simulation test of intelligent integrated system for polymetallic nodule transportation[84]	Prototype
2021	COMRA (CRIMM)	1,306	Full-system integration test at 1,000-meter depth[85]	Integrated Test
2021	China Minmetals (CRIMM)	5,000	Offshore tests of a polymetallic nodule continuous sampler[86]	Prototype
2021	Shanghai Jiao Tong University	1,305	"Kaituo-1" polymetallic nodule mining vehicle prototype sea trial[87]	Prototype
2021	CSSRC	—	Pool test of polymetallic sulfide mining vehicle[88]	Prototype
2022	Shanghai Jiao Tong University	5,600	Prototype test of free-floating in-situ polymetallic nodule collection technology[89]	Prototype
2024	Shanghai Jiao Tong University	4,102	Prototype sea trial of deep-sea mining vehicle[90]	Prototype

78 "我国首次 500 米海底多金属结核采集系统试验纪实," CRIMM, December 25, 2018, http://www.crimm.com.cn/xwzx/mtjj/202303/t20230317_299340.html.
79 "我国首次深海扬矿泵管系统海上试验圆满成功," CRIMM, June 27, 2016, http://www.crimm.com.cn/xwzx/qyxw/202303/t20230316_298847.html.
80 "Environmental Impact Statement Testing of Polymetallic Nodule Collector Vehicle," China Minmetals, page III.
81 "中国网："海洋六号"科考船执行中国大洋 51 航次科学考察任务," COMRA, June 28, 2018, http://www.comra.org/2018-06/28/content_40399809.htm.
82 "深海富钴结壳规模采样装置海上试验取得成功," IDSSE, May 16, 2019, http://www.idsse.cas.cn/yjjz2015/2019/201905/t20190516_5296551.html.
83 "我国科学家完成深海采矿车与载人潜水器的首次联合作业," Research Fleet of Chinese Academy of Sciences, October 4, 2020, http://www.coms.ac.cn/casfleet/cd_gzdt/202010/t20201013_607861.html.
84 "我国首套自主研制的深海采矿智能化混输装备系统圆满完成 500 米级海上试验," CRIMM, September 7, 2021, http://www.crimm.com.cn/xwzx/qyxw/202303/t20230317_299121.html.
85 "深海采矿 保护国家海洋矿产资源," China Minmetals, December 17, 2022, https://www.minmetals.com/kcxfz/zrsj/202212/t20221217_296934.html.
86 Ibid.
87 "上海交大深海重载作业采矿车"开拓一号"完成 1300 米深海试验," Academy of Ocean of China, August 13, 2021, https://aoc.ouc.edu.cn/2021/0814/c9828a344085/pagem.htm.
88 "七〇二所研发深海采矿关键设备取得阶段性进展," CSSRC, December 9, 2021, http://www.cssrc.com.cn/wnewsx/wdetail/1292.html.
89 "实验室自主研制"海龙Ⅴ-曼塔号"浮游式深海多金属结核原位集矿技术验证平台海试成功," State Key Laboratory of Ocean Engineering, December 18, 2022, https://oe.sjtu.edu.cn/msg.php?id=1207.
90 "我国深海重载作业采矿车海试水深首次突破 4000 米," *Xinhua*, July 9, 2024, http://finance.people.com.cn/n1/2024/0709/c1004-40274332.html.

Appendix D: Global Deep-Sea/Seabed Mining Patents Over Time (before June 2025)