

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

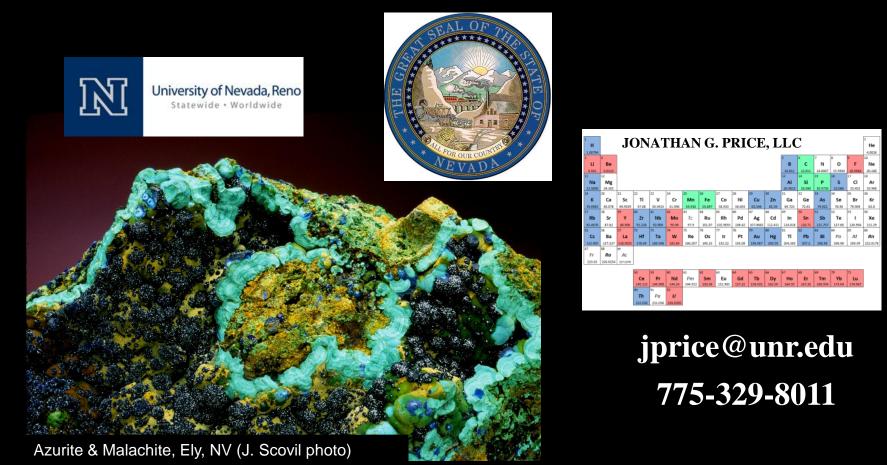
Jon Price Nevada Bureau of Mines and Geology (Emeritus)

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

The Importance of Mineral Resources in a National-International Context

Jonathan G. Price

State Geologist Emeritus Nevada Bureau of Mines and Geology

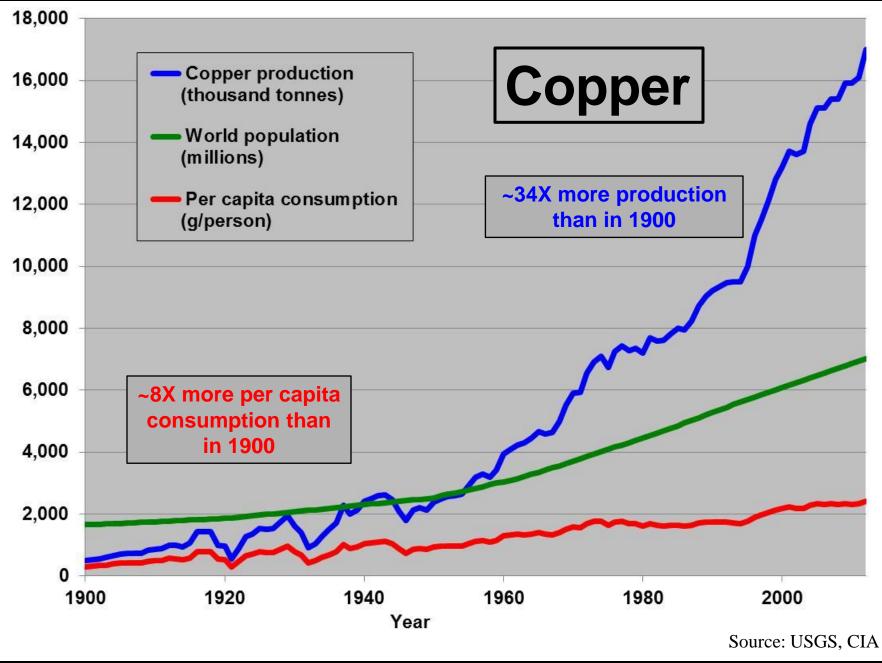


The Future of Mineral Resources

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.

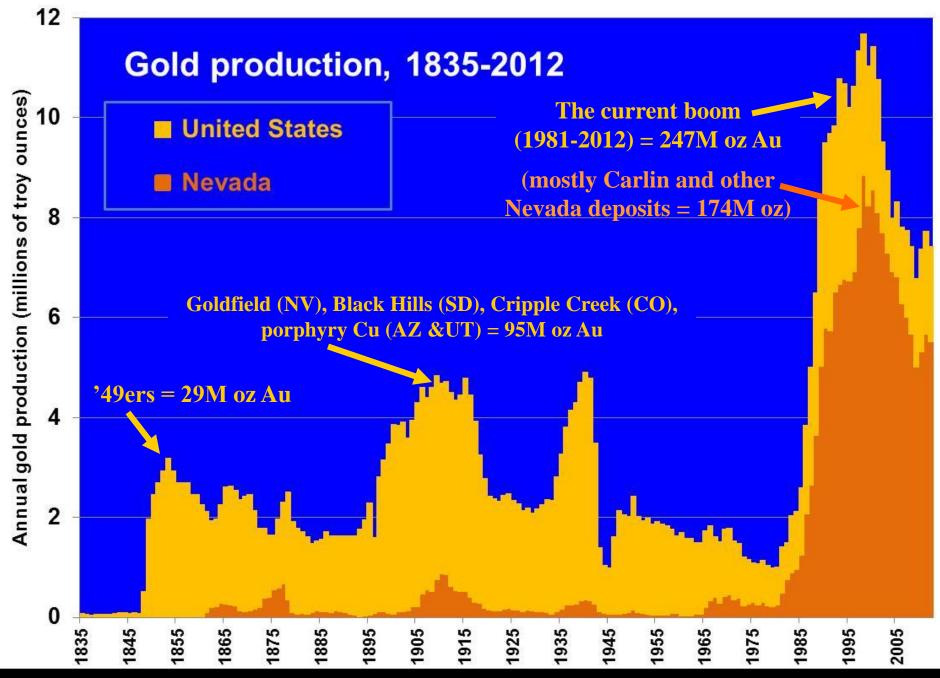


Demand is high for nearly every mineral resource.



The number of mineral commodities in demand for products in society has increased markedly in the last 80 years.

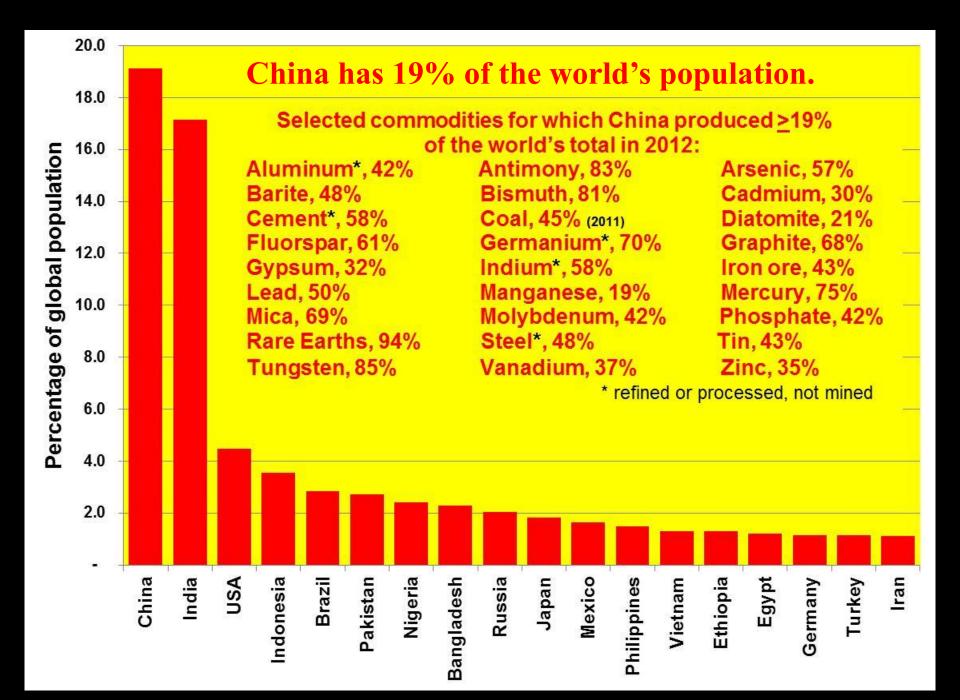
Source: USGS data



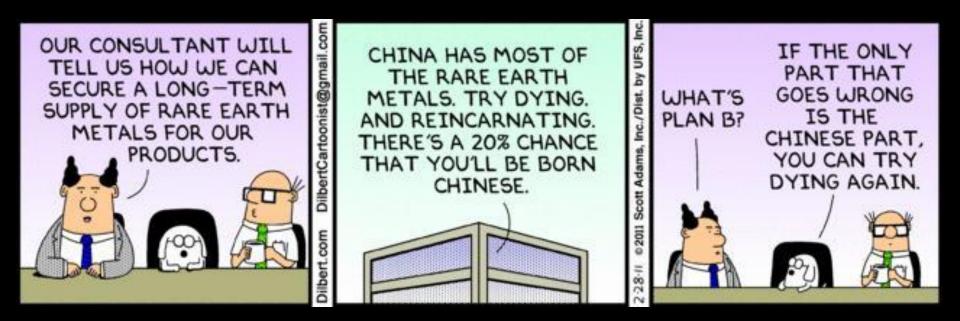
Discoveries continue to feed the biggest gold boom in US and world history.

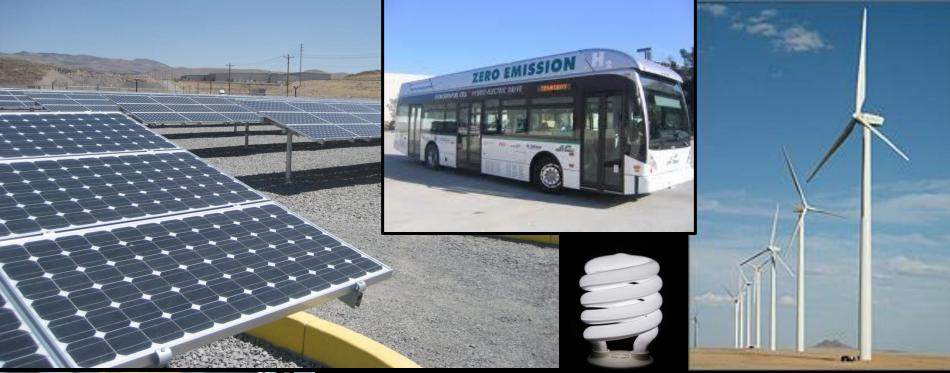
Challenges for the United States

China is #1 in terms of mineral-resource production.



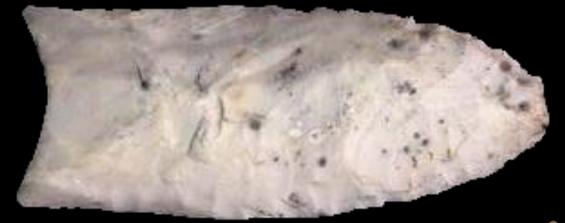
Rare Earth Elements (REEs)







Solar panels	Culn _x Ga _(1-x) Se ₂ , CdTe, GaAs, Ag, and Si _{1-x} Ge _x
Wind turbines	Fe ₁₄ (Nd,Dy) ₂ B, SmCo ₅ , and Sm ₂ Co ₁₇
Batteries	Li, La, Ni, and V
Fuel cells	Pt, Pd
Fluorescent lights	Tb, Eu



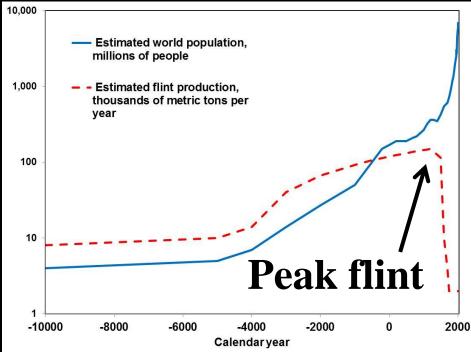


Arrowhead clipart from www.firstpeople.us

Critical and strategic minerals do change with time.







						-		
Energy Critical Elements:						2		
	5)							He Helium
								4.003
			5	6	7		9	10
			В	C	N	0	F	Ne
			Boron 10.811	Carbon 12.0107	Nitrogen 14.00674	Oxygen 15.9994	Fluorine 18.9984032	Neon 20.1797
			13	14	15	16		-
			A	Si	Р	S		
			Aluminum	Silicon	Phosphorus	Sulfur		
28	29	30	26.981538 31	28.0855 32	30.973761 33	32.066 3.4		(
Ni	Ču	Zn	Ga	Ge	As	Se	All and	~
Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	NT.	
58.6934	63.546	65.39	69.723	72.61	74.92160	78.96		
46	47	48	49	50	51	52		
Pd	Ag	Cd	In	Sn	Sb	Те	A second	
Palladium 106.42	Silver 107.8682	Cadmium 112.411	Indium 114.818	Tin 118.710	Antimony 121.760	Tellurium 127.60		
78	79		81	82		84		
Pt	Αu	Hg	TI	Pb	Bi	Po	At	Rn
Platinum		Mercury	Thallium	Lead		Polonium	Astatine	Radon
195.078 65	196.96655 66	200.59 67	204.3833 68	207.2 69	208.98038	(209)	(210)	(222)
тЬ	Dv	Ho	Er	Tm	Yb	Lu		
Terbium	Dysprosium	Holmium	Erbium	Tholium	Ytterbium	LU		
158.92534	162.50	164.93032	167.26	168.93421	173.04	174.967		

Securing Materials for Emerging Technologies

A REPORT BY THE APS PANEL ON PUBLIC AFFAIRS & THE MATERIALS RESEARCH SOCIETY





What minerals will be critical for the country?

2008

MINERALS, CRITICAL MINERALS, AND THE U.S. ECONOMY

HARDROCK MINING ON FEDERAL LANDS



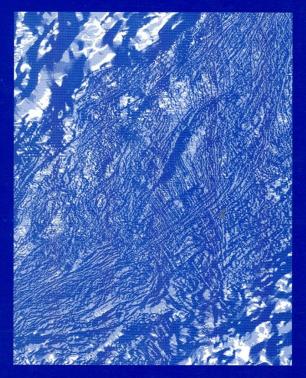
NATIONAL RESEARCH COUNCIL

1999

Will the USA be a major producer of mineral resources in the future?

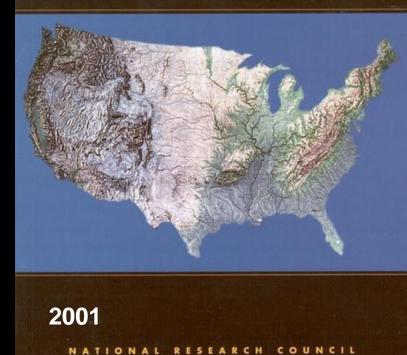
Mineral Resources and Society

A Review of the U.S. Geological Survey's Mineral Resource Surveys Program Plan



NATIONAL RESEARCH COUNCIL 1996

FUTURE ROLES AND OPPORTUNITIES FOR THE U.S. GEOLOGICAL SURVEY





SPEAKERS

Larry Meinert U.S. Geological Survey

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



2013 USGS Congressional Briefing Series

Critical Minerals – Ensuring America's Future

Larry Meinert Mineral Resources Program

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

The New York Eimes

Chinese Civilian Boats Roil Disputed Waters

By EDWARD WONG October 5, 2010 BEIJING – The <u>diplomatic</u> 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 <u>China</u>'s borders: civilian vessels plying disputed waters and sometimes acting as proxies for the Chinese

The New York Times

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 The New York Eimes were comple Specialists in Rare Earths Say a from China Trade Case Against China May that the gov By KEITH BRADSHER investigatii March 13, 2012 The Chine HONG KONG – Even as the United Ministry h States, the European Union and <u>Japan</u> jointly filed a trade case Tuesday against <u>China</u> over its export restrictions on strategic <u>rare earth</u> metals,

The New York Times

China Consolidates **Grip on Rare Earths**

By KEITH BRADSHER September 15, 2011

BEIJING — In the name of fighting pollution, <u>China</u> has sent the price of <u>compact</u> fluorescent light ing in the

> closing pzens of are hich are ficient other

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)



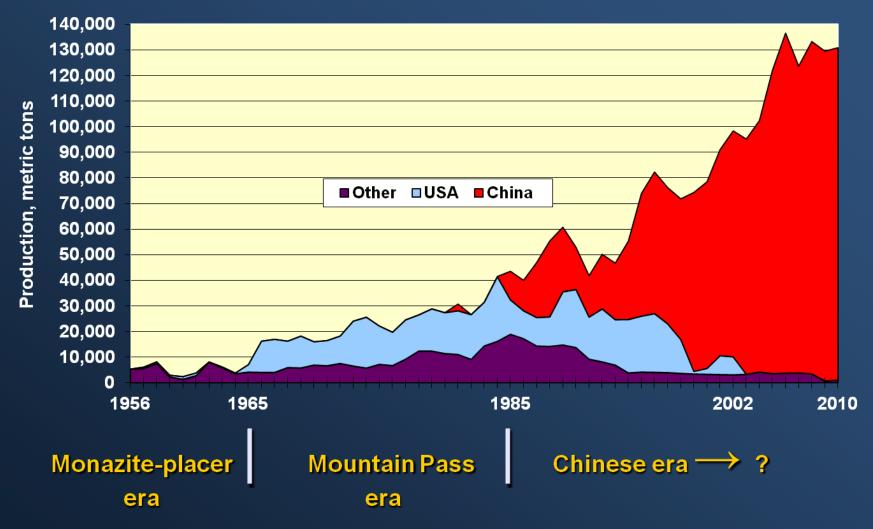
Commodity Pe ARSENIC (trioxide) ASBESTOS BAUXITE and ALUMINA CESIUM FLUORSPAR GRAPHITE (natural) INDIUM MANGANESE MICA, sheet (natural) NIOBIUM (columbium) QUARTZ CRYSTAL (industrial) RUBIDIUM SCANDIUM STRONTIUM TANTALUM THALLIUM THORIUM GALLIUM GEMSTONES VANADIUM BISMUTH PLATINUM GERMANIUM IODINE ANTIMONY DIAMOND (dust, grit, and powder) STONE (dimension) POTASH BARITE COBALT RHENIUM TITANIUM MINERAL CONCENTRATE TIN SILICON CARBIDE (crude) ZINC CHROMIUM GARNET (industrial) TITANIUM (sponge) PEAT SILVER PALLADIUM NICKEL MAGNESIUM COMPOUNDS TUNGSTEN SILICON COPPER NITROGEN (fixed), AMMONIA MAGNESIUM METAL MICA, scrap and flake (natural) VERMICULITE PERLITE ALUMINUM SALT SULFUR PUMICE

GYPSUM

2012 U.S. NET IMPORT RELIANCE¹

ercent		Major Import Sources (2008–11) ²
100		Morocco, China, Belgium
100		Canada, Zimbabwe
100		Jamaica, Brazil, Guinea, Australia
100		Canada
100		Mexico, China, South Africa
100		China, Mexico, Canada, Brazil
100		China, Canada, Japan, Belgium
100		South Africa, Gabon, Australia, China
100		China, Brazil, Belgium, India
100		Brazil, Canada, Germany
100		China, Japan, Russia
100		Canada
100		China
100		Mexico, Germany, China
100		China, Estonia, Germany, Kazakhstan
100		Germany, Russia
100		India, France
99		Germany, United Kingdom, China, Canada
99		Israel, India, Belgium, South Africa
96		Rep. of Korea, Canada, Austria, Czech Republic
92		China, Belgium, United Kingdom
91		Germany, South Africa, United Kingdom, Canada
90		China, Belgium, Russia, Germany
88		Chile, Japan
87		China, Mexico, Belgium, Bolivia
85		China, Ireland, Republic of Korea, Russia
85		China, Brazil, Italy, Turkey
81		Canada, Russia
80		China, India, Morocco
78		China, Norway, Russia, Finland
78		Chile, Netherlands, Germany
ES 77		South Africa, Australia, Canada, Mozambique
75		Peru, Bolivia, Indonesia, China
73		China, South Africa, Romania, Netherlands
72		Canada, Mexico, Peru, Spain
70		South Africa, Kazakhstan, Russia, Mexico
65		India, Australia, China, Canada
64		Japan, Kazakhstan, China, Ukraine,
62		Canada
57		Mexico, Canada, Peru, Poland
54		Russia, South Africa, United Kingdom, Norway
49		Canada, Russia, Australia, Norway
46		China, Canada, Brazil, Australia
42		China, Bolivia, Canada, Germany
36		Brazil, Russia, China, Canada
35		Chile, Canada, Peru, Mexico
35		Trinidad and Tobago, Russia, Canada, Ukraine
31		Israel, Canada, China Canada, China India, Finland
31		Canada, China, India, Finland
30		South Africa, China, Brazil, Australia
24		Greece
20		Canada, Russia, China, Mexico
19		Canada, Chile, Mexico, The Bahamas
19	207	Canada, Mexico, Venezuela
15		Greece, Iceland, Mexico, Montserrat
12		Canada, Mexico, Spain

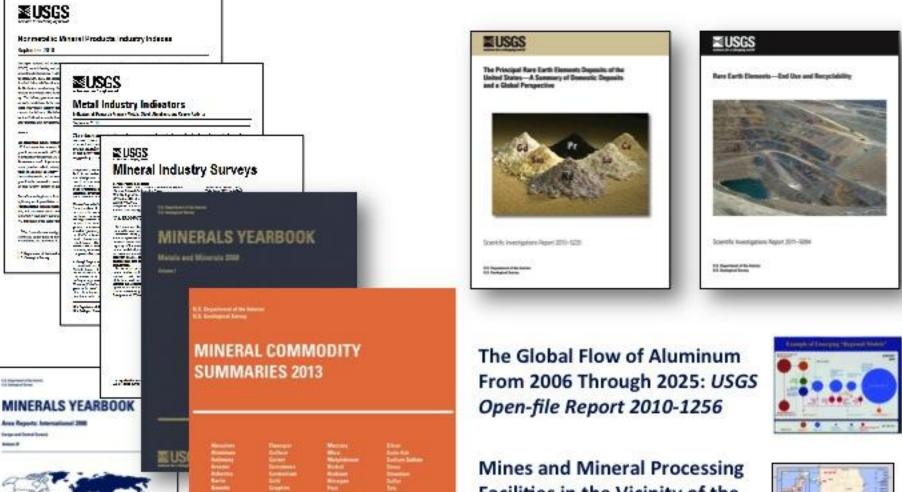
REE Production Trends – 1956 to 2010



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



Information is Critical



≊USGS

Facilities in the Vicinity of the March 11, 2011, Earthquake in Northern Honshu: USGS Openfile Report 2011-1069



Minerals Information

Materials Flow Studies

Materials Flow of Indium in the United States in 2008 and 2009



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

Wind Energy in the United States and Materials Required for the Land-Based Wind Turbine Industry From 2010 Through 2030





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≥USGS

Circular 1365

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

Byproduct Mineral Commodities Used

for the Production of Photovoltaic Cells

ALILAS MAX

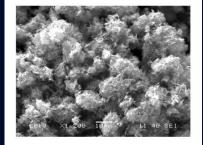
Byproduct Metals and Rare-Earth Elements Used In the Production of Light-Emitting Diodes— Overview of Principal Sources of Supply and Material Requirements for Selected Markets

Provide Law under State Provide Law Under Sta



≊USGS

Lithium Use in Batteries



Circular 1371

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



Mines and Mineral Processing Facilities in the Vicinity of the March 11, 2011, Earthquake in Northern Honshu, Japan

By W. David Merszie, Michael S. Belyer, Dorreld I. Bleisens, and Chin Kup





Recent Strikes In South Africa's Platinum-Group Metal Mines: Effects Upon World Platinum-Group Metal Supplies

By Thomas P. Yagar, Yadaw Solo-Virset, and Jamos J. Barry

Open-File Report 2012-1273

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

Supply Disruption

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

- 9 cement plants
- 8 iodine plants 4 limestone mi
- 4 iron and steel plants 3 copper refineries
- 2 lead refineries
- 4 limestone mines 2 gold 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



Menzie, W.D., Baker, M.S., Bleiwas, D.I., and Kuo, Chin, 2011, Mines and mineral processing facilities in the vicinity of the March 11, 2011, earthquake in northern Honshu, Japan: U.S. Geological Survey Open-File Report 2011–1069, 7 p. (Available only at http://oubs.usgs.gov/of/2011/1069/.)

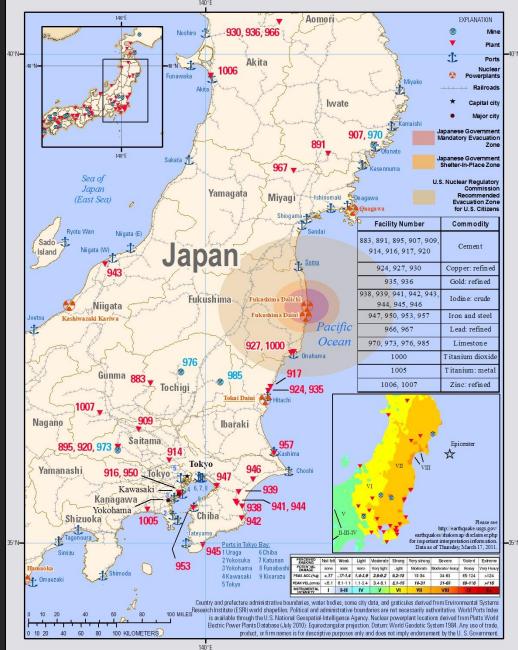


Figure 1.—Map showing the location of mines and mineral facilities in Japan. Modified from Baker and others (2010).

Inventory

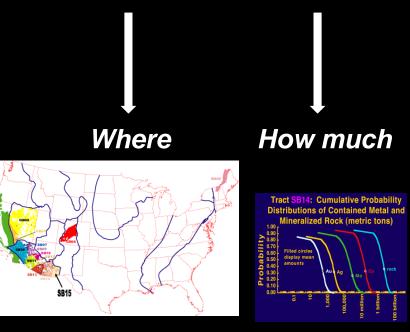
VS

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

<page-header><complex-block>

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

Assessment





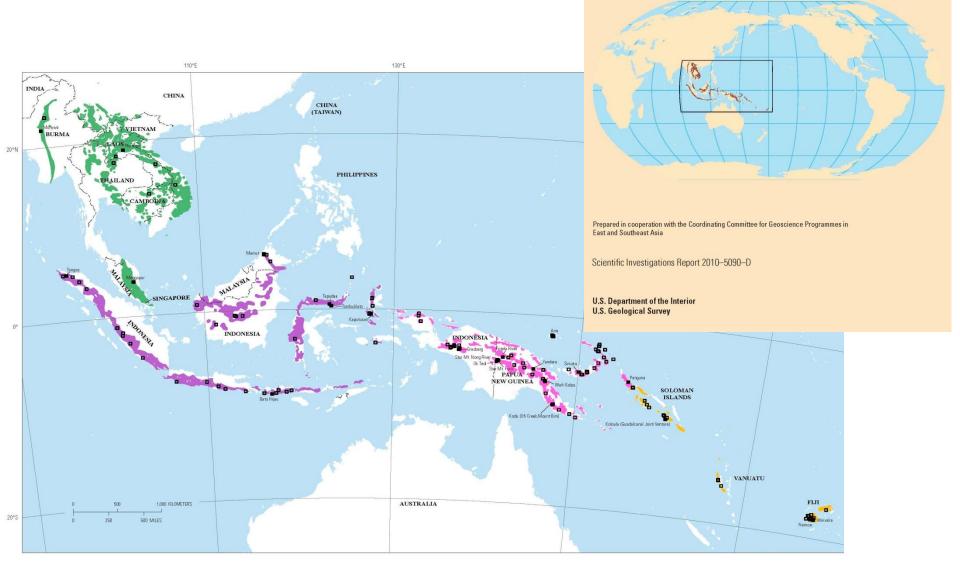
Probabilistic

Indonesia is included in a report on parts of Southeast Asia and Melanesia

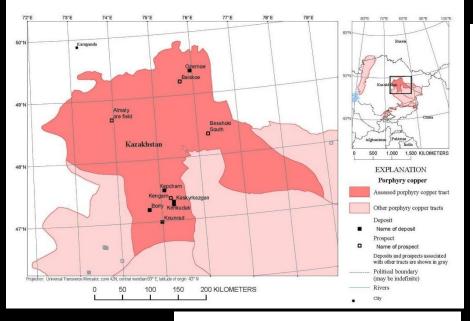


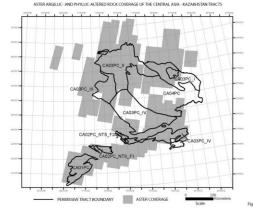
Global Mineral Resource Assessment

Porphyry Copper Assessment of Southeast Asia and Melanesia

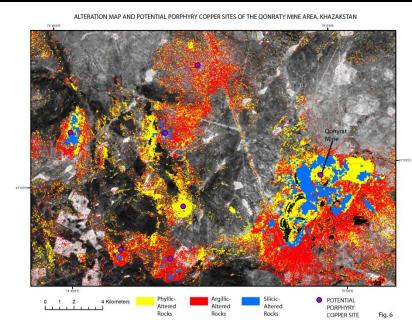


ASTER alteration mapping as a guide for porphyry copper estimates in Central Asia

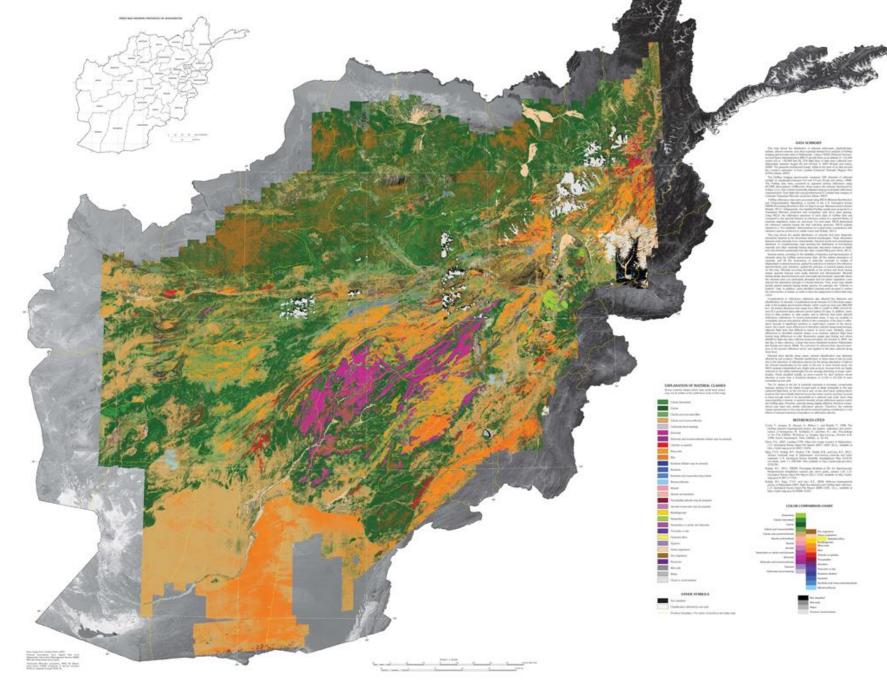






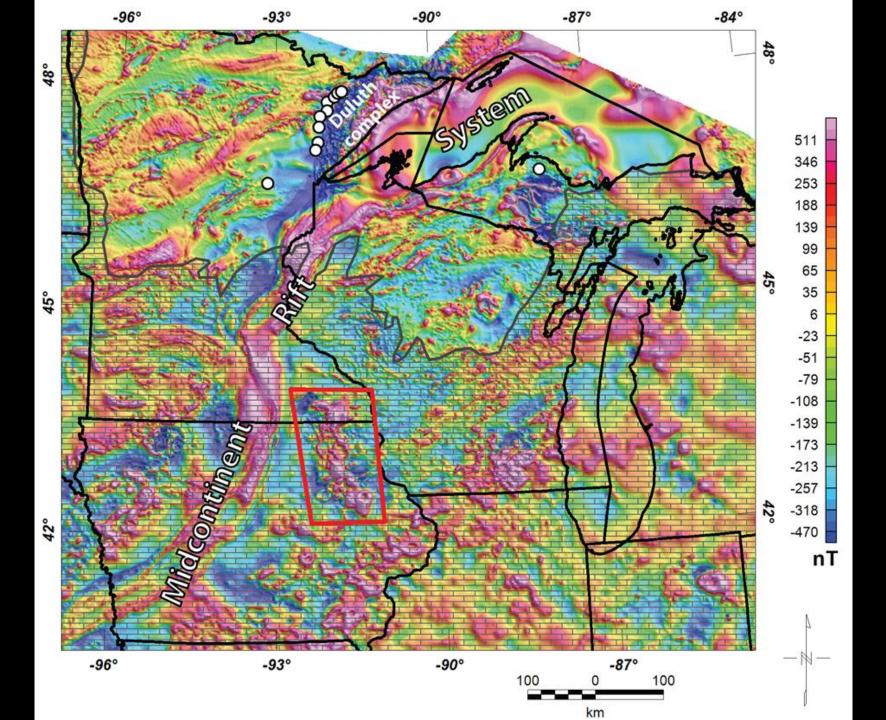


Tract area: 79,500 km² 5 known deposits 90-50-10 Estimate: 1-5-12 5.8 expected undiscovered

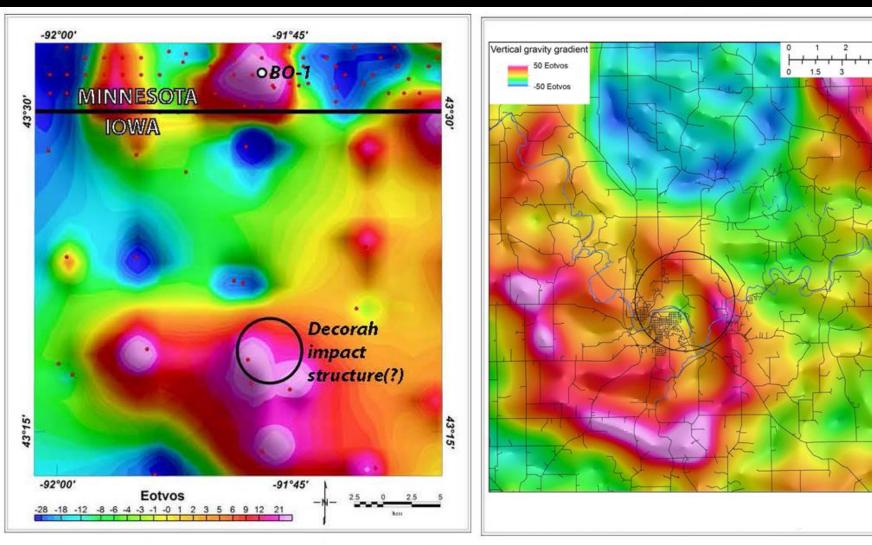


EUSGS

SURFACE MATERIALS MAP OF AFGHANISTAN: CARBONATES, PHYLLOSILICATES, SULFATES, ALTERED MINERALS, AND OTHER MATERIALS







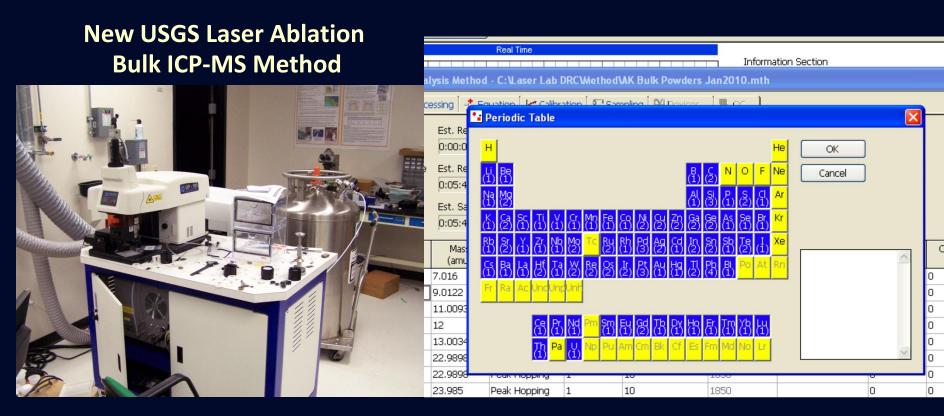
Old ground vertical gradient, calculated

New airborne vertical gradient, measured

4 Miles

6 Kilometers

Inventory and Characterization of Byproduct Critical Mineral Resources Critical Metal Content of Domestic Mineral Deposits



- 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



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



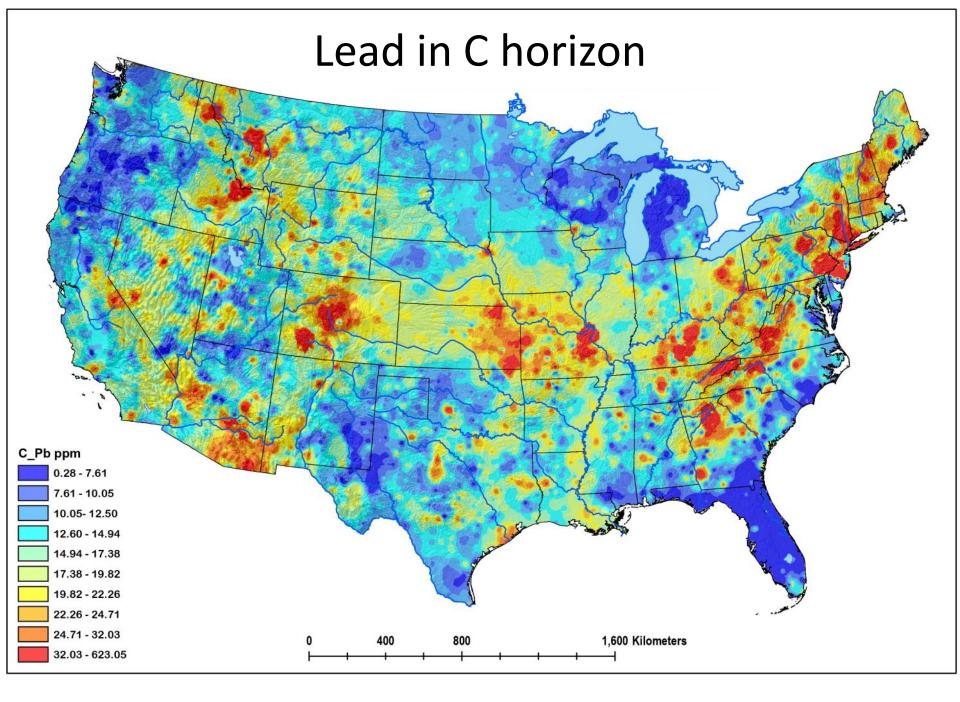
Geochemical and Mineralogical Data for Soils of the Conterminous United States

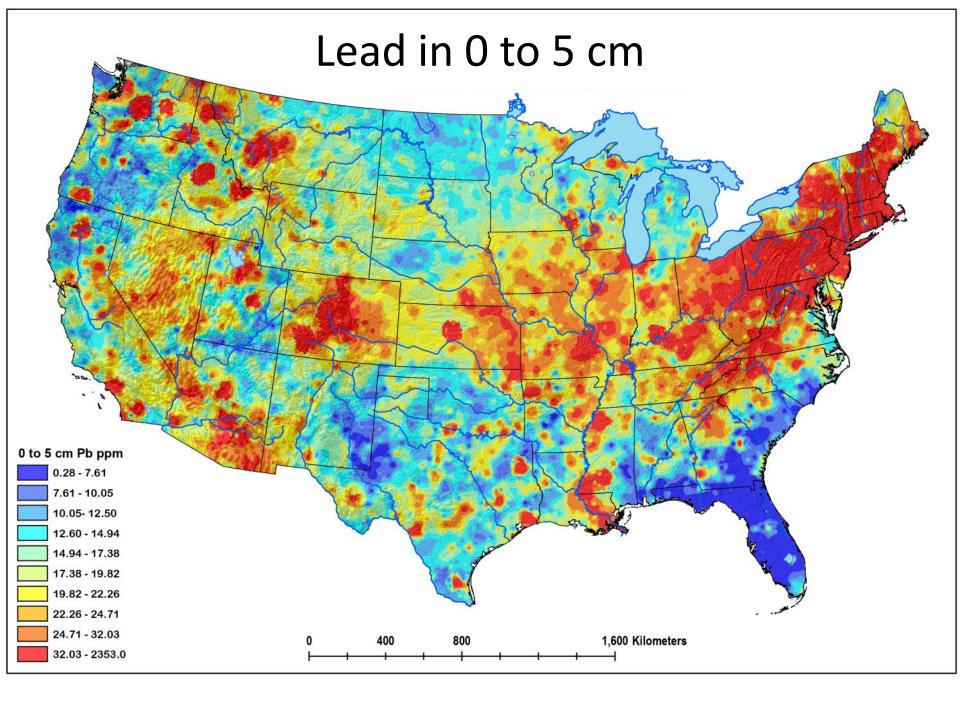


http://pubs.er.usgs.gov/publication/ds801

Data Series 801

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







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minerals.usgs.gov/

Products available online at:

minerals.usgs.gov/global/ minerals.usgs.gov/minerals Contact information:

Larry Meinert Mineral Resources Program U.S. Geological Survey 989 National Center Reston, VA 20192 voice: 703-648-6100 e-mail: Lmeinert@usgs.gov



SPEAKERS

Joe Gambogi U.S. Geological Survey

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



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

	Atomic #	Symbol	Name				
	21	Sc	Scandium				
	57	La	Lanthanum				
rth	58	Ce	Cerium				
цs Ц	59	Pr	Praseodymium				
are	60	Nd	Neodymium				
ht Rare E Elements	61	Pm	Promethium				
Light Rare Earth Elements	62	Sm	Samarium				
_	63	Eu	Europium				
	64	Gd	Gadolinium				
	65	Tb	Terbium				
arth	66	Dy	Dysprosium				
ы С С	67	Ho	Holmium				
ivy Rare E Elements	68	Er	Erbium				
y R Ier	69	Tm	Thulium				
Heavy Rare Earth Elements	70	Yb	Ytterbium				
Ť	71	Lu	Lutetium				
	39	Y	Yttrium				

out	termost	t electrons over full shell			2* S	tomic num	element		Nonmet			73	ou	idency to ter shell b ing electro	y	Tendency to gain electrons to make full outer shell		Noble gases (inert) VIIA 2 He
	14	2A			Helun	tomic weig lame of els				ide series			II.A	IV A	VA	VI A	WA	4.003 Helium
	3 Li 6.905 Libium	4 Be 9.012 Beryllum		Actinide series											7 N 14.007 Nitrogen	8 0 15.9994 Oxygen	9 F 18.998 Fluorine	10 Ne 20.183 Neon
	11 Na 22.090 Sodium	12 Mg 21.1 Magnesium		Tendency to lose electrons												18 Ar ^{30, 948} Argon		
R	19 K 30.102 Manalum	20 Ca 40.00 Caloum	21 Sc 44.05 Scandlum	22 Ti ^{47,00} Titasium	23 V SO.54 Venadum	24 Cr SL00 Chromum	25 Mn S3.54 Manganese	26 Fe 55.85 700	27 Co Sel MO Cobait	28 Ni 50.71 Nokai	29 Cu 63.54 Copper	30 Zn 66.37 Znc	31 Ga Galum	32 Ge 72.58 Gemanum	33 As 74.92 Antenic	34 Se 70.90 Selenium	35 Br 79.000 Bromine	36 Kr ea.co Krypton
1177	37 Rb M0.47 ubidium	38 Sr stortiur	39 ¥ 30.91 1001um	40 Zr 91.22 Zirconium	41 Nb Nobium	42 Mo 90.94 Molybdenum	43 Tc (M) Technetium	44 Ru 101-1 Ruthenium	45 Rh Toz.90 Rhodum	46 Pd 106.4 Paladum	47 Ag 10/6/ Sher	48 Cd 112.49 Cadmum	49 In 114.62 Indum	50 Sn 118.09 Te	51 Sb UZL75 Antimony	52 Te 127.60 Tellurium	53 120.90 odine	54 Xe 131.80 Xeron
	55 Cs 132.11 Desium	66 Ba 137.34 Barum	57 TO 71	72 Hf 178.49 Hathium	73 Ta 180.95 Tentalum	74 W 183.85 Tungaten	75 Re 1862 Rhenium	76 Os 190.2 Osmun	77 Ir 1922 Malum	78 Pt 195.09 Platinum	79 Au 197.0 Gold	80 Hg 20039 Mercury	81 TI 204.37 Thalium	82 Pb 207.19 Lead	83 Bi 208.98 Bismuth	84 Po 210 Polonum	85 At (210) Astantine	86 Rn (222) Radon
P	87 Fr 923) ancium	88 Ra 22105 Radium	89 TO 103	57 La 136.91 Lathenut	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymiu	60 Nd 144.34 Necdymium	61 Pm (147) Promethum	62 Sm 150.35 Semarum	63 Eu tot.90 Europium	64 Gd 157,25 Gadoleium	65 Tb 106.92 Terbium	66 Dy te250 Dysprosium	67 Ho 164.93 Holmium	68 Er 107.20 Erbum	69 Tm Tost.93 Thalium	70 Yb 172,04 Yfferdaun	71 Lu ^{174,97} Latetium
				89 Ac (227) Actinum	90 Th 232.04 Thorium	91 Pa (201) Potactinium	92 U 238.03 Uranium	93 Np (237) Nepturium	94 Pu (242) Platonium	95 Am G43) Amendum	96 Cm Cutum	97 Bk (249) Berustun	98 Cf (251) Californium	99 Es (254) Ensteinur	100 Fm CESS Ferman	101 Md 256 Mendelenu	n Nobelium	103 Lw 257 Lawrencham



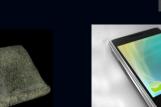
Uses

- 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









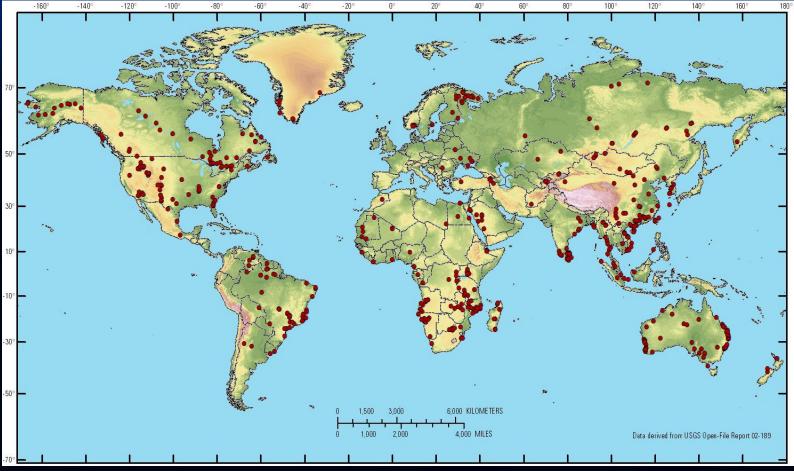






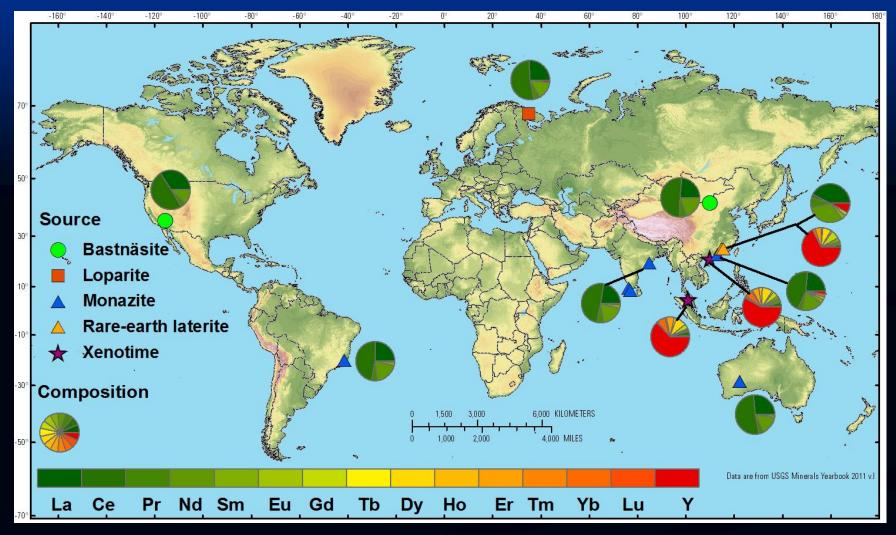


Global Rare–Earth Deposits and Occurrences



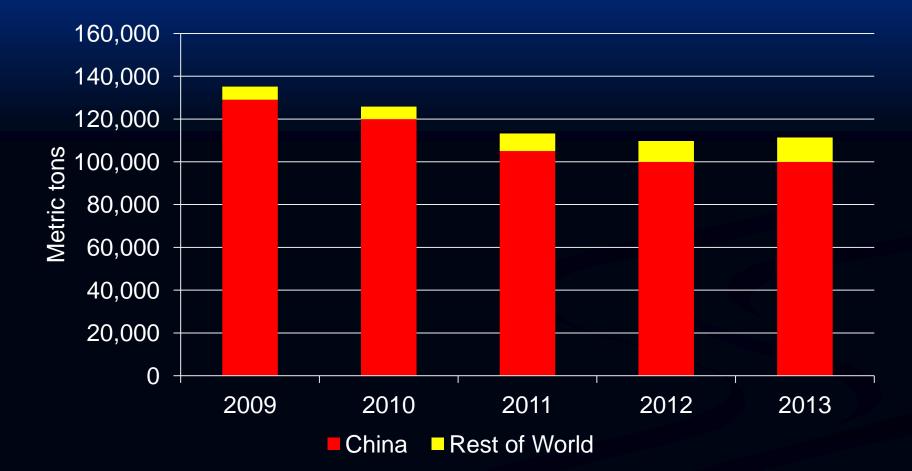


Rare–Earth Mining Locations



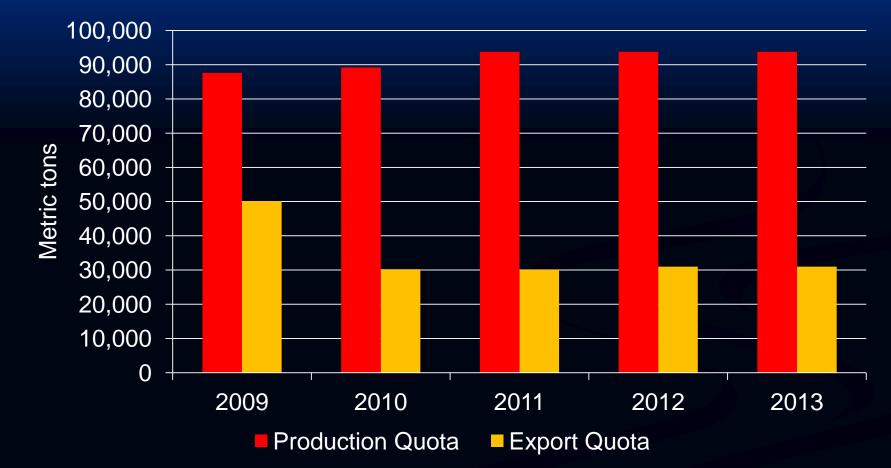


Supply—Rare–Earth Oxide World Mineral Production Trends 2009–2013



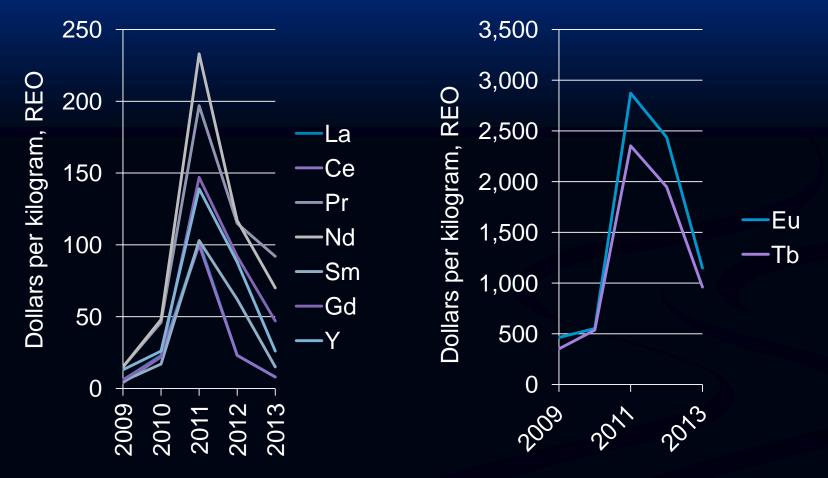


China's Rare-Earth Production and Export Quotas





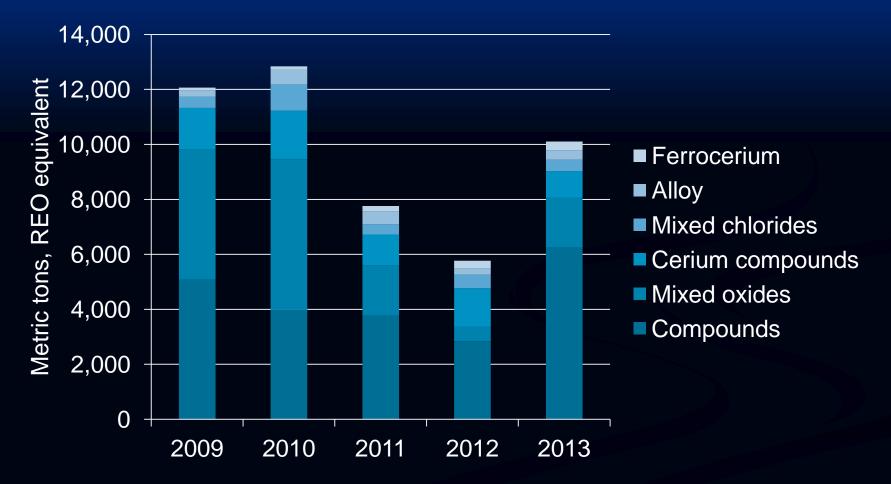
Average Prices of Selected Rare-Earth Oxides (REO)





Source: Metal-Pages Ltd

U.S. Imports for Consumption of Rare–Earth Materials





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

Joseph Gambogi National Minerals Information Center U.S. Geological Survey 989 National Center Reston, VA 20192 voice: 703-648-7718 fax: 703-648-7757 e-mail: jgambogi@usgs.gov http://minerals.usgs.gov/minerals





Market Update for Rare Earths

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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

	Atomic #	Symbol	Name				
	21	Sc	Scandium				
	57	La	Lanthanum				
rth	58	Ce	Cerium				
цs Ц	59	Pr	Praseodymium				
are	60	Nd	Neodymium				
ht Rare E Elements	61	Pm	Promethium				
Light Rare Earth Elements	62	Sm	Samarium				
_	63	Eu	Europium				
	64	Gd	Gadolinium				
	65	Tb	Terbium				
arth	66	Dy	Dysprosium				
ы С С	67	Ho	Holmium				
ivy Rare E Elements	68	Er	Erbium				
y R Ier	69	Tm	Thulium				
Heavy Rare Earth Elements	70	Yb	Ytterbium				
Ť	71	Lu	Lutetium				
	39	Y	Yttrium				

out	termost	t electrons over full shell			2ª S	tomic num	element		Nonmet			73	ou	idency to ter shell b ing electro	Y	Tendency to gain electrons to make full outer shell		Noble gases (inert) VIIA 2 He
	14	2A			Helun	tomic weig lame of els				ide series			II.A	IV A	VA	VI A	WA	4.003 Helium
	3 Li 6.905 Libium	4 Be 9.012 Beryllum		Actinide series											7 N 14.007 Nitrogen	8 0 15.9994 Oxygen	9 F 18.998 Puprine	10 Ne 20.183 Neon
	11 Na 22.090 Sodium	12 Mg 21.1 Magnesium		Tendency to lose electrons												18 Ar ^{30, 948} Argon		
R	19 K 30.102 Manalum	20 Ca 40.00 Caloum	21 Sc 44.05 Scandlum	22 Ti ^{47,00} Titasium	23 V SO.54 Venadum	24 Cr SLOO Chromum	25 Mn S3.54 Manganese	26 Fe 55.85 700	27 Co Sel MO Cobait	28 Ni 50.71 Nokai	29 Cu 63.54 Copper	30 Zn 66.37 Znc	31 Ga Galum	32 Ge 72.58 Gemanum	33 As 74.92 Antenic	34 Se 70.90 Selenium	35 Br 79.000 Bromine	36 Kr ea.co Krypton
1177	37 Rb M0.47 ubidium	38 Sr stortium	39 ¥ 30.91 1001um	40 Zr 91.22 Zirconium	41 Nb Nobium	42 Mo 90.94 Molybdenum	43 Tc (M) Technetium	44 Ru 101-1 Ruthenium	45 Rh Toz.90 Rhodum	46 Pd 106.4 Paladum	47 Ag 10/6/ Sher	48 Cd 112.49 Cadmum	49 In 114.62 Indum	50 Sn 118.09 Te	51 Sb UZL75 Antimony	52 Te 127.60 Tellurium	53 120.90 odine	54 Xe 131.80 Xeron
	55 Cs 132.11 Desium	66 Ba 137.34 Barum	57 TO 71	72 Hf 178.49 Hathium	73 Ta 180.95 Tentalum	74 W 183.85 Tungaten	75 Re 1862 Rhenium	76 Os 190.2 Osmun	77 Ir 1922 Malum	78 Pt 195.09 Platinum	79 Au 197.0 Gold	80 Hg 20039 Mercury	81 TI 204.37 Thalium	82 Pb 207.19 Lead	83 Bi 208.98 Bismuth	84 Po 210 Polonum	85 At (210) Astantine	86 Rn (222) Radon
P	87 Fr 923) ancium	88 Ra 22105 Radium	89 TO 103	57 La 136.91 Lathenut	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymiu	60 Nd 144.34 Neodymium	61 Pm (147) Promethum	62 Sm 150.35 Semarum	63 Eu tot.90 Europium	64 Gd 157,25 Gadoleium	65 Tb 106.92 Terbium	66 Dy te250 Dysprosium	67 Ho 164.93 Holmium	68 Er 107.20 Erbum	69 Tm Tost.93 Thalium	70 Yb 172,04 Yfferdaun	71 Lu ^{174,97} Latetium
				89 Ac (227) Actinum	90 Th 232.04 Thorium	91 Pa (201) Potactinium	92 U 238.03 Uranium	93 Np (237) Nepturium	94 Pu (242) Platonium	95 Am G43) Amendum	96 Cm Cutum	97 Bk (249) Berustun	98 Cf (251) Californium	99 Es (254) Ensteinur	100 Fm CESS Ferman	101 Md 256 Mendelenu	n Nobelium	103 Lw 257 Lawrencham



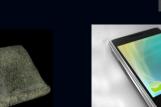
Uses

- 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









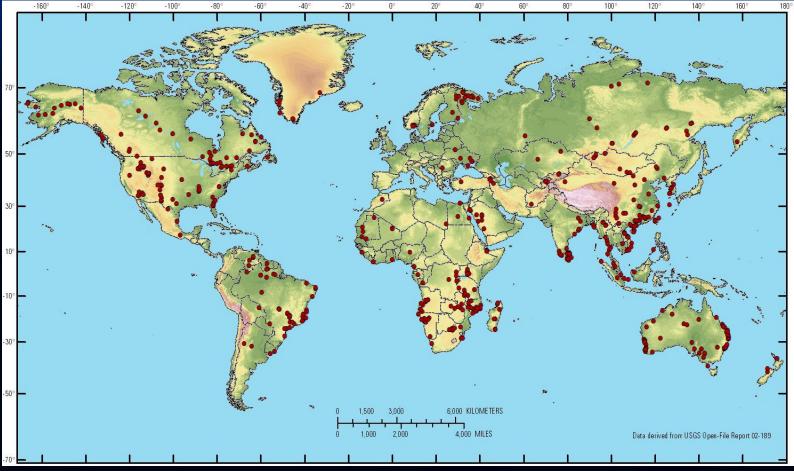






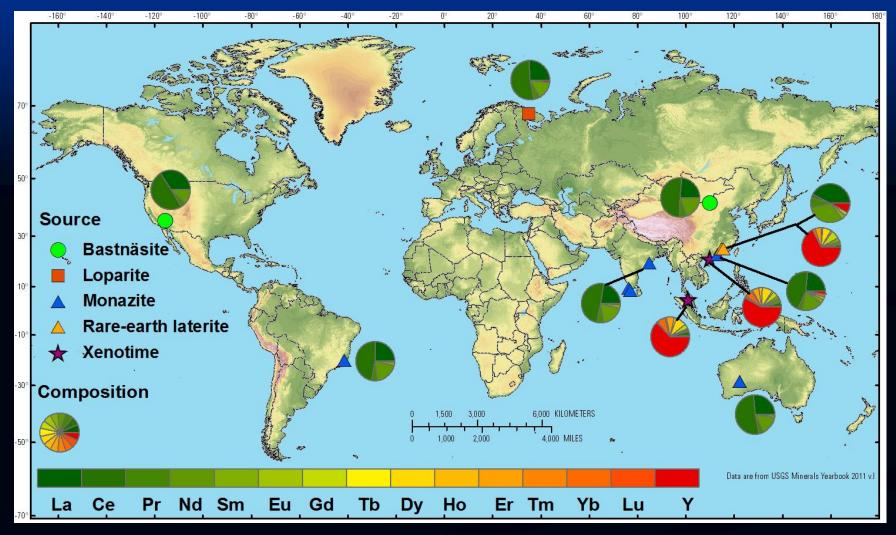


Global Rare–Earth Deposits and Occurrences



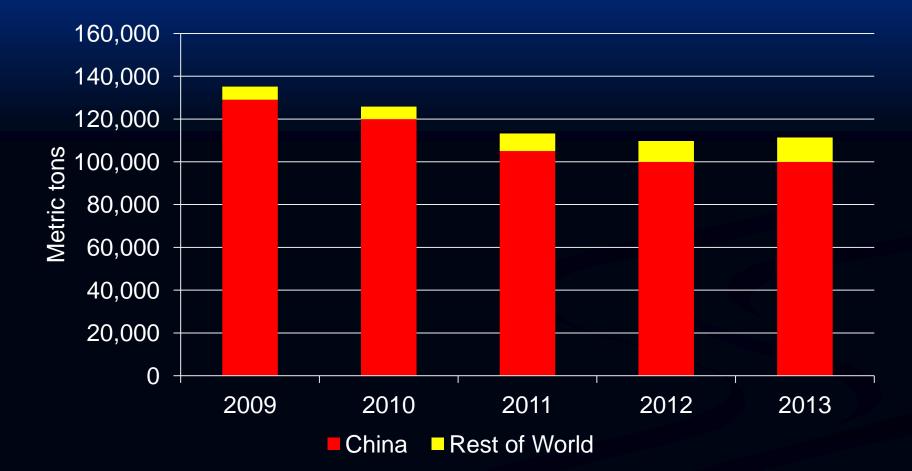


Rare–Earth Mining Locations



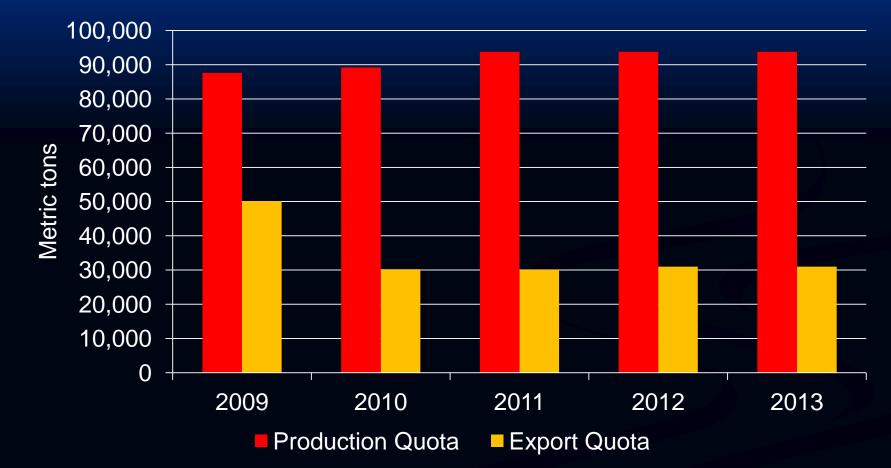


Supply—Rare–Earth Oxide World Mineral Production Trends 2009–2013



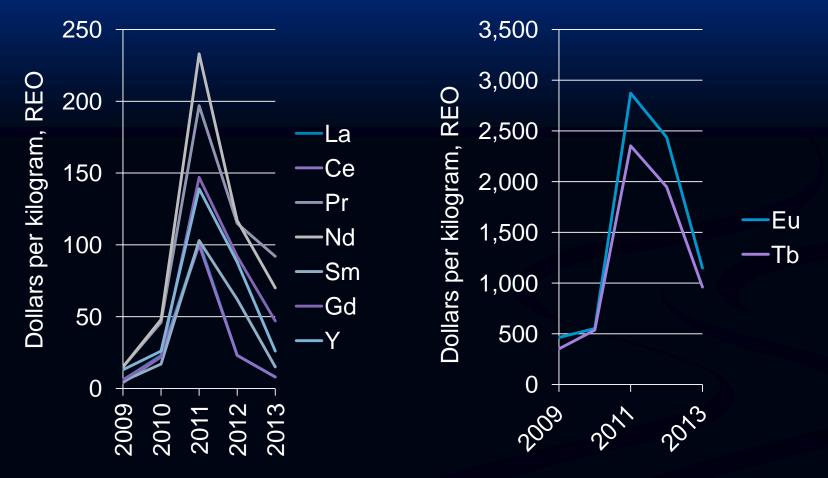


China's Rare-Earth Production and Export Quotas





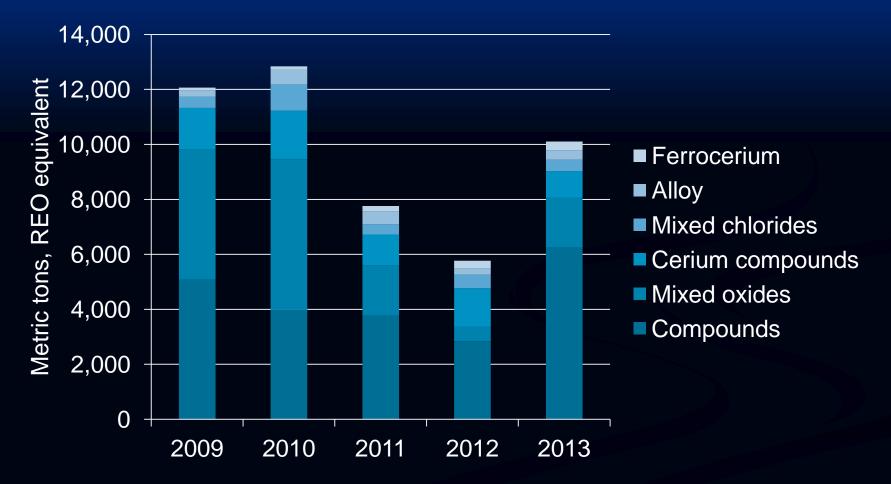
Average Prices of Selected Rare-Earth Oxides (REO)





Source: Metal-Pages Ltd

U.S. Imports for Consumption of Rare–Earth Materials





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



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SPEAKERS

Jon Price Nevada Bureau of Mines and Geology (Emeritus)

Larry Meinert U.S. Geological Survey

Joe Gambogi U.S. Geological Survey

Please check out the Energy and Minerals Science Strategy at: http://pubs.usgs.gov/fs/2013/3111

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