Global Dynamics and Reflections on Critical Minerals

Yina Su [1, 2], Dewen Hu [1, 2, *]

[1] Chinese Academy of Natural Resources Economics, Beijing, China
[2] Key Laboratory of Carrying Capacity Assessment for Resource and Environment, Ministry of Natural Resources, Beijing, China

Abstract. Critical minerals refer to minerals that have an important strategic position in high-tech application and economic development such as national defense, military industry and emerging industry, but their resource security is at risk. In the context of a new round of technological revolution and industrial transformation, critical minerals have become the focus in the world competition. The United States, the European Union, Japan, Canada, Australia and China have released the lists of critical minerals respectively. Their lists have a high degree of coincidence. In terms of the demand and governance situation, the distribution areas of critical minerals are highly concentrated but their demand shows structural differentiation. Moreover, developed countries have great power but China has weak power in the global governance of critical minerals. In terms of improving the global governance capability, China needs to create the evaluation system for sustainable development of critical minerals, strengthen international cooperation, promote the reform of governance and enhance China's voice in the word. Moreover, China should carry out the strategy of critical minerals reserves.

1. Major economies in the world have released the lists of critical minerals

Judging by economic situation, the global economic arrangement is more diversified and continue to show a trend of differentiation and quantitative change. Judging by mineral resources, the international competition for critical minerals has become fierce, being important factors in affecting international relations and geopolitics. Major economies in the world such as the United States, the European Union, Japan, Canada, Australia and China have attached great importance to the protection of mineral resources, released the lists of critical minerals and formulated corresponding support measures.

1.1 Major economies confirmed criticl minerals from strategic development priorities

In 2017, the former president of USA issued executive order 13817, A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals. This executive order called on agencies across the federal government to develop a strategy to reduce the nation's susceptibility to critical minerals supply disruptions. In 2018, the Department of the Interior confirmed the final list of 35 critical minerals including aluminum (bauxite), antimony, arsenic, barite, beryllium, bismuth, cesium, chromium, cobalt, fluorspar, gallium, germanium, graphite (natural), hafnium, helium, indium, lithium, magnesium, manganese, niobium, platinum group metals, potash, the rare earth elements group, rhenium, rubidium, scandium, strontium, tantalum, tellurium, tin, titanium, tungsten, uranium, vanadium and zirconium [1]. This list isn't permanent. It will be dynamic and updated periodically to reflect current data on supply, demand and concentration of production.

In 2018, European Commission launched the European Raw Materials Initiative (RMI). It is integrated strategy that establishes targeted measures to secure and improve access to raw materials. One of the priority actions of RMI was to establish a list of critical raw materials at EU level. EU has had a list since 2011, which has revised every three years based on supply risk and economic importance. The 2020 EU list contains 30 materials such as antimony, baryte, bauxite, beryllium, bismuth, borates, cobalt, coking coal, fluorspar, gallium, germanium, hafnium, HREEs, indium, lithium, LREEs, magnesium, natural graphite, natural rubber, niobium, PGMs, phosphate rock, phosphorus, scandium, silicon metal, tantalum, titanium, vanadium, tungsten and strontium [2].

In 2018, Japanese Ministry of Economy, Trade and Industry released Critical minerals Report, that identified the following 31 minerals as critical minerals: antimony, beryllium, chromium, cobalt, copper, diamond, fluorite, gallium, germanium, gold, indium, lead, lithium, magnesium, manganese, molybdenum, nickel, niobium, phosphorus, platinum group metals, rare earth, rhenium, silver, strontium, tantalum, tin, titanium, tungsten, vanadium, zinc, zirconium [3].

In 2020, Canada and USA finalized Joint Action Plan on Critical Minerals Collaboration to advance mutual interests in securing supply chains for critical minerals. In 2021, Canada's Ministry of Natural Resources released Canadian critical minerals list, which contains 31 minerals and metals: aluminum, antimony, bismuth,

* Corresponding author: dwhu@canre.org.cn

cesium, chromium, cobalt, copper, fluorspar, gallium, germanium, graphite, helium, indium, lithium, magnesium, manganese, molybdenum, nickel, niobium, platinum group metals, potash, rare earth elements, scandium, tantalum, tellurium, tin, titanium, tungsten, uranium, vanadium, zinc [4].

In 2019, the Department of Industry, Innovation and Science released Australia's Critical Minerals Strategy 2019 to position Australia as a world leader in the exploration, extraction, production and processing of critical minerals. The list contains 24 minerals: antimony, beryllium, bismuth, chromium, cobalt, gallium, germanium, graphite, hafnium, helium, indium, lithium, magnesium, manganese, niobium, platinum group elements, rare earth elements, rhenium, scandium, tantalum, titanium, tungsten, vanadium, zirconium [5].

In 2016, the Ministry of Land and Resources of China released National Mineral Resources Planning (2016-2020), which identified 24 strategic minerals as critical minerals to improve supply capability and utilization level. These minerals include 6 energy minerals (coal, coal-seam gas, natural gas, oil, shale gas, uranium), 14 metal minerals (antimony, aluminum, chromium, cobalt, copper, gold, iron, lithium, molybdenum, nickel, rare earth, tin, tungsten, zirconium) and 4 nonmetallic minerals (crystalline graphite, fluorite, phosphorus, potash) [6].

1.2 Critical minerals listed by major economies in the world have a high degree of coincidence

USA, EU, Japan, Canada, Australia and China have listed 54 critical minerals. Five critical minerals of them such as antimony, cobalt, lithium, rare earth and tungsten are generally recognized by all of major economies above mentioned, accounting for 9.3% of the total number. Twelve critical minerals such as chromium, fluorite, gallium, germanium, graphite, indium, magnesium, niobium, platinum group metals, tantalum, titanium and vanadium are recognized by 5 major economies, accounting for 22.2%. Seven critical minerals such as aluminum, beryllium, bismuth, manganese, scandium, tin and zirconium are listed by 4 major economies, accounting for 13.0%. Ten critical minerals such as copper, hafnium, helium, phosphorus, potash, molybdenum, nickel, rhenium, strontium and uranium are listed by 3 economies, accounting for 18.5% (Table 1). It can be found minerals that are recognized as critical by a certain economy are usually vital to other economies. Critical minerals listed by major economies in the world have a high degree of coincidence. These critical minerals play an important role in the strategic emerging industries and high-tech industries born in the new round of industrial revolution. These industries are also important pillar industries for Chinese development.

Table 1. Critical minerals listed by major economies in the world

Minerals	USA	EU	Japan	Canada	Australia	China
Aluminum	√	√		√		√
Antimony	√	√	√	√	√	√
Arsenic	√					
Barite	√	√				
Beryllium	√	√	√		√	
Bismuth	√	√		√	√	
Borate		√				
Cesium	√			√		
Chromium	√		√	√	√	√
Coal						√
Coal-seam gas						√
Cobalt	√	√	√	√	√	√
Coking coal		√				
Copper			√	√		√
Diamond			√			
Fluorite	√	√	√	√		√
Gallium	√	√	√	√	√	
Germanium	√	√	√	√	√	
Gold			√			√
Graphite	√	√		√	√	√
Hafnium	√	√			√	
Helium	√			√	√	
Indium	√	√	√	√	√	
Iron						√
Lead			√			
Lithium	√	√	√	√	√	√
Magnesium	√	√	√	√	√	
Manganese	√		√	√	√	
Molybdenum			√	√		√
Natural gas						√
Natural rubber		√				
Nickel			√	√		√
Niobium	√	√	√	√	√	
Oil						√
Phosphorus		√	√			√
Platinum group metals	√	√	√	√	√	
Potash	√			√		√
Rare earth	√	√	√	√	√	√
Rhenium	√		√		√	
Rubidium	√					
Scandium	√	√		√	√	
Shale gas						√
Silicon		√				
Silver			√			
Strontium	√	√	√			
Tantalum	√	√	√	√	√	
Tellurium	√			√		
Tin	√		√	√		√
Titanium	√	√	√	√	√	
Tungsten	√	√	√	√	√	√
Uranium	√			√		√
Vanadium	√	√	√	√	√	
Zinc			√	√		
Zirconium	√		√		√	√

2. Global supply and demand situation and resource governance of critical minerals

2.1 The distribution areas of critical mineral resources are highly concentrated.

Among 5 critical minerals listed by all of major economies above mentioned, more than half of cobalt, lithium and tungsten reserves are located in Congo (DRC), Chile and China, more than half of antimony reserves are concentrated in China (about 31% share of total) and Russia (23%), and more than half of rare earth reserves are concentrated in China (37%) and Vietnam (18%). Among 12 critical minerals listed by 5 major economies, more than 90% of platinum group metals and niobium reserves are located in South Africa and Brazil, more than 70% of tantalum reserves are concentrated in USA, more than 70% of chromium reserves are concentrated in Kazakhstan (40%) and South Africa (35%), more than 60% of vanadium reserves are concentrated in China (43%) and Russia (23%), more than half of ilmenite reserves (the main source for extracting titanium) are concentrated in China (33%) and Australia (21%), and nearly half of magnesium reserves are concentrated in Russia (30%) and China (13%).

2.2 Demand for critical minerals shows a structural differentiation.

Developed countries have entered the post-industrial era and their demand for mineral resources is showing a downward trend. However, as the scale of high-tech industries continues to expand, the demand for critical minerals will increase. Emerging economies are accelerating their industrialization, which results in a continuous growth of the global demand for critical minerals. Traditional manufacturing industries in China have entered the peak period of production capacity. The vigorous development of emerging industries will drive the demand for critical minerals to stabilize at a high level. Under the combined effect of developed countries and emerging economies, there is a structural differentiation on the demand side of mineral products. Demand for bulk minerals such as oil, iron ore, copper, chromium, manganese and nickel is relatively large but tends to be stable. Meanwhile, demand for critical minerals that are highly related to the development of strategic emerging industries and national defense industries such as cobalt, uranium, niobium, zirconium, antimony, boron, etc. have shown a sustained and rapid growth.

2.3 In today's world the governance rules for energy minerals are relatively complete, but for non-energy minerals have not yet been fully formed.

Energy minerals are widely used and closely related to social and economic development. They are greatly affected by changes in geopolitics and regional situations, and received widespread attention from international communities a long time ago. The global energy minerals organizations are relatively complete, such as Organization of the Petroleum Exporting Countries (OPEC), International Energy Agency (IEA), Energy Transitions Commission (ETC), International Energy Forum (IEF), etc. These international organizations have made important contributions to promoting the standardization and systematization of global energy governance. However, there are very few international non-energy minerals organizations in the world, existing mainly a few organizations such as Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) and Extractive Industries Transparency Initiative (EITI). Only the relevant rules of WTO make provisions on the trade of raw materials. The expert group's judgments on Raw Materials Case and Rare Earth Cases in WTO directly harmed China's interests and also embodied the ambition of the West to use the multilateral trade system to lead the global governance of critical minerals.

2.4 Developed countries have great power in the global governance of critical minerals.

Developed countries play a leading role in the global mineral product pricing mechanism. They use futures trading to control mineral product pricing and trading rules. Representative futures markets are non-ferrous metals, precious metals and energy futures markets. In New York Mercantile Exchange (NYMEX) and Intercontinental Exchange (ICE) in USA, the futures trading commodities include energy, gold, copper, aluminum, etc. In London Metal Exchange (LME) in UK, the futures trading commodities include copper, lead, zinc, tungsten, molybdenum, tin, antimony, nickel and so on. At the same time, developed countries rely on the advantage of financial capital to hold shares in large international mining companies and strengthen their control over critical minerals in the world. For example, among 80 oil companies that entered the Forbes list in 2018, American financial institutions are shareholders in 44 oil companies. In addition, American financial institutions also hold shares in BHP Billiton, Rio Tinto, Vale of Brazil and Mitsui Corporation with the ratio of 46%, 44%, 20% and 25% respectively.

3. Reflections and suggestions on promoting China to improve its critical minerals governance capability

3.1 Create the evaluation system for sustainable development of critical minerals in China.

Drawing on foreign advanced evaluation theories and methods, and combined with China's geopolitics, trade structure, industrial structure and domestic resources, we need to create the quantitative evaluation system with Chinese characteristics from several important indicators such as supply risk, economic development and national defense in order to support researches on critical minerals at national level. At present, the priority field is the energy industry, especially the renewable energy industry. For

example, the U.S. Department of Energy has released the list of critical minerals and materials in the renewable energy industry. The second field is the manufacturing industry, including high-precision manufacturing, electronic information industry, etc. The third field is new environmental protection technologies, new materials, etc. In general, whether it is at the national level or the enterprise level, the final list of critical minerals should not be too many, usually about 10% of the total minerals participating in the assessment internationally. Too many goals will make it difficult to focus on developing effective risk prevention measures.

3.2 Identify the key directions and strengthen international cooperation.

In 2021, IEA released a report "The Role of Critical Minerals in Clean Energy Transition", in which put forward 6 key recommendations for a new, comprehensive approach to mineral security: 1) Ensure adequate investment in diversified sources of new supply; 2) Promote technology innovation at all points along the value chain; 3) Scale up recycling; 4) Enhance supply chain resilience and market transparency; 5) Mainstream higher environmental, social and governance standards; 6) Strengthen international collaboration between producers and consumers [7]. All of countries in the world including China need to make efforts in the above-mentioned 6 approaches in order to establish a unified international governance framework for critical minerals. Because the mineral supply chain spreads over the world and there are many kinds of mineral commodities and complex nature, it is difficult for any country to act alone to improve the mineral security. Taking rare earths as an example, although all the countries around the world are studying the supply diversification, it is impractical and expensive for a single country to gain an advantage in the entire industrial chain, and it is also prone to trade disputes.

3.3 Promote actively the reform of critical minerals governance.

Firstly, take the comprehensive advantages of large demand market, complete industrial configuration, strong financial investment capability and effective policy control, rely on national political and diplomatic influence, strengthen the communication capabilities among governments, enterprises and associations, enhance China's influence and voice in global mineral products pricing, and establish more fair and reasonable international mineral products rules. Secondly, build a smoother overseas investment mechanism for critical minerals. In Africa and Central Asia, take effects of infrastructure, educational and health assistance, industrial development and financial support, use methods of acquiring mining rights, greenfield investment, joint venture development and equity participation, develop deep processing of mineral resources, and extend the industrial chain. In Australia, Canada and South America, adopt joint mining to share profits of mining development, establish long-term trade relations in order to ensure the resources supply to China. Thirdly, support the development of international bulk mineral products futures trading, encourage the development of domestic commodity exchanges, carry out futures trading in the international bulk mineral products trade, establish a distinctive futures market at an appropriate time, expand the scope of exchange entities, enrich the trading types, enhance the functions of price discovery and hedging in the futures market, and create the international pricing center of bulk mineral products in China.

3.4 Enhance China's voice in the global governance of critical minerals.

Firstly, join and develop the global governance organizations or mechanisms on critical minerals such as Intergovernmental Forum on Mining, Minerals Metals and Sustainable Development (IGF), Extractive Industries Transparency Initiative (EITI), United Nations Framework Classification for Fossil Energy and Mineral Reserves (UNFC), Committee for Mineral Reserves International Reporting Standards (CRIRSCO), etc., play a greater role and provide Chinese solutions of formulating global governance rules and innovating global governance methods. Secondly, attach importance to training international talents in the field of mineral resources, support domestic mining enterprises to enter various international mining industry organizations and put forward new propositions, issues and initiatives in the mining field. It can create favorable conditions for China to enhance the global minerals governance capacity. Thirdly, participate actively in construction and development of international mining arbitration and mining corporate social responsibility, and change from the acceptor to the maker of mining rules.

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