

ASSESSMENT OF CRITICAL MINERALS: UPDATED APPLICATION OF SCREENING METHODOLOGY

A Report by the

**Subcommittee on Critical and Strategic Mineral Supply Chains
Committee on Environment, Natural Resources, and Sustainability
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL**



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About the Subcommittee on Critical and Strategic Mineral Supply Chains

The purpose of the NSTC Committee on Environment, Natural Resources, and Sustainability (CENRS), Subcommittee on Critical and Strategic Mineral Supply Chains is to advise and assist the CENRS and the NSTC on policies, procedures, and plans relating to identification and forecasting of mineral criticality, and risk mitigation in the procurement and downstream processing of minerals identified as or forecasted to become critical. Maintaining access to and availability of essential resources also fall within the scope of the Subcommittee, both as raw commodities and as a part of downstream supply chains that may be sensitive to disruptions in global supply.

About this Document

This document provides an update to the 2016 report, *Assessment of Critical Minerals: Screening Methodology and Initial Application*, describing enhancements to the screening tool, the latest application of the screening tool using recent data published by the United States Geological Survey, and the next steps for the NSTC Subcommittee. This report also discusses the interagency collaborative efforts being used to respond to Executive Order 13817, *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*.

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List of Acronyms

CENRS	Committee on Environment, Natural Resources, and Sustainability
DHS	Department of Homeland Security
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor
DOS	Department of State
DOT	Department of Transportation
EPA	Environmental Protection Agency
EU	European Union
GAO	Government Accountability Office
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NSC	National Security Council
NSTC	National Science and Technology Council
OSTP	Office of Science and Technology Policy
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USITC	United States International Trade Commission

Introduction

The modern global economy has increasingly come to depend on access to non-fuel mineral resources. Advanced technologies from satellites to cell phones require a variety of specific minerals with unique chemical and physical properties—minerals that were not widely used or considered essential to manufacturing just a few decades ago. To meet rapidly rising demand, production for most non-fuel mineral resources has significantly increased over the past few decades. However, production of many high-demand minerals is concentrated in just a few foreign countries,¹ creating increased risk of price spikes and supply disruptions. If mineral supplies from these countries were suddenly interrupted, the Nation’s economy and national security could be threatened.

The risk of price spikes and supply disruptions occurring can change over time as a result of geopolitical shifts, rapid increases in demand, or a suite of other supply chain factors. Understanding a mineral’s potential for such disruption and the impact should its supply be disrupted, its “criticality”, enables the United States to establish proactive risk management strategies, including diversifying mineral supplies, developing substitutes for materials and technologies that use specific minerals, increasing recycling, and ensuring critical minerals are efficiently used. For the purposes of this discussion, a mineral is critical if the supply chain is vulnerable to disruption, and it serves an essential function in the manufacturing of a product, the absence of which would cause significant economic or security consequences.

In 2010, the U.S. National Science and Technology Council (NSTC) chartered the Subcommittee on Critical and Strategic Mineral Supply Chains (hereafter referred to as the Subcommittee) to facilitate a Federal interagency effort to identify and address current and emerging risks to critical and strategic mineral supply chains. In 2016, the Subcommittee published a report to Congress² describing a two-stage methodology for assessing critical minerals, as illustrated in Figure 1. The first stage (Stage I) is an early warning screening tool that identifies potentially critical minerals

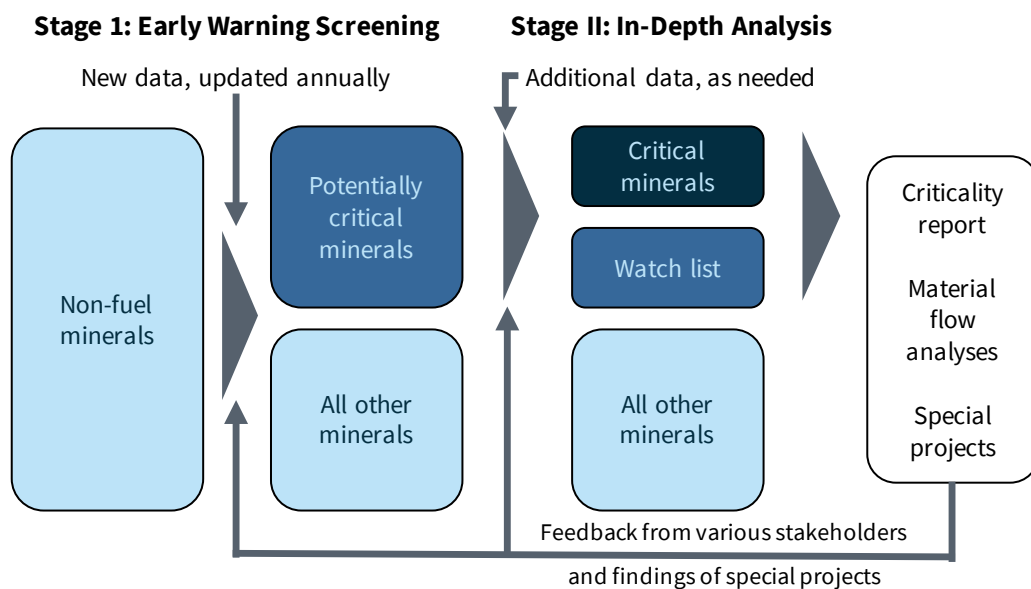


Figure 1. Overview of the interagency methodology for assessing critical minerals.

¹ <https://minerals.usgs.gov/minerals/pubs/mcs/>

² <https://www.whitehouse.gov/sites/whitehouse.gov/files/images/CSMSC%20Assessment%20of%20Critical%20Minerals%20Report%202016-03-16%20FINAL.pdf>

using regularly-reported and publicly-available data. The screening tool was designed so that potential mineral criticality could be evaluated in a repeatable and transparent manner on an ongoing basis. The second stage (Stage II) of the methodology consists of in-depth supply chain analyses of selected minerals identified by the screening tool. This tool is updated annually by the U.S. Geological Survey (USGS) on behalf of the Subcommittee when the USGS releases a new year of mineral production and price data.

This report discusses the status of the interagency methodology for assessing critical minerals, including the updated application of the screening tool, data enhancements, in-depth supply chain analyses, ongoing productive collaborations, and next steps for the Subcommittee.

Supporting a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals

On December 20, 2017, President Trump issued Executive Order 13817, *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*³ that directs Federal agencies to develop a list of critical minerals, strategies to reduce reliance on critical minerals, and actions to support increased domestic supplies of critical minerals. The Executive Order establishes as Federal policy the need to identify new sources of critical minerals; increase activity at all levels of the supply chain, including exploration, mining, concentration, separation, alloying, recycling, and reprocessing critical minerals; ensure that our miners and producers have electronic access to the most advanced topographic, geologic, and geophysical data within U.S. territory; and streamline leasing and permitting processes to expedite exploration, production, processing, reprocessing, recycling, and domestic refining of critical minerals. The Subcommittee is assisting with the interagency coordination required to effectively respond to this Executive Order.

In response to the Executive Order, the Secretary of the Interior, in coordination with the Secretary of Defense and in consultation with the heads of other relevant executive departments and federal agencies, will publish a list of critical minerals in the Federal Registry in February 2018. The Subcommittee's early warning screening tool has been used as a starting point to develop this interagency critical minerals list. Additional input used for the development of this forthcoming list included information on U.S. mineral import reliance statistics, supply chain studies, and expert opinion from the Federal agencies representing the Subcommittee.

Updated Application of the Early Warning Screening Tool (Stage I)

The early warning screening tool assesses a mineral's potential criticality using three fundamental indicators: Supply Risk, Production Growth, and Market Dynamics. The indicators use data published annually by USGS, as well as other sources. The formulas for each indicator are discussed in the 2016 Subcommittee Report to Congress.²

In this update, the early warning screening tool has been applied to 77 mineral resources to generate a new list of potentially critical minerals by incorporating statistics available through USGS. The screening tool identified the following minerals in descending potential criticality: yttrium, the rare earth elements (lanthanum through lutetium on the Periodic Table), gallium, ferromolybdenum, mercury, tungsten, ruthenium, antimony, silicomanganese, graphite, germanium, ferronickel, monazite, strontium, iridium, tantalum, rhodium, bismuth (refinery),

³ <https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/>

niobium, and phosphate. Overall, potential criticality has decreased since the last report, but a number of minerals saw an increase in potential criticality. Minerals identified as potentially critical using the two most recent years of complete data from the USGS are shown in Figure 2. A hierarchical cluster analysis was utilized to help determine which subset of minerals should be identified as potentially critical. The results indicated a criticality potential cut-off value of 0.30.⁴ The aim of this tool is to identify and assess emerging trends in mineral commodities and is not designed to produce a static list.

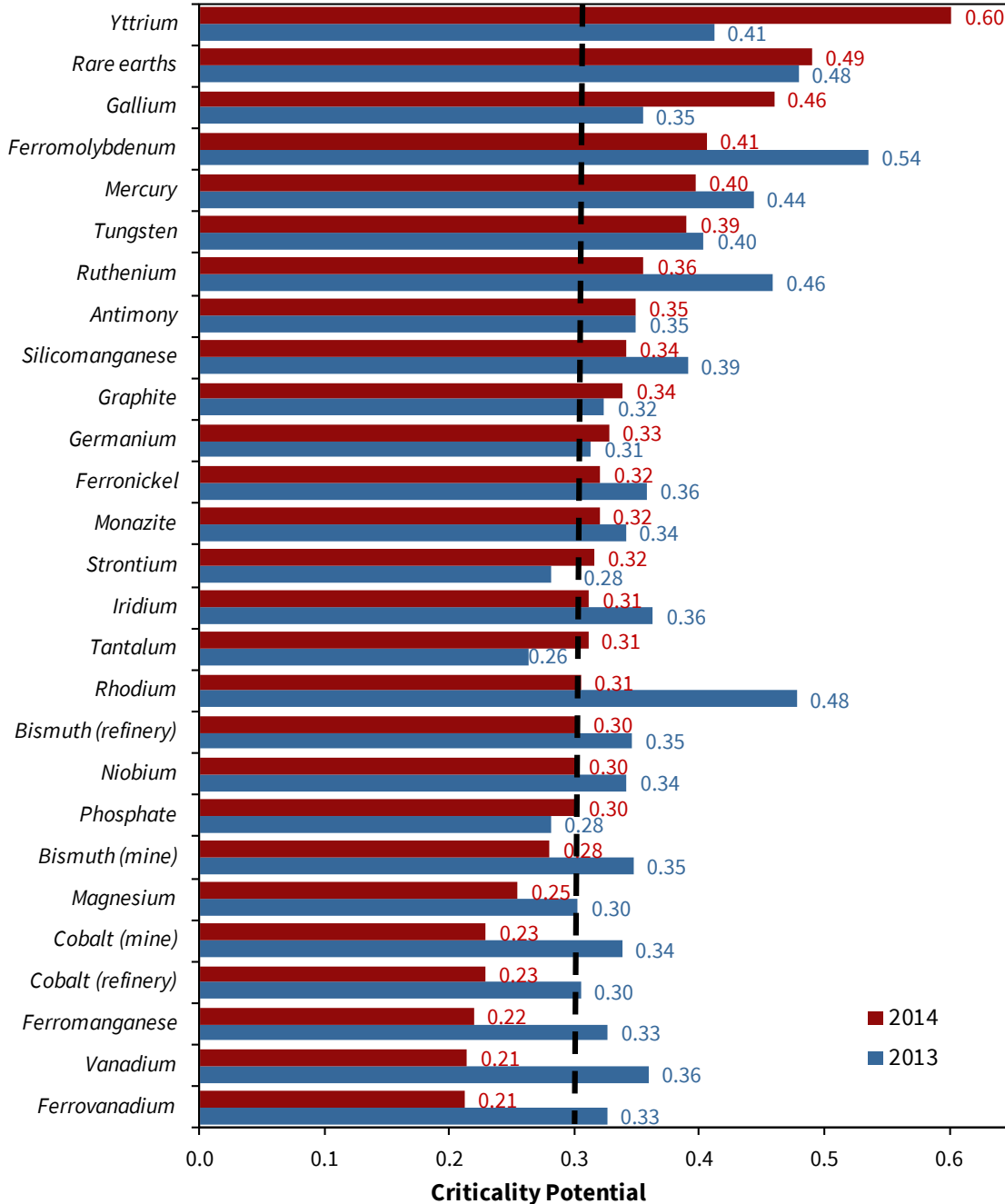


Figure 2. Results from the updated application of the early warning screening tool (Stage I). Only minerals with criticality potential values greater than 0.30 in either year are displayed.

⁴ For more information on trends, in-depth analysis, and data enhancements for the screening tool, see <https://pubs.er.usgs.gov/publication/70191019>

Data Updates and Enhancements

In addition to identifying and stratifying minerals that are potentially critical, the interagency mineral criticality assessment effort also helps to address data needs. The initial application of the early warning screening tool helped identify areas ripe for data improvement in terms of consistency, granularity, and uniformity across data sets. In response, updates to historical information were made and incorporated into the updated application of the screening tool as used to produce the results in Figure 2. In a few cases, such as beryllium, prices were changed to reflect a consistent valuation of a mineral commodity throughout the time series. For instance, in the initial application of the screening tool, the time-series price data utilized differing forms of the same commodity that were not comparable in value. This affected the corresponding Market Dynamics indicator value, which is a component in the overall criticality potential of the mineral. The data were updated to reflect a uniform and more accurate measure of price across years. Another enhancement of price data was the differentiation of prices across multiple processing stages. For example, in the initial application of the screening tool, the same price was used for copper mining, smelting, and refining. This update employs separate prices for the three different forms. Similar efforts to include price data for the intermediate products of other applicable minerals were made.

In a few instances, production data were also modified to assure consistency and accuracy. For example, in the initial application of the screening tool, boron production was based on gross weight. In this updated application, the element content of boron production was utilized to more accurately reflect each country's production. For other minerals, production data were modified based on new, additional, or revised information.

The Subcommittee continues to enhance the performance of the early warning screening tool. By using historical events, such as the "Rare Earth Crisis" in 2010 when China temporarily restricted the export of rare earth elements, the Subcommittee is able to probe the ability of the tool to provide advanced warning of mineral criticality. Such retrospective analysis sheds light on and clarifies uncertainties that might be associated with the output from the tool. It also highlights opportunities to improve and refine the tool's indicators. In addition, to better understand what may be driving the results, the Subcommittee has been investigating the screening tool's sensitivity to variations in all three indicators: Supply Risk, Production Growth, and Market Dynamics.

In-Depth Supply Chain Analyses (Stage II) and Productive Interagency Collaboration

The second stage of the methodology involves detailed analysis of the underlying factors that result in the subset of minerals identified as potentially critical by Stage I of the screening tool. Several in-depth supply chain studies for a subset of minerals identified as potentially critical by the previous application of the screening tool have been recently completed or are ongoing, including studies for yttrium, the rare earth elements, germanium, bismuth, and cobalt.^{5,6,7,8,9} Moving forward, the Subcommittee intends to expand its coverage of Stage II studies. The

⁵ <https://pubs.er.usgs.gov/publication/70176895> (titanium, zirconium, rare earths)

⁶ <https://www.osti.gov/biblio/1257654> (global markets)

⁷ <https://pubs.er.usgs.gov/publication/sir20165152> (major metals)

⁸ <https://minerals.usgs.gov/minerals/pubs/commodity/cobalt/cobalt-supply-security.pdf>

⁹ <https://pubs.er.usgs.gov/publication/70178701> (tellurium, dysprosium, rare earths)

Subcommittee is developing a collaborative process by which appropriate Stage II studies can be prioritized and conducted by member agencies to further illuminate underlying market forces, trends, and risks for minerals identified as potentially critical by the early warning screening tool.

In addition to these in-depth supply chain analyses, numerous Subcommittee member agencies have incorporated the screening tool into their practices to further the objective of their individual missions. For example, the National Aeronautics and Space Administration (NASA) used the outcome of the first application of the screening tool to inform its programs' approaches to risk assessment and mitigation. The Department of Energy (DOE) is examining energy-relevant materials flagged by the screening tool in its upcoming update to the 2011 *Critical Materials Strategy*. The Department of Defense is also utilizing the screening tool to support various internal assessment efforts.

Stimulating Broader Collaboration

In September 2016, the U.S. Government Accountability Office (GAO) released a report¹⁰ examining U.S. efforts to address critical mineral supply issues. In the report, GAO recommended that the Subcommittee strengthen the Federal approach to addressing critical material supply issues through enhanced interagency collaboration; to develop a strategy to address data limitations that are preventing additional materials from being included in the early warning screening tool; and to examine approaches used by other countries to see if there are any lessons learned that can be applied to the United States.

Since GAO issued their report, several agencies, including the Department of Homeland Security, NASA, the U.S. Forest Service, and the Environmental Protection Agency, have become more active in the Subcommittee. The Subcommittee has also helped facilitate the interagency collaboration necessary to effectively respond to Executive Order 13817.

The Subcommittee and its member agencies see the value in analyzing more minerals and non-minerals in the early warning screening tool to help inform policy decisions. In addition, extending coverage further down the supply chain would add significant value. Data for key mineral-derived materials such as specific forms or compounds that are common feedstocks for manufacturing components are often not available because there is no Government agency tasked with the collection of such information. Fulfilling this need will require additional dedicated personnel and financial resources for data collection, analysis, and distribution.

For the past seven years, Subcommittee member agencies have participated in an annual trilateral critical materials conference co-hosted by the United States, the European Union (EU), and Japan. Participation in this conference has enabled the United States to share methodological approaches for mineral criticality assessment, as well as research and development insights on reprocessing, recycling, and technological alternatives. Experts from USGS and DOE are also serving on advisory boards of EU-sponsored projects on mineral information, material flows, and materials criticality. The EU sponsored Mineral Intelligence Capabilities Assessment addresses mineral information and the MinFutures project addresses material flow methodologies. The Department of Defense also includes critical materials in a number of its collaborative efforts with partner countries.

¹⁰ <https://www.gao.gov/products/GAO-16-699>

The Subcommittee intends to further facilitate coordination among agencies to identify, prioritize, and address data gaps; to share learning and insight from in-depth analyses; to prioritize supply chains for further analysis; and to continue to share lessons with international counterparts.

Future Work

The Subcommittee has already begun work on the next application of the early warning screening tool, drawing on recent data from the USGS Mineral Yearbook series. It is evaluating the utility of including additional indicators or making other enhancements to the tool. Decisions to make such changes to the early warning screening tool will be weighed against any impacts they have on the transparency and repeatability of the tool. Continuing to employ regularly-reported and publicly-available data in the screening tool is a high priority for the Subcommittee. Furthermore, member agencies are working with USGS to augment the early warning screening tool to address agency-specific needs. For example, the tool currently presents results from a non-country specific perspective; however, based on user feedback, a U.S.-centric version is under development. Both perspectives will be functional options for users. The Subcommittee intends to report on this work and provide an update on how the tool is being used across the various member agencies later this year.

The Subcommittee's member agencies plan to pursue in-depth supply chain analyses to better understand the risks and vulnerabilities associated with the subset of minerals identified as potentially critical by the early warning screening tool. Special attention will be paid to minerals that are newly identified as potentially critical by each year's updated application of the screening tool, and minerals whose potential criticality has increased significantly since the previous update.

To date, the Subcommittee's collaborative interagency efforts have yielded significant cross-organizational learning, which has led to both direct and indirect benefits, and have provided a richer understanding of mineral vulnerabilities and opportunities for policy interventions. In addition, the Subcommittee's efforts have introduced agencies to new perspectives and approaches, strengthening individual agency projects and laying the foundation for future collaborative efforts. Such benefits enhance the ability of member agencies to meet national needs. Understanding which minerals are vulnerable to emerging supply chain risks is important to ensuring that the United States has an adequate and affordable supply of critical minerals that are vital to our Nation's security and economy.