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House Committee on Natural Resources

Subcommittee on Energy and Mineral Resources

"Examining the Methodology and Structure of the U.S. Geological Survey's Critical Minerals List"

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I. Introduction

Chairman Stauber, Ranking Member Ocasio Cortez, and distinguished members of the Subcommittee, thank you for the invitation to appear before you today.

My name is Reed Blakemore, and I am the Director of Research and Programs at the Atlantic Council's Global Energy Center.

The Atlantic Council is a non-partisan, non-profit policy organization headquartered in Washington, DC. Our work at the Global Energy Center develops and promotes pragmatic and nonpartisan policy solutions designed to advance global energy security, enhance economic opportunity, and accelerate pathways to net-zero emissions. Critical minerals and materials is one of the core pillars of our work.

Before I begin, I should note that my remarks and written testimony represent my observations, and do not necessarily represent the views of my colleagues or institution.

This hearing focuses on the methodology and structure of the USGS Critical Minerals List. However, I would like to provide a broad overview on our understanding of what makes a mineral "critical" and how the United States can best prepare to act on the vulnerabilities inherent in a world of diverse mineral demands.

The distinction of a mineral or material as 'critical' ascribes that a mineral should be treated with additional concern, intended to inform the strategic thinking of policymakers with respect to domestic mining legislation, public investments, trade policy, development policy, and more. It can also signify a need for action from policymakers and government officials, whether that is an addition of a material to the National Defense Stockpile, the DOE Loan Programs Office making an investment in a processing plant at home, or Development Finance Corporation investing in a project abroad.

Yet what determines criticality is ultimately in the eye of the beholder. Minerals that are critical to one industry or policy objective may not be essential for another, and the minerals that are critical for the United States may not be so for another nation. As such, continued reflection on what is 'critical' and how one plans to address that criticality is essential in a minerals and materials-intense world, and I commend this committee for their efforts in this regard. My esteemed co-panelists will explain in detail the methodology of critical minerals list-making and the implications for minerals that are placed on that list. However, I would like to begin with a top-level overview of what factors, generally-speaking, influence the determination of what makes certain minerals or materials fall into this category.

II. Why are certain minerals and materials 'critical'

A suite of core minerals and materials are fundamental pieces of the structure of our economy and national security. While the importance of certain metal commodities to the United States' national economic health is well-understood, a small number of niche, supply-constrained minerals are equally-as important to industries such as pharmaceuticals and semiconductors. Access to these minerals is key/essential to limiting inflation and maximizing economies of scale, making them central to prosperity at home and economic leadership abroad.

Defense needs also entail demand for certain materials that have been deemed critical, such as gallium, ferromanganese, antimony, lithium, nickel, and many others. Every SSN-774 Virginia-class submarine requires about 9,200 pounds (half the weight of a school bus) of rare earth elements, while F-35 Lightning II aircraft require roughly 920 pounds.[1] Cobalt is an important component of permanent magnets which are used in energy technologies, but also military technologies such as smart bombs, aircraft, and guided missiles.[2]

The security of supply of these minerals, therefore, has been strategically relevant to the United States for some time and will continue to be so.

Now, the mineral and material requirements of the energy sector demands equal attention, especially as the energy transition changes the structural makeup of the global economy.

Much of this demand is policy driven. Electrifying large swaths of the economy necessarily implies the use of a significant number of materials that can carry that electricity. Furthermore, renewable energy generation technologies require a large quantity of durable materials, as opposed to our present energy system, which relies on consumable fossil fuels.

Over time, our energy generation, storage, and transmission technologies will become increasingly dependent on materials such as copper, nickel, manganese, graphite, lithium, cobalt, and many others. Since the passage of the Inflation Reduction Act, forecasts of demand in 2035 for lithium have increased by 15 percent, and nickel by 13 percent.[3] The United States' total combined energy technolgy-related demand for lithium, nickel and cobalt will be 23 times higher in 2035 than it was in 2021.[4]

Similar trends around the world amplify the importance of these minerals to the global economy. Globally, policies to decrease greenhouse gas emissions by 2050 are accelerating. A higher reliance on critical minerals is already being observed as a result – since 2010, the average amount of minerals needed for a new unit of power generation capacity has increased by 50 percent as the share of renewables in new investment has risen.[5] Some minerals such as lithium, copper, graphite and nickel may see a 40-fold

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[1] Runde, Daniel F., and Austin Hardman. "Elevating the Role of Critical Minerals for Development and Security." CSIS, September 1, 2023. https://www.csis.org/analysis/elevating-role-critical-minerals-development-and-security#:~:text=Critical%20minerals%20are%20also%20characterized,the%20economy%20or%20national%20security.%E2%80%9D.

[2] Ibid.

[3] "United States Faces New Challenges Meeting Increased Demand for Critical Minerals One Year after Historic Inflation Reduction Act, S&P Global Study Finds." News Release Archive. Accessed September 11, 2023. https://press.spglobal.com/2023-08-15-United-States-Faces-New-Challenges-Meeting-Increased-Demand-for-Critical-Minerals-One-Year-After-Historic-Inflation-Reduction-Act,-S-P-Global-Study-Finds#:~:text=Adding%20the%20post%2DIRA%20demand,than%20it%20was%20in%202021.

[4] Ibid.

[5] International Energy Association. "Executive Summary – the Role of Critical Minerals in Clean Energy Transitions – Analysis." IEA. Accessed September 11, 2023. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary.

increase in demand globally due to their importance in batteries, electric vehicles, semiconductors, transmission lines, and clean electricity generation technologies.[6]

Meanwhile, the steady transformation of a new energy system is opening market opportunities for new clean energy technology exports, with resource security a critical component of the supply chains that will enable leadership in industries new and old.

We have seen this manifest in industrial ambitions for several nations associated with building out mining and processing infrastructure which can meet future demand. For instance, Indonesia is developing polysilicon plants to feed solar panel manufacturing, while also banning unrefined nickel exports, which is necessary for the manufacturing of materials for lithium-ion.[7] Many mineral-rich countries are enacting policies to push investment towards downstream 'value-added' economic activities so they can more effectively control their supply chains during the global transition and capture the windfall that will be associated with producing those materials for export. The latter is particularly true for those countries that view critical mineral industries as a development opportunity, such as Zimbabwe and Namibia, which have banned exports of unprocessed lithium ore, to keep more economic activity in their nations.[8]

This drive to capture value from the economic opportunity of the new energy technologies extends down the energy technology value chain.[9] Global EV sales increased from 716,000 vehicles in 2015 to 10.6 million vehicles in 2022.[10] Solar power saw global growth of nearly 200 Gigawatts – equivalent to the grid of Brazil – the most of any form of electricity generation.[11] Growth in areas such as these form the impetus to capture the value stemming from such a dramatic economic transformation.

Clearly, there is an emerging dynamic wherein influence and access across critical mineral supply chains is viewed as a strategic lever. By a similar vein, concentration and geopolitical risk abound in critical mineral supply chains. One country, the Democratic Republic of the Congo, accounts for 70 percent of global cobalt production.[12] Indonesia holds about 22 percent of the world's total nickel reserves, and about 40 percent of

[6] Ibid.

[7] Listiyorini, Eko. "Tropical Indonesia Wants t Start Making a Key Solar Panel Part." Bloomberg.com, January 24, 2022. https://www.bloomberg.com/news/articles/2022-01-25/tropical-indonesia-wants-to-start-making-a-key-solar-panel-part?sref=a9fBmPFG ; International Energy Association. "Prohibition of the Export of Nickel Ore – Policies." IEA, October 31, 2022. https://www.iea.org/policies/16084-prohibition-of-the-export-of-nickel-ore .

[8] Dempsey, Harry, and Joseph Cotterill. "How China Is Winning the Race for Africa's Lithium." Financial Times, April 3, 2023. https://www.ft.com/content/02d6f35d-e646-40f7-894c-ffcc6acd9b25.

[9] Blakemore, R., & Ryan, P. (2023, August 16). One year after the IRA, the hard work to build resilient mineral supply chains is only beginning. *Atlantic Council Global Energy Center*. September 11, 2023, https://www.atlanticcouncil.org/blogs/energysource/one-year-after-the-ira-the-hard-work-to-build-resilient-mineral-supply-chains-is-only-beginning/

[10] Department of Energy. "2023 Critical Materials Assessment - Department of Energy." 2023 U.S. Department of Energy Critical Materials Assessment, July 2023. https://www.energy.gov/sites/default/files/2023-05/2023-critical-materials-assessment.pdf.

[11] International Renewable Energy Agency. "Record Growth in Renewables Achieved despite Energy Crisis." IRENA, March 21, 2023. https://www.irena.org/News/pressreleases/2023/Mar/Record-9-point-6-Percentage-Growth-in-Renewables-Achieved-Despite-Energy-Crisis.

[12] Kelly, Lauren. "Top 10 Cobalt Producers by Country (Updated 2023)." INN, August 19, 2023. https://investingnews.com/where-is-cobalt-mined/.

global nickel output.[13] Roughly 50-60 percent of lithium resources are found in three countries in Latin America (Argentina, Chile, and Bolivia).[14] Many of the countries that produce and process critical minerals are not our preferred trade partners by means of a free trade agreement. By 2035, it is forecast that as much as 90 percent of all nickel products, for instance, will be processed by countries that do not hold a free trade agreement with the United States.[15] China, meanwhile, enjoys significant control across the minerals supply chain through near-monopolistic control of processing for key minerals, and a dominant position in the financing or ownership of upstream mineral resource development.[16]

Taken together, though minerals have long had a significant role in ensuring the prosperity and security of the United States, the makeup of this role is changing dramatically as the mineral requirements underpinning US energy and geo-economic priorities become more diverse and competitive in response to projected changes in energy markets

III. The Characteristics of 'Listmaking' and Increasing Importance of Relative Criticality

As the 'minerals intensity' of the global economy increases, assessing and acting upon possible vulnerabilities or opportunities will be a feature of the strategic landscape. This is why a priority of the US Government across consecutive administrations has been to identify specific minerals that it deems "critical" and therefore focus policy attention on improving access to or the security of those supply chains.

Though 'listing' has been a feature of US policymaking for over a century, these efforts intensified in 2008 with a National Academy of Sciences study, which informed the creation of the first contemporary critical materials list, the DOE's 2010 Critical Materials Strategy. With Executive Order 13818 under the Trump Administration came the direction for the Department of the Interior to publish a critical minerals list – which has now been published in 2018, and updated in 2022. Other countries have been developing Critical Mineral lists modeled after the US lists, including the EU, UK, South Korea, Japan and Australia, but their definitions of "critical" are different and reflect independent strategic priorities.

Yet as policymakers' attention to the possible vulnerabilities of a minerals-intensive world has grown, the scope of these lists has also evolved considerably. The first mineral list, titled War Minerals, was created in 1917 to aid the US WWI effort. It was comprised of only 5 minerals: tin, nickel, platinum, nitrates, and potash. Now, almost every element on the periodic table is used in global manufacturing, and 50 minerals are now on at least one of the three formal lists being produced across the USG.

This suggests that the United States would do well to think through the features of what makes a particular mineral critical, with particular attention to the relative criticality of minerals that are designated to these lists. Doing so will allow the United States to better understand its mineral and material vulnerabilities, communicate those priorities to partners in the marketplace, and more effectively act to secure key supply chains.

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[13] Falak Medina, Ayman. "Unleashing Nickel's Potential: Indonesia's Journey to Global Prominence." ASEAN Business News, June 20, 2023. https://www.aseanbriefing.com/news/unleashing-nickels-potential-indonesias-journey-to-global-prominence/#:~:text=Indonesia's%20nickel%20reserves,22%20percent%20of%20global%20reserves.

[14] Economic Commission for Latin America and the Caribbean. "Lithium Extraction and Industrialization: Opportunities and Challenges for Latin America and the Caribbean." CEPAL, July 2023. https://www.cepal.org/en/publications/48965-lithium-extraction-and-industrialization-opportunities-and-challenges-latin.

[15] Goodman, Peter S, and Ulet Ifansasti. "How Geopolitics Is Complicating the Move to Clean Energy." The New York Times, August 18, 2023. https://www.nytimes.com/2023/08/18/business/indonesia-nickel-china-us.html.

[16] Wilson Center. "Critical Mineral Maps." Wilson Center, March 17, 2022. https://www.wilsoncenter.org/article/critical-mineral-maps .; Wells, Katherine. "China's Monopoly over Critical Minerals." Georgetown Security Studies Review, May 31, 2023. https://georgetownsecuritystudiesreview.org/2023/06/01/chinas-monopoly-over-critical-minerals/ .

Fundamentally, a determination of which minerals are critical is broadly based on dependency on those minerals (demand – or the *impact of supply risk*) and the ability to access them reliably (supply – *or the risk of supply disruption*). Though the relationship between the two is at the core of whether a mineral should be deemed 'critical' or not, there are some independent features of each that provide some necessary color to a mineral's relative criticality.

The risk of not meeting future demand for minerals is not just a function of global geopolitical risks. It is also affected by the economic forces that impact the ability of mineral supply chains to meet future demand, and thus adequately supply the market.

IV. Demand

Assessing mineral demand is mostly an exercise in forecasting. As mentioned above, the accelerating momentum of renewable energy technology deployment has led to a general consensus of demand growth for key minerals for the next several decades. However, particularly for transition minerals and metals, several additional characteristics of demand warrant consideration. These include:

1) **The trendline of demand over time**. The growth in demand for certain materials will be larger at the outset of the energy transition than it will be over a prolonged period of time. Demand for certain minerals required for the buildout of transition infrastructure will grow rapidly in response to the energy transition but may become steadier over time given the long lifecycle of those projects. Certain minerals may offer opportunities for recycling, as technology matures, suggesting that while a large demand signal for mined material will present itself initially, recycling can alleviate demand stress. Either example offers a framing to better understand vulnerability to certain mineral demands *now* vs. those *over time.*

2) **Demand elasticity.** The relative sensitivity of a particular mineral to being replaced by an alternative in response to disruption also helps contextualize how severe certain mineral vulnerabilities are relative to each other. While the unique properties of most minerals limit elasticity on a 1-1 basis, marginal input elasticity for technologies is emerging – for example in battery chemistries where concerns around cobalt resourcing have enabled the development of zero-cobalt or lithium-phosphate chemistries. Additionally, minerals used for EV batteries will not be necessary for batteries used for stationary grid storage, enabling substitution within that end-use.[17]

3) **Transition Technology Criticality (and corresponding elasticity).** Related is the notion that some technologies (and their underlying minerals) will be more or less replaceable in the energy system of the future. For example, while there are few options to replace transmission infrastructure required for expanding the grid, there are a wide range of possibilities as to the scale of the hydrogen economy. Similar principles apply to highly innovation-exposed sectors of the economy and national defense. The potential variation in deployment of certain technologies implies a range in corresponding materials needed for manufacturing – this is observed in the stark variation observed in modelling of future demand for key minerals. [18]

V. Supply

Assessment of available supply to fulfill mineral demand is twofold: an understanding of the resource base both now and in the future, and the vulnerability of the resource base to disruption.

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[17] Blakemore, Reed, Paddy Ryan, and William Tobin. "Alternative Battery Chemistries and Diversifying Clean Energy Supply Chains." Atlantic Council, September 13, 2022. https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/alternative-battery-chemistries-and-diversifying-clean-energy-supply-chains/.

[18] "IEF Critical Minerals Outlooks Comparison." International Energy Forum. Accessed September 11, 2023. https://www.ief.org/focus/ief-reports/critical-minerals-outlooks-comparison.

Our understanding of the resource base continues to mature, and I applaud the efforts of the USGS to continue to improve our knowledge of where certain minerals are available and in what quantities. Nonetheless, the supply picture is increasingly shaped by a number of additional features that bear strongly on relative criticality.

1) **Project Economics & Ore Quality.** Mining project economics are typically defined by the concentration of the desired material that is found in the ore at the mine site – ore being the naturally occurring sediment or brine. However, ore grades for certain materials are declining globally, precisely as we are in need of more. Mines for those metals are being dug deeper at greater expense and environmental impact (due to higher tailings – wastewater and waste rock). This increases prices to obtain the same quantity of the desired material. In Chile, for instance, which has borne the brunt of this problem due to its degrading copper mines, the capital intensity of new mines has ballooned from 4-5,000 dollars per ton of copper, to as much as 44,000 dollars per ton.[19] Many materials also require specialized technologies and processes to adjust extraction to certain ore profiles. This is the case for lithium, where ore bodies can differ drastically, and for nickel, where new technology has been necessary to adjust to the predominating variety of nickel ore.[20]

2) **Project Lifecycle.** Certain mining projects require much more time to bring supply to market than others. This not only varies between minerals, but in some cases from project to project, with a new lithium brine project requiring much less time to come to production than a lithium hard rock project. Challenging lead times induced by regulatory processes such as permitting also make it difficult for new entrants and projects to break into the market. [21] For instance, critical materials projects in the United States such as Pebble copper mine in Alaska, the Twin Metals copper mine in Minnesota, and a titanium mine in Georgia have failed to progress due to this process.[22]

3) **Non-traditional Sourcing.** New sources of supply are increasingly being developed in response to tightening markets. Full-value mining, which uses tailings from existing material processing to retrieve other critical minerals, is emerging as a useful corollary to circular economies of recycling minerals. These non-traditional sources of supply can offer both additional as well as marginal sources of supply, depending on the mineral. Materials R&D also remains vitally important to developing new processes or materials that can reduce supply chain constraints – whether in recycling, or producing critical materials from other forms of waste, such as captured carbon.[23]

Each of these features add necessary color to our understanding of how big the gap between supply and demand for certain minerals may be and what obstacles may shape the manner in which that gap can be filled.

[19] "Copper mines becoming more capital intensive and costly to run" Ahead of the Herd. Accessed September 11, 2023. https://aheadoftheherd.com/copper-mines-becoming-more-capital-intensive-and-costly-to-run/

[20] Tang, J. (2023, April 25). *Infographic: Indonesian projects to boost Nickel Supply*. | S&P Global Commodity Insights. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/042423-infographic-indonesian-projects-to-boost-nickel-supply

[21] Blakemore, R., Ryan, P., & Bell, R. (2022, March 27). The United States, Canada, and the minerals challenge. *Atlantic Council Global Energy Center* . September 11, 2023, https://www.atlanticcouncil.org/in-depth-research-reports/report/the-united-states-canada-and-the-minerals-challenge/

[22] Northey, H., & Holzman, J. (2022, August 15). *Biden wants minerals, but mine permitting lags*. E&E News by POLITICO. https://www.eenews.net/articles/biden-wants-minerals-but-mine-permitting-lags/

[23] Tobin, W. (2022, April 28). The US should leverage 45Q for the graphite supply crunch. *Atlantic Council Global Energy Center*. September 11, 2023, https://www.atlanticcouncil.org/blogs/energysource/the-us-should-leverage-45q-for-the-graphite-supply-crunch/

Supply risk, meanwhile, can manifest in several ways.[24] Though it primarily comes in the form of trade exposure, wherein there is a high degree of import reliance, these risks are complicated by overconcentration of supply in a certain country, which can create a risk of disruption of supply in certain cases. Provided that the United States cannot supply the entirety of its mineral needs domestically, mitigating supply risk is more art than science -- requiring an assessment of which minerals have relatively clearer pathways to build trusted supply chain partnerships that hedge against or limit the possibility of physical interruptions in the supply chain, market imbalances, and government interventions.

Taken together, these elements of what shapes the relative risk of a critical mineral or material offers some additional nuance to an increasingly diverse suite of minerals that underpin national security and economic prosperity. It helps us understand when risks to certain minerals will be more or less severe (an exercise I commend the Department of Energy for beginning to undertake in its most recent Critical Minerals Assessment), and how policymakers should consider intervening in a world where nearly every mineral and metal is of strategic importance.

VI. Conclusion

To conclude, there are certain minerals that are structurally important to our national and economic security. As energy transition proceeds, those mineral requirements are increasingly diverse and dynamic.

As a result, the practice of designating minerals as critical is necessary as a strategic review of national vulnerabilities in a minerals-intensive world, and the work of USGS and their interagency peers to this end is deeply important.

However, I will end with some final thoughts.

Lists signify a need for action and form the basis for interagency coordination, where it is invariably the case that we need to show our receipts and provide justification for actions that leverage the US taxpayer dollar in an environment of increasing demand for public money.

But while lists are important, we shouldn't rely on lists alone. We need to ensure that our minerals policy does not become overly clerkish, prescribing problems rather than solving them. Maturing those lists to capture the supply/demand dynamism between each critical mineral will illuminate the pathways to address the relative criticality inherent in these lists.

Many of the foremost issues in our minerals policy stem from a need for broader reform, whether in permitting, benefit-sharing, or international engagement.

Nonetheless, a properly curated list helps inform decisions on those fronts.

Thank you and I look forward to your questions.

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[24] NeumannStrengthened Federal Approach Needed to Help Identify and Mitigate Supply Risks for Critical Raw Materials, J., Strengthened Federal Approach Needed to Help Identify and Mitigate Supply Risks for Critical Raw Materials.