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MAJ Tyson E. Erdmann

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14. ABSTRACT
The world is undergoing a massive energy transition to mitigate escalating environmental destruction caused by carbon emissions from fossil fuels. The crucial resource necessary to develop these new energy forms are rare earth metals. Rare earth metals contain properties that are essential to clean energy as well as national defense technology, such as fighter jets, precision guided missiles, aircraft engines, control rods in nuclear reactors, and other applications. Countries that can harness rare earth production will lead the world in clean energy and technology into the next half century. With this energy transition emerges the growing concern that China currently has control of up to 90% percent of the world's rare earth elements and critical metals supply chain. As Beijing emerges as a growing U.S. National Security concern, the U.S. defense industry's reliance on rare earth mining, processing, and manufacturing from China exposes a significant vulnerability. This paper argues that the U.S. should strengthen its national defense by securing its rare earth supply chain, expanding the United States' domestic mining and production, and continuing to diversify the remaining sources amongst the United States' most reliable and capable allies.

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Diversifying the U.S. Rare Earth Element Resource Base is Vital to National Security

The world is undergoing a massive energy transition in order to mitigate escalating environmental destruction caused by carbon emissions from fossil fuels.[i] Each country has individual methods and goals in achieving this, but the majority have embraced this commitment, as evidenced by the United Nation's Paris Accords signed by an overwhelming 196 Parties, including the United States, pledging toward becoming carbon-free by mid-century.[ii] This means that oil and gas is being replaced with alternative energy sources including battery powered electric vehicles and wind turbines. The crucial resource necessary to develop and sustain these new energy forms are rare earth metals.[iii] These rare earth metals are also vital for emerging technology, including cellphones and computers, for both commercial and national defense applications. Countries that can harness rare earth production will lead the world in clean energy and technology into the next half century.

Rare metals consist of approximately thirty raw materials that include Cobalt, tungsten, indium, gallium, and rare earth elements, a term that includes a subset of seventeen metals including samarium, europium, and neodymium, Cerium, Yttrium, terbium, europium, gadolinium, praseodymium, lanthanum, dysprosium, holmium, erbium, thulium, ytterbium, lutetium and scandium.[iv] These materials contain properties that are essential to building an assortment of products that are vital not only for clean energy technology, but also for national defense, such as fighter jets, precision guided missiles, aircraft engines, control rods in nuclear reactors, and other applications.[v]

The United States' greatest adversary, China, currently has control of up to 90% percent of the world's rare earth elements and critical metals supply chain.[vi] Initially specializing in extraction and processing of rare earths, China gradually expanded its global role to include

assembling components and integrating them into systems,[vii] eventually accumulating a monopoly on the global market. Of the small portion that the United States recently began mining domestically, 100% of the heavy rare earth elements are shipped to China for refinement.[viii] China has become unwilling to export its mining products to outside manufacturers to be processed, dictating that processing be done in China.[ix] Chinese control has rendered the United States and its western allies reliant on China for these extremely critical raw materials and the products that require them. In fact, the United States Department of Defense and its defense industrial base (DIB) is completely reliant on China as a source of rare earth elements and derivative products essential to manufacturing critical national defense materiel and equipment, including the F-35 fighter jets and Precision Guided Missiles.[x]

At the same time, Beijing has become a growing United States national security concern in the Pacific.[xi] China has demonstrated aggression in the South and East China Seas highlighted in 2010, when it imposed a rare earth element embargo against Japan and the United States.[xii] This demonstrated its willingness to use its monopoly as leverage when its interests conflict with the United States.[xiii] Reducing some, but not all, of China's control over this critical supply chain will serve to maintain tightly-nested United States-China trade relations, while simultaneously reducing China's ability to abuse its dominance in this critical sector.

The United States should strive to strengthen its national defense by securing its rare earth supply chain. Toward this end, the United States should draw a maximum of 50% from China, expand the U.S. domestic mining and production up to 20% of the United States' total domestic consumption which should include 100% of the United States' defense needs independent of China's market control, and continue to diversify the remaining 30% of sources

amongst the United States' most reliable and capable allies starting with Canada, Australia, and India.

The United States Must Secure Its Rare Earth Metals Resource Base

A series of events have gradually led to the United States' heightened awareness of its general supply chain vulnerability to China. In 2010 the Department of Defense took note of a very specific supply chain threat when China banned rare earth exports to Japan in response to their detaining a Chinese ship captain found fishing off the Senkaku islands in disputed Japanese controlled waters.[xiv] Japan, like the United States was completely reliant on China for their various rare earth needs including guided missile production and other important Japanese defense needs.[xv] The Senkaku Island crisis demonstrated how vulnerable this defense critical supply chain really was to Chinese manipulation. China abused its monopoly over these vital materials in order to coerce Japan to release China's fisherman, allowing China to demonstrate power in the region. Most recently, the COVID-19 Pandemic brought with it several supply disruptions and bottlenecks, highlighting the United States' reliance on China for personal protective equipment (PPE) and other important materials.[xvi] COVID-19 brought United States government-wide attention to its supply chain vulnerabilities which resulted in a much-needed review of the problem. Japan is a key ally of the United States and if this supply chain vulnerability persists, China may be inclined to abuse its superior position again potentially targeting the United States directly next time.

In 2019, China made threats suggesting it would use rare earth exports to posture up in the trade war with the United States and as recently as 2020 China's ministry of Industry and Information Technology drafted potential controls over rare earths production and export

pertaining to United States' defense companies including Lockheed Martin, Raytheon, and Boeing based on their provision of arms to Taiwan.[xvii] Although these controls have not been approved by Beijing as of yet, this demonstrates that such sentiments are being expressed at high levels within the Chinese government and therefore the possibility of such an action is not unrealistic. The possibility that China is capable of taking such measures weakens the United States foreign policy in the Pacific since Japan, South Korea, and other key allies are observing the Taiwan situation in order to gauge United States strength and will in the region. If China proves it can coerce the United States into decreasing arms exports to Taiwan, then Taiwan's resolve to resist China's diplomatic or military agenda will be stifled for fear of an inevitable long-term defeat.

Rare Earths are Critical for National Defense Applications

Major indicators of United States defense sector vulnerabilities resulting from domestic rare earths scarcity can be seen as early as 2012, when the Obama administration found itself seeking exception to the still existing United States' law prohibiting importing specific metals for national weapon system applications.[xviii] Rare Earths are essential in order to produce the latest versions of the assorted Lockheed Martin F-35 fighter jets,[xix] which will play a significant role in the United States' defense preparation for strategic competition with China.[xx] The Fiscal Year 2023 Senate Appropriations Bill makes a robust $1.8 Billion investment in the F-35 program bringing the total aircraft count to 19 with additional spare engines.[xxi] The laws that prohibit importing specific metals for building United States weapons are in place to avoid foreign dependency. For a strategic weapon system such as the F-35 program, any reliance on the very adversary, in this case China, against which the United States is preparing for potential

conflict is counterproductive. When it comes to vital interests like national security the United States should aim to achieve, to the utmost of its capacity, complete independence in the supply chain for the critical rare earths required.

In addition to the F-35 Fighter Jets, rare earths are integral for multiple other important defense applications including munitions, such as the Javelin and the JDAM[xxii] which the United States relied on for precision strikes against its enemies over the course of the Global War on Terror. Rare earths are a key component of the rangefinders used in United States tanks, sonar systems on Navy vessels, and the control vanes for smart bombs.[xxiii] Satellites, coatings for jet engines, antimissile defense systems and communication systems also rely on rare earth composites.[xxiv]

China demonstrated its capability and willingness to embargo rare earth metals to the United States once, in 2010, when its interests conflicted with the United State's and Japan's over the disagreement in the Senkaku Islands.[xxv] Without a rapid diversification of the rare earth supply chain, the United States will remain at the mercy of China's interests when it relates to these strategic weapons productions such as the F-35 and PGMs.

The United States must increase its domestic capacity in each level of the supply chain.

The United States reestablished domestic mining of rare earths and minerals in 2018 at its only production mine, owned by a private corporation named MP Materials, and located in Mountain Pass, CA. Despite this domestic production, the United States relied 100% on imported rare earths for its consumption requirements during 2017-2020, until beginning to show small progress with a 90% reliance on imports in 2021.[xxvi] The United States must continue to invest heavily in this already existing domestic production capability to continue this progress.

This single domestic mining plant alone will not be enough to reach the United States' goals, but it is the best it can do under the given circumstances. Further pursuit of minable rare earth deposits will be required and are in progress but decisive moves to begin permitting and establishing these mines cannot happen quickly enough if the United States is serious about achieving a carbon-free environment by 2050 without it being completely dependent on China to do so.

China's roots in the rare earth metal industry are deep and penetrate various levels. For example, Shenghe resources, which is partially owned and run by the Chinese government and is arguably the largest rare earth production companies world-wide, has also branched into buying significant shares of western producers such as 8% ownership of the United States' sole producer, MP Materials, and 12.5% in the Australian company called Greenland Minerals. Shenghe has been in the industry for several decades accumulating networks, patents, and accomplishments in research and development (R&D). It takes a mine and processing center at least 13 years from the initial building of the plant to the point of production.[xxvii] The United States capitalized on the fact that the Mountain Pass mine was already built and it should maximize its capacity to avoid further lag time in domestic production but more mines will need to be built. The United States should look first to Alaska to build another mine and processing center based on confirmed highly prospective deposits of rare earth elements.[xxviii]

Reducing imports by 10% can be considered progress; however, China also controls nearly 90% of the world's rare earth processing capacity.[xxix] This means that even with domestic production increasing slowly, China has the ability to disrupt the United States' supply chain at the processing level, as it did to Japan in 2010.[xxx] Strengthening the United States supply chain must be comprehensive and cannot leave a potential weakness for Chinese exploitation anywhere

from production to processing and separating to assembling end products. The United States rare earth supply chain is only as strong as its weakest link. It should invest an additional $1.8BIL into developing mining and processing capability in the homeland. Investing this amount now to create new mines is a fraction of the cost that the United States could suffer in losses and negative security implications down the road if it does not.

The United States Must Secure its Rare Earths Resource Base by Diversifying Its Sources

The United States has expressly identified that securing resilient supply chains is essential to achieve success in national security.[xxxi] This principle of maintaining a secure resource base and supply chain is not unique to the United States, nor is it a new concept. The Department of Defense has consistently pointed out that defense industry reliance on non-domestic and competitor-country suppliers breeds vulnerability.[xxxii] The United States has recognized that it must both encourage and invest in its allies and partners when it comes to securing a diverse and resilient supply chain for rare earth elements.[xxxiii] The European Union's Internal Market Commissioner also recently stated, in September 2022, that "Lithium and rare earths will soon be more important than oil and gas…[and] we must avoid becoming dependent again, as we did with oil and gas."[xxxiv]

As tensions increase with China, who arguably controls the world's future energy source, the United States should continue to invest in credible countries who have current capacity for production as well as invest in countries where promising deposits of rare earths have been discovered and verified in concentrations conducive to mining. These countries that already have existing production capacity, such as Australia[xxxv] and India, should serve as a place to invest in a mid-term production increase, whereas the countries with newly discovered deposits, such as

Canada[xxxvi] and Sweden,[xxxvii] should serve as a long-term and final solution to this rare earth mining scarcity. This must be addressed for both the mid and long-term solution in order to prevent China from capitalizing on gaps over time within the United States supply chain as it reaches its goal of a resilient supply chain. Due to the current scramble for mining deposits and opportunities, the United States must continue to keep a close watch on opportunities to invest in credible countries as research confirms viable deposits.

With China so deeply imbedded into the United States rare earth supply chain it is unrealistic and counterproductive to attempt to cut China out completely since doing so would also cause negative impacts in China's economy resulting in resentment toward the United States and potentially a rise in rare earth prices in the near term before any significant domestic production has been able to come to fruition.

Domestic Mining and Processing Will Be Ineffective Due to Negative Environmental Impacts And The Higher Costs Associated With Compliance

Critics will argue that bringing a significant proportion of the rare earth mining, extraction, and processing back into the United States is bound to fail for several reasons. First, extracting and processing the raw material into useable metals is environmentally destructive, and human health risks are higher than the American tolerance threshold. Second, the cost of compliance with domestic mining and environmental laws would price the United States product out of global market competition.

Rare earths are required to produce so-called clean energy technologies, including wind turbines and electric vehicles,[xxxviii] but mining, purification, and disposal of rare earths causes significant negative environmental impacts.[xxxix] The environmental impact of rare earth mining is

caused by the dust and exhaust emissions from equipment and facilities, and toxic ponds created from the waste affect soil and groundwater quality and leave behind radioactive waste after processing.[xl] Furthermore, rare earth mining and processing can implicate human rights issues, including safe working conditions and fairly paid labor at mines and plants.[xli] Effective management of the environmental and human impacts can, however, significantly raise production costs, and ultimately price compliant mining and processing operations out of the rare earth market. The United States has stated its intent to address these concerns but more investment is needed as the domestic mining and processing increases.

China presents examples of costs associated with the environmental impact of unregulated mining as well as the costs associated with environmental compliance. For example, the largest single quantity of contaminated water in China is located in Baotou, polluted by rare earth purification from the mines in Bayan Obo.[xlii] This tailings "pond" contains toxic chemicals and radioactive elements[xliii] that have devastated plant and animal life and caused cancer and other diseases in nearby residents, ultimately devastating the local economy.[xliv] At another mining site in Ganzhou City that produces 9 percent of national extractions, the Chinese government has estimated $5.5 billion in cleanup costs.[xlv] China's level of tolerance for such horrific results has historically been higher than the United States, as evidenced by the immediate shut-down of the Mountain Pass Mine in 2002 when toxic waste was discovered leaking into the ground.

In the last five years, the Chinese Government has begun to address these environmental impacts though regulations aimed at reducing the discharge of pollutants from mining and refining.[xlvi] The Chinese discovered, however, that such regulation caused increased production costs. The government attempted to recoup those costs through taxes and duties, which were

ultimately struck down by the World Trade Organization in 2012 as "not justified under the exception of conservation of exhaustible natural resources," or "necessary for the protection of human, animal or plant life, or health."[xlvii] The WTO ruling led to a significant volatility in rare earth element pricing, reduced Chinese exports, and caused bankruptcy in multiple rare earth companies. To curb the marginal costs of environmental regulation and increase government control over mining and processing, the Chinese government has begun to nationalize and consolidate the rare earth industry.[xlviii] This Chinese governmental approach gives their government greater control over prices, exports, and regulation; however, this option is not as easily accepted by the U.S. government. Instead the United States should seek to accomplish the same goal by offering early investments, grants, and subsidies to companies in the industry.

The United States made the decision decades ago that the rare earth mining industry created an undesired amount of pollution, resulting in increased offshore production which gradually led to the supply chain problem of today. In the United States, a number of federal statutes and regulations control mining in the United States, including the National Environmental Policy Act (NEPA), the Clean Air act (CAA), the Clean Water Act (CWA), the Toxic Substances Control Act (TSCA), the Comprehensive Environmental Response, Compensation and Liability Act, and the Resource Conservation and Recovery Act (RCRA).[xlix] Nonetheless, rare earth mining in the U.S. at the Mountain Pass Mine in California leaked wastewater into the surrounding desert floor in the 1980s and 90s, leading to expensive fines and settlement costs and, ultimately, its closure in 2002.[l] When the mine reopened in 2017, the new management implemented stricter wastewater management and monitoring systems[li] at an estimated cost of nearly 2.4 million per year.[lii] The United States will have to suffer a financial hit by investing heavily in domestic mining, extraction and processing.

Despite the high associated costs, increased domestic extraction and processing is the best course of action because it shifts control back to the United States' over its own supply chain. The financial costs will be high initially until domestic firms are able to profit independent of government investment. The United States will become more self-reliant and less dependent on global market volatility caused by China's geopolitical conflicts with the United States and its allies. Ultimately, the national security benefits outweigh the initial costs, which can be mitigated in the near term through methods such as recycling and reuse of materials. Already, in recent years, U.S. Federal Agencies have taken actions to incentivize recycling and reuse of rare earths through task groups,[liii] grants[liv] and other programs. The White House included recycling and reprocessing as a means to creating greater domestic production and stockpiles of rare earths in its 2021 Execute Order on America's Supply Chains.[lv] At this time, recycling and reuse, by themselves, likely would fail to produce a sufficient amount of material to affect China's hold on the rare earth market. However, when combined with the recommended increased domestic production and additional sourcing from United States' allies, recycling and reuse could be an effective contribution toward off-setting China's current hold. With time, clean and environmentally responsible mining and processing will be a marketable trait in and of itself as the world transitions to primarily consuming this clean energy. It is worth paying the costs for strict adherence up front rather than experience setbacks later for taking shortcuts resulting in production shut-downs, cleanup costs, and liability for damages to human health and property.

Conclusion

The United States has recognized that rare earths are vital to its national defense and that China has imbedded itself deep into the world's corresponding supply chain. The Biden

administration and the Department of Defense have led aggressive measures to assess this vulnerability; however, it is the decisions that lay ahead, such as how much to invest and how aggressively to push domestic rare earth processing, that will determine the fate of who will control and influence the world's future energy supply. More imminently, the United States must carve out its own capability to meet its national defense requirements, completely independent of China, to avoid Chinese coercion, however subtle. The United States is decades behind China in this critical field and the time to act is now by doubling down on domestic investments in mines and processing plants and with allies as well as incorporating stockpiling and recycling to demonstrate and encourage environmental responsibility. In the very near term the United States must continue cooperation with China, taking advantage of fair pricing of imports, while simultaneously increasing its stockpiles with any surplus imports and all of the domestic production until there is a 5 years supply that can serve to bridge a gap in the case of an unfortunate conflict of interest with China that results in unfair prices or a Chinese embargo.

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