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Strategic Adjustment of Key Mineral Resources in European Countries and America and China's Response

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Abstract: This paper focuses on the background of global climate and geopolitical changes, delving into the strategic adjustments made by European countries and America regarding key mineral resources. It systematically reviews their strategies in formulating lists of critical minerals, policy evolution, and international cooperation. Through comparative analysis, it reveals the challenges and opportunities that these adjustments pose to China's security of key mineral resources. The paper also proposes Chinese response strategies from dimensions such as improving evaluation management systems, enriching management toolkits, and enhancing international cooperation, aiming to provide theoretical foundations and policy references for enhancing China's supply assurance capabilities for key mineral resources and promoting international cooperation.

Keywords: European countries and America ; key mineral resources; strategic adjustment; China's response; supply security

1.Introduction

Driven by global climate goals and the compounding of geopolitical situations, the importance of critical mineral resources as a key support for global economic recovery, strategic emerging industries development, and low-carbon transition has become increasingly prominent. Key Mineral Resources refer to mineral resources that have strategic significance for national economic development, industrial security, and defense construction, and are subject to supply risks or highly dependent on imports. "Critical minerals" and "Key Mineral Resources" place more emphasis on definition from the perspectives of economic importance and supply risks, while "strategic minerals" not only incorporate economic and security factors but also emphasize a country's strategic control capabilities over mineral resources and the important supporting role of mineral resources in different industries. There is some overlap and intersection in the concepts of the three, and with the changes in time, national development strategies, and the global resource situation, the specific types of minerals they refer to may also vary. In recent years, competition over critical mineral resources among major global economies has intensified, with European countries and America taking the lead in strategic adjustments to ensure their own resource supply security and industrial competitiveness [1]. As a leader in global climate governance, the EU, and as an important participant in low-carbon technology, China's in-depth study of the strategic adjustments of European countries and America regarding critical mineral resources and its response strategies is of significant practical importance for improving China's policy system on critical mineral resources, maintaining resource security, and promoting win-win cooperation between China and Europe in the context of low-carbon transition [2].

2. Strategic adjustment measures of key mineral resources in European countries and America

(1) Dynamic update and improvement of the list of key minerals

European countries and America attach great importance to the formulation and updating of key mineral inventories, regarding them as crucial references for resource management and policy-making. As early as 1952, the United States proposed the concept of resource constraints in the Palis Report (Paley Report) [3] , and subsequently deepened research and definition of key minerals. In 2008, the National Research Council of the United States conducted the first systematic study on critical non-fuel minerals, proposing a two-dimensional "Criticality Matrix" model to assess the criticality of 11 minerals from the perspectives of supply risk and supply constraints[4]**.** GRAEDEL et al. from Yale University developed a three-dimensional comprehensive assessment method based on supply risk, vulnerability to supply constraints, and environmental impact, applying it to the quantitative analysis of critical metals and metalloids[5]. The European Union introduced the Critical Raw Materials Initiative in 2008, defining "critical raw materials" as those with high risk of supply shortages over the next decade and who are essential to value chains. The first version of the Critical Raw Materials List was released in 2011, updated every three years thereafter. By 2023, the fifth edition had expanded to include 34 key raw materials, such as rare earths, lithium, cobalt, and nickel, and designated 17 of these materials, whose demand is expected to grow exponentially, production is complex, and supply risks are higher, as strategic raw materials. In 2024, the EU passed the Critical Raw Materials Regulation (CRMA),which intended to reduce dependence on key mineral imports and ensure green transformation and national defense security, increasing the number of key minerals from 14 to 34, covering over 95% of conflict minerals. Promoting the "de-Chinese" of the supply chain requires member states to reduce their dependence on China's rare earth, lithium, graphite and other minerals, and establish a localized new energy industry chain. The dynamic update of these lists reflects the deepening understanding of key mineral resources by European countries and America , as well as their positive response to changes in the global resource competition pattern.

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(2) Policy evolution path and goal orientation

The key mineral resource policies of European countries and America have evolved continuously with the time. During the Cold War, these policies were primarily focused on resource control; after entering the market economy driven by globalization, they gradually shifted towards ensuring resource supply security and industrial development. In recent years, influenced by factors such as climate change and geopolitical conflicts, policies have further evolved to enhance supply chain resilience and reduce external dependence. The United States has established international alliances for critical minerals with multiple countries, such as the 2019 Joint Action Plan for Critical Minerals with Canada and Australia, and launched initiatives like the "Mineral Security Partnership" and the "Sustainable Critical Raw Materials Alliance" in 2022, aiming to build a supply chain system that excludes China to strengthen control over critical minerals and ensure a stable supply of resources needed for the clean energy transition[6].The European Union, through policies such as the "European Green Deal" and the "Critical Raw Materials Act," promotes the safety and sustainable development of industrial chains, intensifies research and development of alternative materials and resource recycling, and enhances supply chain resilience and international influence by signing bilateral agreements with resource-rich countries and forming international alliances for critical minerals. For example, the EU strengthens its internal market through the "European Raw Materials Alliance," promotes the establishment of a "Critical Raw Materials Club," and actively participates in multilateral international alliances led by the United States and the West, thereby enhancing its voice in global resource governance.

In addition, there has been a focus on technology leadership and secondary resource development. In terms of technology research and development, Europe and America have increased their investment in deep-sea mining, space resource exploitation, and "urban mine" recycling. For example, the United States has restarted domestic rare earth mining and developed rare earth recycling technology to reduce dependence on China. Regarding environmental and trade barriers, the EU restricts imports of high-carbon footprint mineral products through carbon border adjustment mechanisms (CBAM) and stringent environmental standards, indirectly squeezing China's mineral export space.Simultaneously, the United States has implemented a series of policies to strengthen its domestic mining industry and recycling capabilities, aiming to reduce imports of mineral resources from foreign countries, including China. These measures not only pose challenges to China's mineral export market but also highlight the urgent need for China to strengthen its own resource security and technological innovation capabilities. In response to these external pressures and challenges, China has formulated a comprehensive response strategy.

(3) International cooperation and alliance system construction

European countries and America actively build international cooperation and alliance systems to enhance their influence and control in the critical mineral resources sector. The United States leads the establishment of several international alliances for key raw materials, aiming to weaken China's core position in the global strategic mineral supply chain through groupification and bloc formation. These alliances introduce high-standard environmental, social, and governance (ESG) rules to create environmental barriers, restricting the expansion of China's supply chains. The EU, on the other hand, establishes stable multilateral partnerships with resource-exporting countries such as Australia, Canada, and South Africa through free trade agreements and supply contracts, and strengthens investment in developing countries 'clean energy transitions via initiatives like the "Global Gateway Plan" . At the same time, the EU actively participates in multilateral international coalitions led by the West, promoting the formulation of international rules in the critical mineral resources sector and enhancing its voice in global resource governance. Through domestic legislation (such as the Conflict Minerals Act), the EU intervenes in global supply chains, requiring multinational corporations to disclose their mineral sources, thereby reducing China's resource influence in Africa, South America, and other regions. Europe and America lead the development of technical standards for AI ethics and digital sovereignty, excluding Chinese technological approaches, such as limiting Huawei's participation in European 5G construction. Furthermore, they promote their own values and norms through international organizations and multilateral mechanisms, aiming to shape the global digital governance framework in line with their interests. By excluding Chinese technological approaches, they seek to maintain their technological and strategic advantages, posing challenges to China's digital development and international cooperation.This exclusionary approach not only reflects their deep-seated concerns about China's technological rise but also highlights their desire to maintain a dominant position in the global digital landscape. By doing so, they aim to consolidate their influence and control over key technological areas, thereby shaping the future trajectory of digital development to align with their strategic interests.

3. The impact of strategic adjustment in European countries and America on China

(1) Resource supply security is facing challenges

Strategic adjustments in European countries and America have intensified competition and fragmentation in the global supply chain of key mineral resources. China has a high degree of dependence on foreign sources for some critical minerals, such as cobalt, which is almost entirely dependent on Congo (Kinshasa), with imports accounting for as much as 98%[7]. European countries and America are attempting to reduce their reliance on Chinese key minerals and restrict China's development in the global supply chain of these minerals through means like forming international alliances and implementing trade protectionism. This has led to challenges such as a single-source supply for China's key mineral resources and increased geopolitical risks, threatening the stability of supplies for some critical minerals. For example, multiple international alliances established by Western countries to exclude China have impacted the mining and processing of key minerals like lithium, cobalt, nickel, graphite, and rare earth elements, increasing the difficulty for China to obtain these critical mineral resources.

To address these issues, China has been actively exploring and developing alternative sources of supply, as well as strengthening cooperation with other countries to ensure the stability of mineral resource supplies. Additionally, China has been investing in research and development to find substitutes for critical minerals, in order to reduce its dependence on specific resources. These efforts aim to enhance China's energy security and promote sustainable development in the long run. By diversifying its energy mix and strengthening international cooperation, China hopes to mitigate the risks associated with energy supply disruptions and price fluctuations. Furthermore, the pursuit of sustainable development aligns with China's broader goals of environmental protection and economic growth, ensuring a balanced approach to meeting its energy needs while protecting the planet for future generations.

(2) Increased pressure on industrial development and technological innovation

European countries and America are increasing their R&D investment in key mineral resources, promoting technological innovation, aiming to gain a technological high ground in the development, processing, and application of these mineral. China still has certain gaps compared to European countries and America in some key mineral technology areas, which may constrain the development of related industries in China. For example, the EU emphasizes that policies on critical raw materials serve carbon neutrality and green economy goals in clean energy sectors such as solar photovoltaics, focusing on resource efficiency, alternative material innovations, and environmental footprints throughout the entire lifecycle[8]. By setting stringent technical standards and regulations, European countries and America raise market entry barriers, making it more difficult for Chinese products to export, thereby adversely affecting the international competitiveness of Chinese industries[9]. China leads in technologies such as rare earth smelting and separation, and high-purity nickel purification, but still relies on imports for high-end applications (such as chips and permanent magnet materials). The U.S. restrictions on semiconductor manufacturing equipment exports to China directly impact China's demand for key minerals in the fields of new energy and information technology.

This has led to a shortage of critical components in China, which relies heavily on these imports for the development of its high-tech industries. Moreover, such restrictions exacerbate the challenges faced by Chinese industries in achieving technological self-sufficiency and independence. The dependency on foreign technology and materials poses a significant risk to China's long-term economic and technological development plans.In order to mitigate these risks, China is actively seeking alternative sources for these critical minerals and components, as well as investing heavily in research and development to foster domestic technological innovation. However, the path to achieving full technological self-sufficiency is fraught with challenges, and it will take time and consistent effort for China to overcome these obstacles and establish a robust domestic supply chain.Meanwhile, the international community should also recognize the importance of fair trade and cooperation in promoting technological progress and economic development, and work together to create a more open and inclusive global technological ecosystem.

(3) International cooperation and reshaping of the competitive landscape

The strategic adjustments of European countries and America have reshaped the international cooperation and competition landscape in key global mineral resources. China faces a more complex environment in international cooperation on key mineral resources. On one hand, the international alliance system dominated by European countries and America is squeezing China's space for international cooperation; on the other hand, it also prompts China to actively seek new opportunities for international cooperation. For example, cooperation between China and countries along the "Belt and Road Initiative" in the field of key mineral resources has deepened, but it also faces competition and interference from European countries and America in the region. Moreover, European countries and America are promoting the formulation of international rules, attempting to integrate their values and interests into the international governance system for key mineral resources, which poses a challenge to China's voice and influence in this area.

To address this challenge, China needs to strengthen its own research and development in the field of key mineral resources, enhance its technological innovation capabilities, and actively participate in the formulation of international rules. By promoting cooperation and exchanges with other countries, China can enhance its voice and influence in the international governance system for key mineral resources, and safeguard its own interests. At the same time, China should also strengthen its cooperation with developing countries, jointly resist the hegemony of developed countries, and promote the establishment of a more equitable and reasonable international order.This cooperation can encompass technology transfer, capacity building, and joint exploration and development of mineral resources. By working together, China and developing countries can enhance their bargaining power in the international arena, and push for a more balanced distribution of resources and benefits. Additionally, China can share its experiences and expertise in sustainable development, contributing to the overall progress and prosperity of the global community.

4.China's response strategy to the strategic adjustment in European countries and America

(1) Improve the evaluation and management system of strategic mineral resources

Firstly,optimize Demand Forecasting and Supply Risk Assessment.From a dynamic, systematic, and comprehensive perspective, further improve the system for demand forecasting and supply risk assessment of strategic minerals under climate and geopolitical contexts. In line with China's economic development, industrial upgrading, and low-carbon transition needs, use scientific methods and models to accurately predict the demand trends of key mineral resources. At the same time, strengthen the analysis of global key mineral resource supply patterns, geopolitical risks, and other factors, establish a comprehensive and dynamic supply risk assessment mechanism, and promptly identify potential supply risks.This assessment mechanism should take into account various factors such as the distribution of mineral resources, production capacity, trade policies, and transportation routes, ensuring that we have a clear understanding of the global supply situation of key mineral resources. Additionally, by closely monitoring geopolitical dynamics and potential

conflicts, we can anticipate and respond to potential disruptions in the supply chain, thus safeguarding national economic security and sustainable development.

Secondly,constructing the Resource Material Flow Database.Drawing on the resource material flow accounts of Eurostat and USGS, construct the database for China's strategic mineral resources. By analyzing the entire lifecycle material flow of key mineral resources from extraction, processing, consumption to recycling and reuse, we aim to understand the movement patterns and utilization efficiency of these resources. Utilizing big data and IoT technologies, real-time monitoring and dynamic updates of resource material flow data will be achieved, providing accurate data support for resource management decisions.By integrating advanced analytics and machine learning algorithms, we can derive insights and trends from the vast amounts of data, enabling predictive management and optimization of strategic mineral resource allocation. This holistic approach ensures that China's strategic mineral resources are managed efficiently, sustainably, and in line with national development goals.

Thirdly,establish a Data Set for the Mineral Resource Industry Chain and Supply Chain.From a full lifecycle perspective, develop a multi-process, multi-scale strategic data set for the mineral resource industry chain and supply chain. Integrate information from all links in the industry chain, including data on resource exploration, extraction, processing, trade, and consumption, as well as logistics, capital flow, and information flow within the supply chain. By analyzing the data set of the industry chain and supply chain, optimize the layout of the industry chain, enhance supply chain resilience, and ensure the stable supply of key mineral resources .Furthermore, the strategic data set can facilitate risk assessment and mitigation strategies, addressing potential disruptions in the supply chain.By leveraging advanced analytics and predictive modeling, insights gained from this comprehensive data set can guide policy-making, investment decisions, and operational adjustments, ultimately fostering sustainability and competitiveness within the mineral resource sector.

Fourthly,promote Policy Integration and Synergistic Development.Drive the deep integration of strategic mineral policies with global climate change response, national security strategies, new quality productivity layouts, and policies for the development of strategic emerging industries. Form an effective combination and synergy of top-down macro-level design leadership, bottom-up meso-level industrial layout promotion, and micro-level corporate behavior and technological innovation. For example, aligning the security of key mineral resources with the development of strategic emerging industries such as new energy vehicles and advanced manufacturing to promote coordinated industrial development and enhance the utilization efficiency and security capabilities of key mineral resources.Furthermore, it is crucial to strengthen international cooperation in the field of mineral resources, promoting mutual benefit and win-win results through joint exploration, development, and utilization. By sharing technological advancements and best practices, countries can collectively address the challenges posed by the scarcity and uneven distribution of key mineral resources, ensuring sustainable supply chains and fostering global economic prosperity.

(2) Enrich China's strategic mineral resources management toolbox

Firstly,building an Industry Alliance. Establish a strategic mineral industry alliance that covers the entire industrial chain from upstream exploration, midstream processing to downstream application. Through this alliance, integrate resources, technology, market, and policy advantages across all links of the industrial chain, promoting collaborative innovation and cooperation between upstream and downstream enterprises. Improve strategic reserves and risk management, establish dynamic reserve mechanisms for rare earths, lithium, cobalt, and other minerals to stabilize price fluctuations and prevent supply chain disruptions. Strengthen ties between academia, industry, research, and application, promote the transformation and application of R&D outcomes, and enhance overall industry competitiveness. For example, in key mineral sectors such as rare earths, lithium, and cobalt, form an industry alliance to jointly conduct resource exploration, R&D, and market expansion, thereby elevating China's position in the global key mineral industry chain. Promote consolidation among domestic mineral companies, nurture "chain leader" enterprises, and strengthen control over the global supply chain.

Secondly,establish an Innovation Center. Set up a national strategic mineral resources innovation center, focusing on technological breakthroughs in intelligent mining, green processing, material substitution, and recycling, as well as the formulation of international standards. Increase financial investment and policy support for the innovation center to attract outstanding scientific research talents and enterprises from home and abroad. Through the construction of the innovation center, promote technological innovation in key mineral resource areas, improve resource development and utilization efficiency, reduce production costs, and enhance China's technical influence in key mineral resource fields.Furthermore, the establishment of this innovation center will facilitate international cooperation and exchanges, enabling China to participate more actively in global mineral resource governance and standard-setting processes. By leveraging advanced technologies and international best practices, we aim to achieve sustainable development in the mineral resource sector, contributing to both domestic economic growth and global environmental protection efforts.

Thirdly,establishing Innovation Consortia.Form"government-industry-academia-research-application" innovation consortia to integrate R&D resources from government, universities, research institutions, and enterprises. Focus on technical challenges and bottlenecks in key mineral resource areas for joint efforts. Enhance communication and collaboration among consortium members, establish effective profit-sharing mechanisms, and improve innovation efficiency and technology transfer rates. For example, in lithium battery materials and rare earth functional materials, form "government-industry-academia-research-application" innovation consortia to jointly advance material substitution technology research, reducing dependence on foreign key mineral resources. Strengthen core technology innovation and tackle "chokepoint" technologies. Concentrate resources to break through key technologies such as chip materials, permanent magnet motors, and high-purity metal purification, promoting the extension of advantageous minerals like rare

earths and tungsten into higher-value industrial chains. Upgrade green technologies, develop low-carbon smelting processes to reduce energy consumption and pollution, and address the EU carbon border tax challenge.

Fourthly,establish a Resource Innovation Fund.Set up the "Resource Innovation Fund" to encourage joint establishment of resource development funds by the government and social capital, sharing the pressure of research investment. Develop reasonable fund management methods and investment policies to guide investments in key mineral exploration and development, technological innovation, and recycling. Through the support of the Resource Innovation Fund, accelerate the commercialization of research outcomes and promote the sustainable development of the key mineral resources industry.Furthermore, the Resource Innovation Fund aims to foster collaboration between academia, industry, and government, facilitating knowledge transfer and technology commercialization. By catalyzing innovation and entrepreneurship in the field, the fund will help build a resilient and sustainable mineral resources industry, capable of adapting to global challenges and seizing new opportunities for growth.

(3) Building a global community of shared future for strategic mineral resources

Firstly,establish an International Cooperation Alliance.Unite resource-rich countries, technologically advanced nations, and resource-demanding countries to form a global strategic mineral cooperation alliance that covers exploration, processing, research and development, and application. Through this cooperative alliance, achieve complementary advantages in resources, technology, and markets, forming a collaborative mechanism for shared benefits. Optimize the global resource layout, strengthen cooperation with resource countries such as Kazakhstan (uranium), Congo (cobalt), and Indonesia (nickel), and secure long-term supply through investment for equity. Diversify import channels, expand new sources like lithium from Argentina and niobium from Brazil, reducing dependence on single countries. Enhance cooperation with countries along the "Belt and Road Initiative" and BRICS nations in key mineral resource sectors, jointly conducting projects such as resource exploration and development, infrastructure construction, and technical exchanges. For example, strengthen cooperation with countries in resource-rich regions like Africa and South America to jointly develop key mineral resources, promoting local economic development while ensuring a stable supply of critical minerals for China.

Secondly,establish an International Innovation Center. Set up an international strategic mineral resources innovation center to conduct joint technological research and development across borders, promoting the formulation of global technical standards. Attract top international research institutions and enterprises to participate in the construction of the innovation center, enhancing international scientific and technological cooperation and exchange. Through the platform of the international innovation center, share technological achievements and experiences in key mineral resource areas, jointly addressing global resource challenges. For example, in areas such as new energy vehicle battery materials and rare earth permanent magnet materials, collaborate with international peers on joint research and development, jointly establish international technical standards, and enhance China's influence in the global technology sector of key mineral resources.

Thirdly,initiative to Establish a Global Resource Innovation Fund. The initiative aims to set up a "Global Resource Innovation Fund" involving multiple governments, international organizations, enterprises, and social capital. This fund is designed to provide technical support and financial guarantees for resource-poor countries, promoting the sustainable development and utilization of key mineral resources globally. Through the operation of the Global Resource Innovation Fund, it seeks to enhance international cooperation and exchange in resource matters, narrow the development gap in key mineral resources among different countries, and achieve fair distribution and sharing of global resources.

Fourthly,promote the establishment of a cooperative governance framework. Actively participate in global governance and promote the creation of a "Global Strategic Mineral Resources Cooperative Governance Framework" under the framework of international organizations such as the United Nations. This governance framework should emphasize transparent management and fair distribution of mineral resources, reducing risks of international competition and resource monopolies. By establishing a global strategic mineral resources cooperative governance framework, it can standardize the market order of international key mineral resources and promote cooperation and mutual benefits among countries in the field of key mineral resources. For example, formulate international trade rules for key mineral resources, environmental protection standards for resource development, etc., strengthen supervision over the global market for key mineral resources, and ensure the stability and security of the global supply chain for key mineral resources. Collaborate with BRICS countries and the Shanghai Cooperation Organization to promote fair trade rules and resist the "long-arm jurisdiction" and unilateral sanctions from Europe and America. Highlight the shared interests between China and Europe in new energy and energy storage, downplay ideological differences, for instance, jointly invest in clean energy projects in Africa.

V. Conclusion

In the context of global climate change and shifts in geopolitical dynamics, European countries and America have made strategic adjustments to their key mineral resources, profoundly impacting China's security of critical minerals, industrial development, and international cooperation. The strategic adjustments by these countries focus on "safety" and "de-risking," aiming to weaken China's advantages through technological alliances, supply chain restructuring, and rule barriers. China must respond with a combination of "technological autonomy + resource diversification + rule competition". In the short term, countermeasures should be taken to curb external pressure; In the long term, innovation-driven growth and global collaboration are needed to reshape the dominance of the industrial chain. At the same time, balancing resource exploitation with sustainable development is essential, transforming resource advantages into industrial competitive edges to provide solid support for achieving the "dual carbon" goals and high-quality development.

The essence of the strategic adjustment in European and American mineral resources is the phased substitution of "geopolitical security" for "market efficiency" during the period of globalization's retreat. Its core characteristics include the "de-Chinese" restructuring of supply chains and the "value-oriented" transformation of rule systems. This adjustment poses systemic risks to China's mineral industry, manifesting not only in short-term export disruptions and investment restrictions but also in long-term technological lock-in and rule exclusion. China must fully recognize the challenges and opportunities it faces, and enhance its supply security capabilities for key mineral resources through strategies such as improving the assessment and management system for strategic mineral resources, enriching management tools, and building a global community of shared destiny for strategic mineral resources. At the same time, China should actively strengthen exchanges and cooperation with European countries and America as well as other nations in the field of critical mineral resources, promoting the establishment of a fair, reasonable, and mutually beneficial global governance system for critical mineral resources to achieve sustainable development and utilization. Future research can further focus on the following directions: first, quantitatively assessing the specific impacts of European and American policies on Chinese mining companies (such as changes in market share and cost transmission mechanisms); second, analyzing the strategic choices of emerging market countries (such as Indonesia and Chile) in the mineral trade game between China, Europe, and America; third, exploring the potential application of digital currencies in mineral trade settlements. In-depth research on these issues will provide more precise policy tools for China to seize opportunities amid global resource governance changes.

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