

MPG and Society



Water or natural landscape?

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MPG and Societal Issues

Societal issues offer engagement & can be brought into any level of the geoscience curriculum.

- Introductory geology
- Mineralogy, Petrology
- Environmental Geology

Adds connections to “real life”

Internalize the need for understanding science in everyday decision-making



Mine at Butte, Montana, USA. Photo: B. Dutrow



Danish Wind farm in North Sea. Image: www.fnfacts.com

Strategies for Incorporation



Zn-containing items used daily with sphalerite and zincite, commonly mined for supply. *Photo: B. Dutrow*



- Cover specific issues
 - Health effects of minerals, dust, SiO_2
 - Global warming problems, solutions
 - Zeolites
- “Green” energy
 - Need for REEs
 - Mining and processing
 - Environmental laws

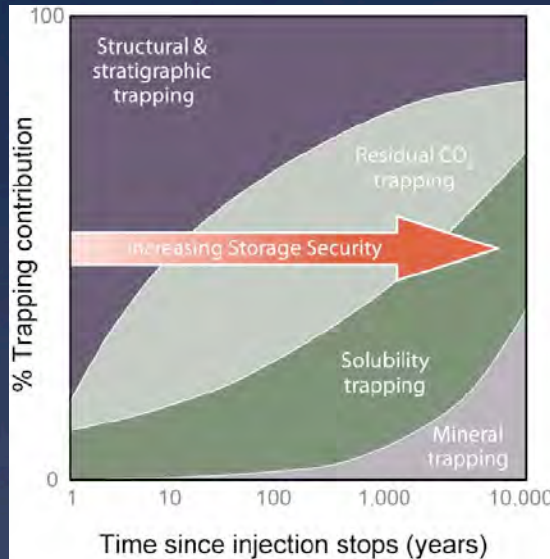
Strategies for Incorporation



Image: www.aaesystems.ca

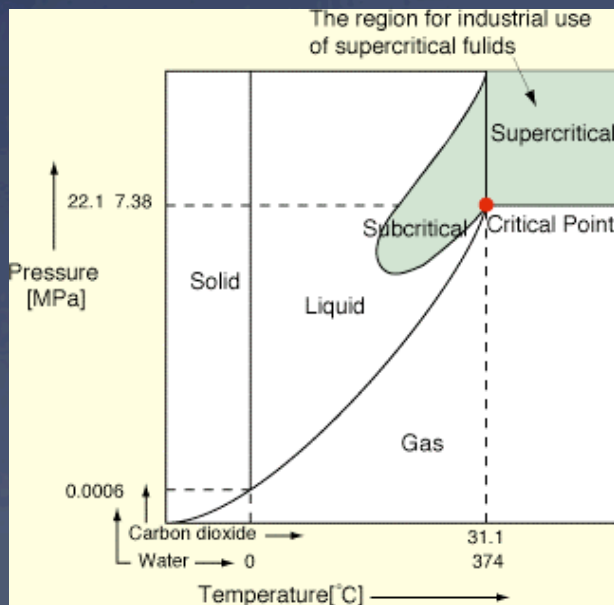
- Notebook of “What’s in the News” (Survey)
 - Report out at each class
 - Continue for the semester
 - Engaged in popular news
 - Becomes template
 - Pb in toys from China
 - Pathogens in fluid inclusions from ice sheets
 - See where it takes you
- Critical-thinking reading assignments
- Research projects

Topics: Climate and CO₂ Sequestration



Mineralogic, geologic aspects:

- sequestration and trapping
 - Deep saline aquifers
 - Carbonation of Ca-Mg silicates
 - Coal-seams
- mineral surfaces and reactions
- phase diagrams for CO₂
- Transportation issues
- Isn't created close to storage



Hydrofracture

“Green Energy” Is there such a thing?



- Critical thinking reinforced through system analyses of different energy options
- **Nuclear**
 - No CO₂ but HL hazardous waste, large fresh water use, proliferation, cost, safety, U mines
 - Pre-Chernobyl and Three Mile Island generation “China Syndrome” (movie), Fukushima

Tunisia - Image: geni.org



- **Solar, wind, geothermal, hydropower**
 - **Require REEs**

Uses of REEs

- Cerium Ce - polishing agent for glass; mirrors to high-precision lenses
- Nd, Sm, Gd, Dy or Pr - alloys for lightweight, high strength magnets allow for miniturization of electronic components
 - Multi-GB portable disk drives and DVD use REE magnets!
 - Reduce the weight of automobiles

[illegible]

REEs in Electric/Hybrid Car



Image: Molycorp.com

Uses of REEs: Connections to Everyday Life

- Europium *Eu* - red phosphor in color cathode-ray tubes and liquid-crystal displays in computer monitors and TVs
 - No substitute is known
 - Low abd, hi demand - \$250 - \$1,00/kg
- Erbium *Er* - used in fiber-optic cables (greater band width) because of laser amplifiers - repeaters
 - \$700/kg
 - It alone posses required optical properties

LANTHANIDE														Copyright © 1998-2003 EniG. (eni@ktf-split.hr)	
(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001) Relative atomic mass is shown with five significant figures. For elements have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.	57 138.91 La LANTHANUM	58 140.12 Ce CERIU	59 140.91 Pr PRASEODYMIUM	60 144.24 Nd NEODYMIUM	61 (145) Pm PROMETHIUM	62 150.36 Sm SAMARIUM	63 151.96 Eu EUROPIUM	64 157.25 Gd GADOLINIUM	65 158.93 Tb TERBIUM	66 162.50 Dy DYSPROSIUM	67 164.93 Ho HOLMIUM	68 167.26 Er ERBIUM	69 168.93 Tm THULIUM	70 173.04 Yb YTTERBIUM	71 174.97 Lu LUTETIUM
ACTINIDE															

Applications of REEs

- Y, La, Ce, Eu, Gd, Tb - Magnetic-refrigerator technology - to reduce CO₂ emissions
- Gd - Tm have unusually large magnetic moments
 - Gd₅(Si₂Ge₂) with 'giant magnetocaloric effect' at near room T will allow magnetic refrigeration to be competitive
 - Reduce CO₂

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However three such elements (Th, Pa, and U)	ACTINIDE															

Uses of REEs

- Y, La, Ce, Eu, Gd, Tb - energy efficient fluorescent lamps that reduce CO₂ emissions
- Phosphors of Rare Earths are applied to the insides of the bulbs and generate light when energy is applied (CFL).
- Incandescence bulbs waste 95% of their energy and convert only 5% to actual light. CFL which converts 25% of input energy to visible light via the Rare Earth phosphor coating. This efficiency results in much lower lamp T, significantly longer life (estimated at 6 to 10 times as long), and less total energy consumed, directly reducing greenhouse gas emissions.

[illegible]

“Green Energy and REEs”

RARE EARTHS	ATOMIC NO.	COMMERICAL USE
Scandium	21	Stadium lights
Yttrium	39	Lasers
Lanthanum	57	Electric car batteries
Cerium	58	Lens polishes
Praseodymium	59	Searchlights, aircraft parts
Neodymium	60	High-strength magnets
Promethium	61	Portable X-ray units
Samarium	62	Glass
Europium	63	Compact fluorescent bulbs
Gadolinium	64	Neutron radiography
Terbium	65	High-strength magnets
Dysprosium	66	High-strength magnets
Holmium	67	Glass tint
Erbium	68	Metal alloys
Thulium	69	Lasers
Ytterbium	70	Stainless steel
Lutetium	71	None

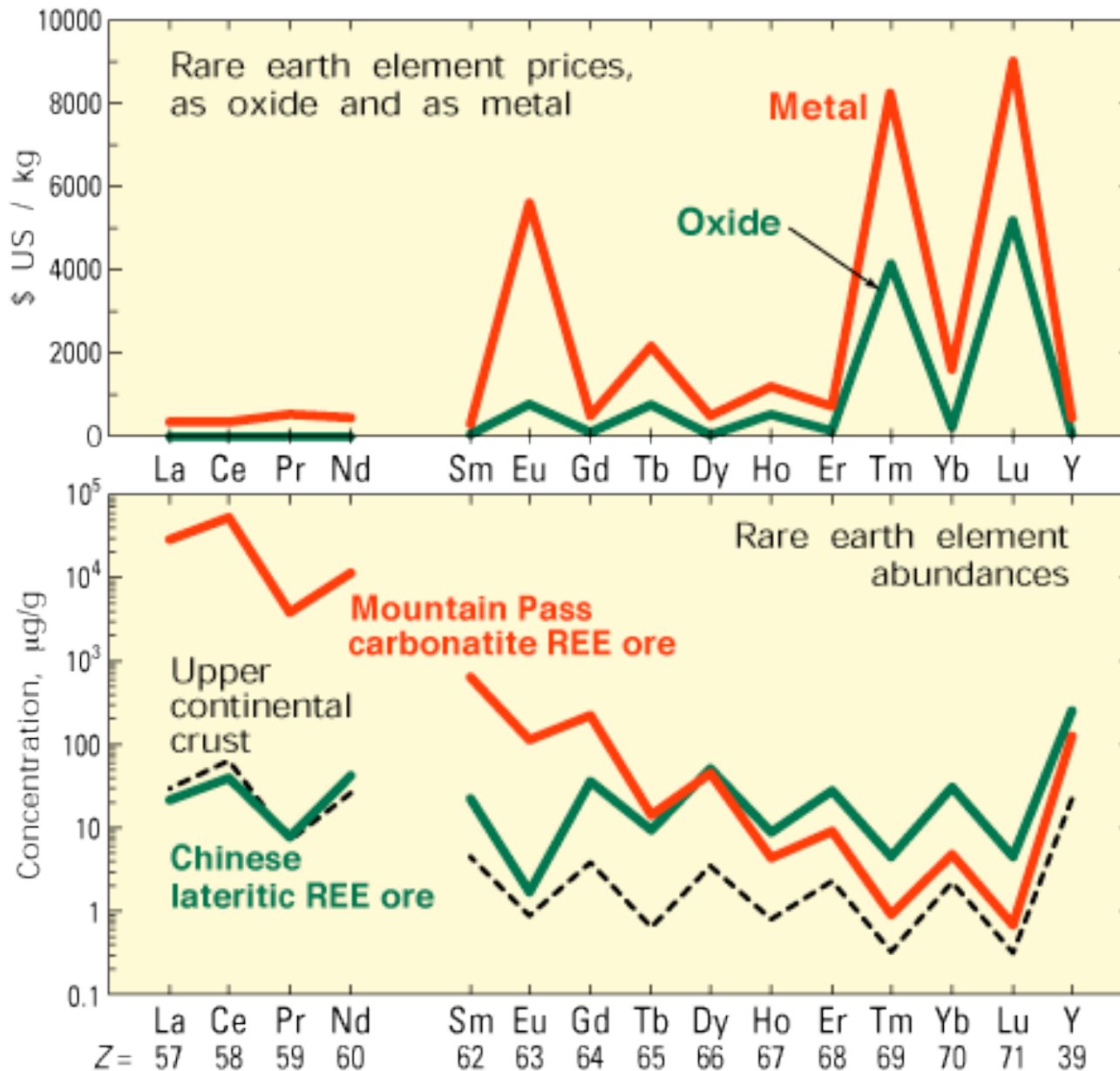
THE NEW YORK TIMES

Many of the Green Energy technologies (including hybrid cars) require considerable quantities of REEs.

Each year every American requires 40,000 lb of new material (as of 1989).

Can our planet sustain this?

REE Prices and Concentration



Prices for 1999 - 2000
 As **oxides** in 2-25 kg packages at 95-99.99% purity.
 As 0.1 - 0.45 kg **metal** ingot at 99.9% purity.

Hi grade **carbonatite ore** - Mtn Pass, CA;

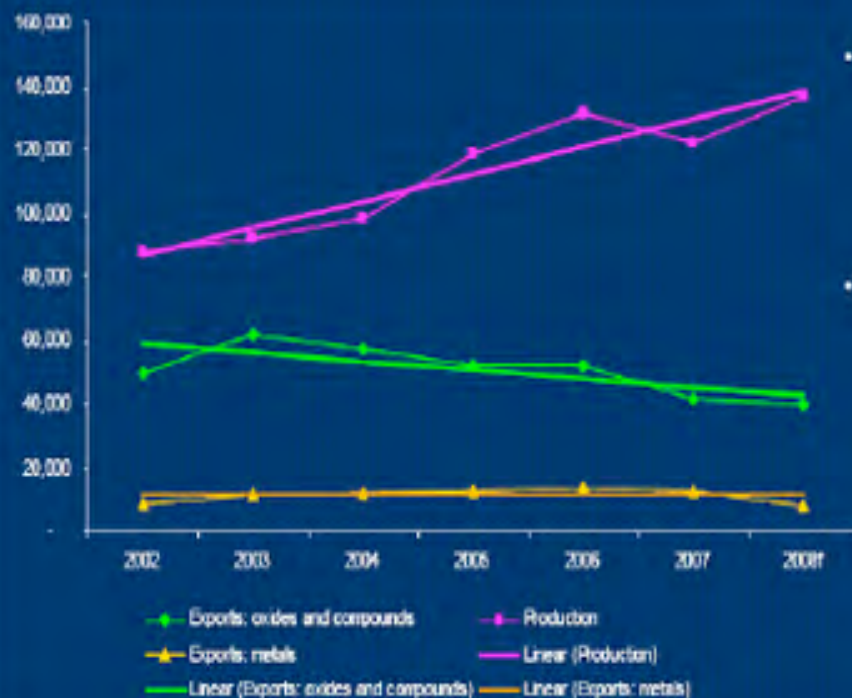
Lateritic ion-adsorption ore from So. China

compared to Earth's upper continental crust

Image: USGS

Production vs. Demand

China: A widening gap between production and exports, 2002-2008



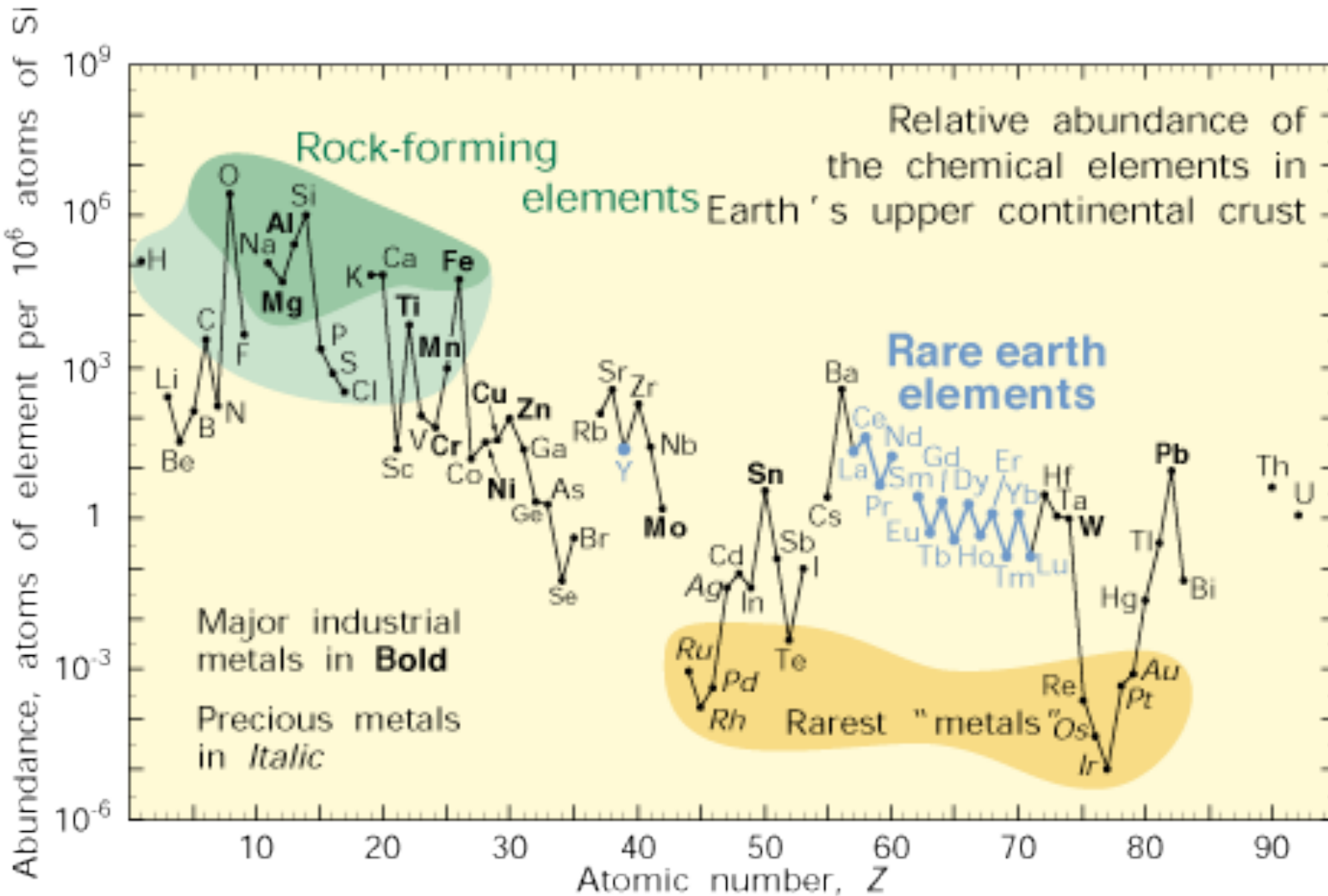
- Decreasing availability of REOs and rare earth metals to processors outside China
- Decline in exports of metals and alloys has not been as steep as exports of oxides and compounds but forecasts for 2008 show a significant decline.

Source: Global Trade Atlas, Roskill estimates

Roskill

EXPANDING THE WORLD'S KNOWLEDGE OF METALS AND MINERALS MARKETS

REE Prices and Concentration



Pt group elements are 'rarest' metals; Image: USGS

REE Production

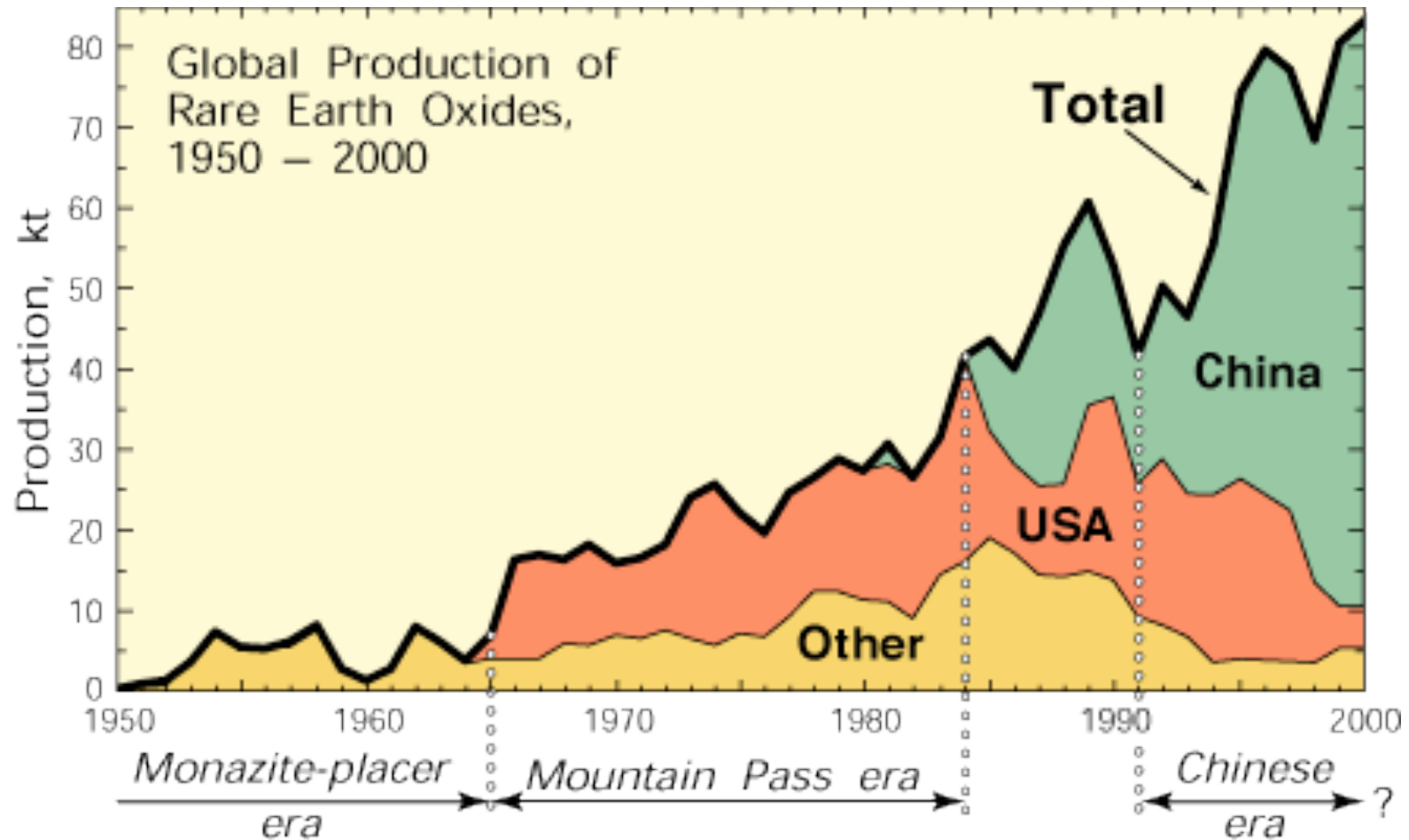
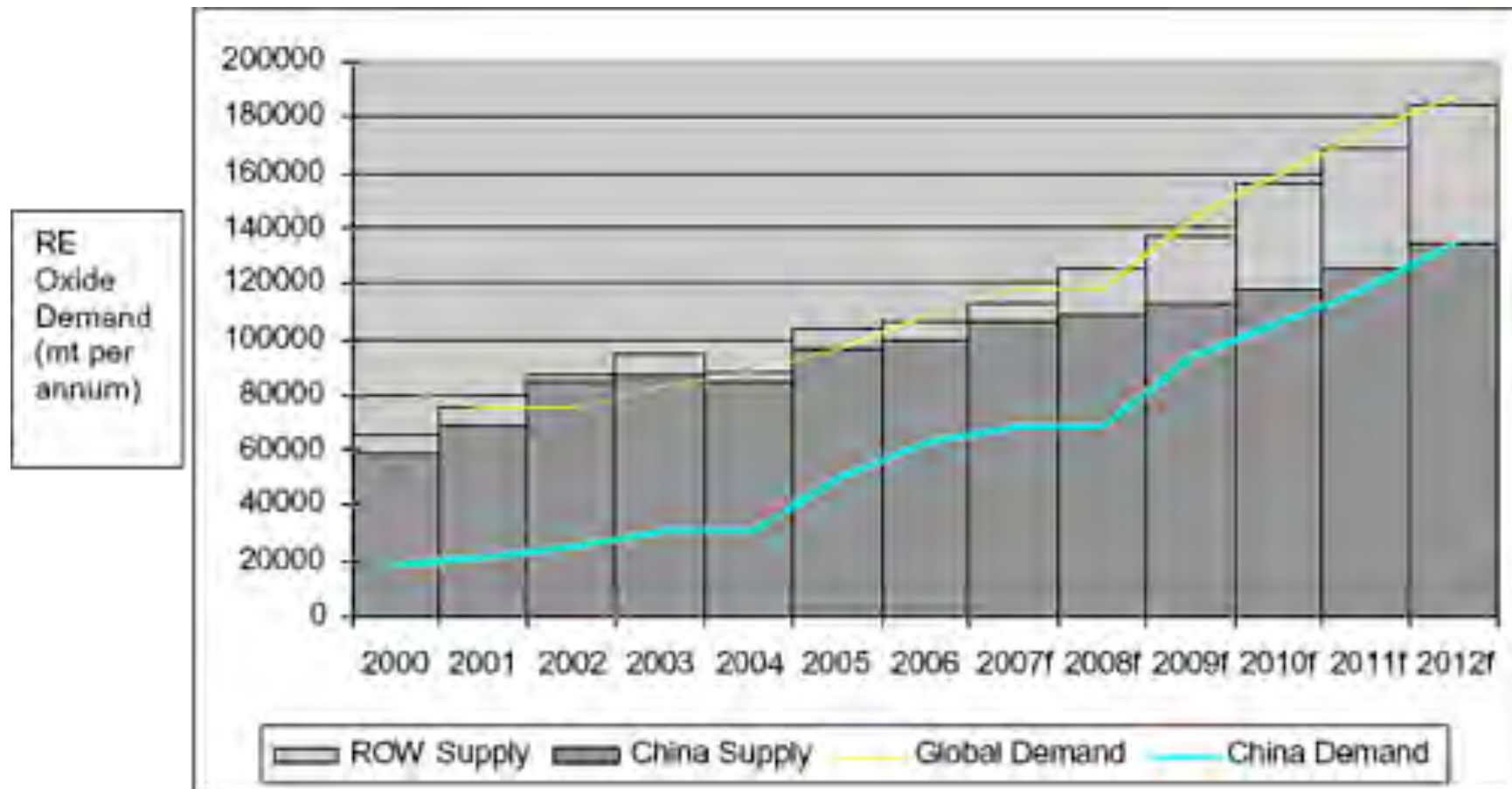


Image source: USGS

REE supply and demand



Mountain Pass, CA



In 1949, carbonatite intrusion with 8-12% REO. By 1966, this single, world-class deposit was paramount source of REE. Average grade of 9.3%; reserves of 20 million tons REO. Remains only large ore deposit mined solely for REE. Used solvent extraction to separate middle REE. Dominant source until 1985.

Mountain Pass, CA



Environment issues and expense reduced profitability.

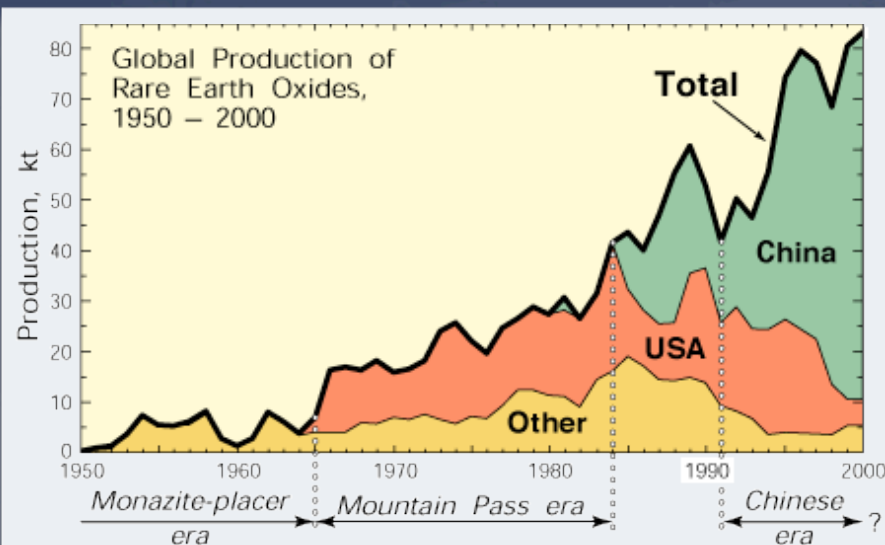
“Green Energy” and REEs

Critical Thinking:

- compare mining practices and environmental regulations in different places in the world
- the locations of reserves
 - geochemistry
- lower vs. higher cost; what are you willing to pay?
- reuse, recycle

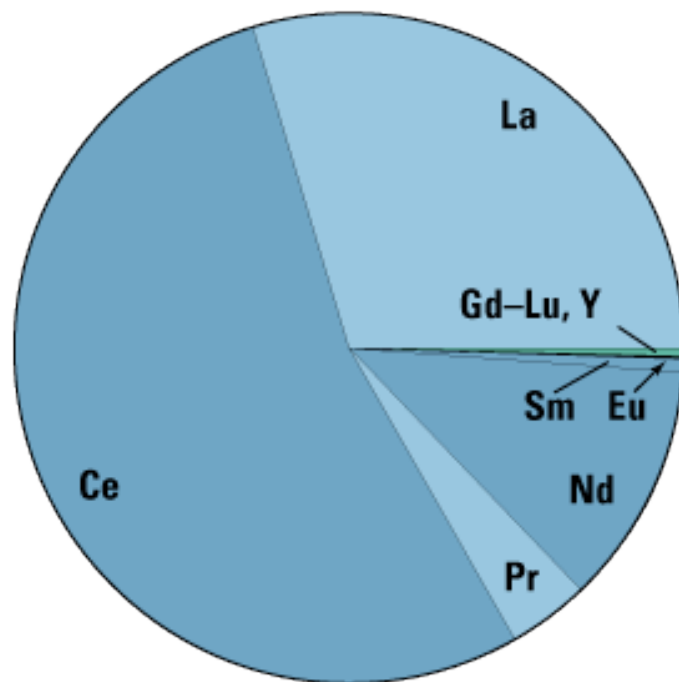


Mining for copper and cobalt, Katanga, Congo. © Per-Anders Pettersson



REEs

Bastnäsite ore, Mountain Pass, California



Lateritic ore, southern China

