Critical Minerals for the Energy Transition: Geopolitical Risks and International Efforts to curb China's Dominance

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Submission date: 29/03/2026 Acceptance date: 31/05/2026 Publication date: 10/06/2026

Abstract:

The modern technological revolution has driven a growing global demand for critical minerals, especially cobalt, lithium, copper and rare earths. These materials are essential inputs in industries related to electric vehicles, semiconductors and batteries. This interconnectedness has contributed to a profound shift in the global landscape, due to the high geographic concentration of minerals on the one hand, and the increased demand for them on the other. However, the dilemma lies in the escalating Chinese supremacy and its efforts to control supply chains by controlling the three main stages: extraction, processing, and marketing. This situation raised complex issues that go beyond the economic dimension to include strategic and geopolitical dimensions.

Accordingly, this study seeks to analyze the importance of minerals in the energy transition process, highlighting the risks of global dependence on China. We also review efforts to contain China's hegemony.

***Keywords*:** *China dominance, critical minerals, Energy Transition, Geopolitics.*

ملخص: دفعت الثورة التكنولوجية الحديثة إلى تنامي الطلب العالمي على المعادن الحرجة وفي مقدمتها الكوبالت، الليثيوم، النحاس والأتربة النادرة والتي تعتبر مدخلات أساسية في الصناعات المرتبطة بالمركبات الكهربائية، أشباه الموصلات، والبطاريات، وقد ساهم هذا الترابط في إحداث تحول عميق في المشهد العالمي، نظراً للتركيز الجغرافي العالي للمعادن من جهة وزيادة الطلب عليها من جهة أخرى. ومع ذلك تكمن المعضلة تكمن في الهيمنة الصينية المتصاعدة وسعيها للسيطرة على سلاسل التوريد من خلال التحكم في مراحل الاستخراج، المعالجة والتسويق، وقد أثار هذا الوضع قضايا معقدة تتجاوز البعد الاقتصادي لتشمل الأبعاد الإستراتيجية والجيوسياسية.

وبناء على ذلك، تسعى هذه الدراسة إلى تحليل أهمية المعادن في مسار الانتقال الطاقوي، مع ابراز مخاطر التبعية العالمية للصين، كما نستعرض الجهود الرامية لتطويق هيمنة الصين على سلاسل التورد.

الكلمات المفتاحية: الهيمنة الصينية، المعادن الحيوية، الانتقال الطاقوي، الجيوسياسية.

Introduction:

World leaders are placing increasing emphasis on achieving the Net Zero Emissions (NZE) target by 2050 as a means of addressing the profound consequences of climate change. Attaining this goal necessitates the adoption of clean technologies as an inevitable pathway for all nations, particularly in light of the proven efficiency of renewable energy projects in reducing the carbon footprint across three key sectors: transportation, industry, and urban development. Moreover, renewable energy demonstrates the capacity to meet energy demand during crises, positioning it as a sustainable and locally available alternative.

The shift away from fossil fuels in favour of expanding renewable energy deployment has unveiled a critical challenge linked to vital minerals. These minerals constitute essential inputs in the production of batteries, semiconductors, magnets, electric vehicles, and related technologies. The manufacturing of such technologies relies heavily on key resources such as lithium, cobalt, nickel, copper, graphite, and rare earth elements, the extraction of which is highly concentrated in a limited number of countries, most of them located in Africa and Latin America.

In recent decades, China has emerged as a pivotal actor in the markets for critical minerals and renewable energies, combining the possession of the largest reserves of rare earth element with the development of advanced industrial capacities in refining, processing, and recycling. Through its control over renewable energy markets, its strategy has focused on making them more affordable and more abundant –particularly solar panels- which has contributed to accelerating the energy transition. Moreover, China has pursued an avtive investment policy in the Global South, taking advantage of financing and technological gaps to reinforce its position as an indispensable supplier of raw materials. This expansion has granted it the ability to steer mineral flows beyond the economic dimension to encompass profound geopolitical implications, raising concerns among many industrialized countries that have come to realize their technological and military security is threatened as a result of excessive dependence on china.

How does China's dominance over critical minerals reshape global power dynamics, and what are the implications for the trajectory of the energy transition?

The study seeks to highlight the importance of critical minerals in the global energy transition and their geopolitical implications, while analyzing the risks of dependence on China. It also offers an overview of international efforts to curb Chinese dominance.

The Conceptual Framework of Critical Minerals

Critical minerals are identified based on the need for a specific element during a given time period, along with other criteria such as supply risks and environmental impacts. According to Geosciences Australia, they are defined as: "minerals and non- metals that are considered vital for the economic well-being of the world's major and emerging economies, yet whose supply may be at risk due to geological scarcity, geopolitical issues, trade policy or other factors". (Shuronjit Kumar Saker, 2022, p. 3) Meanwhile, the U.S Energy Policy Act of 2020 defines them as: "Any mineral, element, substance, or material designated as critical by the Secretary of the Interior, acting through the director of the USGS". (What are critical Minerals and Materials)

The term" Strategic minerals" was first used in the early nineteenth century, and was defined by the Colorado Geological survey (CGS) as:"commodities essential to national defence for which the supply during war is wholly, or in part, dependent upon sources outside the boundaries of the U.S". (Shuronjit Kumar Saker, 2022, p. 3)

strategy minerals are considered as such on the basis of:

- **their contribution to military technologies**: fighter jet guidance systems, submarines, radars, and nuclear power plants all rely on strategic minerals. Their value also depends on their applications in medical fields, and robotics manufacturing.

- **Supply challenge**: there are fewer than 20 companies worldwide engaged in the trade of strategic minerals, distributed as follows: five in Canada (Avalon Rare Metals, Great Western Minerals, Neo Material Technologies, Rare Element Resources VMS Ventures), four in China (Baotou Steel Rare Earth Hi-Tech, China Rare Earth Holdings, Jiangxi Copper, Aluminium Corporation of china), three in Australia (Alkane Resources, Arafura Resources, Lynas Corporation), tow in India (Indian Rare Earth, Kerala Minerals and Metals Limited), one in America (Molycorp), and one in Japan (Showa Denko). (Stefania Massari, 2013, p. 41)

- **Geographic concentration challenge**: the uneven geographic distribution of strategic minerals intensifies international competition over them. More than 70% of cobalt is extracted from the DR, while over half of global lithium production comes from Australia. Indonesia dominates nickel supplies, whereas China controls the production of rare earth elements. Consequently, the geographical concentration of these minerals can create vulnerabilities within global supply chains. (Brooke Escobar, 2025, p. 7)

"Rare earth elements "consist of a group of 17 elements,15 of which are classified in the periodic table under the lanthanides category, with the addition of yttrium and scandium. These metals have unusual fluorescent, conductive, and magnetic properties.

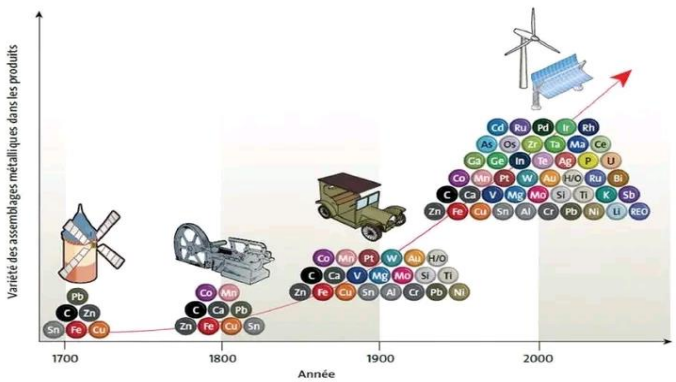
The Energy Transition Requirements for Critical Minerals and the Global Dependency Risks on China

Arab countries have most of the elements of renewable energy, especially solar and wind energy, which makes the region distinct from a global geoenergy standpoint. Below are presented main Arab region potentials regarding these resources

The Energy Transition Requirements for Critical Minerals

During the period from 1700 to 1800, humanity relied on wind power for energy generation, primarily through windmills. During this time, the use of metals was limited to a few, including Zinc, Lead, copper and iron. With the subsequent industrial renaissance, the introduction of new metals such as aluminium, lithium, magnesium, manganese, chromium, nickel, and tin become necessary to support the development of mechanical industries. From the early 2000s to the present, renewable energy technologies have emerged, requiring a broader range of metals. In addition to the previously mentioned metals, other highly important elements such as gold, silver, platinum, palladium, osmium, rhodium, ruthenium, and uranium have been added.

The Increasing intensity of metal utilization in the process of transitioning from conventional to renewable energy



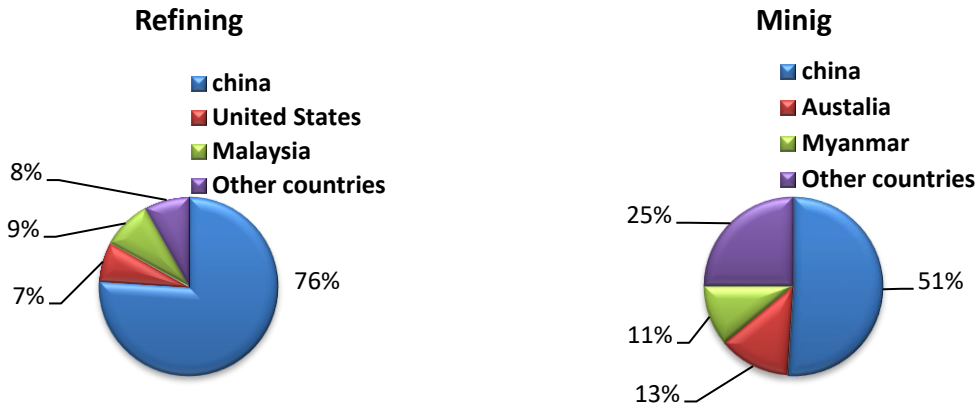
Source: https://www.researchgate.net/figure/Augmentation-de-la-complexite-des-assemblages-metalliques-dans-les-produits-generiques_fig1_316273571

With the accelerating pace of renewable energy deployment, demand is expected to increase for five key metals, namely:

- Lithium : Demand for lithium is expected to grow by 30% due to its use in the electric vehicle and battery sectors. China accounts for more than three-quarters of global demand, followed by Korea and Japan, owing to its manufacturing capacity. (IEA, 2025, p. 116)

- **Nickel**: it is used in over 300.000 products, including aerospace, marine construction, electronics and stainless steel production. It is extracted in around 40 countries; demand is expected to increase by more than 40% by 2040 under the STEPS scenario, and by over 50% under the APS and NZE scenarios. (IEA, 2025, p. 131)
- **Copper**: Global demand for copper is expected to reach approximately 33 million tons by 2035 and 37 million tons by 2050 according to the STEPS scenario, due to the expansion of urban development and electrical grid networks. The majority of demand comes from china, which alone accounts for 60% of refined copper demand in 2024. New competitors, such as India and Vietnam, are expected to emerge around 2040.
- **Cobalt**: it is primarily used in batteries and alloys due to its high resistance to corrosion and wear , demand for cobalt has increasingly risen following the recovery from the COVID-19 pandemic, and it is expected to increase by 50% under the APS scenario and by 55% under the NZE scenario.
- **Rare Earth Elements**: demand for them reached approximately 90 Kilotons in 2024, and the international Energy Agency expects demand to reach around 180 Kt due to the accelerated deployment of renewable energy. (IEA, 2025, pp. 144-172)

Figure 01: The three main producers of rare earth metals by 2030.



Source. Global Critical Minerals Outlook 2025, IEA, p163.

Chinese Dominance over Vital Minerals Supply Chains and Risks of Global Dependency on it.

Chinese steep dominance rise over critical mineral supply chains was not just a coincidence, but rather the result of decades of central government planning. In the 1970s and 1980s, Beijing realized that rare earth elements would be of strategic value. In 1990, the Chinese government declared rare earths and minerals as "protected and strategic minerals," barring foreign investors from extracting them. Under Deng Xiaoping rule, he foresaw the future when he stated in 1997 that "rare earths will become more important than Middle East oil and will give

China prestigious position". (Hamdani, 2023) Prior to 2003, participation with foreign investors required approval from the Ministry of Foreign Trade and Economic Cooperation. During this period, China relied on a combination of direct government support for the mining sector, encouraging national companies to invest in global supply chains and acquiring strategic assets abroad, particularly in Africa and Latin America. In the new millennium, China further consolidated its grip on the sector through merging state-owned enterprises, creating therefore giant entities that globally control the entire supply chain, from extraction and refining to processing and manufacturing. (Hart, 2025, p. 8)

The over dependence on China for mineral supplies is of great risks with multidimensional aspects which can be summarized as follows:

– **Environmental and societal risks**

The paradox of minerals lies in the fact that a large share of production takes place under poor and environmentally unsustainable conditions. China's rare earth mining and refining operations are generally highly polluting, producing toxic and radioactive waste that contaminates soil and water resources. This is obviously inconsistent with global carbon mitigation goals. Lithium extraction also requires large quantities of water, raising concerns in the arid regions of the "Lithium Triangle" in South America (Argentina, Bolivia, and Chile) (Brooke Escobar, 2025, p. 8)

The lack of transparency and labour protection standards in mining has led to increased abuses in resource-rich developing countries. Cobalt mining in the Democratic Republic of Congo has been linked to child labour, unsafe working conditions and the intensification of illegal trade which has led to civil conflicts. Accordingly, the Secretary -General of the U.N **Antonio Guterres** stated: "A world powered by renewable is a world hungry for critical minerals. For developing countries, critical minerals are a critical opportunity-to create jobs, diversify economies, and dramatically boost revenues. But only if they are managed properly, the race to net zero cannot trample over the poor. The renewable revolution is happening-but we must guide it towards justice". (United Nation, 2024, p. 21)

– **Economic Risks**

Price fluctuations caused by China's control over supply chain affect tremendously the stability of global industries. Companies in many countries, particularly Europe, Japan and United States, are facing difficulties in developing long-term planning due to uncertainty about price fluctuations and supplies confidence. Furthermore, strategic stockpile cannot be relied upon due to the sensitivity of these materials. (Hart, 2025, p. 21)

– **Strategic Risks**

China possesses strategic influence that extends beyond economics to stroke national security. Interrupting critical materials supply chains could expose defence industries to multidimensional risks. The European Commission (JRC) believes that strategic risk is measured at the "chokepoint" stage, i.e., when the supply of essential heavy metals is interrupted. However, some argue that mineral supply chains have become fragile due to growing disruptions that could threaten countries' national security.

– **Geopolitical Risks**

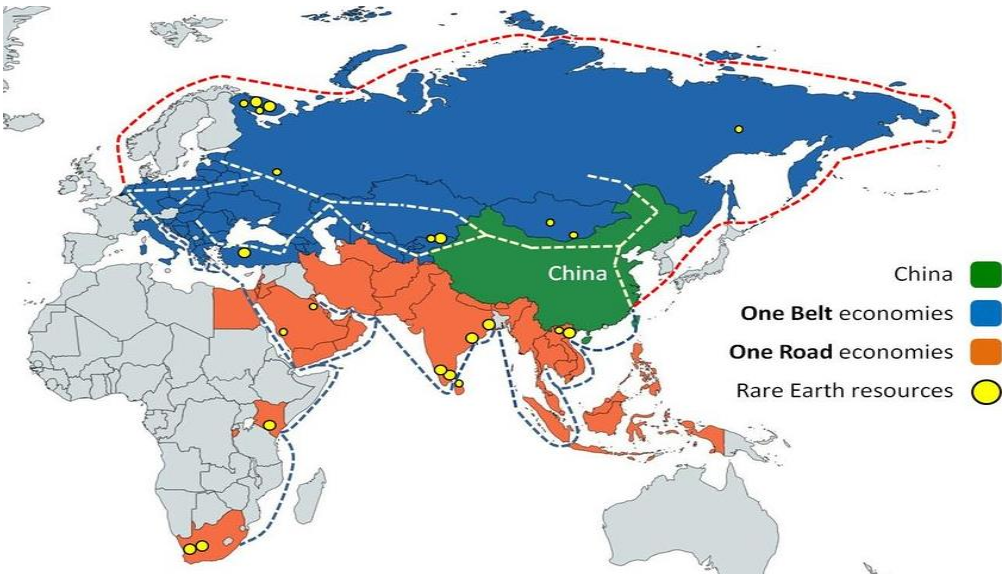
China might use rare earth elements as a geopolitical weapon. Any trade or political dispute could lead to export restrictions, creating therefore an immediate crisis in global industries, such as the 2010 dispute with Japan and the 2019 trade dispute with the United States, where Beijing threatened to cut off supplies.

International Race over rare earth control and Its Impact on the Global Energy Transition

The Chinese monopoly has been fuelling mineral export war since 1978, following the outbreak of conflict in the country's Katanga province, which led to a global cobalt shortage. China also imposed restrictions on rare earths for foreign investors in early 2008. (Manfred Hafner, 2020) In 2021, amid its trade war with the United States, China announced restrictions on the production and export of 17 rare earth elements, essential for the production of F-35 aircraft, electric vehicles, and windmills. This is not to mention its control of 64% of global polysilicon production, a key material for solar panels manufacturing. (Tagotra, 2022) Due to the growing Chinese monopoly, several complaints have been raised before the World Trade Organization, as well as some foreign investment disputes related to coordination regarding rare earths and the rush to deep-sea mining for these minerals. This situation is the beginning of the conflict over raw materials. (E.Vinuales, 2021)

The Chinese model, for foreign partnership known as "Infrastructure vs. Resources," is based on the Belt and Road Initiative (BRI), launched in 2013. The BRI has played a central role in creating new trade corridors. Through its mining giant, Xiamen Tungsten Corporation, China is seeking to acquire numerous mines in Africa in an attempt to expand its mineral exploitation in the Africa Copper Belt region and exploit critical minerals in Angola, Zimbabwe, the Democratic Republic of the Congo, and Rwanda, in addition to its strong presence in Indonesia, Laos, and Myanmar. This initiative is a strategic plan designed to build a network of ports, railways, and roads that will connect China to countries around the world.

Figure 02: Belt and Road Initiative (BRI) Map highlighting rich countries in minerals



Source : https://www.researchgate.net/figure/the-belt-and-road-initiative-roadmap-including-REEsources-found-in-countries-involved-fig1-326271770

The China Development Bank (CDB) and the Export-Import Bank of China (Exim Bank) have significantly contributed to long-term, low-interest loans for infrastructure and resource projects in many developing countries. Between 2000 and 2021, China made one financial commitment worth $9 million and 93 loan commitments worth $56.9 billion to support the extraction and processing of five minerals across 19 low- and middle-income countries in sub-Saharan Africa (SSA) and Latin America and the Caribbean (LAC). The Democratic Republic of Congo alone accounted for nearly half of the total loans, while Latin America and the Caribbean received 20%, with Venezuela and Ecuador being the largest beneficiaries. Asia accounted for the remaining share, with major projects in Indonesia and Laos. (Brooke Escobar, 2025) China's foreign policy is not based on repaying loans back in cash, but rather through guaranteed deliveries of essential commodities such as oil, copper, and cobalt to reduce financial repayment risk. To spoil Chinese ambitions, an American ambition has emerged to expand the exploitation of energy and mineral resources in Greenland, Canada, the Gulf of Panama and the Arctic to enhance American national security. Greenland alone contains 25 types of critical minerals. According to a report issued by the Danish Geological Survey, there are 6 million tons of natural resources of graphite and copper and 36.1 million tons of rare earths, making it second only to China in terms of reserves. Greenland is currently at the center of a major international contest, including American strategy.

The United States is not the lone competitor for critical minerals, it has agreed with India and Japan to develop a Free and Open Indo-Pacific Strategies. The Association of Southeast Asian Nations has also developed a Master Plan on ASEAN Connectivity 2025, while the European Union unveiled a Global Gateway strategy to counter Chinese ambitions.[2]

International efforts to counter Chinese dominance

The Overreliance on China for the supply of essential minerals, supposed the key to energy transition, has raised concerns about the reliability and resilience of supply chains, particularly as competition intensifies and Chinese monopoly policy persistence. This assumption assumes that the greater a country's control over the supply chain, the greater the risk of interruption and flow disruption. In light of this global rush towards a rapid transition to new and renewable alternative energies, the International Energy Agency expects that "The world will move from a fuel-intensive energy system to a mineral-intensive energy system." Thus, the present competition between major oil companies is being transformed into a competition between "big shovel" (Yergin, 2022, p. 13) mining companies. Given this situation, industrialized nations have made minerals a priority for protecting their national security.

To mitigate the risk of a potential supply disruption, several countries have already adopted strategies to protect their interests. For example, in 2017, the United States announced a Federal Strategy to ensure a secure and reliable supply chains. This strategy includes technological alternatives and opportunities to develop cooperation with its allies to support the exploration of new mineral resources. Also, India has joined this conflict, successfully establishing a joint venture known as KABIL (Khanij Bidesh India Limited) with several countries, including Australia, Argentina, Bolivia, and Chile, (Tagotra, 2022, p. 4) for mineral production. It has also worked to develop "free and open" Indo-Pacific strategies with Japan and the United States. Separately, the Association of Southeast Asian Nations developed the Master Plan on ASEAN Connectivity 2025, while the European Union unveiled its Global Gateway Strategy to counter Chinese ambitions.

Multilateral cooperation on critical minerals has been a positive step in reducing mineral supply chains disruption concerns. In June 2022, the United States announced the establishment of the Minerals Security Partnership (MSP), described as a "**metal NATO**." This alliance includes Australia, Canada, Finland, France, Germany, Japan, the Republic of Korea, Sweden, the United Kingdom, the United States, and the European Commission.

Cooperation between industrialized and mineral-rich developing countries contributes significantly to create poles of competition with Chinese strategies. This involves offshore relocation or transfer of smelting and refining capabilities to allies' countries in the purpose of preventing strategic competitors from

exploiting their market advantage in metals and reducing the risk of harming the US and its allies economies. The European Commission also considers substitution (SIES) and recycling to be measures that reduce supply risks represented by offshore relocation or the transfer of smelting and refining capabilities to friendly countries. (Rodrigo. C. P, 2022, p. 12) This strategy aims to prevent strategic adversaries from exploiting their market advantage in minerals and reduce the risk of harm to the economies of the United States and its allies. The European Commission also considers substitution (SIES) and recycling to be excellent measures that reduce supply risks.

Conclusion

In conclusion, none can deny that the global economy has benefited in recent years from China's role in mineral processing and clean energy production. China has deployed these technologies at reasonable prices and supported several programs to develop renewable energy projects in most parts of the world. However, monopoly, control, and exploitation remain hallmarks of Chinese strategy, manifested by its dominance over supply chains and production area. Therefore, the consequence of a global mineral shortage will be different from those resulting from oil supplies shortages; There will be no direct impact on consumers, but it is going to be of economic and geopolitical dimensions, depicted by projects slowdown and industries shut down because of strategic mineral reserves shortages, along with the emergence of new alliances working to secure alternative sources.

The success of the energy transition depends on a safe and fair management of supply chains, in which everyone is subject to international law rules that regulate supply and demand. To reduce the risk of continued Chinese hegemony, we recommend the following:

- Promoting investment in mineral-rich regions, while developing Deep-sea mineral exploration
- Establishing a global database by mapping critical minerals and assessing their reserves;
- Establishing new storage methods for strategic minerals to avoid supply chains disruption;
- Promoting research and innovation to develop alternative materials against critical minerals, such as neodymium-free magnets;
- Enacting legislation to regulate mineral market and fight illicit trade;
- Develop new economical recycling technologies to reduce the need for direct extraction;

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