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The Impact of COVID-19 on Vulnerable Mineral Supply Chains

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Overview

Throughout our history, the vast mineral wealth of the United States has been a pillar of economic growth and of a high standard of living. Mineral resources have undergirded the strength of the manufacturing sector for over 200 years. Abundant energy resources have helped metals industries as well as modern technology sectors to flourish. In recent decades however, this leadership position has been challenged by competitors ranging from Europe and East Asia to developing economic powers like China, Mexico, and Brazil.

Moreover, the drivers of dynamism in the global economy have evolved to more technologically sophisticated industries such as telecommunications, semiconductors, advanced computing, robotics, medical products, and aerospace. Many of these new industries require different types of natural resources, combined with advanced scientific expertise, to create innovative new products for the global economy. The United States does not always have the needed mineral resources, or the ability to procure them in an economically and environmentally efficient manner, to compete with competitors – especially those with substantial state subsidies behind their extraction and manufacturing sectors. While the United States remains a leader in many of these industries and the digital services and technologies enabled by them (such as artificial intelligence, autonomous vehicles and the Internet of Things), its leadership is increasingly challenged by competitors such as China and Russia.

Part and parcel of the challenge has been China's record of exploiting a country's own natural resources, or gaining control of resources in other countries, needed for advanced industries. China's tactics, encapsulated in its Made in China 2025 and Belt and Road (BRI) programs, include purchasing mining assets from Central Asia to Africa, South America and even Australia.[1] In the first decade of aggressive Chinese state investments to acquire natural resources outside its borders, nearly 50% of its purchases were in energy and 20% in mineral resources.[2]

The COVID-19 pandemic has accelerated some important preexisting trends toward bringing industrial supply chains, including medical products, back to the United States. First, the cut-off of medical supplies, not just from China but from Europe and other allies to some extent, brought the vulnerabilities of relying on outside sourcing into clearer and more immediate focus. 90 countries blocked the exports of medical products during the early months of the pandemic. Second, border closures around the world, even within the European Union, added to the worries about interruptions in supply chains, including for workers and logistics. 70% of the world's points of entry restricted foreign travelers at some point as the pandemic grew.[3] Third, border closures and supply chain interruptions increased tension between nations, especially between the United States and China, which was heavily criticized for its suppression of information at the start of the pandemic. Cooperation between the United States and allies also suffered. Fourth, the economic collapse due to the pandemic response again focused attention on the need to create more domestic jobs, including those in the hard-hit industrial sector. Finally, all of these developments led allies such as the United Kingdom, Japan and the European Union to reinvigorate thinking, and create new policy proposals meant to bring production back to home territories. Clearly, these trends support policies to increase the resiliency of domestic production even beyond the parameters of defense and medical security.

This report will concentrate on select examples of the growing US vulnerability to global competitors due to shortages of key mineral resources in our domestic supply base. Dependence on China for raw materials and competition with its manufacturing firms is also a key focus. Shortages do not always indicate a problem because our close allies in mineral-rich countries like Australia and Canada can mitigate gaps in domestic supply. However, China's growing control over many basic materials, and its history of using that control as leverage for its own economic and political goals, makes this a cause of concern for the continued strength of the US manufacturing economy.

Impacts of Mineral Shortages on US Manufacturing

Traditional Industries

It is worthwhile to note at the outset the most recent example of US strength in natural resources, and how the combination of new extraction technologies with these resources has led to stellar growth in manufacturing. The US chemicals industry, a nearly $800 billion per year giant, has greatly benefited from new drilling and mining techniques to become the world's leading producer of natural gas. According to the American Chemistry Council, the recent boom in domestic supplies of natural gas has led to over $200 billion in new capital investment in chemicals production in the United States, much of it by large European and Asian firms.[4] The related plastics industry in turn benefits from increased supplies of basic chemical feedstocks such as ethane at competitive prices. Over 400,000 jobs have been created in the United States by increased production and investment in the chemicals and related industries. The United States is now a large exporter of both natural gas and chemicals.

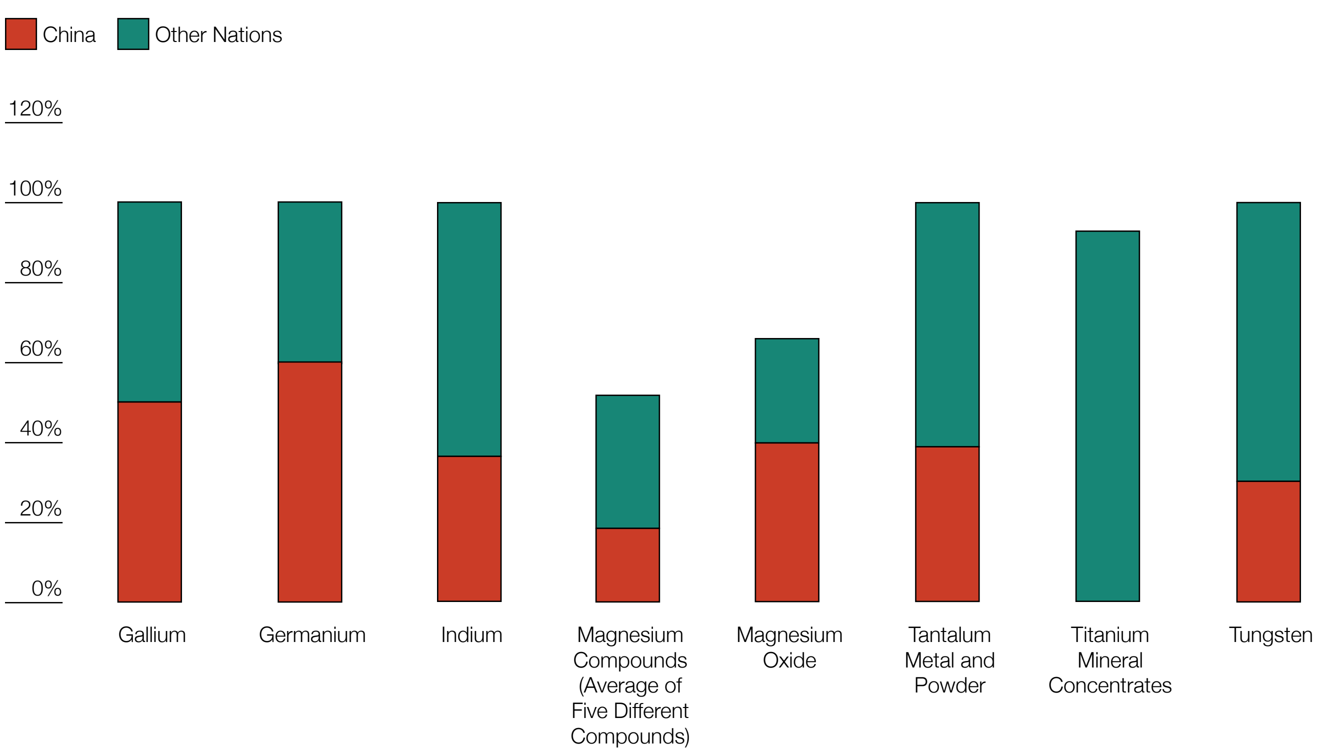
The US automobile industry remains one of the pillars of the manufacturing sector but faces tough competition for the products of the future. Among the many challenges are competitively producing lighter weight and electric vehicles. Meeting carbon emission goals for this sector will require progress in replacing steel parts with lighter materials. A key component of lighter weight vehicles is magnesium. The metal is 70% lighter and stronger than steel. Its use of course is not limited to automobiles. It is important to all transportation equipment, construction materials, cases for laptop computers and cell phones, and batteries. Unfortunately, the United

States produces virtually no raw manganese ore or finished magnesium (see Figure 1).[5]

China is now the world's largest producer and exporter of raw manganese and refined magnesium, which is used in both steel and aluminum alloys. Much of China's access to raw materials results from its ownership of mines in Africa. While China produces over 80% of this vital mineral, the United States is highly dependent on foreign sources for manganese and magnesium metal. There are many other sources for magnesium compounds and metals, such as Canada, Australia, Brazil, Israel and Mexico. And although the United States has blocked imports of most finished magnesium from China, much of this originates in China and is reexported to the United States because of its dominance of global production. The Chinese auto industry, spurred by the Made in China 2025 program, prioritizes the production of lighter vehicles and plans to increase the amount of magnesium parts by over 500% in the next decade.[6]

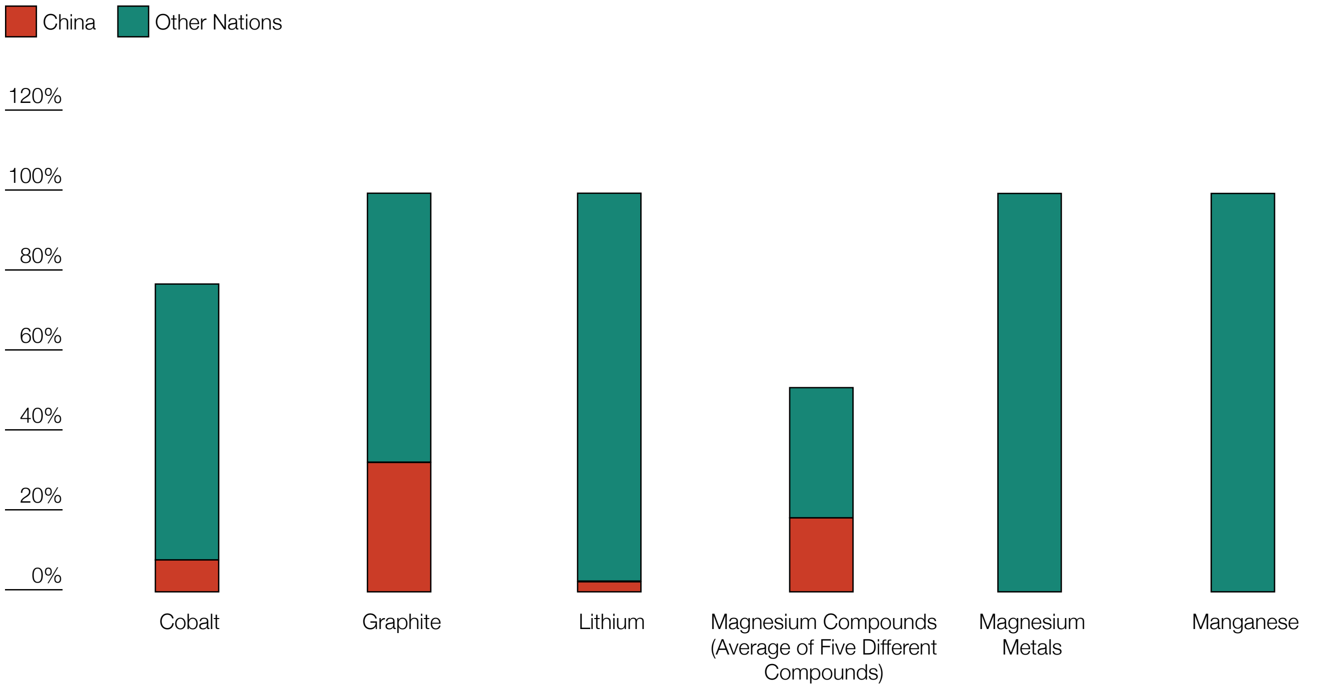
China is also determined to dominate the production of electric vehicles and their key component, advanced lithium-ion batteries. It has systematically acquired mining resources throughout the world for the metals that are used in these batteries (see Figure 2). China has a goal of reaching 80% domestic production of electric vehicles for the Chinese domestic market, the world's largest, by 2025.[7] Lithium-ion batteries are also crucial to electronic products such as

Figure 1: Dependency on China for Major Minerals



Source: US Geological Survey (USGS), Mineral Commodity Summaries, National Minerals Information Center, January 2020.

Figure 2: Import Dependency on Primary Lithium-ion Battery Components



Source: US Geological Survey (USGS), Mineral Commodity Summaries, National Minerals Information Center, January 2020.

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computers and cell phones. China has acquired substantial cobalt, lithium, magnesium oxide and graphite resources in major producing countries. The largest cobalt producer in the world is the Republic of the Congo, where China has bought 8 of the 14 largest mines. It also owns mines in Chile and Australia. The United States is totally dependent on imports, including from China, for these materials. Indeed, as much as 60% of imported magnesium oxide originates in China. A 2018 report from the Wall Street Journal bluntly concludes that "There is a global race to control batteries and China is winning."[8]

Chinese battery manufacturers are not yet as agile and sophisticated as Japanese, Korean, and American firms. Nonetheless, China accounts for 37% of global battery production and 51% of US supply, as of 2019. Moreover, its dominance in raw materials and refining, along with its status as the world's largest producer and consumer of automobiles, cell phones and computers, will likely result in superior economies of scale and a larger market share for advanced batteries in the future.[9] China also has plans to increase battery production from its current level of 110 Gigawatt hours (GWh) to 260 GWh in the next few years, often with massive government subsidies. By comparison, Tesla's "Gigafactory" in Nevada hopes to achieve annual production of 35GWh this year.[10] China has also captured 69% of the global market for recycling lithium-ion batteries.[11]

China's capture of fundamental raw materials for automobiles and battery production is a major threat to auto manufacturers in the United States, Europe, and East Asia. The challenge is especially important because it has proven to be an unreliable supplier to foreign firms. China's control of battery production, if it continues to expand, will also make any return of advanced electronics production to the United States difficult. But there are other challenges for the high technology industries where the United States is now the world leader.

Advanced Technology Industries

It is well known that China has been the major force in the production of so-called rare earths and the metals derived from them, partly because of its lower standards for environmental protection than in the United States and other advanced countries. The US government, led by the Department of Defense (DoD), is supporting efforts to reenter the rare earths business because of the importance of these materials in high technology products such as cruise missile guidance systems, night vision devices, and other defense-related electronics.

Additionally, rare earths are a vital component to the huge and growing semiconductor industry. The United States is a leader in this field whose applications range from computers and cell phones to cloud computing. It is worth noting that modern transportation vehicles are increasingly reliant on advanced electronics. Semiconductors also are the heart of computing and communications products that facilitate leading edge manufactured products such as autonomous vehicles and electric (rather than hydraulic) internal control systems for commercial airliners.

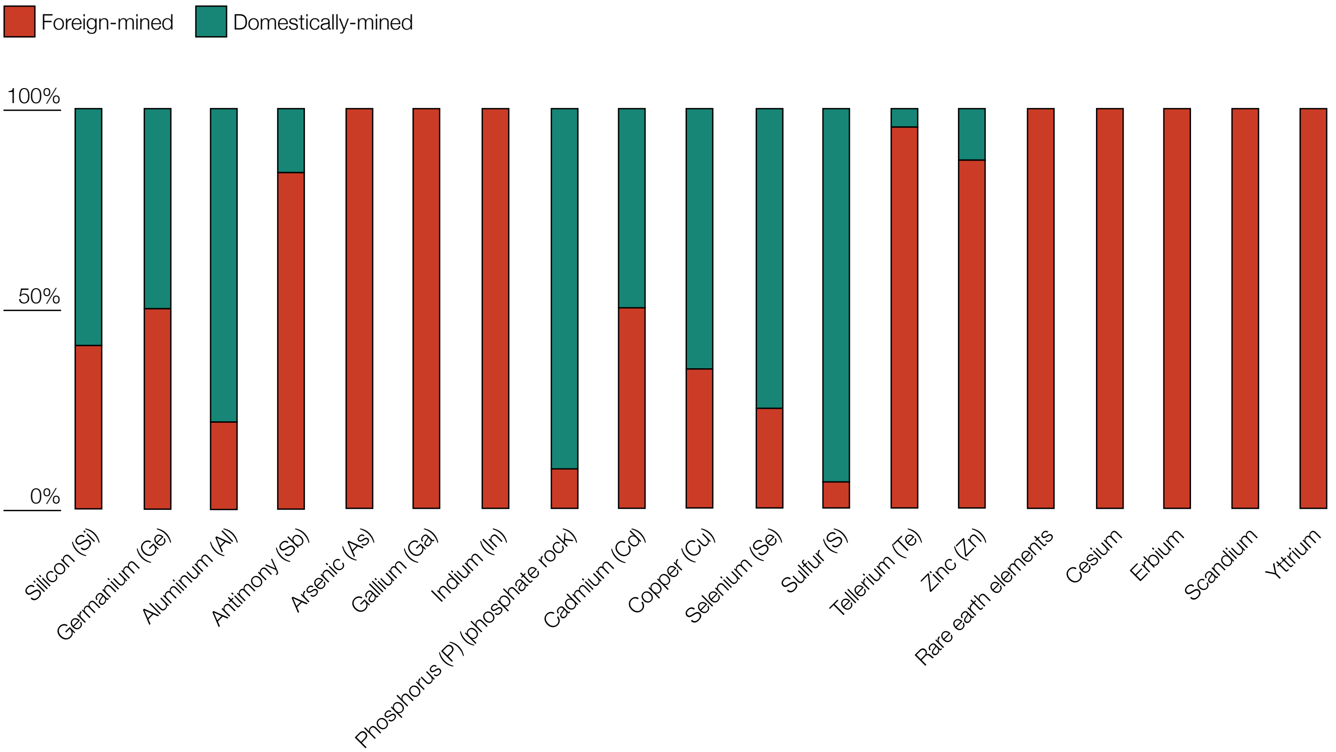
Gallium is not a rare earth but is a fundamental component of high-performance semiconductors which are used in defense and mobile phone applications. Again, the United States has virtually no domestic sources for gallium and relies on China for some 50% of its supplies (see Figure 1). China accounts for around 80% of global capacity for gallium, according to US Geological Survey data. The metal is also important to Light Emitting Devices (LEDs) and fiber optic systems. Worldwide consumption of gallium arsenide chips is expected to grow from $4 billion in 2018 to $22 billion in 2026.[12]

Other metals important to semiconductor production and for which the United States possess little or no domestic supply and depends on China for much of its imports include tantalum (39% of imports from China), tungsten (31% from China), and indium (36% from China). China currently accounts for about 85% of global production of rare earths and around 80% (more in some recent years) of US imports of these metals.[13] Other important elements of semiconductor production include selenium and tellurium (see Figure 3). The estimated size of the global advanced semiconductor market is around $500 billion.[14]

It is hard to exaggerate the importance of semiconductors to the US economy.[15] Although 55% of the actual physical production of US-designed semiconductors is done outside of the country, most leading edge designs originate in domestic firms such as Intel, NVIDIA, Texas Instruments, Micron Technology, and AMD. Some US firms such as Qualcomm, a leading designer of advanced chips used in cell phones and other communication equipment, contract most of their designs to fabricators such as Taiwan Semiconductor Manufacturing Corporation (TSMC). US firms represent 47% of world production of semiconductors and maintain a large trade surplus in these products, despite producing many of them abroad. They exported more than $45 billion worth of products in 2019 and maintain a large trade surplus. The US industry devotes around 20% of revenues to research and development to maintain its technological lead over competitors in China, Japan, Taiwan, Korea and Europe. This spring TSMC, the world's largest fabricator, announced it will build a new $12 billion facility in Arizona.[16]

If the United States wants to expand its lead in semiconductors and its domestic production footprint, it would benefit from having a greater capacity to produce the rare earths and other minerals listed in Figure 3 that form the basis of advanced electronic circuits. As noted earlier, the large and growing computer and telecommunications sectors depend

Figure 3: US Dependence on Imports for Major Metal Components of Semiconductors



Source: Christiana Honsberg & Stuart Bowden, "Semiconductor Materials," PVeducation, 2019; US Geological Survey (USGS), *Mineral Commodity Summaries*, National Minerals Information Center, January 2020.

on advanced semiconductors. The US electronics industry requires a more reliable resource base to maintain, and preferably expand, is manufacturing footprint.

Two other high technology sectors also require many of the same materials as the semiconductor industry. Although challenged by subsidized Chinese competitors, US solar photovoltaic manufacturers are leaders in this growing field that is critical to meeting commitments for reduction of greenhouse gases. First Solar, the largest US player in the market, uses a "thin film" technology with an electronic core of cadmium and tellurium compounds.[17] While US suppliers produce about 50% of the cadmium required for its products, they must import almost all of the tellurium. China supplies over 90% of annual US consumption of this rare earth.

The fiber optic cable and laser industries also depend on rare earths, including erbium, ytterbium, neodymium, thulium and holmium. The first three are the most widely used.[18] Tungsten, titanium and zirconium are also integral components of fiber optic systems, the backbone of the digital transmission network.[19] Lasers are a key part of these systems, ensuring the generation and amplification for long-distance transmission of light impulses carrying data, and they utilize many scarce raw materials. China is the major source of the most important rare earth metals for fiber optic systems, as well as a significant source of tungsten and titanium. The United States does not produce any raw tungsten and relies on China for 31% of supply. This metal is also important for metalworking and oil and gas drilling equipment. The United States also has minimal amounts of domestic titanium, producing only about 9% of consumption, although most supplies originate in Japan.

Chinese telecommunication giant Huawei is a major competitor in fiber optic cable systems.[20] Given the importance of these systems as the backbone of modern digital communications, it is essential for US fiber optic and laser industries to maintain leadership and market share in these technologies. Access to scarce raw materials is crucial. Lasers are also extremely important, and becoming even more so, for national defense applications.

US Strategy Ideas for Key Minerals Used in Advanced Manufacturing

The Trump administration has already begun to address the underlying problem of import dependence for critical minerals. A 2017 presidential executive order on "critical materials" charged the executive branch with developing a comprehensive strategy to reduce dependencies. In May 2018, the Department of the Interior issued a list of 35 critical minerals, which includes all the major minerals highlighted in this report. DoD has also been active in defining mineral resources needed for national defense and has built stockpiles of many of the most important of these. These efforts are a starting point and deserve Congressional support. This is particularly important in terms of budgetary support and clear legislative authorization for minerals used in commercial applications not covered by DoD priorities. The bipartisan "American Mineral Security Act," S. 1317, is an excellent start to accomplishing this national priority.[21] This important bipartisan legislation promotes research in processing technology, recycling, and development of the appropriate workforce for the mining and processing industries.

In view of the importance of the critical materials to the highly productive and innovative manufacturing sector, and of the goal to consolidate production and supply chains in the United States (or at least away from unreliable and subsidized Chinese sources) other ideas ought to be considered by the Congress. Senator Cruz has proposed tax incentives for onshore investment in rare earth mines, and for a 200% deduction for purchases of domestically produced rare earth metals.[22] His bill also requires DoD to source all purchases of rare earths from US suppliers. Furthermore, Professor Willi Shih of the Harvard Business School outlines a policy of broad "demand side" stimulus from federal purchasing power for critical industries, as well as methods to allow "pre-competitive research consortia" to promote public-private collaboration in developing new technologies.[23] These ideas could be applied to the mineral resources and processing industries.

DoD recently awarded, then shortly thereafter suspended, two contracts for seed funding for rare earth processing in the United States.[24] Opposition in the Congress to the Australian awardee, Lynas, was based on debate about whether to use US government funding for minerals from a foreign source.[25] Questions about a minor Chinese stake in the California-based awardee, MP Materials, was behind the freezing of the second contract. These concerns are appropriate for Congress to debate but do not seem insurmountable. Overall, the underlying idea of supporting new process-manufacturing technology is sound, as is using federal resources for incentivizing demand for domestic production. Using federal purchasing power to stimulate the demand side is appropriate for other critical materials.

On the larger question of reliable supplies of critical materials, US strategy ought to include coordination with the "Five Eyes" intelligence sharing group.[26] Its members are historically our most consistent allies, and share both a common economic philosophy as well as a willingness to push back on growing Chinese influence. They can be trusted to be part of critical supply chains, as suggested by London's Henry Jackson Society. Fortunately, members of this group—Canada, Australia, United Kingdom and New Zealand—are significant producers of the minerals, metals, and manufactured goods needed for defense and advanced technology leadership. Some analysts, including the Henry Jackson Society, have also supported the idea of eventually bringing Japan into the Five Eyes.

If the United States is to reinvigorate mining, recovery, and processing of critical minerals, it will require a new look at how these industries are regulated. Competing with China and its growing natural resources network in developing countries means either incentivizing production by lowering well-known regulatory barriers or simply deciding to pay more for the critical resources, either through use of public funds or by imposing more costs on the users of these materials.[27] One idea for consideration is placing a time limit, perhaps three years, on completing necessary environmental and land use permitting.

US trade policy represents another basket of tools to reduce import dependency due to unfair trade practices or to meet national security requirements.[28] Actions to increase tariffs on China and reduce its ability to buy strategic assets have already reduced the ability of China to use its economies of scale to climb the technology ladder in manufacturing. Other related tools, but ones not widely recognized, are the antidumping and countervailing duty laws. These are the most widely used trade actions in the US arsenal, and are partially effective in blocking subsidized products. Magnesium metal imports are just one target among the hundreds of actions directed against China.[29] US trade policy should also be coordinated with close allies and partners, not only the Five Eyes group but with Europe, Japan, Korea, Taiwan and, hopefully, India.[30] China is simply too large an economy, with growing political reach, for the United States acting alone to influence decisively. The World Trade Organization could be helpful in curbing China's mercantilist policies of subsidization and theft of intellectual property, but it requires significant reform before it can be effective in doing so.[31]

This memo is adapted from testimony given by Dr. Thomas Duesterberg before the US Senate Committee on Energy and Natural Resources on June 24, titled "The Impact of COVID-19 on Mineral Supply Chains, the Role of those Supply Chains in Economic and National Security, and Challenges and Opportunities to Rebuild America's Supply Chains"

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