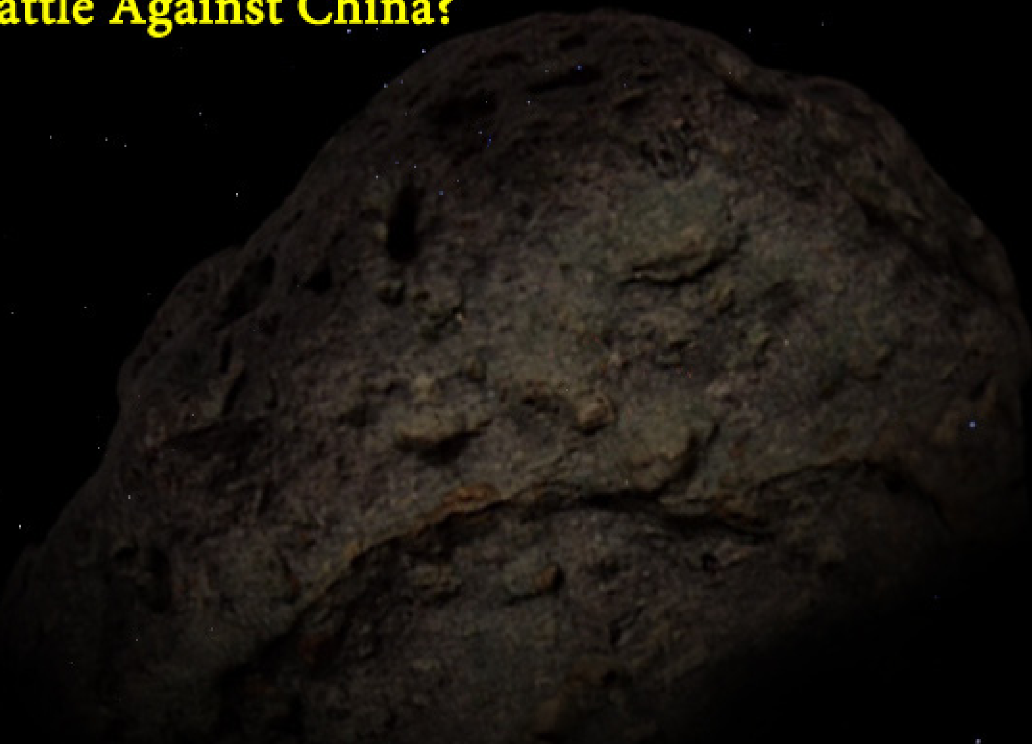
VIF Brief | February 2021

Rare Earth

Has US Lost the Technology Battle Against China?



Brigadier V Mahalingam (Retd.)

Vivekananda International Foundation

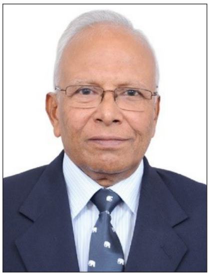
Published in 2021 by

Vivekananda International Foundation

3, San Martin Marg | Chanakyapuri | New Delhi - 110021
Tel: 011-24121764 | Fax: 011-66173415
E-mail: info@vifindia.org
Website: www.vifindia.org

Follow us on

Twitter | @vifindia
Facebook | /vifindia



Brigadier V Mahalingam (Retd.), is a former commander of a Mountain Brigade and former Force Commander of the National Security Guard the country's elite Counter-terrorism Force. He is a highly regarded defence and strategic analyst and an author.

Rare Earth: Has US Lost the Technology Battle Against China?

Introduction

"A Chinese company bought Magnequench," "Not only did the jobs go to China, but so did the intellectual property and the technological know-how to make those magnets…. I'm not comfortable with the fact that we now have to buy magnets for our bombs from China," said the exasperated Senator Hillary Clinton in a speech in Pittsburgh on April 14, 2008[1]. Ten years later, in May 2018, the Department of Interior of the US Government published a list of 35 mineral commodities including the 'rare earth elements group' and classified them as "critical mineral", as they were considered critical for the economic and national security of the United States[2].

1 Tom Curry, 'In Indiana, Clinton plays the China Card', NBC News, April 29, 2008, available at https://www.nbcnews.com/id/wbna24315615, accessed on January 12, 2021.

2 Office of the Secretary Interior, 'Final List of Critical Minerals 2018', Federal Register of the US Government, May 18, 2018, available at https://www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018, accessed on January 13, 2021.

Two years further down the line, the US President Donald Trump declared a 'National Emergency'[3] to deal with the situation created by China attaining monopoly over the production and processing capabilities of Rare Earths (RE) and Rare Earth Elements (REE). Explaining the rationale, the Executive Order, cites the importance of RE thus: "These critical minerals are necessary inputs for the products our military, national infrastructure, and economy depend on the most". It further goes on to elaborate by stating "Our country needs critical minerals to make airplanes, computers, cell phones, electricity generation and transmission systems, and advanced electronics".

Explaining US concerns, the document states, "these minerals are indispensable to our country, we presently lack the capacity to produce them in processed form in the quantities we need. American producers depend on foreign countries to supply and process them. For 31 of the 35 critical minerals, the United States imports more than half of its annual consumption. The United States has no domestic production for 14 of the critical minerals and is completely dependent on imports to supply its demand.

Elucidating China's part in the crisis the Order states "Our dependence on one country, the People's Republic of China (China), for multiple critical minerals is particularly concerning. The United States now imports 80 percent of its rare earth elements directly from China, with portions of the remainder indirectly sourced from China through other countries. In the 1980s, the United States produced more of these elements than any other country in the world, but China used aggressive economic practices to strategically flood the global market for rare earth elements and displace its competitors. Since gaining this advantage, China has exploited its

3 EXECUTIVE ORDERS, 'Executive Order on Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries', THE WHITE HOUSE, September 30, 2020, available at https://www.whitehouse.gov/presidential-actions/executive-order-addressing-threat-domestic-supply-chain-reliance-critical-minerals-foreign-adversaries/, accessed on January 13, 2021.

position in the rare earth elements market by coercing industries that rely on these elements to locate their facilities, intellectual property, and technology in China".

The real concern is, by controlling the exports of these vital minerals and raising costs, Beijing can put US' hi-tech industries out of business, casting aside US into a position of industrial and technological irrelevance. The shifting and growth of industries manufacturing expensive futuristic equipment in China is bound to perk up its economy. Cumulatively, these changes are certain to undermine US' global leadership role. The situation of Europe, Japan and South Korea, the three major sophisticated equipment manufacturing countries is no different though Japan had started addressing the problem after the September 2010 trawler incident wherein a Chinese trawler operating in disputed waters near the Senkaku islands collided with Japanese Coast Guard patrol boats despite warnings. Following this incident Japan arrested the trawler Captain and as retaliation China stopped export of REE temporarily to Japan unannounced. The message from Beijing was clear – REE will be used as a tool to coerce countries to meet its geopolitical ends.

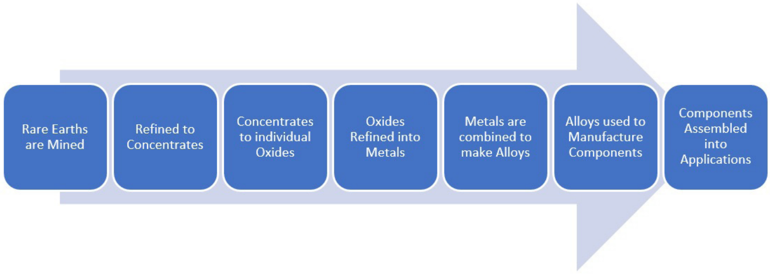
Logically speaking, a country such as US which was the lead producer of RE and REE, with all the wherewithal and the economic backing should have further developed and grown leaving behind rest of the world in the race for leadership in REE technology. On the contrary US today is dependent on China for the supply of RE related material for its industries, threatening its position as the global technology leader and an economic power. How has such a situation developed within a matter of 30 years? Read on.

What are Rare Earth Elements?

REEs are 15 lanthanides with atomic numbers 57 to 71 in the Periodic Table. In addition to these 15, it also includes Scandium and Yttrium with

Atomic Numbers 21 and 39 respectively. Their physical and chemical properties are vastly similar to those 15 mentioned earlier. REEs are not rare as the name suggests but are found in low concentrations all over the world. The real challenge is in finding minable deposits which can be quarried and processed economically. The lanthanide elements are classified under two groups, namely, light rare elements (LREEs) and heavy rare earth elements (HREEs). Lanthanum, cerium, praseodymium, neodymium, promethium, and samarium are the LREEs. Yttrium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium are the HREEs. Scandium is found in most rare earth element deposits and is sometimes classified as a rare earth element. The International Union of Pure and Applied Chemistry includes Scandium in their rare earth element definition[4]. The LREEs are generally used in high-tech applications. For example, lanthanum is used in night-vision goggles, neodymium in laser range-finders, guidance systems, communications, samarium in precision-guided weapons etc.

Broadly the stages of processing and manufacture are as follows[5]:



4 Hobart M. King, PhD, RPG, 'REE - Rare Earth Elements and their Uses' Geology.com, available at https://geology.com/articles/rare-earth-elements/#:~:text=Heavy%20and%20light%20rare%20earth,%2C%20erbium%2C%20thulium%2C%20ytterbium%2C, accessed on December 29, 2020.

5 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Original Paper, Mineral Economics, January 07, 2020, page 132, available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on January 8, 2021.

The processes to separate the REEs from mined material are long drawn and complicated involving several stages of physical and chemical procedures. A high energy consumption process, the mining and the separation if not managed with due precautions can cause serious environmental hazards. The treatment and disposal of residual waste in the form of gas, liquids and their monitoring holds health related risks and needs to be handled and controlled with due safety measures.

Importance of Rare Earth Elements

REE are critical raw materials in the manufacturing of modern military systems and sophisticated equipment for use in the civilian sector. They are difficult to be replaced. Intermediary industries exploit the exclusive properties of REE to manufacture components for complex modern high-tech devices such as laser systems, night vision appliances, radars, aircrafts, space vehicles, precision guided ammunition, guided missiles, fiber optics, automobiles, etc. Industries that are involved in the manufacture of glass, permanent magnets, oil refining, oxygen sensors, batteries, consumer electronics, fuel cells, optical equipment, CFL and LED lighting also use REE extensively.

Colour cathode-ray tubes and liquid-crystal displays used in computer monitors and television screens use europium as the red phosphor. No substitute has yet been identified. Miniaturisation of several electrical and electronic components used in appliances, audio and video equipment, computers, automobiles, communications systems, and military gear are attributable to REE magnets. Miniaturised multi-gigabyte portable disk drives and DVD drives could not have been designed without REE magnets. A newly developed alloy 'Gadolinium-silicon-germanium' alloy Gd5Si2Ge2, it is believed will bring about the next generation high technology magnetic refrigeration replacing the existing gas-compression refrigeration. This REE supported alloy could be used in freezers and air conditioners without the use of flammable and toxic refrigerants or depleting the Earth's ozone layer. Electric Vehicles are yet another REE supported product which is being rapidly inducted in the transport sector that is expected to reduce pollution.

Aluminum Garnet (Nd YAG) lasers are used in many range finding applications that form a part of advanced weapon systems. These lasers have become equally important in the civilian sector being used in surgery as well as in the jewelry industry. Yttrium Iron Garnets as well as Yttrium Gadolinium Garnets are used in manufacturing microwave components that form a part of advanced Communications and Radar systems. RE Cathode elements are also used to produce high power tubes and ion thrusters that are used in radar and communication systems and advanced satellites respectively[6].

To sum up, no high-tech military or civil applications can be manufactured without REE.

In around early 1990s China realised the strategic value of RE and accordingly evolved its strategy to make best use of this resource.

China's Aim and REE Strategy

China has had the fortune of having RE, a strategic natural resource in abundance. Added to it, it's Belt and Road Initiative (BRI) has increased China's access to RE material from participating countries across the globe in Africa, Eurasia, and South America where these vital materials are available in plenty. REE which are extracted from these natural resources has tremendous potentials which were yet to be fully understood and exploited. China realised at some point in time that without REE, manufacture of high-tech products be it military or civil was unconceivable.

6 'Rare Earth Elements—Critical Resources for High Technology', US Geological Survey (USGS) Fact Sheet 087-02, available at https://pubs.usgs.gov/fs/2002/fs087-02/, accessed on January 5, 2021.

Consequently, China's REE strategy revolved around expanding the research and production of its own REE industry while creating conditions to retard the mining and development of RE industry in the US and other parts of the world so that it can gain a lead and advantage in this domain. This would enable Beijing to upgrade its hi-tech industries capable of producing world class state of the art futuristic equipment which would give a boost to its economy besides being able to establish itself as the global technology leader.

China's larger aim of its REE strategy therefore was to become the leading hi-tech power in the world overtaking the position held by the US.

Beijing's strategy evolved in stages. This was probably because at the initial stages China may not have been aware of the full potential of the REE. Subsequently, the movement of manufacturing operations of hi-tech companies from across the world to China, owing to easy access to REE and those consequent to acquisition by China, helped China to gain practical experience and intellectual property.

Understandably, the first stage was set to develop its REE research and industries on priority. Once its industry was in a position to meet the requirements of domestic and export needs, Beijing triggered the second stage which was to keep the price of REE adequately low so as to put all its competitors in the field out of business and thus killing research and domestic production of Rare Earth (RE) in US and the West. China would thus be in a position to control REE market in the world. In the third stage, China imposed a well calibrated and coordinated rationing and taxation policy for RE and REE products besides regulating the flow of these vital commodities to exports as well as domestic markets. These measures resulted in the escalation of the market price of the merchandises. On the other hand, priority for supply of these vital inputs for domestic high-tech industries was accorded. This was a message to the global hi-tech companies that if they needed free flow of REE supplies they should set up shop in China. In the fourth stage, China resorted to strategic acquisition of companies which employ unique technologies in its manufacturing thereby gaining access to high-tech intellectual properties.

Implementation of REE Strategy

Stage 1: Development of RE Industry

In 1975, the State Council of China established the 'National Rare Earth Development and Application Leading Group (Think Tank)[7], which also acted as the national administrative office to oversee the functioning and control of the RE industry. This office also acted as a broker for deals between domestic suppliers and foreign buyers with officials travelling overseas "begging the others to buy our rare earth products[8]".

Between 1975 and 1990 the Chinese RE industrial policy was aimed at encouraging the development of its nascent RE mining industry. China introduced 'export-product tax reimbursement' to the extent of 13 percent for RE ores and 17 percent for RE metals. This provided an incentive to domestic producers to increase production and expand their export market as domestic consumption alone was not sufficient to support the growth of the industry or improve its foreign exchange reserves[9]. China shut its eyes and allowed the not so effectively regulated private players to operate and grow. These measures lowered costs for Chinese mining companies and helped them gain foothold in the global markets. Consequently, between 1985 and 1990, China's RE minerals production

7 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Original Paper, Mineral Economics, January 07, 2020, page 130, available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on November 27, 2020.

8 Yujia He, 'Reregulation of China's rare earth production and export', International Journal of Emerging Markets Vol. 9 No. 2, 2014, pp 240, available at ReregulationofChinasrareearthprod uctionandexport-YujiaHe.pdf, accessed on December 03, 2020.

9 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Mineral Economics, Original Paper, January 07, 2020, pp 130 available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on November 27, 2020.

increased from 8500 tons to 16,500 tons with an annual growth rate of 14 percent. This allowed Beijing to surpass US in RE production. By late 1990s China was the dominant producer of RE[10].

Details of World Mine Production and Reserves and China's Rare Earth Production and Exports during the period 2006-2011 are given at Annexure 1 and 2 respectively.

Research and Development -REE Industry

China's domestic innovation drive in REE caught up when in March 1986 three scientists jointly proposed a plan to step up the country's high technology development. Deng Xiaoping, the then Chinese leader put in place the 'National High Technology Research and Development Program', namely 'Program 863'. The project's objective, according to China's Ministry of Science and Technology was to "boost innovation capacity in the hi-tech sectors, particularly in hi-tech strategic sectors in order to gain a foothold in the world arena; to strive to achieve breakthroughs in key technical fields that concern the national economic lifeline and national security; and to achieve 'leapfrog' development in key high-tech fields in which China enjoys relative advantages or should take strategic positions in order to provide high-tech support to fulfill strategic objectives in the implementation of the third step of China's modernization process.[11]"

This was followed by the announcement of the 'National Basic Research Program of China (973 Program)' announced by China's Ministry of

10 10 Carlos Aguiar de Medeiros Nicholas M. Trebat, 'Transforming natural resources into industrial advantage: the case of China's rare earths industry', Brazilian Journal of Political Economy, vol. 37, available at https://www.scielo.br/pdf/rep/v37n3/1809-4538-rep-37-03-504.pdf, accessed on November 29, 2020.

11 Ministry of Science and Technology of the People's Republic of China, National High-tech Program (863 Program) available at http://www.most.gov.cn/eng/eng/programmes1/200610/t20061009_36225.htm, accessed on November 30, 2020.

Science and Technology in March 1997[12]. Research programmes involving study of REE for oil refining, for example will fall under this scheme. These projects follow a 2+3 management pattern whereby after two years, a mid term evaluation of the project is carried out to decide on the course of the project for the next three years. Advisory groups consisting of experts in specific fields were set up to follow through and manage the project's movement and ensure that the scheme's goals are achieved. This group provided the necessary feedback and advised the Ministry of Science and Technology on the progress and future course for the extension of the project.

In early 1990s Professor Xu Guangxian, considered the father of Chinese rare earth chemistry who chaired the chemistry sector of the 'National Natural Science Foundation of China' launched several research programmes in RE. By 1999 he was still not satisfied with the research on the application of REE in electronic parts and other high-tech industries[13].

There are two key state laboratories in China 'The State Key Laboratory of Rare Earth Materials Chemistry and Applications' affiliated to Peking University and 'State Key Laboratory of Rare Earth Resource Utilisation' affiliated to Changchun Institute of Applied Chemistry Under the Chinese Academy of Sciences'. In addition, 'The Baotou Research Institute of Rare Earths' and the 'General Research Institute of Nonferrous Metals (GRINM) also works in this field[14].

12 National Basic Research Program of China (973 Program),Ministry of Science and Technology of the People's Republic of China available athttp://en.most.gov.cn/eng/programmes1/200610/t20061009_36223.htm, accessed on November 30, 2020.

13 Cindy Hurst, 'China's Rare Earth Elements Industry: What can the West Learn', Institute for the Analysis od Global Security, March 2010, available at http://www.iags.org/rareearth0310hurst.pdf, accessed on December 2, 2020.

14 Cindy Hurst, 'China's Rare Earth Elements Industry: What can the West Learn', Institute for the Analysis od Global Security, March 2010, available at http://www.iags.org/rareearth0310hurst.pdf, accessed on December 2, 2020.

Stage 2: Keep Price Low to put competitors out of Business

Till 1990, US was the major RE producer while China was still wrestling to develop and keep its RE industry going. However, owing to low labour costs, lax environmental restrictions incentivised by the promulgation of "Let Water Flow Rapidly" strategy in 1981[15] and the absence of administrative regulations constraining the industry, the production of RE was substantial. The production costs had stabilised and were relatively low compared to the market price causing the industry to become profitable. Competition amongst RE producers and illegal production adding to supply resulted in fall in prices despite increase in demand. RE producers tried to stabilise prices by trying to form a cartel[16].

Domestic demand in the US for RE on the contrary dropped in 2002 compared to 2001and the separation plant at 'Mountain Pass'[17], US' biggest RE mine was becoming financially unviable. The plant needed capital investment which was not forthcoming. There were complaints about ecological damage being caused by the plant. The owners were further exasperated by the bureaucratic hassles involved in obtaining the permit to continue. The proprietors of the mining company 'Unocal' therefore decided to stop production. China's production of RE during that period

15 Kevin Jianjun Tu, 'An Economic Assessment of China's Rare Earth Policy' Publication: China Brief Volume:10 Issue 22, November 08, 2010, Jamestown Foundation, available at https://jamestown.org/program/an-economic-assessment-of-chinas-rare-earth-policy/, accessed on December 8, 2020.

16 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Original Paper, Mineral Economics, January 07, 2020, page 130, available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on December 8, 2020.

17 US Geological Survey (USGS), 'Rare Earths Statistics and Information', Mineral Commodity Summaries 2003, Rare earths, available at https://s3-us-west-2.amazonaws.com/prd-wret/assets/palladium/production/mineral-pubs/rare-earth/740303.pdf, accessed n December 11, 2020.

on the contrary, was soaring.[18] [19]

Consumption of REE in China's domestic industry increased from 4888 tons in 1987 to 19,270 tons in early 2000 and further to around 125,000 tons in 2018[20]. This was a clear indication of the extent of progress China had made in the research, development, production and usage of REE. Obviously, its domestic industries had made substantial progress in the manufacture of hi-tech equipment.

At this stage France and Japan made an unintended strategic miscalculation which benefited China and initiated the regression of RE and REE industries in the west. In late 1989 and early 1990, France decided to end the contract given to its company Rhone-Poulenc for disposal of radioactive waste at its processing plant La Rochelle, France. This resulted in the company shifting of its extraction and solvent extraction facilities to China. At around the same time Japan too decided to close down and shift a number of its RE processing facilities and plants to China along with the technology in return for supply contracts. A crucial technology along with readymade processing plants thus got transferred from Japan to China providing job opportunities and a significant technology asset which was to force Japan to struggle for REE material in later years[21].Unfortunately, these countries failed to realise that excessive dependence on any one source or country for vital raw material and components is a serious risk

18 Eugene Gholz, 'Rare Earth Elements and National Security' Council on Foreign Relations, October 2014, available at https://www.cfr.org/sites/default/files/pdf/2014/10/Energy%20Report_Gholz.pdf, page2, accessed on December 11, 2020.

19 Nabeel Mancheri Lalitha Sundaresan, S. Chandra,shekar 1991–1998, DOMINATING THE WORLD CHINA AND THE RARE EARTH INDUSTRY, April 2013, available at China-rare-earth-strategy-Highlight_1-15-14.pdf, accessed on January 18, 2021.

20 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Mineral Economics, Original Paper, January 07, 2020, pp 130 available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on December 9, 2020.

21 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Mineral Economics, Original Paper, January 07, 2020, pp 130 available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on December 11, 2020.

for its own industries should supply of raw materials fail in a future date for some reason or motive.

Even after the regulatory situation was resolved, owing to China undercutting prices of various REE material and ensuring free flow of supply from China, the producers particularly 'Mountain Pass' were stressed and the long-term viability of 'Mountain Pass' as a supplier of separated REE for high-technology applications was threatened[22] and became unworkable. Though there are no hard proofs, Beijing's support to environmental lobbies to shut down 'Mountain Pass' cannot be ruled out and is a distinct possibility.

With the development and maturing of China's RE mining industry, the western countries following their self-engineered near closure of their RE mining industries, shifted their production to China taking advantage of the country's low labour costs, weak environmental regulation and their poor implementation. Chinese companies on the contrary took advantage these partnerships to gain knowledge and experience from the foreign companies in this field. The shifting of mining industries from across the world to China led to virtually ending any supply chain competition for China.[23]

It is apparent US had surrendered its leadership in REE technology by 2002 which it had held in 1990. The reality is China has been successful in enticing the Western world to give up on their mining, research, development and production of RE material. The unfortunate part of it is, the West had failed to read the Chinese intentions and fell into the trap. China on the other hand, having realised the vital importance of REE,

22 Gordon B. Haxel, James B. Hedrick, and Greta J Orris, 'Rare Earth Elements—Critical Resources for High Technology', US Geological Survey (USGS), available at https://pubs.usgs.gov/fs/2002/fs087-02/fs087-02.pdf, accessed on December 11, 2020.

23 China Power Team. 'Does China Pose a Threat to Global Rare Earth Supply Chains?' China Power. July 17, 2020, updated September 24, 2020, available at https://chinapower.csis.org/china-rare-earths/, accessed on December 16, 2020.

espoused a long-term strategy and showed patience that led to its near leadership status in RE technology.

Stage 3: Rationing Policy, price escalation and priority to domestic manufacturers

Mining

With the situation thus created, China declared rare earths as protected and strategic mineral[24]. Consequently, in 1990, foreign investors were prohibited from mining rare earths and were not allowed to participate in rare-earth smelting and separation projects except in joint ventures with Chinese firms[25]. Foreign investors were also prohibited from taking part in projects that damaged the environment and natural resources[26]. Countries which had shifted their RE processing operations to China and had closed down their own had been double-crossed and were thus put in a predicament. The squeeze had thus begun to take shape. China had caused globalisation appear an untrustworthy concept.

Beginning early 1991, China started restricting the renewal of mining licenses to only qualified firms. Issue of fresh licenses were controlled and allotted only to projects in which the government either participated or was involved in some way. The aim seemed to be to restrict the supply of RE with a view to increase profits taking advantage of the fact that foreign countries had no option but to buy RE products from China, irrespective of price escalation to stay put in the hi-tech industry. It is noteworthy

24 Tse, Pui-Kwan, 2011, 'China's rare-earth industry' US Geological Survey Open-File Report 2011–1042, available at https://pubs.usgs.gov/of/2011/1042/of2011-1042.pdf, accessed on January 19, 2021.

25 Pui-Kwan Tse, 'China's Rare Earth Industry', U.S. Geological Survey Open-File Report 2011–1042, 2011 available at https://pubs.usgs.gov/of/2011/1042/of2011-1042.pdf, accessed on December 2, 2020.

26 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Mineral Economics, Original Paper, January 07, 2020, pp 131 available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on December 12, 2020.

that China has consistently encouraged foreign investment in the RE downstream manufacturing sector starting 1990[27]. The obvious objective was to allow the component manufacturing industry within the country to grow and in the process gain experience in the field.

RE Products

RE product ionic clays were classified as "national protective exploitation minerals[28]" and RE office took control of middle to long-term ionic clay resource development, planning and domestic trade. Priority for development of RE ionic clays was given to State owned mining establishments. Production by collective-owned and private firms were restricted and limited to low grade reserves. They were not permitted to produce ionic RE concentrates and smelting products. Despite these restrictions the annual growth of RE products rose up by 22 percent with mineral production increasing from 16,150 tons in 1991 to 65,000 tons in 1998. China's market share of RE minerals went up from 33 to 85 percent. Export tax reimbursement for production and exports however continued[29]. Further development of the sector and revenue were the apparent considerations.

Once the RE product industry was fully developed, between 1999 and 2009, with a view to limit the availability of raw material at reasonable cost to foreign manufacturers, production and export quotas were imposed and export taxes were levied on RE products. The aim was also to step up the cost of RE products. Further restrictions on foreign investments

27 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Mineral Economics, Original Paper, January 07, 2020, pp 130 available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on December 15, 2020.

28 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Springer, January 07, 2020, available at https://link.springer.com/article/10.1007/s13563-019-00214-2, accessed on January 19, 2021.

29 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Mineral Economics, Original Paper, January 07, 2020, pp 131 available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on December 12, 2020.

were also imposed. In addition to these measures in 2010 China further tightened the flow of RE products by abruptly cutting down the export quotas by 37 percent to limit exports to just about 30259 tons. This resulted in the prices of RE products soaring phenomenally from $9,461 a ton in 2009 to nearly $66,957 in 2011[30]. With these restrictions, manufacturing companies in US, Europe and Japan were left with no option but to shift their operations to China to remain in the market.

Primary Products

In addition to measures imposed to constrict RE exports, in 2000 China imposed specific reduced quotas for the export of primary products and chlorides while increasing the quotas for oxides and metals. Magnetic materials were totally exempt from any quotas or restrictions. By reducing the export of primary products and increasing the export of intermediary products, the incentive for further research and development in alloy metals and new products that could be used in the manufacture of groundbreaking state of the art hi-tech equipment in foreign countries was in a way subdued. On the other hand, with a view to increase the production and export of more advanced hi-tech products from within the country China permitted the local authorities to allocate quotas to its own medium to large-scale state-owned companies.[31] The advantages provided by these measures to increase its own innovation, manufacture and export of advanced hi-tech equipment to dominate the hi-tech market and limit the extent of research and development in the areas of REE technologies outside China cannot be missed.

30 China Power Team. 'Does China Pose a Threat to Global Rare Earth Supply Chains?' China Power. July 17, 2020, updated September 24, 2020, available at https://chinapower.csis.org/china-rare-earths/, accessed on December 17, 2020.

31 Yuzhou Shen, Ruthann Moomy and Roderick G. Eggert, 'China's public policies toward rare earths, 1975–2018', Mineral Economics, Original Paper, January 07, 2020, pp 131 available at Shen2020_Article_ChinaSPublicPoliciesTowardRare.pdf, accessed on December 13, 2020.

Keeping in line with the policy to restrict export of RE and primary products, from 2004, the reimbursement of export-tax for these products were gradually reduced and the tax-reimbursement scheme for RE metals and oxides were finally withdrawn in 2005. On the other hand, from 2007, 10 percent export taxes were levied on RE ore, oxides and compounds. These taxes were further increased between 15 and 25 percent to different products. From 2010 an export tax on the end-use-product neodymium magnet alloy (NdFeB) that was not used for permanent magnets was imposed. In 2012, China also started taxing NdFeB rapid-setting permanent magnet slices, another advanced product[32].

The results of these measures were there to see. The export quota caused a decline in exports from 69,547 tons in 1999 to 63,149 tons in 2005. Subsequent export restrictions, the production quota, export taxes and controls on Foreign investments contributed to the fall in annual production growth from 9.25 percent during the period 1999-2005 to about 2 percent during the period 2005-2009. The domestic consumption of primary and midstream RE products by manufacturers shot-up[33].

In a significant move, alongside its rationing policy, in 2007, China cut off RE supplies to WR Grace a major US manufacturer of catalysts for the petroleum refining industry, announcing that if global manufacturers needed preferential treatment[34] for access to RE material, they ought to set up shop in China. The bait worked and WR Grace moved to China.

China cut off RE supplies to Japan after the September 2010 'trawler incident' described earlier. This incident highlighted the fact that China which controlled 97 percent of global supply of RE materials, a vital input

32 Ibid.

33 Ibid.

34 Nabeel Mancheri Lalitha Sundaresan, S. Chandra,shekar 1991–1998, DOMINATING THE WORLD CHINA AND THE RARE EARTH INDUSTRY, April 2013, available at file:///C:/Material%201/Material%201/Rare%20Earth%20Minerals/China-rare-earth-strategy-Highlight_1-15-14.pdf, accessed on January 18, 2021.

to the state-of-the-art gadgets manufacturing sector the world over, can effectively pressure the world's consumers[35]. This is also a clear signal that China can use RE as a weapon to intimidate countries to fall in line to achieve its geo-political ends.

Realising the risks involved in being singularly dependent on China to keep its manufacturing sector going and to end similar disruptions in future, Japan's Sojitz Corporation and government-owned Japan Oil, Gas and Metals National Corporation (JOGMEC) decided to invest $250 million in Australian RE company in return for Lynas agreeing to supply RE to Japan in a stable manner. This boost made it possible for Lynas to establish itself as the world's only major rare-earth producer outside China. Lynas today is Japan's largest supplier of REE[36].

WTO Dispute and China's Counter

As brought out earlier, in 2010 with a view to limit the availability of raw material at reasonable cost to foreign manufacturers, China imposed production and export quotas and levied export taxes on RE products. This prompted US, Japan and European Union (EU) whose hi-tech industries were dependent on import of RE products, to sue China at the World Trade Organisation (WTO). These countries contended[37] that China's export taxes on ores, primary RE products and restrictions on the export of RE products violated the terms of WTO and the Protocol signed

35 Hiroko Tabuchi , 'Japan Calls on China to Resume Rare Earth Exports' The New York Times, October 24, 2010, available at https://www.nytimes.com/2010/10/25/business/global/25rare.html, accessed on December 17, 2020.

36 Fumi Matsumoto, , Nikkei staff writer, 'US and Australia team up against China's dominance in rare earths' Nikkei Asia, July 28, 2019, available at US and Australia team up against China's dominance in rare earths - Nikkei Asia, accessed on December 17, 2020.

37 'United States Wins Victory in Rare Earths Dispute with China: WTO Report Finds China's Export Restraints Breach WTO Rules', Office of the United States Trade Representative, March 26,m2014, available at https://ustr.gov/about-us/policy-offices/press-office/press-releases/2014/March/US-wins-victory-in-rare-earths-dispute-with-China#:~:text=Washington%2C%20D.C.%20%E2%80%93%20United%20States%20Trade,rare%20earths%2C%20tungsten%2C%20and%20molybdenum, accessed on January 6, 2021.

by Beijing. China lost the RE dispute case. Consequently, China canceled its export quota and export tax on RE products in 2015.

China did not leave the matter at that. This time China decided to tax just the export of REE to the extent of 5 to 20 percent and left out the REE sold for internal consumption. Tax was also not imposed on the manufactured goods using REE. The export tax thus imposed additional costs on US manufacturers and was in reality an indirect subsidy to internal manufacturers which is contrary to the WTO rules. In July 2016, US once again filed a case with the WTO on China's taxation policy[38]. These measures however, are unlikely to end China efforts to use REE to achieve its ambitions of becoming the global technology leader. Unfortunately, the WTO dispute settlement mechanism has also been rendered defunct by none other than the US.

Stage 4 - Strategic acquisition of companies which employ unique technologies in manufacturing

Magnequench

General Motors, set up Magnequench a RE permanent magnet manufacturing company in Anderson, Indiana in 1986 augmented by Pentagon grants[39]. The company was put for sale in early 1990s. A financial advisory and private equity firm called the Sextant Group with two Chinese state-owned metals firms, San Huan New Material and China National Nonferrous Metals Import and Export Company (CNNMIEC) acquired the company in 1995. Both these companies had very close links with the Chinese Communist Party (CPC). The heads of both these

38 Tim Worstall, 'US Sues China At WTO Over Minerals Export Taxes Again - And Is Likely To Win', Forbes, July 14, 2006, available at https://www.forbes.com/sites/timworstall/2016/07/14/us-sues-china-at-wto-over-minerals-export-taxes-again-and-is-likely-to-win/?sh=4ad8e73e2e26#699536985831, accessed on January 6, 2021.

39 Jeffrey St Clair, "The Saga of Magnaquench", Counter Punch, April 07, 2006 available at https://www.counterpunch.org/2006/04/07/the-saga-of-magnequench/, accessed on December 21, 2020.

companies were the in-laws of the Chinese President Deng Xiaoping[40]. The Sextant group headed by Archibald Cox Jr, was set up in October 1993, three years after Magnequench was announced for sale, acquired the company in just a matter of three years after its incorporation. 62 percent of Magnequench's share went to the two Chinese companies. China had enticed General Motors into selling Magnequench in return for General Motors setting up an automotive production line in Shanghai. The automobile manufacturer fell into the set-up. In hindsight the entire deal, including the teaming up of the three companies, appointment of Cox as the head of Sextant Group and China allowing the establishment of the General Motors manufacturing unit in Shanghai seems to have been engineered to acquire the crucial high-tech US company.

Immediately after the expiry of the date till when China had agreed to keep Magnequench in US, China moved the entire assembly line from the Anderson plant to China along with the high-tech computer equipment. According to a report in Insight magazine, these computers could be used to facilitate the enrichment of uranium for nuclear warheads[41].

Shortly after taking control of the company, China duplicated Magnequench's Neodymium-Iron-Boron magnet production line at a setup built by a Chinese company. Neodymium-Iron-Boron magnets are crucial elements in the manufacture of Joint Direct Attack Munition (JDAM) which is a guidance tail kit that converts existing unguided free-fall bombs into accurate, adverse weather 'smart' munitions. Incidentally, the new tail section contains an inertial navigational system and a global positioning system guidance control unit. JDAM is a joint U.S. Air Force

---

40 Jeffrey St Clair, "The Saga of Magnaquench", Counter Punch, April 07, 2006 available at https://www.counterpunch.org/2006/04/07/the-saga-of-magnequench/, accessed on December 21, 2020.

41 Richard (Rick) Mills, 'Magnaquench Has Left the Building', Ahead of the Herd, available at https://aheadoftheherd.com/Newsletter/2012/Magnequench-Has-Left-the-Building.html, accessed on December 22, 2020.

and Department of Navy program[42]. The magnets for JDAM bombs were being manufactured by the Valparaiso, the last factory of Indiana plant which was also closed and moved to China.

In June 2000, the production facilities at GA Powers, a subsidiary of Magnequench that manufactures the fine granules used in mini magnets was closed and moved from Idaho Falls to a newly constructed plant in Tianjin, China. GA Powers was a Department of Energy project established by scientists at the Idaho National Engineering and Environmental Lab (INEEL) which was transferred to Magnequench in 1998 after Lockheed Martin took over the operations of INEEL.

According to Dr Peter Leitner, an Advisor to Pentagon on trade in Strategic Material, China went all out to acquire Magnequench to press on with the development of its long-range Cruise missiles. China now has the monopoly on the REE used in manufacturing missile magnets[43].

Unocal Corporation

In 2005, China, as a part of its Operation 'Treasure Hunting Ship', made an unsolicited $18.5 billion offer for acquiring a US oil company Unocal Corporation. The acquirer, China's National Offshore Oil Corporation Ltd. (CNOOC) was China's third largest oil and gas company in which the Chinese government had 71 percent stakes. The cash offer was supplemented by $500 million break-up fees to Chevron the competitor, whose cash plus stock offer of $16.4 billion was accepted by Unocal earlier

42 'Joint Direct Attack Munition JDAM', Military.com, available at https://www.military.com/equipment/joint-direct-attack-munition-jdam, accessed on December 22, 2020.

43 Jeffrey St Clair, "The Saga of Magnaquench", Counter Punch, April 07, 2006 available at https://www.counterpunch.org/2006/04/07/the-saga-of-magnequench/, accessed on December 22, 2020.

and necessary regulatory approval had been accorded. An additional $300 million for consulting[44] was also extended.

The Chinese Government controls companies like CNOOC by bringing them under the administrative control of State-Owned Assets Supervision and Administration Commission of the State Council (SASAC), directly under the State Council. SASAC owns 70 percent shares in CNOOC. It is apparent that the deal could not have been offered without the concurrence of the State Council. SASAC director Li Rongrong had very close connections with the CPC[45].

Though the Chairman and CEO of CNOOC Fu Chengyu had described the deal as normal business activity based on the principles of free market, the Chinese offer had much more than what meets the eye. Firstly, the conspicuous question was why was China willing to pay a higher price despite the risks that the company may face in US including a backlash that might crop up from US citizens for selling a potentially strategic American asset to China? Secondly, Beijing had hired a public relations firm whose vice chairman, Mark McKinnon, had led President Bush's media campaign in the 2004 elections. The company had also appointed Goldman Sachs and J.P. Morgan some amongst the best US financial advisers besides renowned legal and lobbying firms such as Akin Gump Strauss Hauer & Feld and Davis Polk & Wardell[46]. Why? Thirdly, CNOOC the acquiring company offered $7 billion as loan, while $6 billion came

44 Wenran Jiang, The Unocal Bid: China's Treasure Hunt of the Century', China Brief, The Jamestown Foundation, July 19, 2005, available at https://jamestown.org/program/the-unocal-bid-chinas-treasure-hunt-of-the-century/, accessed on December 24, 2020.

45 Nabeel Mancheri Lalitha Sundaresan, S. Chandra,shekar 1991–1998, DOMINATING THE WORLD CHINA AND THE RARE EARTH INDUSTRY, April 2013, available at file:///C:/Material%201/Material%201/Rare%20Earth%20Minerals/China-rare-earth-strategy-Highlight_1-15-14.pdf, accessed on January 18, 2021.

46 Leslie Wayne and David Barboza, 'Unocal Deal: A Lot More Than Money Is at Issue' The New York Times, June 24, 2005, available at https://www.nytimes.com/2005/06/24/business/worldbusiness/unocal-deal-a-lot-more-than-money-is-at-issue.html, accessed on December 26, 2020.

from Industrial Commercial Bank of China, a Chinese Government owned bank and $3 billion from the financial advisers JP Morgan and Goldman Sachs. Why was the Chinese Government funding the project in which it had shown no direct interest? Fourthly, while making the bid, Xiao Zongwei pointed out that "an acquisition of Unocal would not pose any threat to America's energy security. Unocal's oil and natural gas output in the US would continue to be sold in the American market - output that represents less than one percent of the total US consumption of oil and natural gas.[47]" If that be so, why was China acquiring the Company at such a huge cost? Obviously, Chinese interest was not American oil and gas but was aimed at something more attractive.

The Chain of ownership of companies hidden in the arrangement throws a pointer to the Chinese actual aim behind the deal. Unocal, the oil and gas company owned Molycorp Inc a US mining corporation headquartered in Colorado which had in its earlier avatar as Molybdenum Corporation of America acquired most of Mountain Pass's mining claims and had started small scale production in 1952. Unocal was sold to Chevron in 2005 after the deal with China's CNOOC had failed. The fact Chevron sold Mountain Pass Mine in 2008 to a privately owned Molycorp Minerals LLC, a company formed to revive Mountain Pass mine gives a clear indication that had CNOOC acquired UNOCAL instead of Chevron, CNOOC, could have sold Mountain Pass to any Chinese company especially being under Chinese control. The production of Neodymium and Samarium Oxide by Mountain Pass in 1989 added value to the company. Acquisition of Unocal would have given China control of substantial RE reserves outside its borders that would have enabled it to have total monopoly and control over future RE and REE global supply chain.

47 'Is CNOOC's Bid for Unocal a Threat to America? ' Wharton, November 21, 2005, available at https://knowledge.wharton.upenn.edu/article/is-cnoocs-bid-for-unocal-a-threat-to-america/ , accessed on December 25, 2020..

Generally, such takeover bids are decided in favour of the highest bidder. But in this case the deal fell through not because of the price offered or the implications of handing over the company to China but because of intense opposition to the bid in the Congress despite a number of write ups in favour of the sale possibly influenced by intense paid lobbying. In June 2005, the lawmakers passed a resolution calling for review of the deal. They followed it up in September 2005 by introducing a clause in the energy bill that would have considerably delayed the Chinese company clinching the contract[48]. CNOOC finally dropped the offer for the takeover of UNOCAL. Astonishingly, the US Government or its intelligence agencies were unable to read the real intent of such an expensive proposition till the end.

Acquisition of other Mines

China also made attempts to acquire Australian RE mining companies Lynas and Arafura Resources without any success. However, they managed to pick up minority stakes in these companies in 2008 and 2009 respectively. China also acquired the Baluba Mine in Zambia[49].

In nutshell, by 2017, China had started producing more than 80 percent of the world's RE metals (not to be confused with RE) and compounds in the world. Major hi-tech equipment manufacturing countries of the world are dependent on China for over 90 percent of their requirement of RE metals and alloys as China controls not only the raw materials but also the production of key intermediates that go into many hi-tech growth industries. The irony is, nearly all the rare earths mined anywhere in the world, including the US are processed in China today. The extent of

48 Matt Pottinger, Russell Gold, Michael M. Phillips and Kate Linebaugh Staff Reporters of THE WALL STREET JOURNAL, 'Cnooc Drops Offer for Unocal, Exposing U.S.-Chinese Tensions', The Wall Street Journal, August 03, 2005, available at https://www.wsj.com/articles/SB112295744495102393 , accessed on December 27, 2020.

49 Hobart M. King, PhD, RPG, 'REE - Rare Earth Elements and their Uses', Geology.com, available at https://geology.com/articles/rare-earth-elements/, accessed on January 10, 2021.

reliance of major hi-tech manufacturing countries on Chinese Rare Earth Metals and Alloys (2018) is given at Annexure 3.

China had thus established monopoly over this vital component for the manufacture of state-of-the-art systems both for military and civil use. Though China had implemented a policy to restrict export of REE products right from 2000 onwards as brought out earlier, the decrease in REE exports from 2010 onwards signifies shifting of manufacturing companies from across the world to China as well as to further deduction in export quotas.

Conclusion

China did not insert itself into US, Japan or other European countries or interfere with the research or development related to RE or REE in these states. Unfortunately, US which has led many breakthrough discoveries in RE, REE, RE alloys and manufacturing of hi-tech equipment has allowed its dominant position to erode to an extent that it is today dependent on China's good will to process the RE mined in US and for REE supplies for its own industries. By manipulating its own mining, investment, trade policies including export taxes and cost of REE, China today has reached a point where it is in a position to restrict or even render hi-tech manufacturing in US unviable. Simply put, China's dominance over the entire RE supply chain is disturbing.

China's efforts to develop RE, REE and high-value state-of-the-art equipment was no secret. Even before 1990s, its effort to step up R and D in this sector, 'export-product tax' reimbursement, its 'National High Technology Research and Development Program, namely Program 863' and 'National Basic Research Program of China, Program 973 were right in the open. Its 1981 "Let Water Flow Rapidly" philosophy should have indicated the rare urgency with which the industry was being advanced. The famous comment "The Middle East has oil and China has rare earth,"[50]made by the Communist Party leader Deng Xiaoping while visiting the JL MAG Rare-Earth Co in 1992 in the Jiangxi city of Ganzhou Province should have made the Western Powers to sit up and realise the importance of RE. The present Chinese President Xi Jinping too paid a visit to this establishment in 2019 along with his emissary for trade talks with the US, Liu He, whose presence though seemed out of place, was most probably intended to make a statement which the US would have hopefully taken note of.

Unfortunately, the Western powers failed to realise that the strategic worth of RE was much more than its monetary value. They lacked the vision and a long-term understanding of the industry's needs. They were oblivious to the fact that giving up one's own facilities hoping for ever uninterrupted flow of raw material from a country that had monopoly over a vital raw material and components was a recipe for uncertainty and risk even to the extent of ending up with the only option of force shutting the dependent industries in the country.

Short term narrow economic considerations impeded their capacity to visualise the long-term need for stability. The agencies of the US and its allies including their intelligence agencies and foreign policy elites failed to read the long-term effects of Chinese monopoly over the RE supply chain which gives way to Chinese rule making and price setting.

US in the meanwhile seems to have started initiating corrective measures to increase production of RE and REE in the country. The Mountain Pass mine in California which was shut down in 2002 has been reopened under new proprietorship in 2017 with the support of the Department of Defence and has commenced production. However, the mined materials

50 James T Areddy, 'Xi Jinping Flexes China's Trade Muscle With Visit to Rare-Earths Hub', The Wall Street Journal, May 21, 2019, available at https://www.wsj.com/articles/xi-jinping-flexes-china-s-trade-muscle-with-visit-to-rare-earths-hub-11558442724, accessed on January 16, 2021.

are being sent to China for processing[51]. The Elk Creek Mine in Nebraska, Bear Lodge Mine in Wyoming and Round Top in Texas are set to be launched. A mining cum processing facility at the Bokan Mine in Alaska, a pilot processing plant in Colorado besides processing facilities at Texas and California are in the process of being set-up[52].

As of today, the process of setting up full-fledged research and development establishments and developing these industries within the affected countries will take a minimum of 10 to 15 years keeping in mind the lead the Chinese would have gained in the interim. The affected countries will have to be patient and bide time. Various options will have to be evaluated to commence RE processing and manufacturing. Cooperation and technology sharing by the countries which have the know-how may be one of the options to increase RE and REE output in the world. Working on alternate technologies casting aside REE may be yet another possibility.

US needs to end its trade war with China. Though much may not come through diplomatic actions, US will have to end its contests with WTO and WTO's dispute settlement mechanism, the world's primary trade referee and work through the organisation to manage supply side and cost issues pertaining to REE at par with China's internal companies as required by the WTO rules. US will have to take on the leadership role to get the allies, friendly countries and countries with shared concerns pertaining to REE supply chain disruption to formulate and coordinate strategies including possible quid pro quos for ensuring regular supply of REE materials, components and objective pricing till its own production of REE matures.

51 China Power Team. 'Does China Pose a Threat to Global Rare Earth Supply Chains?' China Power. July 17, 2020, updated September 24, 2020, available at https://chinapower.csis.org/china-rare-earths/, accessed on January 18, 2021..

52 James Mattis, James O Ellis Jr, Joe Felter, and Kori Schake, 'Ending China's Chokehold on Rare-Earth Minerals', Bloomberg, September 18, 2020, available at https://www.bloomberg.com/opinion/articles/2020-09-18/ending-china-s-chokehold-on-rare-earth-minerals?sref=tfvLTMFt, accessed on January 18, 2021.

Annexure 1: World Mine Production and Reserves[53]:

	Mine production		Reserves
	2018	2019	
United States	18,000	26,000	1,400,000
Australia	21,000	21,000	3,300,000
Brazil	1,100	1,000	22,000,000
Myanmar	19,000	22,000	NA
Burundi	630	600	NA
Canada	—	—	830,000
China	120,000	132,000	44,000,000
Greenland	—	—	1,500,000
India	2,900	3,000	6,900,000
Madagascar	2,000	2,000	NA
Russia	2,700	2,700	12,000,000
South Africa	—	—	790,000
Tanzania	—	—	890,000
Thailand	1,000	1,800	NA
Vietnam	920	900	22,000,000
Other countries	60	—	310,000
World total (rounded)	190,000	210,000	120,000,000

Note:

1. Data includes lanthanides and yttrium but exclude most scandium.
2. For Scandium and Yttrium[54]

53 Rare Earths, US Geological Survey, Mineral Commodities Summaries, January 2020, available at https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-rare-earths.pdf, accessed on January 11, 2021.

54 'Rare Earths Statistics and Information', National Minerals Information Center, US Geological Survey (USGS), available at https://www.usgs.gov/centers/nmic/rare-earths-statistics-and-information, accessed on January 11, 2021.

Annexure 2: China's Rare Earth Production and Exports, 2006-2011[55]

(In Metric Tons)

	2006	2007	2008	2009	2010	2011
Official Chinese production quota	86,520	87,020	87,620	82,320	89,200	93,800
USGS reported production	119,000	120,000	120,000	129,000	130,000	105,000
Chinese export quota	61,560	60,173	47,449	50,145	30,259	30,246

Source: China Ministry of Land and Resources. U.S. Geological Survey, Ministry of Commerce of China

Note: USGS production data exceeded Chinese quotas, some of which is attributed to illegal mining.

The value of U.S. rare earth imports from China rose from $42 million in 2005 to $129 million in 2010, an increase of 207.1%. However, the quantity of rare earth imports from China fell from a high of 24,239 metric tons in 2006 to 13,907 metric tons in 2010, a 42.6% decline.

55 'Rare Earth Elements: The Global Supply Chain', EveryCRSReport.com, July 28, 2010 to December 16, 2013, available at https://www.everycrsreport.com/reports/R41347.html#_Toc374976453, accessed on January 7, 2021.

Annexure 3: Reliance on Chinese Rare Earth Metals and Alloys (2018)[56]

Economy	Imports from China (metric tons)	Total Imports	% of Imports from China
EU	869.2	882.2	98.5
USA	417.6	438.6	95.2
South Korea	86.1	94.6	90.9
Japan	4,233.4	8,729.2	48.5

Note: Excludes oxides and other compounds

56 China Power Team. 'Does China Pose a Threat to Global Rare Earth Supply Chains?' China Power. July 17, 2020, updated September 24, 2020, available at https://chinapower.csis.org china-rare-earths/, accessed on January 8, 2021.

About the VIVEKANANDA INTERNATIONAL FOUNDATION

The Vivekananda International Foundation is an independent non-partisan institution that conducts research and analysis on domestic and international issues, and offers a platform for dialogue and conflict resolution. Some of India's leading practitioners from the fields of security, military, diplomacy, government, academia and media have come together to generate ideas and stimulate action on national security issues.

The defining feature of VIF lies in its provision of core institutional support which enables the organisation to be flexible in its approach and proactive in changing circumstances, with a long-term focus on India's strategic, developmental and civilisational interests. The VIF aims to channelise fresh insights and decades of experience harnessed from its faculty into fostering actionable ideas for the nation's stakeholders.

Since its inception, VIF has pursued quality research and scholarship and made efforts to highlight issues in governance, and strengthen national security. This is being actualised through numerous activities like seminars, round tables, interactive dialogues, Vimarsh (public discourse), conferences and briefings. The publications of VIF form lasting deliverables of VIF's aspiration to impact on the prevailing discourse on issues concerning India's national interest.

VIVEKANANDA INTERNATIONAL FOUNDATION

3, San Martin Marg, Chanakyapuri, New Delhi – 110021

Phone: +91-11-24121764, 24106698

Email: info@vifindia.org,

Website: https://www.vifindia.org

Follow us on twitter@vifindia