CRITICAL MINERALS AND CHINA'S DOMINANCE OVER THE SUPPLY CHAIN

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Introduction

Critical minerals are gaining huge prominence in numerous ways from finding importance in renewable technologies to scrambling for non-fuel minerals in resource-rich underdeveloped countries. A combination of several factors – growing competition over resources, increasing demand for clean energy systems, control of supply chains, and monopoly of China in the market of these metals – has compelled states to review the state of minerals. The dispute between China and Japan which led to a restriction on the export of rare earth elements by the Chinese government was one significant event when states realised geopolitical risk. The risk of supply chain disruption and its implications on the economy has prompted countries to list the minerals critical to national security.

China, today, controls the supply chain of most of the critical minerals. For instance, its monopoly of rare earth elements (REEs), especially the heavy rare earth, has been the cause of concern for states heavily dependent on imports from China. Apart from the rare earth elements, other critical minerals having strategic importance are lithium, copper, cobalt, silicon, and nickel owing to the decarbonisation of economies. As the global economy embraces clean energy technologies in wake of the climate crisis, a race has begun among nations to safeguard supplies of critical minerals. In this race, China seems to be at the forefront from acquiring major mines to manufacturing and export of finished products. China's increasing footprints in Africa for its untapped natural resources and investments in infrastructure development are to be monitored closely. The scramble for non-fuel minerals is not limited to only the African continent rather China has made inroads in South American countries which have the largest reserves of some of the critical minerals.

This paper identifies the minerals critical to the economies of the United States (US), Australia, and India. The first section will give an understanding of critical raw minerals and their growing significance. The next section explicates the leading countries in global reserves and production. Finally, the paper investigates China's dominance of supply chains of critical minerals by analysing China's strategy of acquisition of mining and production in overseas territories.

Understanding Critical Raw Minerals

The minerals deemed 'critical' are not fixed and have been changing over time. This variation is a result of technological advancement and innovation. There has been no fixed definition of critical minerals so far. However, there has been some consensus on factors determining the criticality of a mineral. The two key factors determining the criticality of metal are the economic importance of the mineral to the nation and the risk to the supply chain. Critical minerals can be referred to as those minerals "which are essential inputs in the production process of an economy, and whose supplies are likely to be disrupted on account of non-availability or risks of unaffordable price spikes" (Chadha & Sivamani, 2022).

The notion of 'critical minerals' gained prominence since the dispute between China and Japan in 2011 which led to supply disruption of the rare earth elements. Subsequently, developed economies have made significant efforts on understanding mineral resource security. Furthermore, policymakers have focused on identifying minerals critical to national security. According to the US,

> The Energy Act of 2020, Section 7002(c)(4)(A), defined critical minerals as those which:
>
> (i) "are essential to the economic or national security of the United States;
>
> (ii) the supply chain of which is vulnerable to disruption (including restrictions associated with foreign political risk, abrupt demand growth, military conflict, violent unrest, anti-competitive or protectionist behaviors, and other risks through-out the supply chain); and
>
> (iii) serve an essential function in the manufacturing of a product (including energy technology-, defense-, currency-, agriculture-, consumer electronics-, and healthcare-related applications), the absence of which would have significant

consequences for the economic or national security of the United States" (Survey U. G., 2021).

The 2018 list of critical minerals included 35 commodities which have been expanded to 50 in the 2021 draft list of critical minerals (Survey U. G., 2021). The minerals included in this list are the ones vulnerable to disruption of the supply chain as the state either lack reserves or production facility.

According to Australia: -

"A critical mineral is a metallic or non-metallic element that has two characteristics:

1. It is essential for the functioning of our modern technologies, economies, or national security and
2. There is a risk that its supply chains could be disrupted" (Critical Minerals at Geoscience Australia, n.d.).

The country's list of critical minerals includes 26 minerals: High Purity Alumina, Antimony, Beryllium, Bismuth, Chromium, Cobalt, gallium, germanium, graphite, hafnium, helium, indium, lithium, magnesium, manganese, niobium, Platinum group elements, rare-earth elements, rhenium, scandium, silicon, tantalum, titanium, tungsten, vanadium, and zirconium (Government, 2022).

In the case of India, a significant attempt to identify minerals 'critical' to the manufacturing sector was made by the Council on Energy, Environment and Water (CEEW) and National Science and Technology Management Information System (NSTMIS) division of the Department of Science and Technology (DST). The study was conducted on 49 minerals and an assessment was made showing an impact on the manufacturing sector arising from supply constraints. The 2016 report titled 'Critical Non-Fuel Mineral Resources for India's Manufacturing Sector: A Vision for 2030′ has considered both economic importance and supply risks in evaluating the criticality of minerals (Gupta, Biswas, & Ganesan, 2016). As per the study conducted by the CEEW, 13 minerals were identified as most critical for India by 2030, of which six were critical in the reference year 2011 (Gupta, Biswas, & Ganesan, 2016). The list of minerals critical to India's manufacturing sector includes beryllium, chromium, germanium, graphite, lithium, silicon, strontium, limestone, rhenium, tantalum, zirconium, niobium, and rare earth elements (Gupta, Biswas, & Ganesan, 2016, pp. 33-34). India has almost 100 percent import dependence on these 13 critical minerals thus increasing the vulnerability of its economy.

Significance of Critical Minerals

After analysing the list of critical minerals of the three countries, this study has identified 38 minerals as ‘critical’ owing to their contribution to the manufacturing sector in present times and their increasing demand. Some of these minerals, even though required in small quantity, form a significant part of modern technologies, emerging green technologies, and strategic sectors. The table in annexure 1 shows the minerals identified as ‘critical’ and their status of criticality to Australia, India, and the US along with their applications.

The shift to renewable energy sources is set to push demand for the minerals required for clean energy systems. The energy sector is evolving as one of the major areas in the minerals market. A clean energy-driven system such as solar photovoltaic (PV) plants, wind turbines, and electric vehicles (EV) requires more minerals than conventional ones. It also uses various minerals which vary with technology. Copper, lithium, and cobalt are used in storage batteries for the automotive industry. Lithium, cobalt, nickel, graphite, and manganese are essential for the performance, energy density, and longevity of batteries. Rare earth elements such as neodymium, and praseodymium is vital for permanent magnets used in wind turbines, and copper and aluminium are essential for electricity networks. Platinum group metals such as platinum and palladium are important in catalytic converters used in automobiles and fuel cells. As per the World Energy Outlook Special Report by IEA, minerals demand used in battery storage and EVs will grow at least 30 times by 2040 where lithium is projected to have the fastest growth (over 40 times) followed by graphite, cobalt, and nickel (around 20-25 times) (IEA, 2022, p. 8). Out of these energy technologies, offshore and onshore wind systems employ the maximum number of mineral types making wind power generation material-intensive followed by solar PV than the conventional sources which are largely fuel-intensive. For instance, an offshore wind generation system requires minerals such as copper, zinc, rare earth elements, molybdenum, chromium, manganese, and nickel.

While the energy sector will lead as the mineral-intensive sector, others such as automotive, and telecommunications will as well face the increasing demand for these minerals. These minerals are crucial in the manufacturing of components used in automotive, electronics, and strategic sectors such as aerospace, defence, ships, high-technology components, and nuclear (Annexure 1).

Global Reserves and Production of Critical Minerals

Most of these critical minerals are found in developing countries of the world. Some are highly concentrated in a few regions. The African continent is home to around 30 percent of the world's mineral reserves, having about 90 percent of chromium and platinum along with the largest reserves of cobalt in the world (UNEP, n.d.). Around 75 percent of coltan (a mixture of columbite-tantalite from which niobium and tantalum are extracted), an essential component of electronics and mobile phones, is found in DRC. A considerable amount of beryllium, copper, chromium, cobalt, platinum group metals (PGMs), tantalum, and zirconium are found in Africa. The region also holds 39 percent manganese with South Africa leading at 30 percent of the world's manganese reserves along with a significant amount in Gabon and Ghana (USGS, 2022). According to the USGS data, South Africa alone contributed around 34 percent to manganese production output (annexure 3). It has a significant amount of aluminium, graphite, lithium, and vanadium reserves as well. Zimbabwe is probably the only African country with lithium reserves accounting for 1 percent of the global reserves (annexure 2). Kazakhstan and South Africa together account for 95 percent of the world's chromium reserves making it one of the geographically concentrated minerals. The Democratic Republic of the Congo (DRC) accounts for more than 70 percent of the world's cobalt production (Energy, 2021). The largest reserves of nickel, another important mineral in batteries, are held by Indonesia followed by Australia where Indonesia also leads in its global production (refer annexure 2&3). About 80 percent of the deposits of platinum group metals (PGMs), a group of six elements namely platinum, palladium, rhodium, ruthenium, iridium, and osmium, are held by South Africa. South American states Argentina, Brazil, Chile, and Peru have huge reserves of copper, lithium, molybdenum, niobium, rhenium, tantalum, and nickel.

Supply Risks of Critical Minerals

The supply risk of non-fuel critical minerals is determined by indicators such as domestic resource endowment, geopolitical risk, level of substitutability, and recycling capability (Gupta, Biswas, & Ganesan, 2016, p. 19). A country dependent on import for domestic manufacturing has concerns associated to supply risk due to monopoly of production, the concentration of reserves in few regions, geopolitical confrontations, or poor trade relations with the countries holding reserves (Gupta, Biswas, & Ganesan, 2016, p. 20). The availability of cheap and abundant substitute minerals reduces the risk of supply chain disruption. In addition, the presence of recycling technology reduces dependency on the primary source.

In this study, it is seen that minerals such as beryllium, niobium, tantalum, tellurium, and platinum group metals (PGMs) are highly susceptible to supply disruption due to the concentration of reserves in a few states (refer to annexure 2). As per the analysis, the supply risk for beryllium, chromium, cobalt, germanium, niobium, vanadium, and platinum group metals (PGMs) is high because of a lack of diversity in production (refer to annexure 3). Out of the critical minerals studied, the production of 11 minerals is dominated by China (refer annexure 3). Thereby giving China leverage over the market associated with these minerals**.** For example, the People's Republic of China (PRC) held around 58 percent of the global production of rare earth elements in 2020 (refer annexure 3). Also, China has around 35 percent share in the refining of nickel, 50-70 percent for cobalt and nickel, and nearly 90 percent for REEs (IEA, 2022, p. 12). The supply of beryllium, a key material in the paper industry, is controlled by the US and China having 94 percent of global production (refer annexure 3). Some of these minerals have no direct substitute available. For instance, the direct substitution of rare earth minerals, particularly in renewable energy technologies such as wind turbines has not yet been discovered to offer similar or higher efficiency (Pavel, et al., 2017). Similarly, minerals such as beryllium, chromium, molybdenum, cobalt, niobium, and tantalum in their major applications have fewer substitutes however with lesser efficiency (USGS, 2022).

China's Investments in Critical Minerals

China has diversified its investments geographically and expanded its economic influence in mineral-rich countries. In the past two decades, countries from Africa, South America, Central

Asia, and Southeast Asia have been receiving huge finances from China in the form of loans, grants, and other credits. The investments have been in sectors ranging from transportation, infrastructure, mining, and energy. Out of the total investment, loans constitute the largest share followed by the share of grants for all the nine countries namely Argentina, Brazil, Chile, Democratic Republic of the Congo (DRC), Indonesia, Kazakhstan, South Africa, Zambia, and Zimbabwe (refer annexure 4).

In need of development, these countries readily accept financial assistance and investments from China. Africa, a continent endowed with natural resources, is plagued with poverty, corruption, poor governance, and terrorism resulting in low development. With corrupted regimes and a lack of environmental laws, China has been able to exploit resources in exchange for investments in infrastructure development. Chinese inroads in Africa began in the late 20th century with the acquisition of the Dilokong chromite mine in South Africa. South Africa leads the world's chromite production output while China lacks any reserves of chromite ore. This compels China to depend on importing almost 50 percent of chromium from South Africa utilised in the manufacturing of finished products. Thereby making China the leading consumer of chromium which is used in ferrochromium and stainless-steel production (USGS, 2022). DRC, the world's largest producer of cobalt and Africa's leading producer of copper, has a joint venture with China's Molybdenum Co. Ltd (CMOC) in Tenke Fungurume Mine where CMOC also controls Kisanfu copper-cobalt deposits (Reuters, 2020). As per the data analysis by The Times and Benchmark Mineral Intelligence, 15 out of the 19 cobalt-producing mines in Congo were either owned or financed by Chinese companies as of 2020 (Searcey, Forsythe, & Lipton, 2021). In 2008, China signed a contract with the government of Congo under which Chinese state-backed companies were allowed to build infrastructure in exchange for 68 percent stakes in the Sicomines venture (Standard, 2021). As per the contract, China will be involved in the construction of 3200 km of railway tracks between the south-eastern Katanga province and Matadi, the DRC's Atlantic port (Edinger & Jansson, 2008). Zijin Mining has a joint venture with Ivanhoe Mines on the Kamoa-Kakula Copper project based in Congo as well (Mines, n.d.). Las Bambas in Peru, the world's second-largest copper-producing country, is owned by a Chinese company accounting for about 2 percent of the global supply (Rochabrun, 2022). Chinese company Chinalco has an investment in Peru's Toromocho copper mine (Reuters, 2018). Also, Zambia's mining firm NFC Africa is largely controlled by China's Non-Ferrous metals company involved in the extraction of copper at the Chambishi main mine and West mine (ZCCM-IH, n.d.).

Understanding the growing importance of raw materials in the manufacturing of batteries for a carbon-free economy and achieving net-zero targets by 2050, the PRC has secured a supply of minerals to its industry. China is the largest consumer of lithium, accounting for about 39 percent of global consumption, and depends on imports from Australia (Times, 2021). China also has the largest share in the global production of lithium-ion batteries (Yu & Sumangil, 2021). Lithium, one of the key minerals in batteries, is also found in Zimbabwe which has the largest deposits in Africa. China's Zhejiang Huayou Cobalt has invested in lithium mines in Zimbabwe and acquired mines Bikita and Arcadia (Chronicle, 2022). Although Australia, Chile, and Argentina are key miners and extractors of lithium, China has established dominance over the processing of the mineral and its companies have made strategic investments in upstream production as well. Chinese company Tianqi Lithium Co. has 51 percent stakes in Tianqi Lithium Energy Australia which owns the Kwinana plant in Western Australia (Lithium, n.d.). China's economic influence in the "Lithium Triangle" has helped in increasing its dominance in the global lithium market. For instance, Chinese company Tanqui has acquired a 24 percent share in Socieded Quimica y Minera de Chile's (SQM) (Peraza, 2022). Furthermore, the Chinese Xinjiang TBEA Group has secured a deal with Bolivia's Yacimientos de Litio (YLB), acquiring 49 percent in YLB, for the development of lithium extraction and processing plants (Peraza, 2022). In addition, a memorandum of understanding (MoU) is signed between China's Ganfeng Lithium and Argentina's mining ministry to develop a lithium battery manufacturing plant (Peraza, 2022). Despite having reserves, China is gradually increasing its nickel footprints in Indonesia and other countries. For instance, China's privately-owned company Tsinghsan and state-backed Zhejiang Huayou Cobalt Co. have investments in Indonesia (Zhang & Patton, 2022). China's Tsingshan Group is building a nickel-based processing plant in Indonesia (ANI, 2022). In Indonesia, PT Dairi Prima Mineral Project (DPM) a joint venture between China Nonferrous Metal Mining Group having majority stakes, and Bumi Resources Minerals will focus on the extraction of zinc (ANI, 2022). Currently, niobium is mined only in Brazil and Canada with Brazil holding the world's largest reserves followed by Canada. Brazil's Companhia Brasileira de Metalurgia e Mineracao (CBMM) and Anglo American Niobio Brasil and Canada's IAMGOLD Corp produces about 90 percent of global niobium (TIC, n.d.). CBMM alone is responsible for about 75-80 percent of niobium production which is in the form of ferroniobium. China is the largest importer of ferro-niobium, (OEC, n.d.) and a group of five Chinese companies holds a 15 percent stake in CBMM (MercoPress, 2011). China has a significant investment in South African platinum mining. Chinese companies the Jinchuan Group and the China-Africa

Development Fund have made significant investments in Wesizwe Platinum by acquiring 45 percent stakes (Reuters, 2010).

The Chinese investment in resource-rich countries has several motivations. Firstly, to keep its economic growth rate an uninterrupted supply of raw materials which fuels its industries is vital. Secondly, these mines give access to key minerals which are either depleted or on the verge of depletion in China in near future to fulfill its growing domestic as well as global demand. Thirdly, infrastructure development such as the construction of railway lines, roads, and seaports is a part of China's ambitious 'Belt and Road Initiative'. This involves connecting China to Central Asia and Europe through land restoring the ancient "Silk Road". The other part includes connectivity via maritime route, through the South China Sea, and the Indian Ocean connecting China to Africa, West Asia, and Europe, known as the "Maritime 'Silk Road'".

Conclusion

The transformation of economies into much cleaner ones is increasing dependence on critical minerals. For the states to achieve climate goals and fulfill national interests, it is crucial to have uninterrupted access to these essential raw materials. In today's interconnected world through global supply chains, supply disruption of raw materials due to any reason will have severe implications on the global economy. Thus, an uninterrupted supply of these minerals would be crucial for continued economic growth for national development. In this race, China has been at the forefront of increasing footprints in resource-rich countries through strategic investments. Chinese investments are serving two purposes, on the one hand developing infrastructure which will support its belt and road initiative and on the other hand securing its supply chain.

China seems to have a greater edge over other states in having control over the supply chain. With China having dominance over the supply chain, it is important for other states, especially major economies such as India, to make efforts towards building resilient supply chains and preventing disruption of a free market. India is dependent on the import of most of these critical minerals, so it would be in India's interest to focus on domestic exploration and extraction. Also, diversification of its sources by increasing investments in resources from mineral-rich countries to secure its supply of raw materials.

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ANNEXURES

Annexure 1: List of Critical Minerals and their Applications

	Critical Mineral	On India List	On US list	On Australia list	Applications
1	Aluminium	N	Y	Y	Transportation, packaging, construction, electrical transmission lines, consumer durables, machinery
2	Antimony	Y	Y	Y	Electronic, Space, defence, Flame retardants, Ammunitions, photographic material
3	Arsenic	N	Y	N	Paper, wood preservatives, arsenic, textiles, ammunitions,
4	Barite	N	Y	N	Hydrocarbon production
5	Beryllium	Y	Y	Y	Electronics & communication equipment, automotive, aerospace, medical, nuclear and computer industries
6	Bismuth	Y	Y	Y	Pharmaceuticals, Alloys, cosmetics, Fire detectors
7	Cerium	N	Y	N	Catalytic converters, glass, metallurgy, ceramics
8	Caesium	N	Y	N	Atomic clocks, optical glass, drilling fluids
9	Chromium	Y	Y	Y	Pigments, alloys, stainless steel
10	Cobalt	Y	Y	Y	Lithium batteries, pigments, superalloys, catalyst, magnets
11	Copper	Y	N	N	Power generation, clean energy, electric vehicles
12	Fluorspar	N	Y	N	Manufacture of aluminium, steel, cement, gasoline
13	Gallium	Y	Y	Y	Electronics, Light Emitting Diodes, solar cells, satellites, optoelectronic devices, integrated circuits
14	Germanium	Y	Y	Y	Semiconductors, Solar electric, fibre optics, infrared optics
15	Graphite	Y	Y	Y	Lubricant applications,
16	Hafnium	N	Y	Y	Nuclear reactors,
17	Indium	Y	Y	Y	TV, smartphones, electronics, semiconductor industry
18	Lithium	Y	Y	Y	Batteries, glass, ceramics, electric vehicles
19	Magnesium	N	Y	Y	Medicine, aeroplane and car construction, fireworks
20	Manganese	N	Y	Y	Batteries, fertilisers, steel making
21	Nickel	Y	Y	N	Rechargeable batteries, stainless steel, defence industry, plating
22	Niobium	Y	Y	Y	Super-alloys, steel industry,
23	Rhenium	Y	N	Y	Turbine engine, catalytic converters
24	Scandium	N	Y	Y	Ceramics, fuel cells, alloys

25	Silicon	Y	N	Y	semiconductors
26	Tantalum	Y	Y	Y	Medical technology, personal computers, jet engine components, cutting tools,
27	Tellurium	Y	Y	N	Solar cells, thermoelectric devices
28	Tin	N	Y	N	Alloys for steel, coatings, cans & containers, construction, transportation
29	Titanium	N	Y	Y	Pigments, superalloy
30	Tungsten	N	Y	Y	Lighting, electronics, alloys, cemented carbide, mill products
31	Vanadium	Y	Y	Y	Catalyst, batteries, automobiles
32	Zinc	N	Y	N	Metallurgy to produce galvanized steel
33	Zirconium	Y	Y	Y	Nuclear reactors
34	Platinum Group Metals	Y	Y	Y	Catalytic converters, electronics, fuel cells
35	Rare Earth Elements	Y	Y	Y	automotive catalytic converters, polishing media for mirrors, glass
36	Limestone	Y	N	N	Building material, mining, paper production, steel manufacturing, water treatment and purification
37	Strontium	Y	N	N	Fireworks, flares
38	Molybdenum	Y	N	N	Catalysts, alloying agent, lubricant

Source: Institute for Defence Studies and Analyses (IDSA) (Lele & Bhardwaj, 2014), United States Geological Survey (USGS)

ANNEXURE 2: Global Reserves

critical Minerals	World Total Reserves (rounded)	Countries Leading in Reserves							
Antimony	›2,000,000 m.t	China 4,80,000 m.t	Russia 3,50,000 m.t	Bolivia 3,10,000 m.t	Kyrgyzstan 2,60,000 m.t	Burma 1,40,000 m.t	Turkey 1,00,000 m.t	Australia 1,00,000 m.t	Canada 78,000 m.t
Beryllium*	100,000 m.t	U.S. 20,000 m.t							
Bismuth (2017)	3,70,000 m.t	China 2,40,000 m.t	Vietnam 53,000 m.t	Bolivia 10,000 m.t	Mexico 10,000 m.t	Canada 5000 m.t			

Chromium	570,000 thousand m.t	Kazakhstan 230,000 thousand m.t	South Africa 200,000 thousand m.t	India 100,000 thousand m.t	Turkey 26,000 thousand m.t	Finland 13,000 thousand m.t	U.S. 620 thousand m.t		
Cobalt	7,600,000 m.t	DRC 3,500,000 m.t	Australia 1,400,000 m.t	Indonesia 600,000 m.t	Cuba 500,000 m.t	Philippines 260,000 m.t	Russia 250,000 m.t	Canada 220,000 m.t	Madagascar 100,000 m.t
Copper	880,000 thousand m.t	Chile 200,000 thousand m.t	Australia 93,000 thousand m.t	Peru 77,000 thousand m.t	Russia 62,000 thousand m.t	Mexico 53,000 thousand m.t	U.S. 48,000 thousand m.t	DRC 31,000 thousand m.t	Poland 31,000 thousand m.t
Gallium **									
Germanium **									
Graphite	320,000,000 m.t	Turkey 90,000,000 m.t	China 73,000,000 m.t	Brazil 70,000,000 m.t	Madagascar 26,000,000 m.t	Mozambique 25,000,000 m.t	Tanzania 18,000,000 m.t	India 8000,000 m.t	Uzbekistan 7,600,000 m.t
Indium **									
Lithium	22,000,000 m.t	Chile 9,200,000 m.t	Australia 5,700,000 m.t	Argentina 2,200,000 m.t	China 1,500,000 m.t	U.S. 750,000 m.t	Zimbabwe 220,000 m.t	Brazil 95,000 m.t	Portugal 50,000 m.t
Molybdenum	18,000,000 m.t	China 8,300,000 m.t	Peru 2,800,000 m.t	U.S. 2,70,0000 m.t	Chile 1,40,0000 m.t	Russia 1,00,0000 m.t	Turkey 80,0000 m.t	Mongolia 37,0000 m.t	Armenia 15,0000 m.t
Nickel	>95,000,000 m.t	Indonesia 21,000,000 m.t	Australia 21,000,000 m.t	Brazil 16,000,000 m.t	Russia 7,500,000 m.t	Philippines 4,800,000 m.t	China 2,800,000 m.t	Canada 2,000,000 m.t	U.S. 340,000 m.t
Niobium	>17,000,000 m.t	Brazil 16,000,000 m.t	Canada 1,600,	U.S. 170,000 m.t					

			000 m.t						
Rhenium	2,400 m.t	Chile 1,300 m.t	U.S. 400 m.t	Russia 310 m.t	Kazakhstan 190 m.t	Armenia 95 m.t	Peru 45 m.t	Canada 32 m.t	
Silicon**									
Tantalum	>140,000 m.t (2021)	Australia 99,000 m.t	Brazil 40,000 m.t						
Tellurium	31,000 m.t	China 6,600 m.t	U.S. 3,500 m.t	Canada 800 m.t	Sweden 670 m.t				
Vanadium	24,000,000 m.t	China 9,500,000 m.t	Australia 6,000,000 m.t	Russia 5,000,000 m.t	South Africa 3,500,000 m.t	Australia 120,000 m.t	U.S. 45,000 m.t		
Zirconium	70,000,000 m.t	Australia 50,000,000 m.t	South Africa 5,900,000 m.t	Mozambique 1,800,000 m.t	China 500,000 m.t	U.S. 500,000 m.t	Kenya 50,000 m.t		
Platinum Group Metals	70,000,000 m.t	South Africa 63,000,000 m.t	Russia 4,500,000 m.t	Zimbabwe 1,200,000 m.t	U.S. 900,000 m.t	Canada 310,000 m.t			
Rare Earth Elements	120,000,000 m.t	China 44,000,000 m.t	Vietnam 22,000,000 m.t	Brazil 21,000,000 m.t	Russia 21,000,000 m.t	India 6,900,000 m.t	Australia 4,000,000 m.t	U.S. 1,800,000 m.t	Greenland 1,500,000 m.t

Source: United States Geological Survey (USGS) 2022

*World Resources

**Quantitative estimates not available

ANNEXURE 3: Global Production in 2020

critical Minerals	World Total Production (rounded)	Countries Leading in Production							
Antimony	111,000 m.t	China 61,000 m.t	Russia 25,000 m.t	Tajikistan 13,000 m.t	Australia 3,900 m.t	Bolivia 2,600 m.t	Burma 2,200 m.t	Turkey 1,330 m.t	Mexico 700 m.t
Beryllium	250 m.t	U.S. 165 m.t	China 70 m.t	Uganda 7 m.t	Brazil 3 m.t	Mozambique 3 m.t	Madagascar 1 m.t	Nigeria 1 m.t	Rwanda 1 m.t
Bismuth (2019)	21,100 m.t	China 16,000 m.t	Laos 3000 m.t	Republic of Korea 930 m.t	Japan 540 m.t	Kazakhstan 270 m.t	Bulgaria 50 m.t	Canada 25 m.t	Bolivia 15 m.t
Chromium	37,000 thousand m.t	South Africa 13,200 thousand m.t	Turkey 8000 thousand m.t	Kazakhstan 7000 thousand m.t	India 2500 thousand m.t	Finland 2290 thousand m.t			
Cobalt	142,000 m.t	DRC 98,000 m.t	Russia 9000 m.t	Australia 5630 m.t	Philippines 4500 m.t	Cuba 3800 m.t	Canada 3690 m.t	Papua New Guinea 2940 m.t	Morocco 2300 m.t
Copper (Refinery Production)	25300 thousand m.t	China 10,000 thousand m.t	Chile 2330 thousand m.t	Japan 1580 thousand m.t	DRC 1350 thousand m.t	Russia 1040 thousand m.t	US 918 thousand m.t	Republic of Korea 671 thousand m.t	Germany 643 thousand m.t
Gallium	327 m.t	China 317 m.t	Russia 5 m.t	Japan 3 m.t	Republic of Korea 2 m.t				
Germanium	131 m.t	China 85 m.t	Russia 5 m.t						

(Refinery Production)									
Graphite	966,000 m.t	China 762,000 m.t	Brazil 63,600 m.t	Mozambique 28,000 m.t	Russia 25,000 m.t	Madagascar 20,900 m.t	Ukraine 16,000 m.t	Norway 12,000 m.t	North Korea 8100 m.t
Indium (Refinery Production) 2019	968 m.t	China 535 m.t	Republic of Korea 225 m.t	Japan 70 m.t	Canada 61 m.t	France 40 m.t	Belgium 20 m.t	Peru 12 m.t	Russia 5 m.t
Lithium	82,500 m.t	Australia 39,700 m.t	Chile 21,500 m.t	China 13,300 m.t	Argentina 5,900 m.t	Brazil 1420 m.t	Zimbabwe 417 m.t	Portugal 348 m.t	
Molybdenum	294,000 m.t	China 130,000 m.t	Chile 56,000 m.t	U.S. 43,600 m.t	Peru 30,400 m.t	Mexico 16,600 m.t	Armenia 5000 m.t	Canada 3900 m.t	Iran 3500 m.t
Nickel	2,510,000 m.t	Indonesia 771,000 m.t	Philippines 334,000 m.t	Russia 283,000 m.t	Australia 169,000 m.t	Canada 167,000 m.t	China 120,000 m.t	Brazil 77,000 m.t	U.S. 16,700 m.t
Niobium	67,700 m.t	Brazil 59,800 m.t	Canada 6,500 m.t						
Rhenium	59.3 m.t	Chile 30 m.t	Poland 9.510 m.t	U.S. 8.830 m.t	Uzbekistan 4.900 m.t	Republic of Korea 2.800 m.t	China 2.500 m.t	Kazakhstan 0.500 m.t	Armenia 0.260 m.t
Silicon	8,120,000 m.t	China 5,600,000 m.t	Russia 576,000 m.t	Brazil 404,000 m.t	Norway 345,000 m.t	U.S. 277,000 m.t	France 112,000 m.t	Malaysia 109,000 m.t	Kazakhstan 67,000 m.t
Tantalum	2,100 m.t	DRC 780 m.t	Brazil 470 m.t	Nigeria 260 m.t	Rwanda 254 m.t	China 74 m.t	Ethiopia 69 m.t	Russia 49 m.t	Mozambique 43 m.t

Tellurium	562 m.t	China 330 m.t	Russia 71 m.t	Japan 70 m.t	Canada 44 m.t	Sweden 42 m.t	Bulgaria 3 m.t	South Africa 2 m.t	
Vanadium	105,000 m.t	China 70,000 m.t	Russia 19,500 m.t	South Africa 8,580 m.t	Brazil 6,620 m.t	U.S. 17 m.t			
Zirconium	1,200,000 m.t	Australia 400,000 m.t	South Africa 280,000 m.t	China 140,000 m.t	Mozambique 110,000 m.t	Indonesia 64,000 m.t	Senegal 60,000 m.t	U.S. 30,000 m.t	Kenya 29,000 m.t
Platinum Group Metals (PGM) - **Platinum**	166 m.t	South Africa 112 m.t	Russia 23 m.t	Zimbabwe 15 m.t	Canada 7 m.t	U.S. 4.200 m.t	China (e) 2.500 m.t	Finland 1.276 m.t	Australia 0.522 m.t
Palladium	217 m.t	Russia 93 m.t	South Africa 73.5 m.t	Canada 20 m.t	U.S. 14.6 m.t	Zimbabwe 12.9 m.t	China (e) 1.3 m.t	Finland 0.858 m.t	Serbia (e) 0.100 m.t
Other PGMs	N.A.	South Africa 46.835 m.t	Zimbabwe 3.230 m.t	Russia 2 m.t	Canada (e) 1.2 m.t	U.S. (e) 0.100 m.t			
Rare Earth Elements (REEs)	2,40,000 m.t	China 1,40,000 m.t	U.S. 39,000 m.t	Burma 31,000 m.t	Australia 21,000 m.t	Thailand 3,600 m.t	India 2,900 m.t	Madagascar 2,800 m.t	Russia 2,700 m.t

Source: United States Geological Survey (USGS) 2022, British Geological Survey (BGS) (Idoine, et al., 2022)

(e) – Estimated

N.A. – Not Available

ANNEXURE 4: Chinese Finances to Resource-Rich Countries

	Chinese Investments and Loans between 2000-2017 (in million USD)								
TYPE	**Argentina**	**Brazil**	**Chile**	**Democratic Republic of the Congo (DRC)**	**Indonesia**	**Kazakhstan**	**South Africa**	**Zambia**	**Zimbabwe**
Grant	-	0.1	15.58	283.8	76.2	158.5	10.6	5252.3	6032.8
Loan	26634.5	58671.04	910.99	11742.3	85418.9	44647.9	15588.4	2900.78	6839.48
Export Buyer's Credit	5551.9	9937.2	-	360	9706.5	3882.3	1500	3139.4	2216.2
Scholarships/training in the donor country	-	-	-	3.77	1.69	0.73	-	-	6.90
Vague TBD	50	-	-	15.4	-	26017.2	-	131.28	-
Debt forgiveness	-	-	-	56.75	-	-	-	299.80	52.67
Supplier's Credit/Export Seller's Credit	-	9.61	-	-	390	-	-	205.35	291.89
Free-standing technical assistance	-	-	-	-	0.51	-	-	1.36	-
TOTAL	**32236.5**	**68617.9**	**926.5**	**12462.2**	**95593.9**	**74706.7**	**17099.02**	**11930.4**	**15440.1**

Source: AidData (Custer, et al., 2021)