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China's Energy and Important Mineral Resources Demand Perspective

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Abstract
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Keywords
energy resources; mineral resource; consumption history; limits to growth; demand outlook

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The history of human civilization is the history of human development and utilization of mineral resources. There are more than 86 chemical elements in mineral resources that can be used by humans at present. From the agricultural society to the industrial society and then to the post-industrial society, human beings are consuming the energy and mineral resources on earth at an unprecedented speed to pursue a good and happy life. Since 1900, 197.2 billion tons of petroleum, 134 trillion cubic meters of natural gas, 379.3 billion tons of coal, 59 billion tons of crude steel, more than 800 million tons of copper, and 1.4 billion tons of aluminum have been consumed [1,2]. In the past 70 years, China has consumed 10.9 billion tons of petroleum, 2.56 trillion cubic meters of natural gas, 83.7 billion tons of coal, 13.9 billion tons of crude steel, 150 million tons of refined copper, and 340 million tons of primary aluminum[3,4]. The massive consumption of mineral resources is promoting the rapid development and the continuous improvement of people's living standard in China. How much energy and mineral resources China needs to maintain its economic development in the future is an important topic of concern.

The demand for energy and mineral resources will not increase indefinitely with the development of economy [5–7]. With the continuous improvement of infrastructure and urbanization, as well as the rapid accumulation of social wealth in the process of industrialization, the consumption of important mineral resources and their products will reach a relatively saturated state. At this state, the relationship between supply and demand will change. Besides, the industrial structure begins to change. That is, the traditional industry characterized by high energy consumption and material consumption will gradually give way to the high-end manufacturing with low energy consumption and material consumption, and the latter will become dominant in the post-industrial economic development. The growth of consumption of important bulk mineral resources will slow down and become zero or even negative. Meanwhile, with the rapid development of the high-end manufacturing industry, the mineral resources consumption will increase sharply, and the rare-metal, rare-scattered, and rare-earth elements and minerals will be widely used in strategic emerging industries, which leads to huge demand.

At present, China is in the late stage of industrialization. With the continuous improvement of infrastructure, urbanization rate, and people's housing, as well as the rapid accumulation of social wealth, the growth of bulk mineral resources consumption in China has begun to slow down. The vigorous development of strategic emerging industries is forming a huge demand for critical mineral resources. In this context, it is of great significance to discuss China's future demand for energy and mineral resources.

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1 China's energy and mineral resources consumption

1.1 Energy and important mineral resources provide strong material support for building a moderately prosperous society

The history of energy and important mineral resources consumption in China can be divided into two stages.

The first stage: 1949–2000, in which the major task was to solve the problem of food and clothing. During this stage, the per capita GDP in China increased from 500–600 US dollars to 2 500–3 000 US dollars (purchasing power parity). In order to solve the problem of food and clothing, China had consumed 30.1 billion tons of coal, 3.6 billion tons of petroleum, 0.5 trillion cubic meters of natural gas, 2.3 billion tons of crude steel, 20.93 million tons of copper, 32.7 million tons of primary aluminum, 9.63 million tons of lead, and 15.66 million tons of zinc.

The second stage: 2001–2020, in which the major task was to build a moderately prosperous society. From 2001 to 2018, China had consumed 54.1 billion tons of coal, 7.36 billion tons of petroleum, 2.13 trillion cubic meters of natural gas, 11.6 billion tons of crude steel, 128 million tons of copper, 305 million tons of primary aluminum, 64 million tons of lead, and 81.5 million tons of zinc [2–4,8]. The consumption of energy and important mineral resources in the 18 years was 2–8 times of that in the first stage, and the number will be larger in the case of counting till 2020. China's consumption of mineral resources is changing from overall rapid growth to differential growth. After experiencing slow growth and rapid growth, the consumption of energy and important mineral resources presents mild growth at present (Figure 1). However, the consumption of critical mineral resources, such as the rare-metal, rare-scattered, and rare-earth elements and minerals with large demand in aerospace equipment, advanced rail transit, large nuclear power plants, artificial intelligence, and new energy industries, is still growing rapidly. The massive consumption of mineral resources is changing the appearance of China and promoting the continuous improvement of people's living standards.

1.2 China is still the world's largest consumer of energy and important mineral resources in 2018

The per capita consumption of energy and important mineral resources is an important indicator to measure the economic development of a country or a region. Due to the large population base and the stage of industrialization development, the consumption of energy and mineral resources in China accounts for a large proportion of that in the world. In 2018, China's consumption of 30 minerals among the 40 minerals in global statistics ranked first in the world [9]. Statistics show that in China's consumption of energy and important mineral resources, the consumption of 12 and 23 minerals is over 50% and 40% of the world's, respectively (Figure 2). These mineral resources include bulk mineral resources (e.g., coal, limestone for cement, iron, manganese, copper, aluminum, lead, zinc, and phosphorus) and critical mineral resources (e.g., rare earth, tungsten, stannum, antimony, lithium, cobalt, germanium, and gallium). Compared with those at the beginning of the 21st century, the output and trade volume of China's energy and important mineral resources have increased significantly. There are 17 minerals with the output exceeding 30% of the world's, and 9 minerals with the trade volume exceeding 30% of the world's. Therefore, China is the world's largest producer and trade country of mineral resources.

2 Mechanism of energy and important mineral resources supporting economic development

The trend of per capita consumption of energy and mineral resources and per capita GDP follows the S shape from the agricultural society to the industrial society and then to the post-industrial society. It reflects the internal relationships of

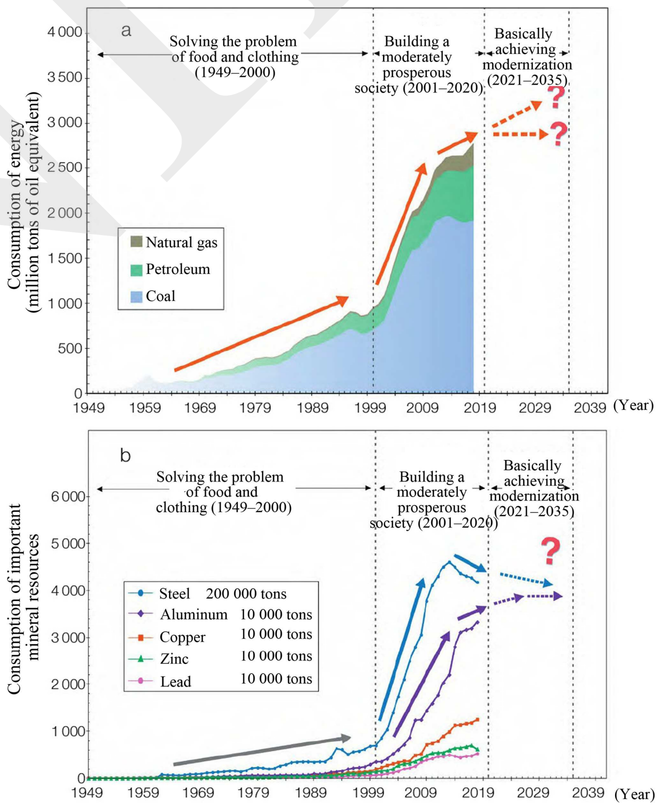

Figure 1 Growth trend of China's consumption of energy (a) and important mineral resources (b)

Data sources: World Metal Statistical Yearbook [2], China Energy Statistical Yearbook [3], and China Statistical Yearbook [4].

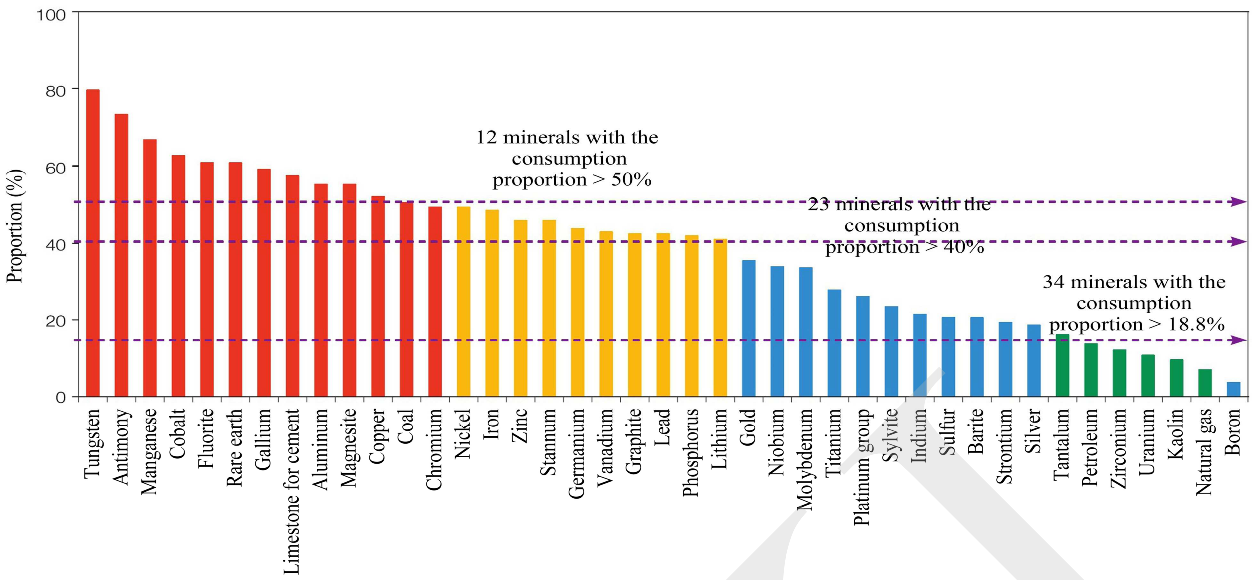

Figure 2 Proportion of China's consumption of important mineral resources in the world's in 2018

Data sources: United States Geological Survey (USGS) ①, British Petroleum (BP) [1], and World Bureau of Metal Statistics (WBMS) [2].

energy and important mineral resource consumption with urbanization rate, infrastructure construction, social wealth accumulation, and economic structure changes [5,6,10–14] (Figure 3).

(1) Agricultural society (per capita GDP less than 2 500–3 000 US dollars). Economic development in this period depends on slash-and-burn farming. People live in concentrated areas with crop cultivation and produce little GDP. Due to the lack of infrastructure, limited social wealth accumulation, and slow economic development, energy consumption was mainly used to maintain basic living needs and a small amount of mineral resources was used to make simple tools of labor. Therefore, the consumption of energy and mineral resources in the agricultural society was low and presented slow growth.

(2) Industrial society (per capita GDP of 3 000–20 000 US dollars). Economic growth has shifted from agriculture to the manufacturing industry. With the rapid growth of per capita GDP, the consumption of energy and mineral resources generally increased in this period. This period can be divided into two stages. (1) The first stage was characterized by the rapidly growing consumption of energy and mineral resources (per capita GDP of 3 000–12 000 US dollars). During this stage, the mode and focus of economic growth shifted from agriculture to industry. Energy consumption per unit of GDP kept increasing; steel and cement consumption grew rapidly; the proportion of the secondary industry kept rising. The urbanization rate, infrastructure construction, and social wealth accumulation increased rapidly. (2) The second stage was characterized by decelerated growth of energy and mineral resource consumption (per capita GDP of 12 000–20 000 US dollars). With the improvement of infrastructure construction and social wealth accumulation, people's living standard continued to improve and the tertiary industry characterized by high-tech developed rapidly. Energy consumption per unit of GDP began to decline; crude steel and cement consumption showed zero growth; per capita consumption of bulk mineral resources such as copper, lead, and zinc slowed down and gradually presented zero or negative growth. The proportion of secondary industry exceeded the peak and the industrial structure changed significantly. In the meantime, the growth rate of urbanization rate, infrastructure construction, and social wealth accumulation slowed down, and social development began to transform into post-industrialization.

(3) Post-industrial society (GDP per capita over 20 000–22 000 US dollars). With the huge accumulation of social wealth and people's living standard reaching a high level, the tertiary industry characterized by high-tech with low energy consumption has replaced the high-energy consuming industry and become the main contributor of GDP. The primary energy consumption and terminal energy consumption of the transportation sector reached zero growth and then showed a slow decline trend. The growth rate of electricity consumption slowed down and the infrastructure was basically complete. The urbanization rate and social wealth accumulation reached a high level, and the consumption of bulk mineral resources showed zero or negative growth.

① U.S. Geological Survey. Historical Statistics for Mineral and Material Commodities 1900–2019. [2020-02-27]. https://www.usgs.gov/centers/nmic/historical-statistics-mineral-and-material-commodities-united-states.

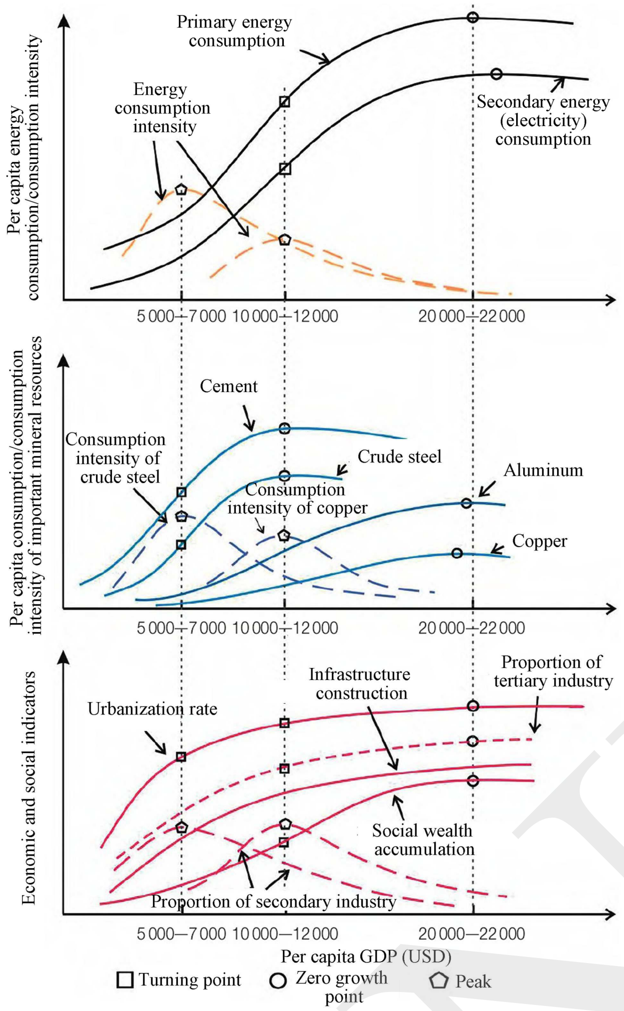

Figure 3 Relationship between important energy resources consumption and economic development

3 Prospect of China's demand for energy and important mineral resources in 2035

In 2018, China's per capita GDP was 15 000 US dollars (purchasing power parity). With the continuous improvement of urbanization rate, industrial structure change, social wealth accumulation, and infrastructure construction, China's consumption of primary energy, electricity, and bulk mineral resources will slow down, and the consumption of crude steel has declined. According to the S-shaped trend, the consumption of important bulk mineral resources in China will gradually reach the peak around 2025; the consumption of primary energy will reach the turning point around 2030; the consumption of critical mineral resources will reach the peak after 2035.

3.1 Energy demand will peak around 2030

In 2018, China's consumption of primary energy, petroleum, natural gas, and coal was 3.274 billion tons (oil equivalent), 630 million tons, 283 billion cubic meters, and 3.813 billion tons, respectively [9]. It is predicted that the peak of primary energy demand will come around 2030, with annual demand of 4.1–4.2 billion tons (oil equivalent), and the per capita energy demand in the peak period is only 1/4–1/3 of that in the United States. The peak of petroleum demand will come around 2030–2035, with annual demand of 700 million tons. During the peak period, the per capita petroleum demand is about 1/4 of that in the United States and 1/3–1/2 of the average level in developed economies. In the next 15 years, China's demand for natural gas will keep growing. Due to environmental constraints, the peak coal demand is set to arrive around 2020. By 2035, China's per capita demand for coal will be equivalent to about 3/4 of that in the United States in the peak period and about 1.5 times higher than the average level in developed economies (Figure 4a).

3.2 Demand for important mineral resources will reach the turning point around 2025

In 2018, China's consumption of iron (crude steel), manganese, and chromium was 835 million tons, 12.05 million tons, and 6.45 million tons, respectively [9]. The annual demand for iron and manganese has reached the peak around 2015, surpassing the peak values of 920 million tons and 11.80 million tons, respectively, and the current consumption is flat and declines slowly. The demand peak for chromium will arrive before 2025 and the annual demand will be 18.80 million tons (chromium ore) (Figure 4b).

In 2018, China's consumption of copper, aluminum, lead, zinc, nickel, and molybdenum was 12.48 million tons, 33.30 million tons, 5.24 million tons, 6.18 million tons, 1.07 million tons, and 0.096 million tons, respectively [9]. The peak demand will arrive together in 2020–2025, with annual demand of 15.33 million tons, 36.83 million tons, 6.10 million tons, 7.52 million tons, 1.35 million tons, and 0.087 million tons, respectively (Figure 4c). During the peak period, China's per capita demand for aluminum is about twice the average level of developed economies. The reasons for the high aluminum demand in China are the short history of large-scale utilization and great changes in the consumption structure. China's per capita demand for lead is lower than that of Germany, higher than that of Japan and South Korea, close to that of France, and equivalent to the average level of developed economies. Due to environmental constraints and the replacement of new energy batteries, China's demand for lead will decline rapidly.

3.3 Demand for critical mineral resources will keep growing

The United States and countries in the European Union have long promoted the supply security of critical mineral resources as a national strategy. In 2018, the U.S. Department of the Interior released a list of 35 key minerals, and in 2019,

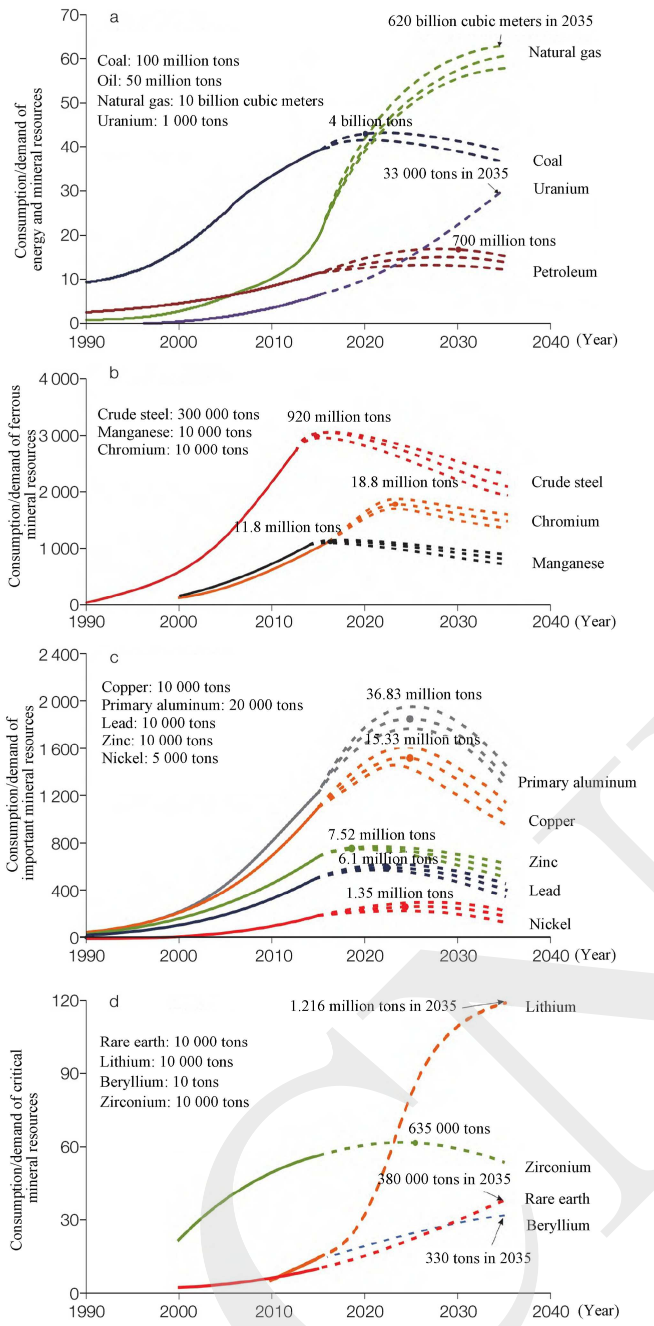

Figure 4 Consumption history and demand forecast of energy (a), ferrous metal resources (b), important mineral resources (c), and critical mineral resources (d) in China

the U.S. Department of Commerce released A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals. Most of the critical minerals defined by the United States and the European Union overlap with those by China, and thus competition is inevitable.

Critical mineral resources include rare earth, lithium, strontium, beryllium, zirconium, niobium, tantalum, gallium, germanium, and indium, the demand for most of which will still grow (Figure 4d). In 2018, China's consumption of rare earth and lithium was 0.104 million tons and 0.035 million tons, respectively [9]. It is predicted that the demand will keep growing till 2035. The demand for rare earth is increasing in the main application fields. Lithium is mainly used in the field of new energy vehicles, which accounts for about 2/3. With the continuous development of electric vehicle industry, the demand for lithium will grow rapidly.

4 Suggestions for ensuring the supply security of energy and important mineral resources

Although China has entered the late stage of industrialization, mineral resources will still be an important material basis for China's economic and social development. In the face of huge demand for resources and the continuous increase of international environmental uncertainties, it is essential to take precautions in times of safety and ensure the supply security of energy and mineral resources in China.

(1) Planning of the top-level design. The domestic and foreign resources, environment, industries, market, investment, and trade should be coordinated, including transportation corridor security and reserves, for the construction of a global big data system of the whole industry chain and the formulation of China's global strategy for mineral resources.

(2) Implementation of major national projects. The special projects of prospecting, exploration, and technical and economic evaluation of critical mineral resources should be implemented for the seeking of reserve bases of new critical mineral resources. The development of comprehensive utilization technologies of important critical minerals such as niobium, scandium, and beryllium should be promoted, and scientific research should be carried out on the mineral processing and comprehensive utilization of beryllium and other metals in Shizhuyuan. Furthermore, the scientific research on the beneficiation and comprehensive utilization of niobium and scandium in Bayan Obo should be promoted.

(3) Construction of a relevant mechanism. The coordinated response mechanism of the whole industrial chain of mineral resources, the "going global" coordination mechanism of Chinese enterprises, the emergency management mechanism of mineral resources safety, and the coordination mechanism of various government departments should be constructed.

(4) Formulation and improvement of policies. The policies for the taxes, dues, and mining rights transfer of mineral resources, investment and financing policies of the capital market for venture mineral exploration, financial and tax policies supporting enterprises "going global," and incentive policies of domestic prospecting, exploration, development and "going global" should be formulated and improved.

References

1 BP. BP Statistical Review of World Energy (67 Ed). [2020-02-27]. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bpstats-review-2018-full-report.pdf.

2 World Bureau of Metal Statistics. World Metal Statistics Yearbook 1984–2019. England: World Bureau of Metal Statistics, 1984–2019.
3 Department of Energy, National Bureau of Statistics. China Energy Statistical Yearbook: 1999–2018. Beijing: China Statistics Press, 2000–2019 (in Chinese).
4 National Bureau of Statistics. China Statistical Yearbook: 1999–2019. Beijing: China Statistics Press, 1999–2019 (in Chinese).
5 Wang A J, Wang G S. 矿产资源与国家经济发展. Beijing: Seismological Press, 2002 (in Chinese).
6 Wang A J, Wang G S. 能源与国家经济发展. Beijing: Geological Publishing House, 2008 (in Chinese).
7 Wang A J, Wang G S, Zhou F Y. The limits and cycles of the growth of energy and mineral resources consumption. Acta Geosciences Sinica, 2017, 38 (1): 1–8 (in Chinese).
8 Wang A J, Wang G S, Deng X Z, et al. Security and management of China's critical mineral resources in the new era. Bulletin of National Natural Science Foundation of China, 2019, (2): 133–140 (in Chinese).
9 Liu Q Y, Liu G W, Liu C H. Review of the global mineral resources situation in 2018//Wang A J, Wang G S. Work report of strategy research on global mineral resources. Beijing: Research Center for Strategy of Global Mineral Resources, Chinese Academy of Geological Sciences, 2019 (in Chinese).
10 Wang A J, Wang G S. The mineral resources demand theory and the prediction model. Acta Geosciences Sinica, 2010, 31 (2): 137–147 (in Chinese).
11 Wang A J, Wang G S, Chen Q S, et al. S-curve model of relationship between energy consumption and economic development. Natural Resources Research, 2015, 24: 53–64.
12 Gao X R, Wang A J, Liu G W, et al. Expanded S-curve model of a relationship between crude steel consumption and economic development: Empiricism from case studies of developed economies. Natural Resources Research, 2019, 28: 547–562.
13 Dohrn R, Kratschell K. Long-term trends in steel consumption. SSRN Electronic Journal, 2013, 27 (415): 43–49.
14 Ghosh S. Steel consumption and economic growth: Evidence from India. Resources Policy, 2006, 31 (1): 7–11.

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