SPEAKERS

Jon Price
Nevada Bureau of Mines and Geology (Emeritus)

Larry Meinert
U.S. Geological Survey

Joe Gambogi
U.S. Geological Survey

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

Jon Price
Nevada Bureau of Mines and Geology (Emeritus)
The Importance of Mineral Resources in a National-International Context

Jonathan G. Price
State Geologist Emeritus
Nevada Bureau of Mines and Geology

Azurite & Malachite, Ely, NV (J. Scovil photo)

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The Future of Mineral Resources

• Demand for mineral resources will continue to grow.

• We are unlikely to run out of mineral resources (globally).

• Nonetheless, there are challenges for the United States.
Demand is high for nearly every mineral resource.

Source: USGS, CIA
The number of mineral commodities in demand for products in society has increased markedly in the last 80 years.

Source: USGS data
The current boom (1981-2012) = 247M oz Au
mostly Carlin and other Nevada deposits = 174M oz

Goldfield (NV), Black Hills (SD), Cripple Creek (CO), porphyry Cu (AZ & UT) = 95M oz Au

’49ers = 29M oz Au

Discoveries continue to feed the biggest gold boom in US and world history.
Challenges for the United States

China is #1 in terms of mineral-resource production.
China has 19% of the world’s population.

Selected commodities for which China produced ≥19% of the world’s total in 2012:

- Aluminum*, 42%
- Barite, 48%
- Cement*, 58%
- Fluorspar, 61%
- Gypsum, 32%
- Lead, 50%
- Mica, 69%
- Rare Earths, 94%
- Tungsten, 85%
- Antimony, 83%
- Bismuth, 81%
- Coal, 45% (2011)
- Germanium*, 70%
- Indium*, 58%
- Manganese, 19%
- Molybdenum, 42%
- Steel*, 48%
- Vanadium, 37%
- Arsenic, 57%
- Cadmium, 30%
- Diatomite, 21%
- Graphite, 68%
- Iron ore, 43%
- Mercury, 75%
- Phosphate, 42%
- Tin, 43%
- Zinc, 35%

* refined or processed, not mined
Our consultant will tell us how we can secure a long-term supply of rare earth metals for our products.

China has most of the rare earth metals. Try dying and reincarnating. There’s a 20% chance that you’ll be born Chinese.

What’s Plan B?

If the only part that goes wrong is the Chinese part, you can try dying again.

Rare Earth Elements (REEs)
<table>
<thead>
<tr>
<th>Material Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar panels</td>
<td>CuIn$<em>x$Ga$</em>{(1-x)}$Se$<em>2$, CdTe, GaAs, Ag, and Si$</em>{1-x}$Ge$_x$</td>
</tr>
<tr>
<td>Wind turbines</td>
<td>Fe$_{14}$(Nd,Dy)$_2$B, SmCo$_5$, and Sm$<em>2$Co$</em>{17}$</td>
</tr>
<tr>
<td>Batteries</td>
<td>Li, La, Ni, and V</td>
</tr>
<tr>
<td>Fuel cells</td>
<td>Pt, Pd</td>
</tr>
<tr>
<td>Fluorescent lights</td>
<td>Tb, Eu</td>
</tr>
</tbody>
</table>
Critical and strategic minerals do change with time.
What minerals will be critical for the country?
Will the USA be a major producer of mineral resources in the future?
Mineral Resources and Society
NATIONAL RESEARCH COUNCIL 1996

FUTURE ROLES AND OPPORTUNITIES FOR THE U.S. GEOLOGICAL SURVEY
2001
NATIONAL RESEARCH COUNCIL
SPEAKERS

Larry Meinert
U.S. Geological Survey
China Is Said to Halt Trade in Rare-Earth Minerals With Japan

By KEITH BRADSHER and HIROKO TABUCHI
September 24, 2010

HONG KONG — Akihiro Ohata, the Japanese trade minister, said Friday that his ministry had been informed by Chinese traders that the Chinese government had ceased selling rare-earth minerals, which are used in energy-efficient light bulbs and many other products.

China Consolidates Grip on Rare Earths

By KEITH BRADSHER
September 15, 2011

BEIJING — In the name of fighting pollution, China has sent the price of compact fluorescent light bulbs soaring in the United States. By closing or nationalizing dozens of rare-earth producers, China has consolidated its grip on a valuable and politically sensitive mineral that is essential to many high-tech products.

China and Japan are in diplomatic discord set off by Japan’s recent detention of a Chinese fishing trawler captain points to what foreign military officials say is a growing source of friction along China’s borders: civilian vessels plying disputed waters — and sometimes acting as proxies for the Chinese Ministry of Defense.

Specialists in Rare Earths Say a Trade Case Against China May Be Too Late

By KEITH BRADSHER
March 13, 2012

HONG KONG — Even as the United States, the European Union and Japan jointly filed a trade case Tuesday against China over its export restrictions on strategic rare-earth metals, many analysts say there is little they can do to reverse China’s pricing strategy.
Historical Perspective

➢ WWI & WWII
  • War Dept., 1922: antimony, chromium, graphite, iodine, manganese, mercury, mica, nickel, platinum, potash, tin, tungsten, vanadium
  • 1939: plus aluminum, asbestos, cadmium, cryolite, fluorspar, titanium
  • *Strategic and Critical Materials Stock Piling Acts of 1939, 1946*

➢ Oil Embargo of 1970s
  • Rising commodity prices
  • *Strategic and Critical Materials Stock Piling Revision Act of 1979*
  • *National Materials and Minerals Policy, Research and Development Act of 1980*

➢ Resource War of 1980s
  • Concern that USSR was denying access to strategic resources needed for U.S. economy and defense
  • Concern about increasing import dependence
  • Research by government and academia on Chromite, Cobalt, Manganese, …
  • International Strategic Mineral Inventory (ISMI)
  • *The National Critical Materials Act of 1984*

➢ Rise of Developing Economies in the 21st Century
  • Concerns about reliable supply
  • National critical mineral strategy development – multiple OSTP working groups
  • *Currently several bills pending in 113th Congress*
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 (2013)
REE Production Trends – 1956 to 2010

Sources: USGS Fact Sheet 087-02 updated with recent USGS Minerals Yearbook data
Information is Critical


Minerals Information

Materials Flow Studies
Facilities in impact zone of March 11, 2011, magnitude 9.0 earthquake and associated tsunami:

- 9 cement plants
- 8 iodine plants
- 4 iron and steel plants
- 4 limestone mines
- 3 copper refineries
- 2 gold refineries
- 2 lead refineries
- 2 zinc refineries
- 1 titanium dioxide plant
- 1 titanium sponge processing facility.

These facilities have the capacity to produce the following percentages of the world’s nonfuel mineral production:

- 25% of iodine (Japan is world’s second leading producer (after Chile))
- 10% of titanium sponge (metal)
- 3% of refined zinc
- 2.5% of refined copper
- 1.4% of steel

The 9 cement plants produce 30% of Japan’s annual cement production.

Reference:
Inventory vs Assessment

**Inventory**
- Identified resources
- Near- and medium-term supply
- Often classified by commodity
- Important first step for assessment

**Assessment**
- Undiscovered resources
- Long-term potential supply
- Classified by mineral deposit type
- Qualitative and Quantitative

**Where**
- Probabilistic
Indonesia is included in a report on parts of Southeast Asia and Melanesia.
ASTER alteration mapping as a guide for porphyry copper estimates in Central Asia

Tract area: 79,500 km²
5 known deposits
90-50-10 Estimate: 1-5-12
5.8 expected undiscovered
Old ground vertical gradient, calculated

New airborne vertical gradient, measured
New USGS Laser Ablation Bulk ICP-MS Method

- Low cost, efficient, and accurate analytical method
- Entire periodic table (minus H, He, N, O and F) in a single rapid analysis
- Trace and ultra trace detection (ultra trace to less than 10 ppb in some cases)
- 100+ analyses per day
New National-scale Soil Geochemical and Mineralogical Data for the Conterminous United States

4,857 sites (1 site/1,600 km²); >14,400 samples, 2007-2010

Geochemical and Mineralogical Data for Soils of the Conterminous United States

http://pubs.er.usgs.gov/publication/ds801

U.S. Department of the Interior
U.S. Geological Survey
Lead in 0 to 5 cm
General information:
minerals.usgs.gov/

Products available online at:
minerals.usgs.gov/global/
minerals.usgs.gov/minerals

Contact information:
Larry Meinert
Mineral Resources Program
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e-mail: Lmeinert@usgs.gov
SPEAKERS

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U.S. Geological Survey

U.S. Department of the Interior
U.S. Geological Survey
Rare Earths — the Lanthanide Series, Scandium, and Yttrium

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<thead>
<tr>
<th>Atomic #</th>
<th>Symbol</th>
<th>Name</th>
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<tr>
<td></td>
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<tr>
<td>57</td>
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<td>Lanthanum</td>
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<tr>
<td>58</td>
<td>Ce</td>
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<tr>
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<td>Pr</td>
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<tr>
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<td>Tb</td>
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<td>Thulium</td>
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<td>70</td>
<td>Yb</td>
<td>Ytterbium</td>
</tr>
<tr>
<td>71</td>
<td>Lu</td>
<td>Lutetium</td>
</tr>
<tr>
<td>39</td>
<td>Y</td>
<td>Yttrium</td>
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Uses

- Catalysts: Ce, La, Nd
- Metallurgical
  - Alloys
  - Batteries: La, Ce, Nd, Pr
- Magnets: Nd, Pr, Sm, Dy, Tb
- Polishing: Ce, La, Nd
- Other
  - Ceramics: Y
  - Phosphors: Eu, Y, Tb
  - Electronics
  - Fiber optics and lasers: Er, Y, Nd, Yb, Tm, Pr, Ho
  - Glass additives: Ce, La, Nd, Er
  - Neutron absorption: Nd
Global Rare–Earth Deposits and Occurrences
Supply—Rare–Earth Oxide World Mineral Production Trends 2009–2013

Metric tons

- China
- Rest of World

2009
2010
2011
2012
2013
China’s Rare-Earth Production and Export Quotas

- **2009**: Production Quota = 90,000 tons, Export Quota = 50,000 tons
- **2010**: Production Quota = 90,000 tons, Export Quota = 50,000 tons
- **2011**: Production Quota = 90,000 tons, Export Quota = 50,000 tons
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- **2013**: Production Quota = 90,000 tons, Export Quota = 50,000 tons

**Source**: USGS
Average Prices of Selected Rare-Earth Oxides (REO)

Source: Metal-Pages Ltd
U.S. Imports for Consumption of Rare–Earth Materials

Metric tons, REO equivalent

2009 2010 2011 2012 2013

Ferrocerium
Alloy
Mixed chlorides
Cerium compounds
Mixed oxides
Compounds

USGS

2,000 4,000 6,000 8,000 10,000 12,000 14,000
Closing Thoughts

- China continues to dominate rare-earth supply
- Numerous projects for mining and separation underway
- Prices of rare-earths have decreased significantly
- U.S. imports of rare-earths increased in 2013
- Consumers pursuing conservation and recycle programs
Contact Information

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Reston, VA  20192
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e-mail: jgambogi@usgs.gov
http://minerals.usgs.gov/minerals
Market Update for Rare Earths

2013 USGS Congressional Briefing Series
December 13, 2013

Joseph Gambogi
Rare Earth Commodity Specialist
USGS National Minerals Information Center

U.S. Department of the Interior
U.S. Geological Survey
# Rare Earths — the Lanthanide Series, Scandium, and Yttrium

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## Heavy Rare Earth Elements

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  - Neutron absorption: Nd
Global Rare–Earth Deposits and Occurrences
Rare–Earth Mining Locations

Source
- Bastnäsite
- Loparite
- Monazite
- Rare-earth laterite
- Xenotime

Composition

La Ce Pr Nd Sm Eu Gd Tb Dy Ho Er Tm Yb Lu Y

(Data are from USGS Minerals Yearbook 2011 v1)
Supply—Rare-Earth Oxide World Mineral Production Trends 2009–2013

[Bar chart showing production trends from 2009 to 2013 for China and the Rest of the World. The chart indicates a decrease in production from 2009 to 2013.]
China’s Rare-Earth Production and Export Quotas

<table>
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<tr>
<th>Year</th>
<th>Production Quota</th>
<th>Export Quota</th>
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<tbody>
<tr>
<td>2009</td>
<td>88,900</td>
<td>49,600</td>
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<tr>
<td>2010</td>
<td>94,800</td>
<td>49,600</td>
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<tr>
<td>2011</td>
<td>97,700</td>
<td>49,600</td>
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Metric tons, REO equivalent

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- Alloy
- Mixed chlorides
- Cerium compounds
- Mixed oxides
- Compounds

- 2009
- 2010
- 2011
- 2012
- 2013

0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
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Please check out the Energy and Minerals Science Strategy at: http://pubs.usgs.gov/fs/2013/3111