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Good morning, Chairman Manchin, Ranking Member Barrasso, and Members of the Committee. Thank you for the opportunity to discuss the U.S. Geological Survey's efforts related to critical minerals. My name is Steve Fortier and I am the Director of the National Minerals Information Center (NMIC) at the U.S. Geological Survey (USGS).

Background

The USGS quantifies the geologic potential for mineral deposits still in the ground and in mine wastes across the Nation and globe, and provides data on global supply, demand, and consumption of mineral commodities essential to the Nation's economy and national security. USGS mineral resource science looks across applications and economic sectors, analyzes near-term supply chain disruption potential, and evaluates long-term strategies for securing supply chains.

Current Risks to Supply Chains

Monitoring supply chains for individual minerals across manufacturing sectors allows us to understand supply risk in the short term and forecast potential disruptions in the future. USGS data show that domestic and global demand for mineral commodities continues to increase[1]. An increasingly broad range of mineral commodities is used in consumer and national security applications, especially those involving advanced technologies. The United States remains a major mineral producer, with an estimated total value of non-fuel mineral resources of $90.4 billion in 2021.

No single country possesses the full breadth of non-fuel mineral commodities required to meet the needs of today's high-tech economies. The U.S. relies on foreign sources for many raw and processed mineral materials. As shown on Figure 1, in 2021, the Nation was 100 percent import-reliant for 17 mineral commodities and at least 50 percent import-reliant for an additional 30 mineral commodities.

Figures 1 and 2 illustrate the United States' reliance on trade by mineral commodity and by trade partner.

[1] U.S. Geological Survey, 2022, Mineral commodity summaries 2022: U.S. Geological Survey, 202 p., https://doi.org/10.3133/mcs2022.

Commodity	Net import reliance as a percentage of apparent consumption	Major import sources (2017–20)[2]
ARSENIC, all forms	100	China, Morocco, Belgium
ASBESTOS	100	Brazil, Russia
CESIUM	100	Germany, China
FLUORSPAR	100	Mexico, Vietnam, South Africa, Canada
GALLIUM	100	China, United Kingdom, Germany, Ukraine
GRAPHITE (NATURAL)	100	China, Mexico, Canada, India
INDIUM	100	China, Canada, Republic of Korea, France
MANGANESE	100	Gabon, South Africa, Australia, Georgia
MICA (NATURAL), sheet	100	China, Brazil, Belgium, India
NEPHELINE SYENITE	100	Canada
NIOBIUM (COLUMBIUM)	100	Brazil, Canada
RUBIDIUM	100	Germany
SCANDIUM	100	Europe, China, Japan, Russia
STRONTIUM	100	Mexico, Germany, China
TANTALUM	100	China, Germany, Australia, Indonesia
VANADIUM	100	Canada, China, Brazil, South Africa
YTTRIUM	100	China, Republic of Korea, Japan
GEMSTONES	99	India, Israel, Belgium, South Africa
TELLURIUM	>95	Canada, Germany, China, Philippines
POTASH	93	Canada, Russia, Belarus
IRON OXIDE PIGMENTS, natural and synthetic	91	China, Germany, Brazil
RARE EARTHS,[3] compounds and metals	>90	China, Estonia, Malaysia, Japan
TITANIUM, sponge	>90	Japan, Kazakhstan, Ukraine
BISMUTH	90	China, Republic of Korea, Mexico, Belgium
TITANIUM MINERAL CONCENTRATES	90	South Africa, Australia, Madagascar, Mozambique
ANTIMONY, metal and oxide	84	China, Belgium, India
STONE (DIMENSION)	84	China, Brazil, Italy, India
CHROMIUM	80	South Africa, Kazakhstan, Russia, Mexico
PEAT	80	Canada
SILVER	79	Mexico, Canada, Chile, Poland
TIN, refined	78	Indonesia, Peru, Malaysia, Bolivia
COBALT	76	Norway, Canada, Japan, Finland
DIAMOND (INDUSTRIAL), stones	76	South Africa, India, Congo (Kinshasa), Botswana
ZINC, refined	76	Canada, Mexico, Peru, Spain
ABRASIVES, crude fused aluminum oxide	>75	China, France, Bahrain, Russia
BARITE	>75	China, India, Morocco, Mexico
BAUXITE	>75	Jamaica, Brazil, Guyana, Australia
SELENIUM	>75	Philippines, China, Mexico, Germany
RHENIUM	72	Chile, Canada, Kazakhstan, Japan
PLATINUM	70	South Africa, Germany, Switzerland, Italy
ALUMINA	58	Brazil, Australia, Jamaica, Canada
GARNET (INDUSTRIAL)	56	South Africa, China, India, Australia
MAGNESIUM COMPOUNDS	55	China, Brazil, Israel, Canada
ABRASIVES, crude silicon carbide	>50	China, Netherlands, South Africa
GERMANIUM	>50	China, Belgium, Germany, Russia
IODINE	>50	Chile, Japan
TUNGSTEN	>50	China, Bolivia, Germany, Canada
CADMIUM	<50	Australia, China, Germany, Peru
MAGNESIUM METAL	<50	Canada, Israel, Mexico
NICKEL	48	Canada, Norway, Finland, Australia
COPPER, refined	45	Chile, Canada, Mexico
ALUMINUM	44	Canada, United Arab Emirates, Russia, China
DIAMOND (INDUSTRIAL), bort, grit, dust, and powder	41	China, Ireland, Republic of Korea, Russia
LEAD, refined	38	Canada, Mexico, Republic of Korea, India
PALLADIUM	37	Russia, South Africa, Germany
FELDSPAR	32	Turkey
SILICON, metal and ferrosilicon	32	Russia, Brazil, Canada, Norway
SALT	29	Chile, Canada, Mexico, Egypt
MICA (NATURAL), scrap and flake	28	Canada, China, India
LITHIUM	>25	Argentina, Chile, China, Russia
BROMINE	<25	Israel, Jordan, China
ZIRCONIUM, ores and concentrates	<25	South Africa, Senegal, Australia, Russia
PERLITE	23	Greece, China, Mexico, Turkey
VERMICULITE	20	South Africa, Brazil

Figure 1. *2021 U.S. net import reliance[2], expressed as a percentage of apparent consumption. (Source: USGS Mineral Commodity Summaries 2022.)*

[2] In descending order of import share.

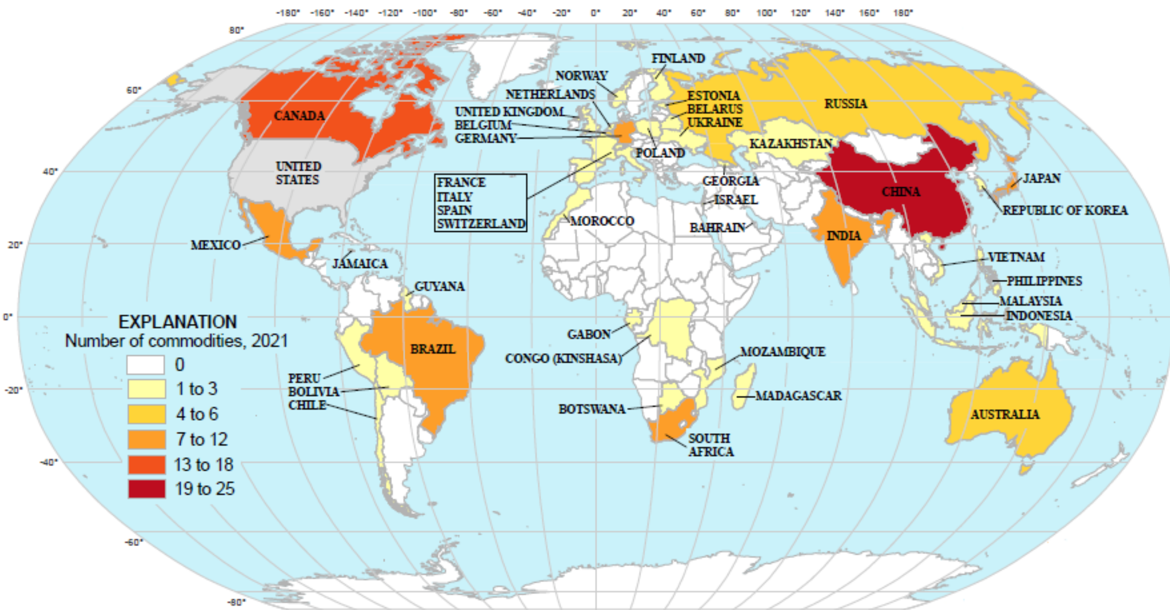

Figure 2. *Major import sources of non-fuel mineral commodities, shaded to indicate the number of commodities for which the United States was more than 50 percent net import reliant in 2021. For example, China, followed by Canada, supplied the largest number of non-fuel mineral commodities for which the U.S. is more than 50 percent import reliant. (Source: USGS Mineral Commodity Summaries 2022.)*

A 2018 study by the USGS and Natural Resources Canada found that trade within North America reduces supply chain risk and reliance on imports from other countries[3]. According to the study, "[a]s a single entity, North America is much less dependent on other nations for the supply of materials for high-technology applications than as individual parties." The combined results for North America, using 2014 data, showed greatly reduced net import reliance for nearly all of the commodities evaluated, which is largely the result of pooling the resources of production and recovery in Canada and Mexico of materials that are consumed in the United States. This study highlights the mitigation of potential supply risk for critical materials that results from trade within the North American trade bloc.

<u>Critical Minerals and the Nation's List of Critical Minerals</u>

The Energy Act of 2020 defined critical minerals as those which are essential to the economic or national security of the United States; have a supply chain that is vulnerable to disruption; and serve an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economic or national security of the United States. Based on the Energy Act of 2020 definition, water; common varieties of industrial minerals such as sand, gravel, stone, pumice, cinders, and clay; and fuel minerals are excluded from consideration in this analysis. In 2021, the USGS published, "Methodology and technical input for the 2021

[3] Brainard, J.L., Sinclair, R.G., Stone, K., Sangine, E.S., Fortier, S.M., 2018, North American net import reliance of mineral materials in 2014 for advanced technologies: Mining Engineering, v.70, no. 7, p. 107-12. https://doi.org/10.19150/ME.8365

review and revision of the U.S. Critical Minerals List," Open-File Report 2021–1045.[4] The report documented the updated evaluation methodology and the resultant updated draft list of minerals recommended for inclusion in the list of critical minerals. The USGS subsequently published a draft revision to the list of critical minerals in the Federal Register and considered public comments on the methodology and the draft list.[5] The final list was published in the Federal Register on February 24, 2022.[6] The 2022 list of critical minerals contains 50 individual mineral commodities. It differs from the 2018 list of critical minerals by individually listing the rare-earth elements and platinum-group elements by specific element forms rather than as two groups, adding nickel and zinc, and removing helium, potash, rhenium, strontium, and uranium (to comply with the Energy Act of 2020 and the Mining and Mineral Policy Act of 1970).

The methodology for identifying non-fuel mineral commodities as "critical" involved a quantitative assessment based on a risk modeling framework in which commodities with the greatest supply risk were those whose (i) global production was concentrated in countries that may become unable or unwilling to continue to supply to the United States; (ii) U.S. consumption was predominantly dependent on foreign supplies; and (iii) U.S. consumption represented a large expenditure for U.S. manufacturing industries with low profitability but who contributed greatly to the U.S. economy.[7]

In addition to the quantitative assessment, which focused on foreign supply disruptions, an evaluation of domestic supplies was also performed. Specifically, commodities with a single domestic producer along their raw materials supply chains were identified as having a single point of failure and were automatically recommended for inclusion on the list.

A total of 54 mineral commodities had sufficient data to be analyzed using the quantitative assessment. Of the 54 mineral commodities analyzed using the quantitative assessment, 36 met the quantitative threshold criterion, as shown in Figure 3. Three additional commodities were included on the 2022 list based on the single point of failure criterion: beryllium, nickel, and zirconium. Three commodities on the 2018 list of critical minerals (cesium, rubidium, and scandium), as well as the other rare earth elements (europium, gadolinium, terbium, holmium, erbium, thulium, ytterbium, and lutetium) were not evaluated using the quantitative method due to insufficient data. Based on a qualitative evaluation of their supply and demand, none of these commodities were removed from the list. Overall, of the commodities evaluated, two commodities not on the 2018 list of critical minerals were added to the list (nickel and zinc) and four on the 2018 list of critical minerals (helium, potash, rhenium, and strontium) did not meet either the quantitative assessment or the single point of failure criteria and consequently were removed from the list.

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[4] Nassar, N.T., and Fortier, S.M., 2021, Methodology and technical input for the 2021 review and revision of the U.S. Critical Minerals List: U.S. Geological Survey Open-File Report 2021–1045, 31 p., https://doi.org/10.3133/ofr20211045.
[5] 2021 Draft List of Critical Minerals, 86 Fed. Reg. 62199 (November 9, 2021). https://www.federalregister.gov/documents/2021/11/09/2021-24488/2021-draft-list-of-critical-minerals.
[6] 2022 Final List of Critical Minerals, 87 Fed. Reg. 10381 (February 24, 2022). https://www.federalregister.gov/documents/2022/02/24/2022-04027/2022-final-list-of-critical-minerals.
[7] Nassar, N.T., Brainard, J., Gulley, A., Manley, R., Matos, G., Lederer, G., Bird, L.R., Pineault, D., Alonso, E., Gambogi, J., and Fortier, S.M., 2020, Evaluating the mineral commodity supply risk of the U.S. manufacturing sector: Science Advances, v. 6, no. 8, p. eaay8647 https://www.science.org/doi/10.1126/sciadv.aay8647.

Commodity	Supply risk													Leading producing countries
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Recency-weighted mean	Names and process stages
Gallium													0.67	China
Niobium													0.66	Brazil
Cobalt													0.65	DRC (mining), China (refining)
Neodymium													0.65	China (mining and refining)
Ruthenium													0.63	South Africa
Rhodium													0.62	South Africa
Dysprosium													0.61	China (mining and refining)
Aluminum													0.60	China (alumina and aluminum); Australia (bauxite)
Fluorspar													0.60	China
Platinum													0.60	South Africa
Iridium													0.59	South Africa
Praseodymium													0.58	China (mining and refining)
Cerium													0.56	China (mining and refining)
Lanthanum													0.56	China (mining and refining)
Bismuth													0.55	China
Yttrium													0.54	China (mining and refining)
Antimony													0.53	China
Tantalum													0.53	DRC
Hafnium													0.51	France
Tungsten													0.51	China
Vanadium													0.51	China
Tin													0.50	China (mining and smelting)
Magnesium													0.49	China
Germanium													0.49	China
Palladium													0.48	Russia
Titanium													0.48	Australia (mineral concentrate), China (sponge)
Zinc													0.48	China (mining and smelting)
Graphite													0.47	China
Chromium													0.47	South Africa
Arsenic													0.45	China
Barite													0.44	China
Indium													0.41	China
Samarium													0.40	China (mining and refining)
Manganese													0.40	South Africa
Lithium													0.40	Australia (mining), China (refining)
Tellurium													0.40	China
Lead													0.39	China (mining and refining)
Potash													0.38	Canada
Strontium													0.36	China
Rhenium													0.36	Chile
Nickel													0.36	Indonesia (mining), China (refining)
Copper													0.34	Chile (mining), China (smelting and refining)
Beryllium													0.33	United States
Feldspar													0.32	Turkey
Phosphate													0.25	China
Silver													0.25	Mexico
Mica													0.22	China
Selenium													0.23	Japan
Cadmium													0.11	China
Zirconium													0.09	Australia
Molybdenum													0.07	China
Gold													0.00	China
Helium													0.00	United States
Iron ore													0.00	Australia

Supply risk

Low risk — High risk

***Figure* 1.** *Heat map displaying supply risk for all 54 commodities examined for years 2007–2018. Warmer (i.e., orange to red) shades indicate a greater degree of supply risk. Commodities are listed in descending order of their 2015–2018 recency-weighted mean supply risk, as described in Nassar and Fortier, 2021. As indicated by the dashed horizonal line, 36 commodities with a recency-weighted mean supply risk greater than or equal to 0.40 were recommended for inclusion on the list of critical minerals based on quantitative criteria. Leading producing countries were based on cumulative production for the entire period of analysis for the different stages of production or commodity forms, where applicable.*

The updated list of critical minerals does not include a number of economically significant minerals, such as copper, molybdenum, gold, silver; and industrial minerals such as phosphate rock and boron, that are produced domestically in large quantities. Given current levels of domestic production, the U.S. is not highly reliant on imports for these minerals and typically has a combination of domestic reserves and reliable foreign sources adequate to meet foreseeable domestic consumption requirements. Therefore, while these minerals are important to a modern society for the purposes of national security, technology, infrastructure, and energy production from both fossil fuels and renewable energy generation, they do not currently meet the definition of "critical" for purposes of the list produced in response to the Energy Act of 2020.

Domestic Mineral Resources, the Earth Mapping Resources Initiative, and the Bipartisan Infrastructure Law

There are multiple mechanisms to reduce the supply risk for essential mineral commodities, including (i) reducing demand through manufacturing improvements or substitution with other materials and (ii) increasing supplies obtained from reliable trading partners, domestic secondary production (recycling and reprocessing mine wastes), or domestic primary production (mining). Both domestic primary production and secondary production will be supported by an updated and more detailed understanding of potential resources as envisioned by the USGS Earth Mapping Resources Initiative (Earth MRI). The Bipartisan Infrastructure Law funding to support Earth MRI is an historic investment in modernizing the Nation's mapping of resources both still in the ground and in mine wastes.

Earth MRI is a partnership of the USGS, the State geological surveys, and other Federal, State, Tribal and private-sector organizations to modernize the Nation's surface and subsurface mapping. The Bipartisan Infrastructure Law provided $320 million to the USGS to support Earth MRI's national mapping and interpretation of mineral resources data; as well as $24 million for the preservation of geophysical, geochemical, and geological data and samples. Data collected through Earth MRI will support development of a national mine waste inventory, assessments quantifying the Nation's domestic mineral resources as called for in the Energy Act of 2020, and identification of locations suitable for sustainable development as called for in the June 6, 2021 report[8] developed pursuant to Executive Order 14017, "America's Supply Chains."

[8] The White House. (2021, June). Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth. https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf

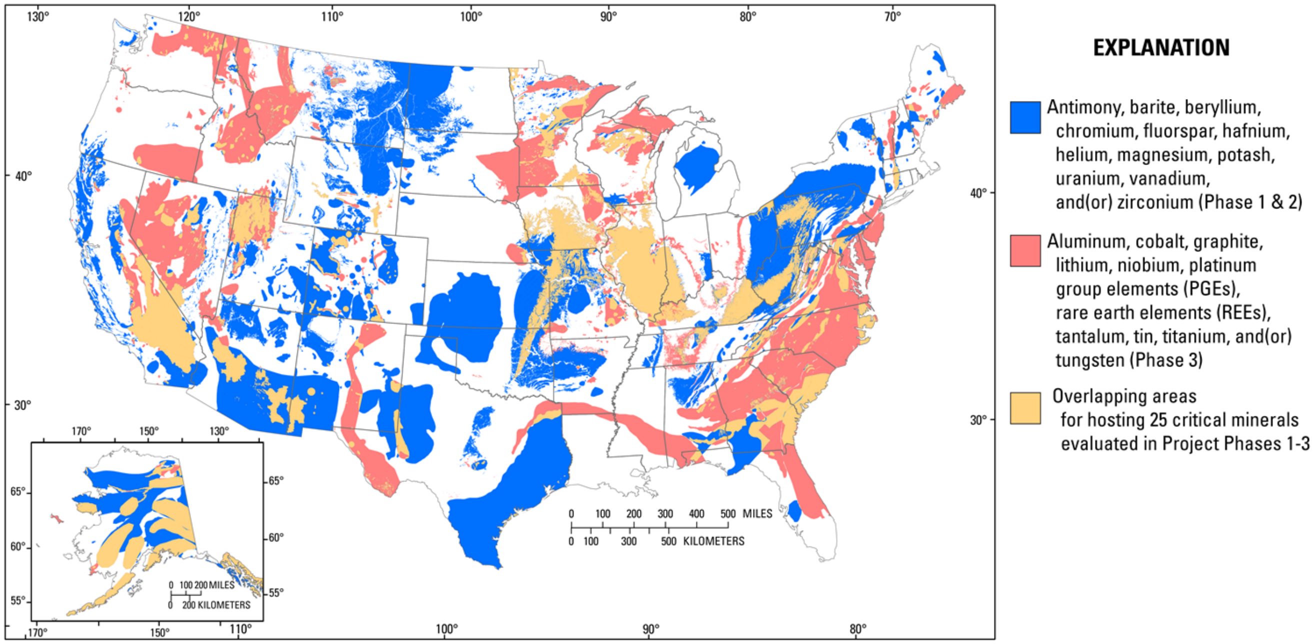

Figure 4. *The USGS, with input and expertise from the State geological surveys, has produced the Nation's first national map of areas favorable for the occurrence of 25 critical minerals, combining data and science from over 530 study areas. Sources: Dicken and others, 2021, USGS data release, https://doi.org/10.5066/P9WA7JZY and Dicken and Hammarstrom, 2020, USGS data release, https://doi.org/10.5066/P95CO8LR.*

Figure 4 shows the first national map of areas favorable for the occurrence of 25 critical minerals, which is the result of a Federal-State partnership to integrate existing geoscience information and identify priority areas for Earth MRI data collection. The new data and interpretations developed through Earth MRI will accelerate development of assessments quantifying the Nation's domestic mineral resources as called for in the Energy Act of 2020. These assessments will in turn refine the understanding of the Nation's long-term supply chains and inform policies to manage supply risk.

Thank you for the opportunity to testify and I look forward to any questions you may have.