"The Threat to Rare Earths, Precious Metals and Minerals and the Electronic Materials Supply Chain"

December 13, 2011

Welcome

Karen Savala
President
SEMI Americas

Karen Savala is president of SEMI Americas. Savala assumes responsibility for the association's Americas programs, including events, products and services. She is responsible for relationships with SEMI members as well as industry, government and academia in the region.

Savala joined SEMI in 1984 and has served in numerous managerial and executive roles, including positions in International Standards, executive programs, publishing, and outreach and membership. She established the "Voice of the Customer" program which helped drive product and service improvements to improve SEMI member satisfaction.

Savala earned a business management and communications degree from San Jose State University in San Jose, California.

The SEMI Chemicals and Gases Manufacturers Group's first webinar offering on precious metals, minerals and the Materials supply chain will help you:

- get up to speed on material issues that are critical to electronics manufacturing
- give you what you need to know about emerging markets, new materials, the changing supply chain and new business models.

Lita Shon-Roy
Sr. Managing Partner
Techcet Group, LLC.

Lita Shon-Roy's experience in the electronics industry spans from marketing and sales of semiconductor chips, equipment and specialty process materials to process engineering of TFT displays. She has worked for companies up and down the materials supply chain. Lita holds a Masters degree in electrical engineering from USC, a Bachelor's degree in chemical engineering from UC San Diego and is working toward completion of her MBA.

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Rare Earths, Metals and Minerals – Threats to Electronics Business

By Techcet CA, LLC.
L. Shon-Roy
Sr. Partner

SEMI Materials Webinar

Lshonroy@techcet.com 12/13/2011

Disclaimer

- This presentation represents the interpretation and analysis of information generally available to the public or released by responsible agencies or individuals. Data was obtained from sources considered reliable. However, accuracy or completeness is not guaranteed.

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Outline

- Overview of Rare Earths, Metals, Minerals – What and Why? (Techcet)
- Market Dynamics Changing given problems with Rare Earth/Metals availability (Techcet)
- Materials at most risk and associated market sizes (USGS)
- Geopolitical Situation (USGS)
  - Those at most risk
  - Supply chain security
  - Depletion

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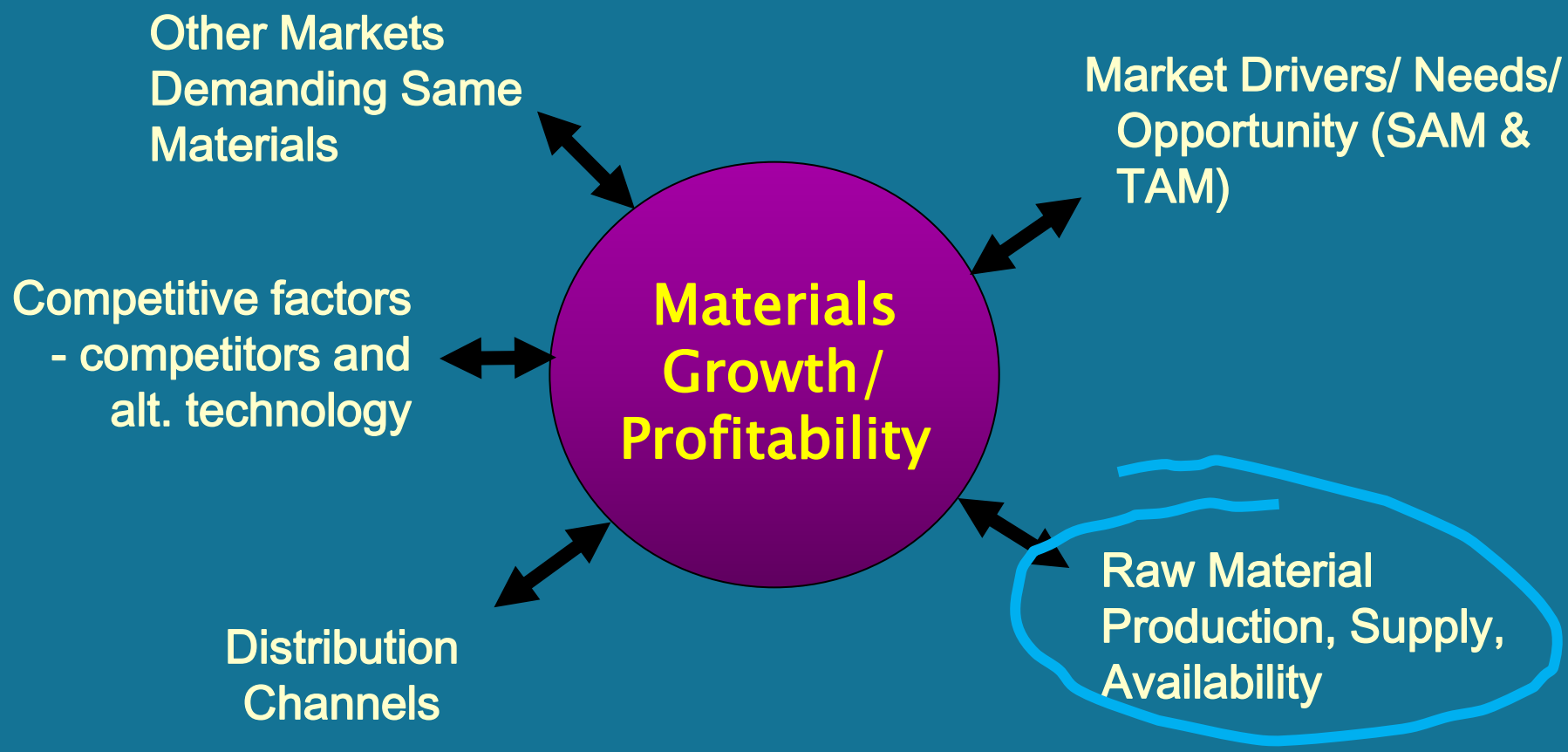
Market Dynamics



Techcet MegaTrends™

- **Rare Earth Elements – China Puts Materials on Allocation**
  - **All raw REE have export quotas**
- **Asian Countries "Require" Local Content**
  - **Significant Market Capture of Materials Business by Locals (and Seeming Local)**
- **Cost of "Earth, Wind, and Fire" Climbing – REE, Metals, and Minerals will continue to be constrained given increased cost of energy and depletion of existing mines.**

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Three Types of Business Threats

1. Unprocessed rare earths, metals and minerals controlled or at risk of being limited by China
2. Unprocessed metals/minerals that are limited or at risk because of only few mines in existence.
3. The processing of ore being limited or at risk because of few processing sites in existence.

Looming Shortage of Chinese Exported Materials

- The Rare Earth Elements ('REEs'), precious metals and minerals
  - Critically important to tech world: communication, transportation, & energy.
- For many applications there are no alternatives

- China - Major Producer
  - China Supplies about 90% of REEs.
  - China's Increased Internal Demand
  - 2011 35% Decrease in Export of REEs
- Alternative Producers
  - Lower Abundance: Much Exploration, Little Mining
  - Complex Isolation Chemistry

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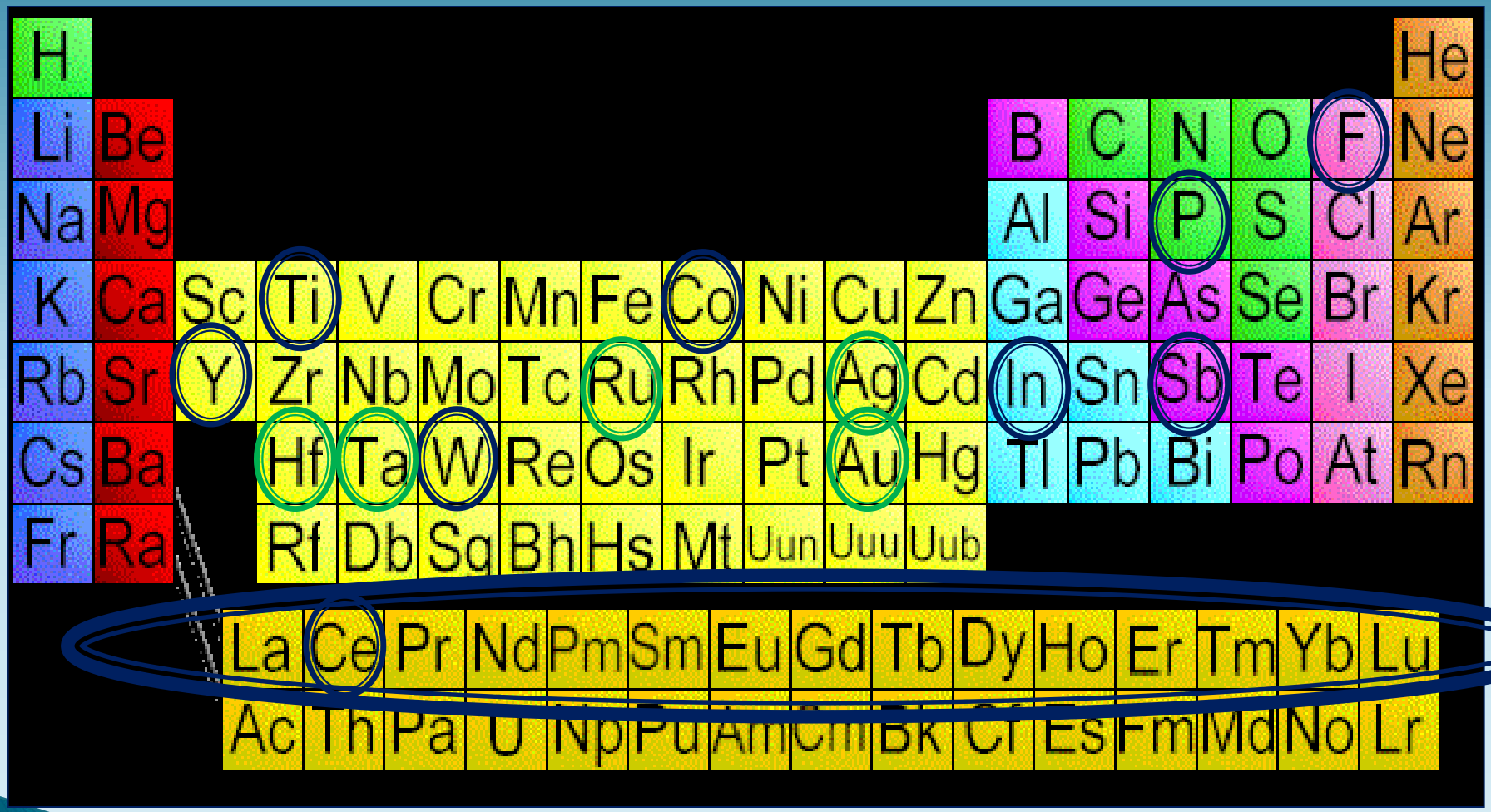
Rare Earth Elements, and Semi/ Precious Metals



= China controlling/limiting supply

= Another country controlling/limiting supply

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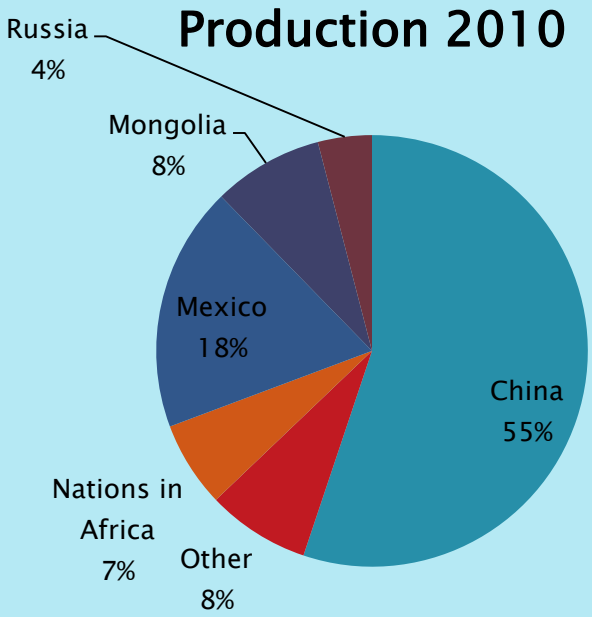
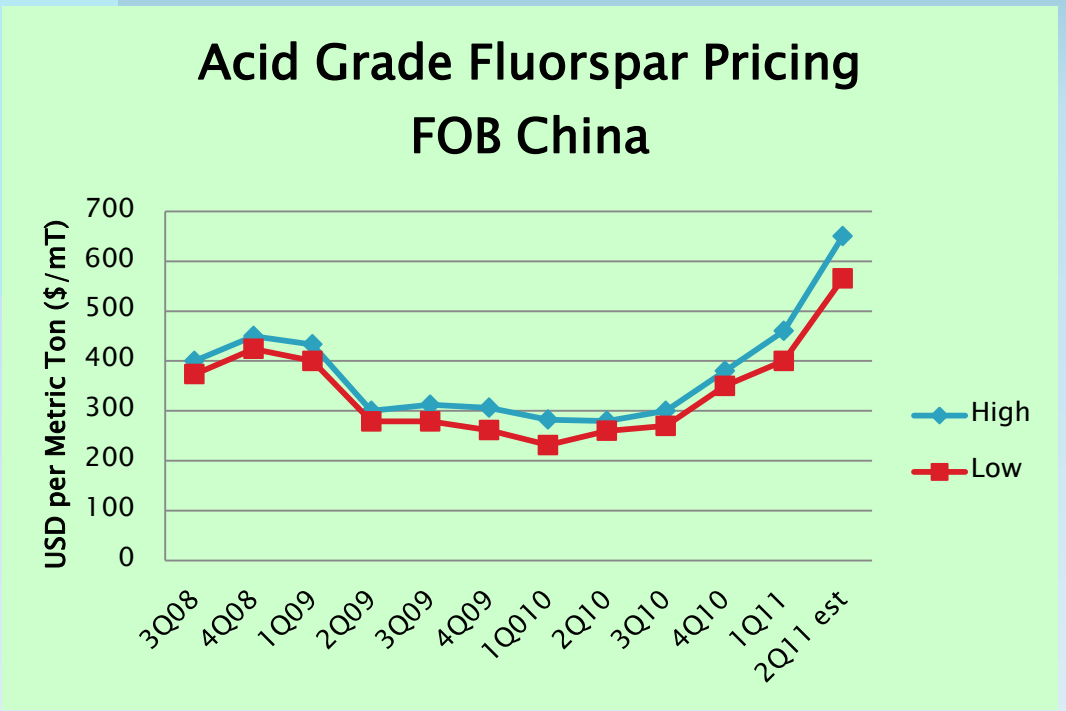
Materials at Highest Risk

Semiconductor	Material	Application
	Ceria	Chemical Mechanical Polishing (CMP)
	Tantalum	Sputter Targets for 90nm and beyond
	Tungsten	WF6 for interconnect
	Phosphor rock	Wet clean: phosphoric acid
	Fluorspar	Wet clean: HF
	Titanium	Sputter Targets
	Molybdenum	Photomasks and disk drive heads
	Cobalt	Gate and capping layers
	Antimony	Doping
	Germane	Strain –gate
	Platinum group metals	Bonding/packaging and specialty applications
	Copper	Electroplating metal
	Ruthenium	Interconnect material
	Hi purity Quartz and silica	Quartz equipment parts
Displays/TFTs	**Material**	**Application**
	Indium*	ITO for transparent conductive oxide
	Molybdenum	Interconnect metal
	* also used for PV applications	

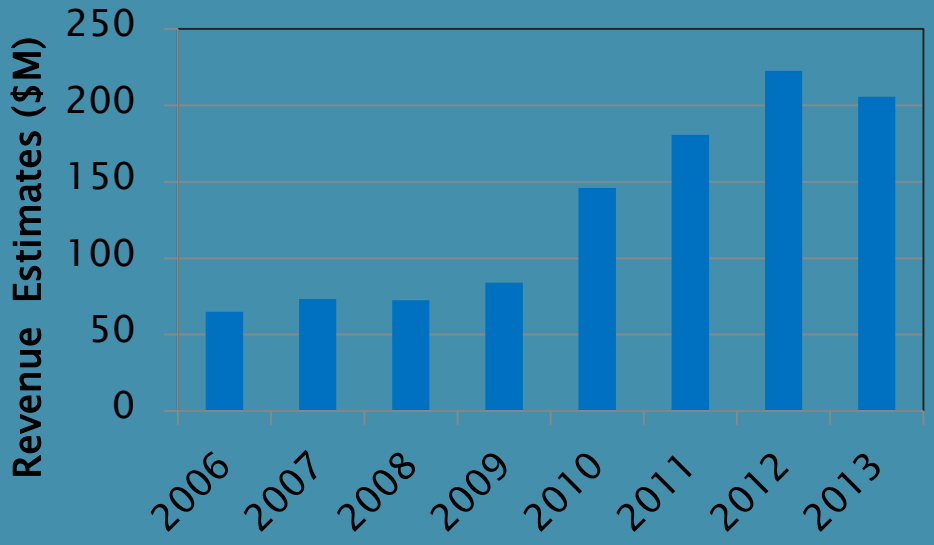
Fluorspar Prices Escalating



- China dominates supply
- Gov't restrictions limit export /availability driving prices up



Tantalum Supply and Demand



2009 Ta Target Revenues ~ $70M will soar to >$140M in 2010 due to price escalation; 2012 growth will be mostly attributed to price escalation

- **Jay Roberge (Equitas Resources) "there is no commodity in a greater supply shortfall than tantalum"**
- **Ta ore has escalated in price from $45-47/lb in 2008 to $120-$130/lb in 2011**

Ta Supply	**2000**	**2010**	comments
Australia	1.3	0.8	1- mining Op. 3-companies
Africa	0.79	2.1	Humanitarian issues
Brazil	0.42	1.8	
China	0.37	0.33	
SE Asia	0.25	0.27	
Canada	0.17	0.25	
Others	0.05	0.2	
Recycled	0.75	0.5	
Stockpiles	0.65	0.4	
Total Supply	5.25	6.65	
Demand	5.2	6.95	
Shortfall	0.05	**-0.30**	

Techcet Group

- Business Development and Strategic Planning Consulting –electronic materials business & technical trends
- Techcet Critical Material Reports* :

- High K & Metal ALD/CVD Precursors
- Interconnect Materials Beyond 65nm
- Solar Cell Process Materials
- Solar Cell Equipment Consumables
- Polysilicon Market and Supply Chain
- Ceramics
- Ion Implant Sources
- Liquid Dopants
- Low Temperature Dielectric Precursors
- CMP Consumables
- Gases
- Graphite
- Masks and Reticles
- Photoresists and Photoresist Ancillaries
- Quartz
- Silicon Carbide
- Sputter Targets
- Wet Chemicals

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Keith Long
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Western Mineral and Environmental Resources Science Center
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Keith Long earned a PhD in Mineral Economics from the University of Arizona in 1988 and is currently a Senior Mineral Resource Analyst for the U.S. Geological Survey in Tucson, Arizona. His current research is on strategic and critical minerals, especially the Energy Critical Minerals (ECEs) required for alternative energy technologies.

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Future Supplies of Critical Elements

Geologic, technical, and political-economic constraints

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Measures of Mineral Supply Risk

- **Concentration of suppliers**
  - When production is concentrated in a few countries, supply risk is greater
  - Use two-country Concentration Ratio; percent of world production represented by the two largest producing countries
- **Political Risk Index**
  - Use risk of default on sovereign debt as a proxy for political risk – range from 0 (low) to 7 (high) risk

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	CR2	PRI	Production metric t	Value billion USD
Antimony	91	2.3	135,000	1.1
Cobalt	50	1.4	88,000	4.1
Copper	44	2.4	16,200,000	120
Fluorspar	72	2.4	5,400,000	0.6
Germanium	58	0.9	120	0.1
Indium	68	1.2	574	0.3
Molybdenum	57	1.6	234,000	3.7
Phosphate	48	2.3	176,000,000	9.0
Rare Earths	99	2.0	134,000	0.9
Ruthenium	79	1.5	32	0.2
Tantalum	75	2.0	670	0.05
Titanium Metal	46	1.5	132,000	1.5
Tungsten	81	2.3	61,000	1.2
Quartz	100	0.0	NA	NA

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CR2: Two country Concentration Ratio; PRI: Political Risk Index based on risk of default on sovereign debt

Rare Earth Elements

- What are the rare earths?
- How did China take over world production from the United States?
- What are the prospects for new REE mines outside of China?
- What has been the effect of Chinese export restrictions?

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PERIODIC TABLE OF THE ELEMENTS

1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magne-sium											13 Al Aluminum	14 Si Silicon	15 P Phos-phorus	16 S Sulphur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manga-nese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge German-ium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molyb-denum	43 Tc Techne-tium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Cesium	56 Ba Barium	57-71 Lantha-nides see below	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89-103 Actinides see below	104 Rf Rutherfor-dium	105 Db Dubnium	106 Sg Seabor-gium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Uum Unun-nilium								

Lanthanoids	57 La Lantha-num	58 Ce Cerium	59 Pr Praseo-dymium	60 Nd Neo-dymium	61 Pm Pro-methium	62 Sm Samarium	63 Eu Europium	64 Gd Gado-linium	65 Tb Terbium	66 Dy Dys-prosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
	89 Ac Actinium	90 Th Thorium	91 Pa Pro-tactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Califor-nium	99 Es Ein-steinium	100 Fm Fermium	101 Md Mende-levium	102 No Nobelium	103 Lr Lawren-cium

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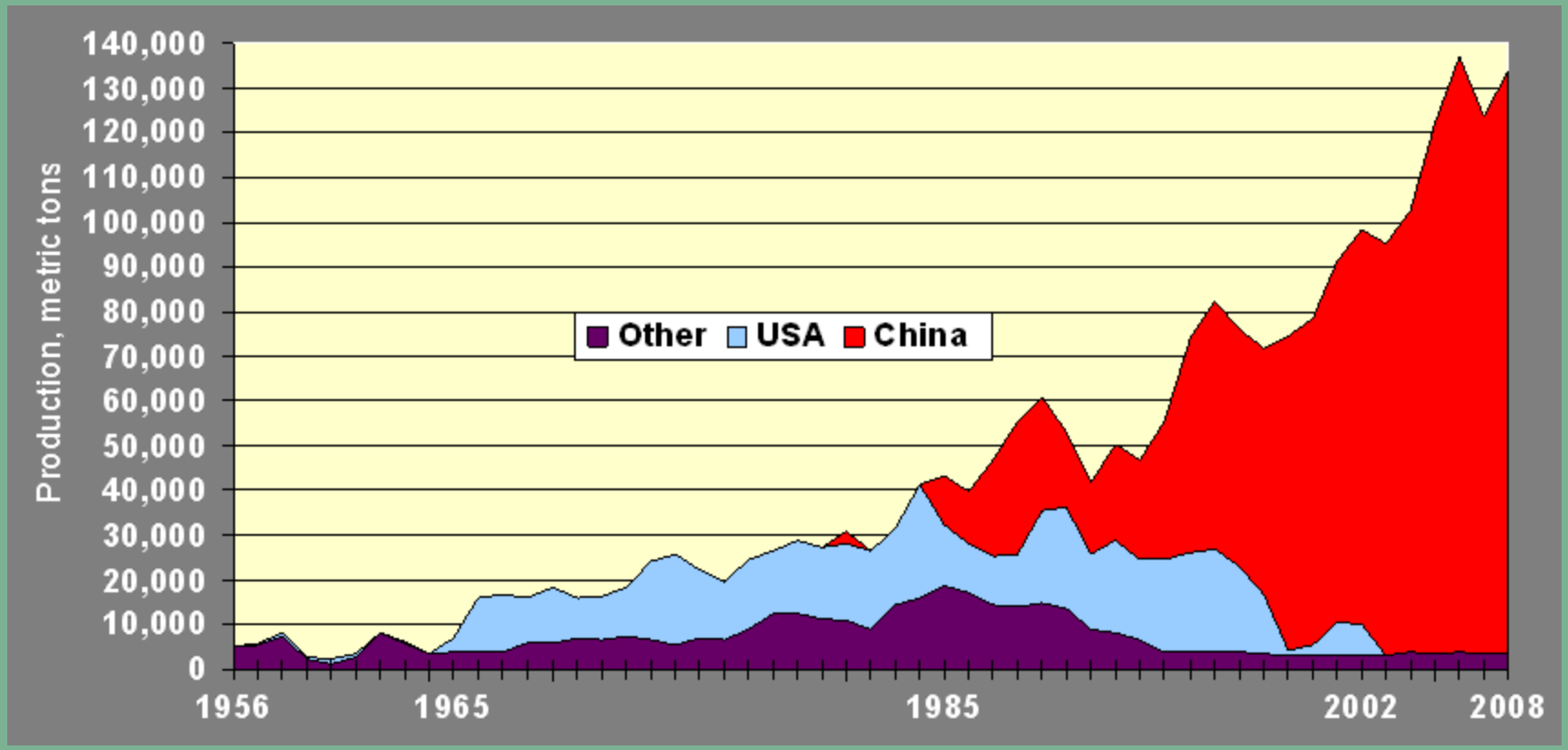
REO Production Trends



Monazite-placer era | **Mountain Pass era** | **Chinese era → ?**

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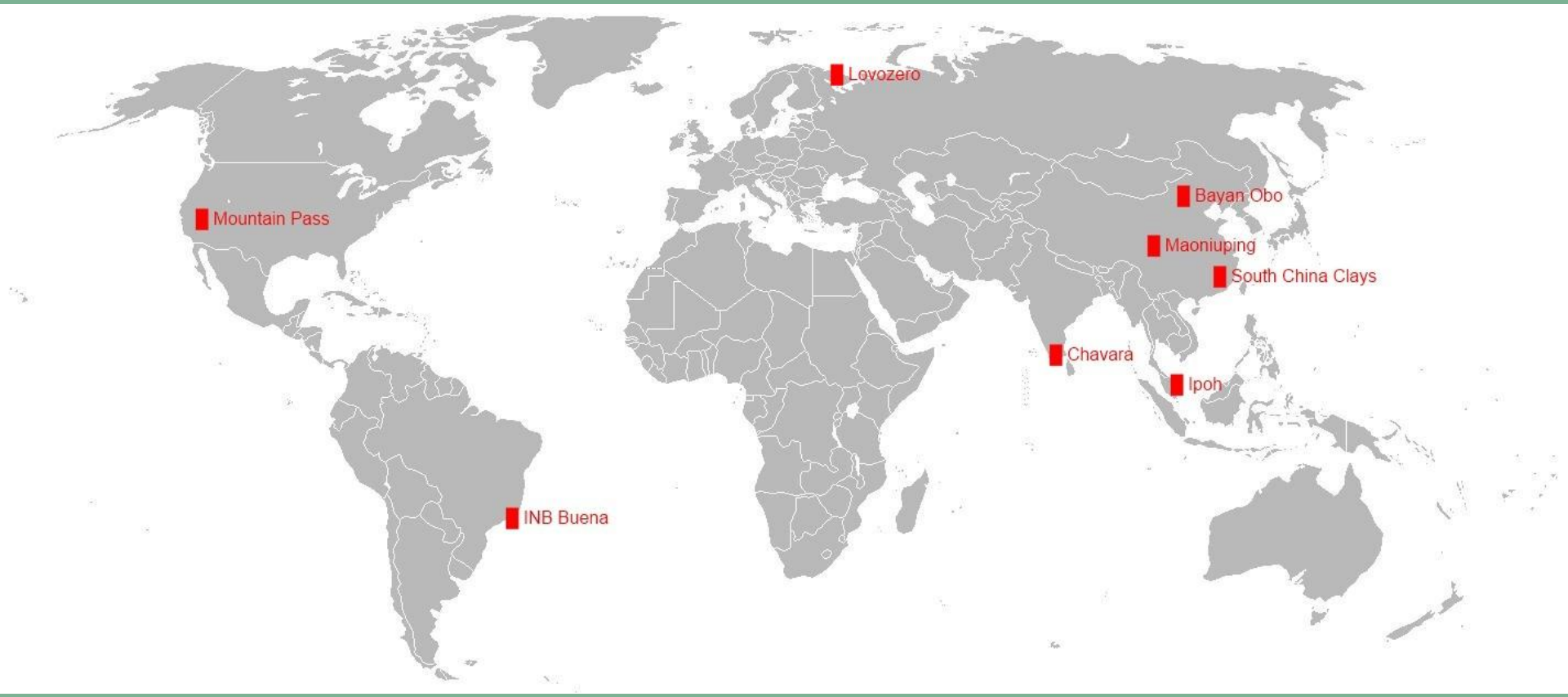
Source: US Geological Survey Minerals Yearbook

Operating REE Mines



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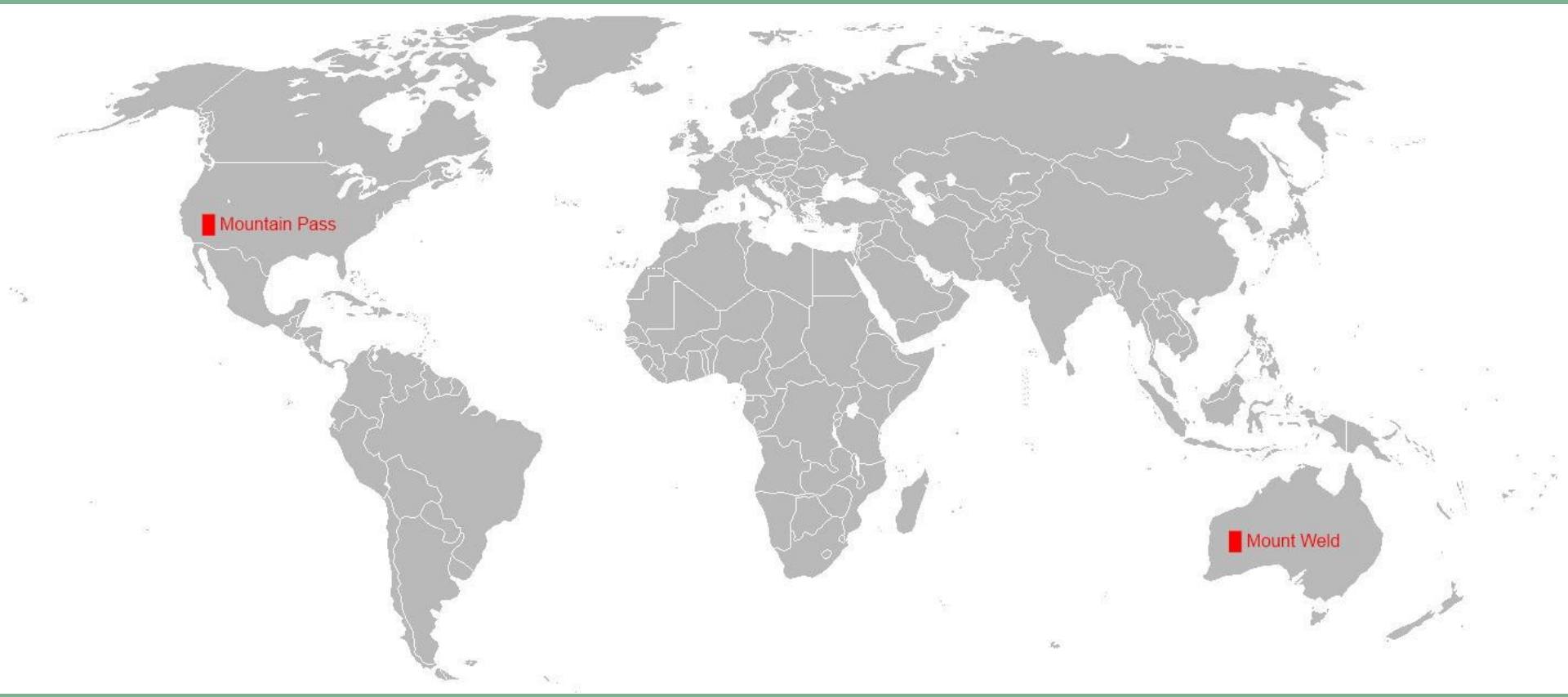
REE Mine Development Projects



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Advanced REE Mine Projects

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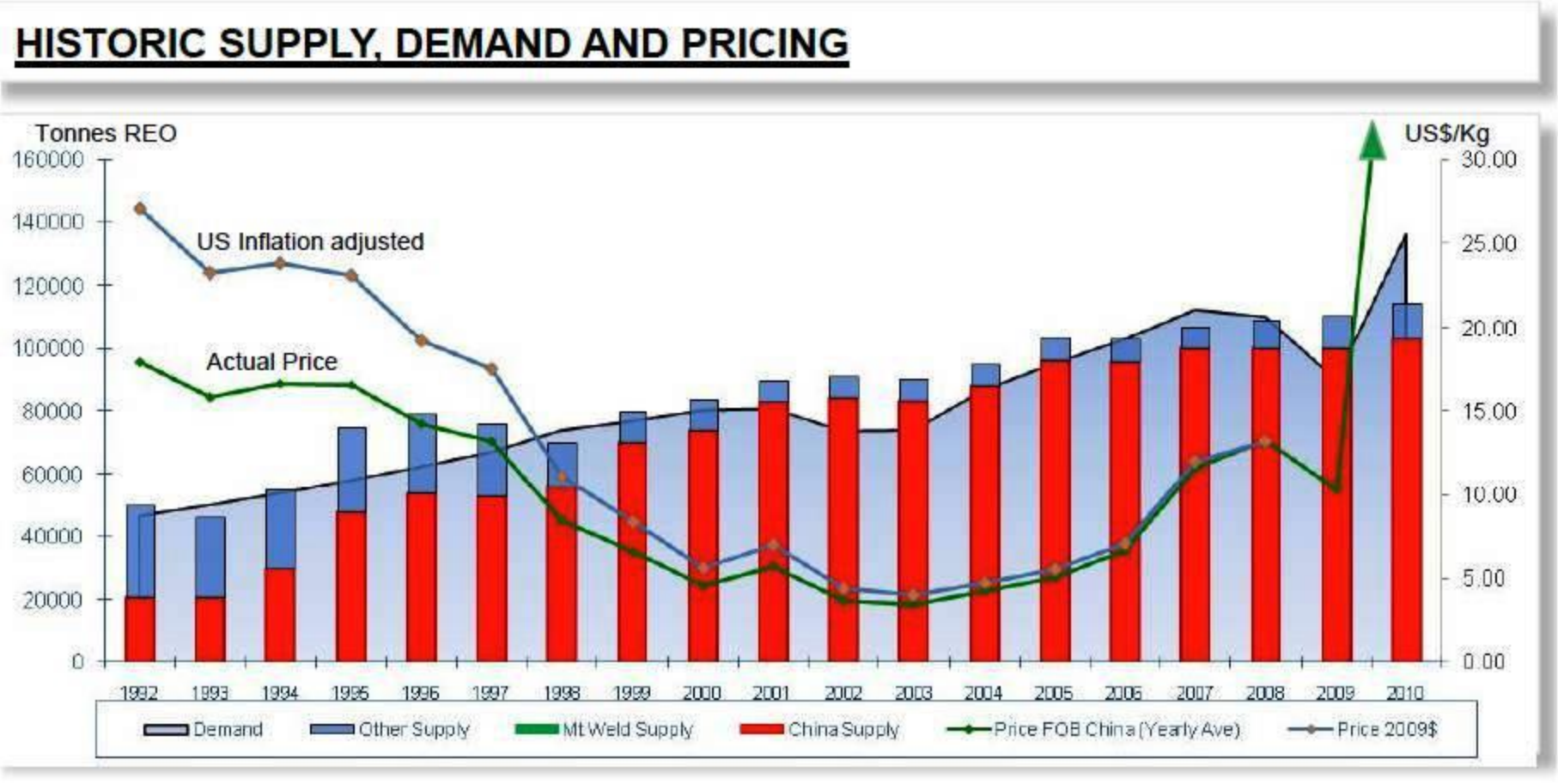
Historic REO Price Trends



Source: Lynas Corp

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Sources of Titanium Metal

- Ultimate source is from titanium minerals in coastal heavy-mineral sands
- Most titanium minerals mined are used for pigments
- Many countries produce titanium metal
- United States imports about two-thirds of the titanium metal it uses
- Principal import sources are Kazakhstan and Japan

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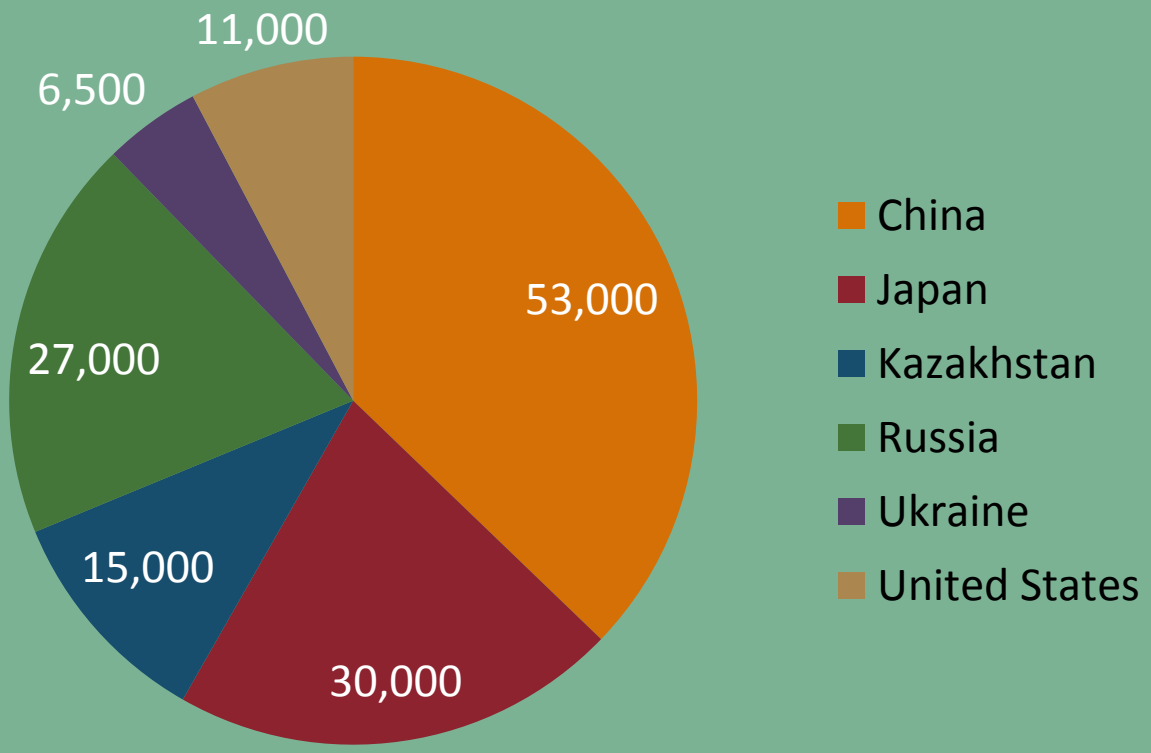
Titanium Metal Production by Country



2010 Production in metric tons titanium sponge
Source: U.S. Geological Survey

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Problems With Titanium Metal

- Domestic capacity can meet about one-third of domestic demand
- Global production concentrated in China, Kazakhstan, and Russia
- Raw materials for domestic production of titanium metal largely imported
- Titanium ores used for making metal mainly produced in Australia, South Africa, and Canada (~47%)

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U.S. Geological Survey Minerals Information

- **http://minerals.usgs.gov/minerals**
- **Source of statistics and information on:**
  - Global mineral production, demand, and reserves
  - Mineral material life-cycles
  - Historic mineral prices
  - Trends in production and demand
  - Mineral Commodity Summaries
  - Minerals Yearbook

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Questions and Answer Session

Thank you