



Critical Minerals in the Context of Global Mineral Resources

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Why Are Minerals Important?

Technology is growing more complex...



Old

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cp	Fl		Lv			

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

~30 elements

New



H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cp	Fl		Lv			

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

~75 elements

China used more cement in the last three years than the U.S. used in the entire 20th century.

U.S.
in 100 years

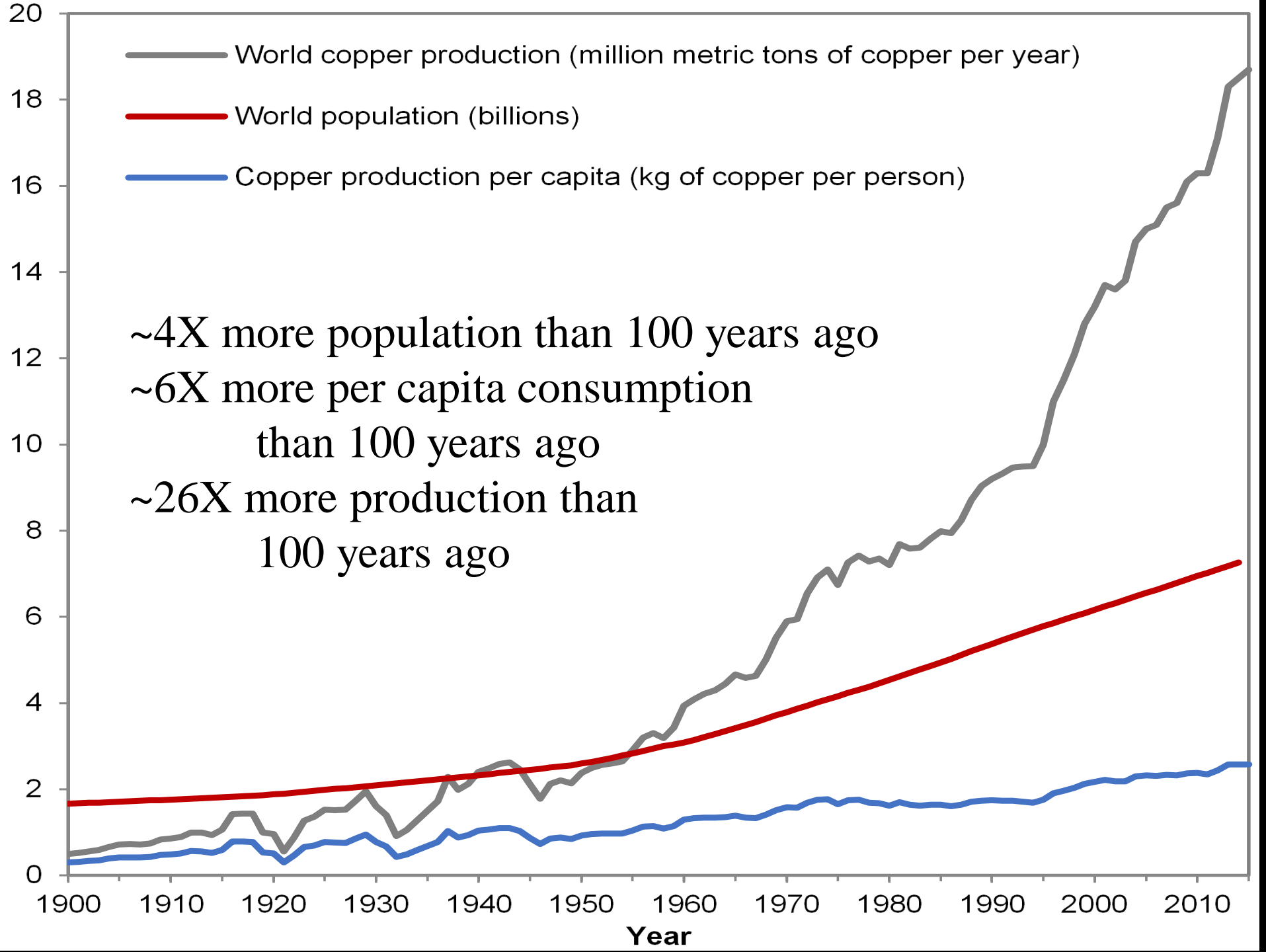


4.5 gigatons
[1901-2000]

CHINA
in 3 years



6.6 gigatons
[2011-2013]

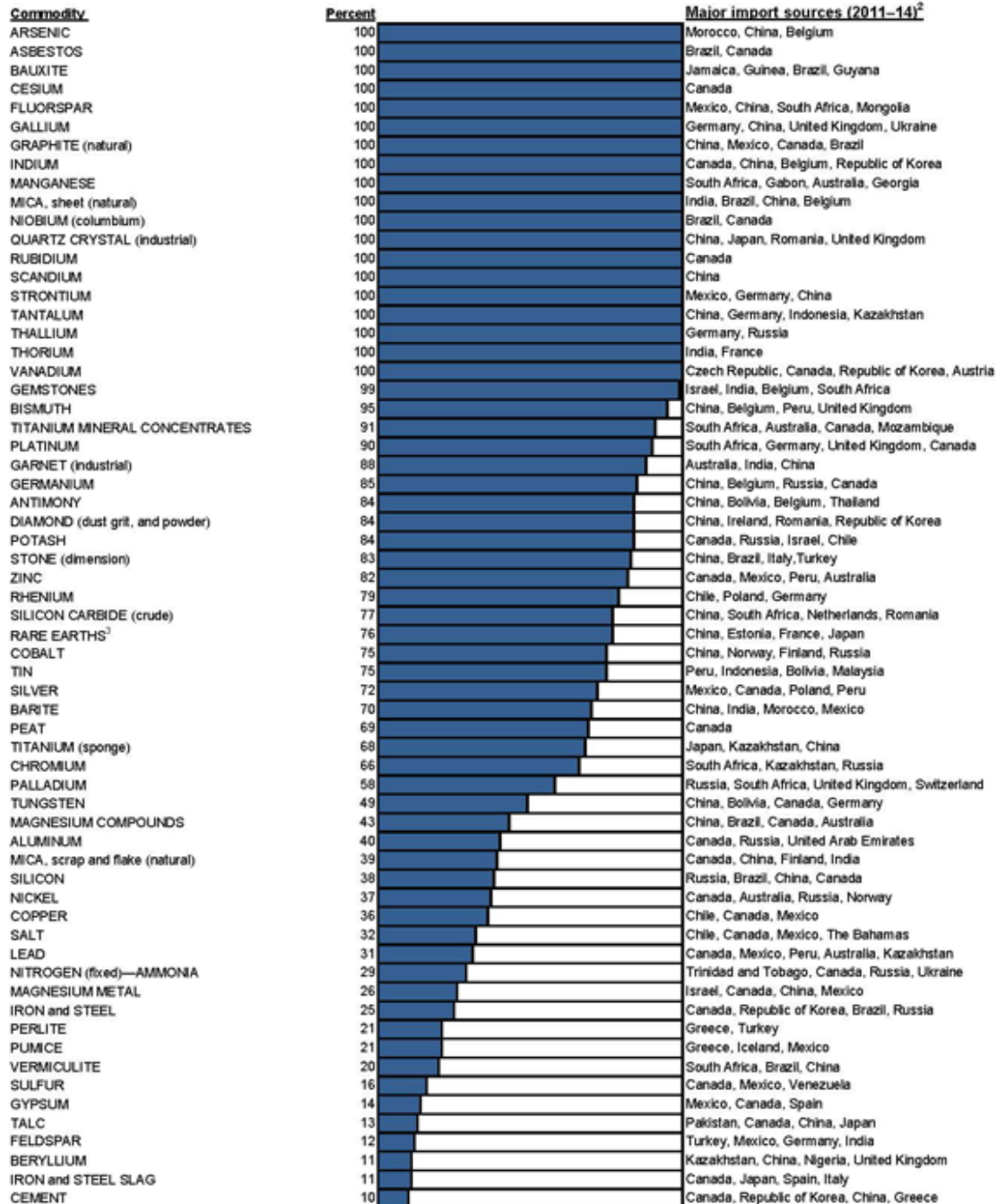


Main Points:

- ◆ As world population and standards of living increase, new resources are needed
- ◆ Recycling, even if 100% efficient, cannot supply entire need
- ◆ More efficient or innovative manufacturing and technology can help, but cannot supply entire need
- ◆ Complete life cycle analysis needs to include upstream (exploration, discovery, and production) as well as downstream (manufacturing, recycling, disposal) parts of the cycle

World Trade

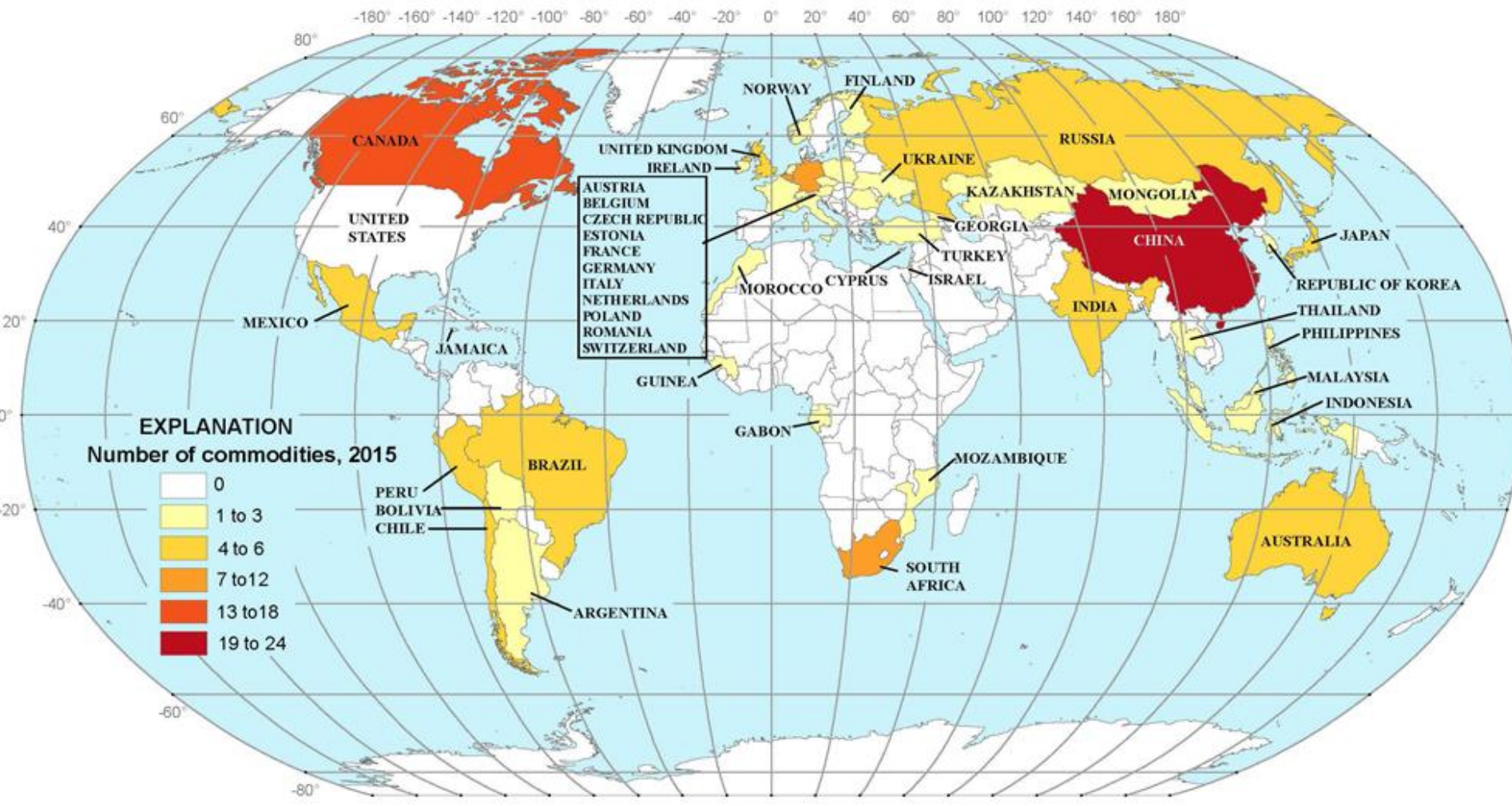
Although the US is a major producer and exporter of many commodities such as molybdenum and beryllium, it relies on world trade for most mineral resources and is >90% reliant on imports for 24 commodities, including REE



Source: USGS Mineral Commodity Summaries (2016)

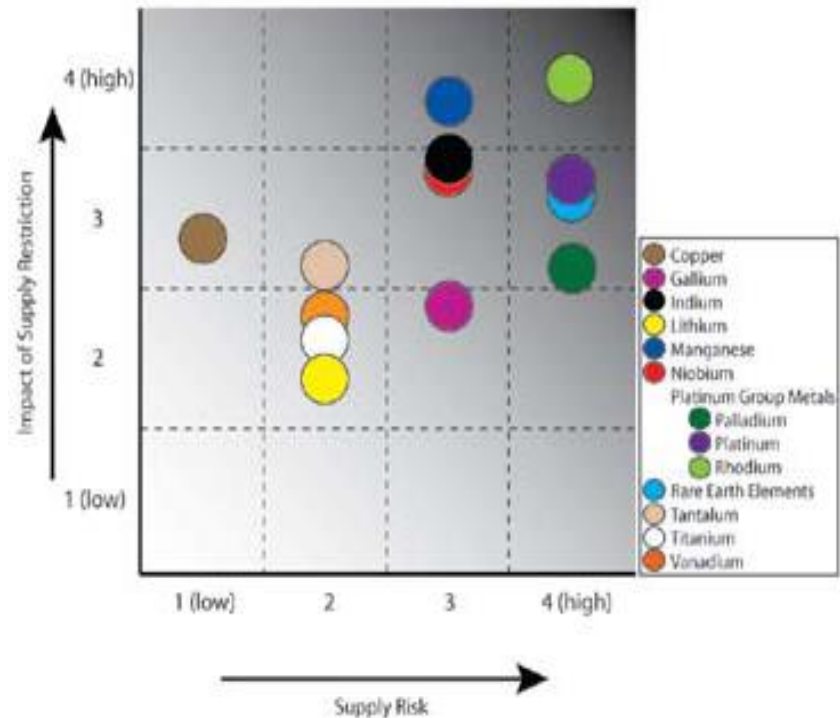
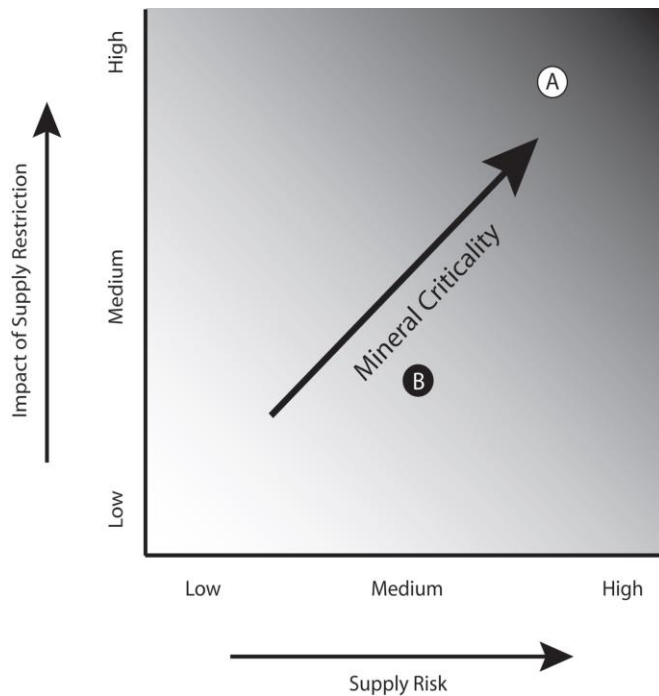


MAJOR IMPORT SOURCES OF NONFUEL MINERAL COMMODITIES FOR WHICH THE UNITED STATES WAS GREATER THAN 50% NET IMPORT RELIANT IN 2015



Source: U.S. Geological Survey

A critical mineral as defined in a 2008 National Academy of Sciences report is one that is both essential in use and subject to the risk of supply restriction



Information is Critical

USGS
science for a changing world

Nonmetallic Mineral Products Industry Indexes
September 2010

This report analyzes and explains (USGS) monthly leading and cost index products industry (OAG) the new, clay, glass, and cement Standard Industrial Classification (SIC) the North American Industry Classification System (NAICS) will be added to the index. This industry processes cement and other products and tracks some of the total value of these products in the construction industry. The index back to 1948 and are available at <http://minerals.usgs.gov/minerals>.

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Metal Industry Indicators
Indicators of Domestic Primary Metals, Steel, Aluminum, and Copper Activity
September 2010

The primary metal industry continues to be depressed with steel and copper manufacturing in the near term. The steel industry is expected to remain depressed in the near term. The aluminum industry is expected to remain depressed in the near term. The copper industry is expected to remain depressed in the near term.

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Mineral Industry Surveys

The primary metal industry continues to be depressed with steel and copper manufacturing in the near term. The steel industry is expected to remain depressed in the near term. The aluminum industry is expected to remain depressed in the near term. The copper industry is expected to remain depressed in the near term.

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MINERALS YEARBOOK
Metals and Minerals 2008
Volume I

U.S. Department of the Interior
U.S. Geological Survey

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MINERAL COMMODITY SUMMARIES 2016

Aluminum	Antimony	Barium	Bismuth
Beryllium	Bismuth	Chromium	Cobalt
Copper	Fluorine	Gold	Iron
Lead	Mercury	Nickel	Platinum
Phosphorus	Silver	Vanadium	Zinc
... (many more)

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The Principal Rare Earth Elements Deposits of the United States—A Summary of Domestic Deposits and a Global Perspective

Scientific Investigations Report 2010-5220

U.S. Department of the Interior
U.S. Geological Survey

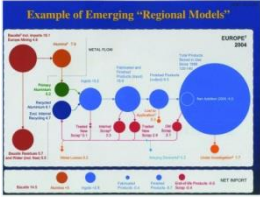
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Rare Earth Elements—End Use and Recyclability

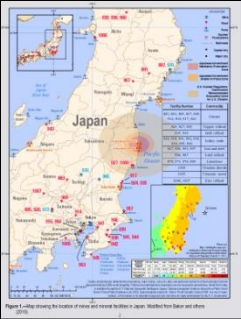
Scientific Investigations Report 2011-5094

U.S. Department of the Interior
U.S. Geological Survey

The Global Flow of Aluminum From 2006 Through 2025: *USGS Open-file Report 2010-1256*



Mines and Mineral Processing Facilities in the Vicinity of the March 11, 2011, Earthquake in Northern Honshu: *USGS Open-file Report 2011-1069*



The Principal Rare Earth Elements Deposits of the United States—A Summary of Domestic Deposits and a Global Perspective

USGS Scientific Investigations Report 2010–5220
<http://pubs.usgs.gov/sir/2010/5220/>



Critical Minerals Summary

- 1) World reserves are adequate, but production is limited and/or dominated by a few sources – e.g., China; supply disruption is possible.
- 2) Several bills concerning critical minerals currently pending in Congress
- 3) Future Federal policy guided by the work of several ongoing White House (OSTP) studies:
 - a) Critical Materials - Criteria & prioritization
 - b) Critical Materials information – sources, gaps, needs
 - c) Critical Materials - Long term R&D strategy & needs
 - d) Materials Genome Initiative
- 4) Data & Research cooperation with EU, EC, and Tri-Lateral Commission
- 5) New and ongoing research
 - USGS – Genesis and resources of REE deposits, e.g., Mountain Pass, Bokan Mtn, etc.
 - USGS – Annual Mineral Commodity Summaries & Minerals Yearbook
 - DOE – Critical Materials Institute (CMI) – discussed by Rod Eggert