The mineral commodity supply risk of the U.S. manufacturing sector

Critical Minerals and the Energy Transition Webinar Series
Co-hosted by the Institute of the Americas and the Payne Institute, Colorado School of Mines

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U.S. Geological Survey

U.S. Department of the Interior
U.S. Geological Survey
Mineral commodities are essential to numerous energy applications.

Oil drilling and refining

- Ba 56: Barium
- Pt 78: Platinum
- Re 75: Rhenium
- La 57: Lanthanum
- Ce 58: Cerium

Gas turbines

- Al 13: Aluminum
- Cr 24: Chromium
- Co 27: Cobalt
- Ni 28: Nickel
- Mo 42: Molybdenum
- Ta 73: Tantalum
- Ru 44: Ruthenium
- W 74: Tungsten

Renewable energy

- In 49: Indium
- Ga 31: Gallium
- Se 34: Selenium

- Nd 60: Neodymium
- Dy 66: Dysprosium

Thin-film solar PV

Photo credit: Testbourne, Ltd.

Offshore direct drive wind turbine

Photo credit: US DOE

Electric vehicles and energy storage

- Li 3: Lithium
- C 6: Carbon
- Co 27: Cobalt
- Ni 28: Nickel
- Mn 25: Manganese

Photo credit: Tesla, Inc.
Renewable energy technologies are expected to comprise an increasing share of global electricity generation capacity.

World electricity generation capacity projections

In the United States, CdTe has the largest market share of the thin-film solar PV technologies.
Solar PV technologies require different minor metals that are produced mainly or only as byproducts.
Many of the mineral commodities required for advanced technologies are recovered only as byproducts during the processing of other minerals.

Production of many mineral commodities is highly concentrated in a few countries.

Share of each element’s global production from various countries

Data source: USGS Minerals Yearbooks
Not all elements assessed
China’s share of global primary production has increased markedly over the past two decades for many commodities.

<table>
<thead>
<tr>
<th>Element symbol</th>
<th>Data source: USGS Minerals Yearbooks</th>
</tr>
</thead>
</table>

**EXPLANATION**

- **China’s share of global primary production**
- **Time series** (1996-2015)
- **Element symbol**

**Diagram:**
- Visual representation of China’s share of global primary production for various elements.

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**Table:**

<table>
<thead>
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</table>

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The United States is highly import reliant for a large and growing number of mineral commodities.
Analyzing mineral import reliance of nations concurrently highlights interdependencies and competition potential.

Through foreign investment, China has been able to secure a sizable portion of its supply for cobalt and other mineral commodities.

China’s overseas investments

- Chinese firms have acquired equity shares in overseas mineral assets including:
  - Cobalt in D.R. Congo, Zambia, and Papua New Guinea
  - Niobium in Brazil
  - Lithium carbonate in Australia and Chile

- These acquisitions may limit the availability of these commodities

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Co-chairs

Subcommittee members

Functions

- Develop, apply, and periodically update a methodology for dynamically assessing mineral criticality and for signaling emerging critical or strategic minerals
- Review and analyze domestic and global policies that affect the supply of critical and strategic minerals, assess their implications on U.S. manufacturing, and evaluate potential strategies for risk mitigation as needed
- Advise on international interactions involving critical and strategic mineral supply chains
- Consider and offer recommendations for enhanced U.S. minerals data collection and economic analysis
An enhanced methodology for assessing supply risk for the U.S. manufacturing sector has been developed.

\[ R = H \cdot E \cdot V \]

**Supply Risk**
Risk associated with a supply disruption

**Hazard**
Likelihood of a supply disruption

**Exposure**
Degree of exposure to a supply disruption

**Vulnerability**
Ability to withstand the effects of a supply disruption

All components are necessary, but each alone is an insufficient condition for risk.

### Disruption Potential
- Likelihood of a foreign supply disruption

### Trade Exposure
- Degree of exposure to a supply disruption
- Net import reliance as a percentage of apparent consumption

### Economic Vulnerability
- Ability to withstand the effects of a supply disruption
- Annual expenditure on the mineral commodity by each industrial sector relative to each sector's profitability

#### Indicator
- Concentration of production in countries that may become unable or unwilling to supply the United States
- Willingness to Supply Index

#### Annual Survey of Mining Companies
- Stock releases
- Stock additions
- Secondary production (recycling)
- Primary production

#### Net Import Reliance
- Annual import reliance as a percentage of apparent consumption

#### Willingness to Supply Index
- Imports
- Exports

#### Stock Releases
- Domestic
- Foreign

#### Stock Additions
- Domestic
- Foreign

#### Secondary Production
- Domestic
- Foreign

#### Primary Production
- Domestic
- Foreign

#### Apparent Consumption
- Domestic
- Foreign

#### Secondary Production (Recycling)
- Domestic
- Foreign

#### Primary Production
- Automotive
- Petroleum
- Chemical
- Electrical
- Glass
- Medical & dental
- Jewelry
- Other
\[
Economic\ Vulnerability_{i,t} = \sum_{j} \frac{VA_{j,t}}{GDP} \cdot \frac{Exp_{i,j,t}}{OP_{j,t}}
\]

China’s threats to cut-off supplies drive global prices for rare earths to unprecedented levels.

Production outside China, mainly in Australia, ramps up.

Rare earth prices fall markedly due excessive capacity and illegal production in China.

A subset of commodities pose the greatest supply risk for the U.S. manufacturing sector.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Supply Risk (SR)</th>
<th>Leading Producers</th>
<th>Most Vulnerable Applications</th>
<th>2016 EV scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysprosium</td>
<td></td>
<td>China</td>
<td>Permanent magnets</td>
<td></td>
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<tr>
<td>Yttrium</td>
<td></td>
<td>China</td>
<td>Advanced ceramics</td>
<td></td>
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<tr>
<td>Neodymium</td>
<td></td>
<td>China</td>
<td>Permanent magnets</td>
<td></td>
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<tr>
<td>Cobalt</td>
<td></td>
<td>D.R. Congo</td>
<td>Superalloys</td>
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<tr>
<td>Lanthanum</td>
<td></td>
<td>China</td>
<td>Catalysts</td>
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<tr>
<td>Cerium</td>
<td></td>
<td>China</td>
<td>Catalysts</td>
<td></td>
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<tr>
<td>Graphite</td>
<td></td>
<td>China</td>
<td>Refractories</td>
<td></td>
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<tr>
<td>Bismuth</td>
<td></td>
<td>China</td>
<td>Chemicals</td>
<td></td>
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<tr>
<td>Aluminum</td>
<td></td>
<td>China, Russia</td>
<td>Passenger cars and light trucks</td>
<td></td>
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<tr>
<td>Antimony</td>
<td></td>
<td>China</td>
<td>Batteries</td>
<td></td>
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<tr>
<td>Tantalum</td>
<td></td>
<td>Rwanda, D.R. Congo</td>
<td>Capacitors</td>
<td></td>
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<tr>
<td>Praseodymium</td>
<td></td>
<td>China</td>
<td>Permanent magnets</td>
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<tr>
<td>Tungsten</td>
<td></td>
<td>China</td>
<td>Cemented carbides</td>
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<td>Rhodium</td>
<td></td>
<td>South Africa</td>
<td>Catalytic converters</td>
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<tr>
<td>Ruthenium</td>
<td></td>
<td>South Africa</td>
<td>Electronics</td>
<td></td>
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<tr>
<td>Magnesium</td>
<td></td>
<td>China</td>
<td>Aluminum alloys</td>
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<tr>
<td>Platinum</td>
<td></td>
<td>South Africa</td>
<td>Catalytic converters</td>
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<tr>
<td>Niobium</td>
<td></td>
<td>Brazil</td>
<td>Steel alloys</td>
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<tr>
<td>Gallium</td>
<td></td>
<td>China</td>
<td>Integrated circuits</td>
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<tr>
<td>Palladium</td>
<td></td>
<td>Russia, South Africa</td>
<td>Catalytic converters</td>
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<tr>
<td>Iridium</td>
<td></td>
<td>South Africa</td>
<td>Electronics</td>
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<td>Titanium</td>
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<td>China, Japan</td>
<td>Aerospace alloys</td>
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<tr>
<td>Germanium</td>
<td></td>
<td>China</td>
<td>Fiber optics</td>
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</tbody>
</table>

A federal strategy to ensure secure and reliable supplies of critical minerals provides six calls to action.

**Calls to Action**

1. Advance Transformational Research, Development, and Deployment Across Critical Mineral Supply Chains
2. Strengthen America’s Critical Mineral Supply Chains and Defense Industrial Base
3. Enhance International Trade and Cooperation Related to Critical Minerals
4. Improve Understanding of Domestic Critical Mineral Resources
5. Improve Access to Domestic Critical Mineral Resources on Federal Lands and Reduce Federal Permitting Timeframes
6. Grow the American Critical Minerals Workforce

**Lead agencies**
Developing detailed regional and national maps of mineral facilities and related infrastructure is one of our priorities.

Mineral production and processing facilities

Mineral exploration sites

Mineral resources

Oil and gas production and reserves

Transportation infrastructure

Electricity generation & transmission

Oil and gas terminals and pipelines

Future work will examine additional hazards that may disrupt mineral supplies.

Spatial concentration of mineral production in tectonically active areas may pose a higher risk of supply disruption.
A combination of trends and issues raise concerns regarding the reliability of supply for certain non-fuel mineral commodities.

An enhanced assessment based on a risk-modeling framework has been developed to help identify minerals that are at the greatest risk of a supply disruption.

A federal strategy to ensure secure and reliable supplies of critical minerals has been developed and is being implemented.