Rare Earths, Critical Metals, Energy and National Security

Supply Chain Issues of Importance for the United States of America

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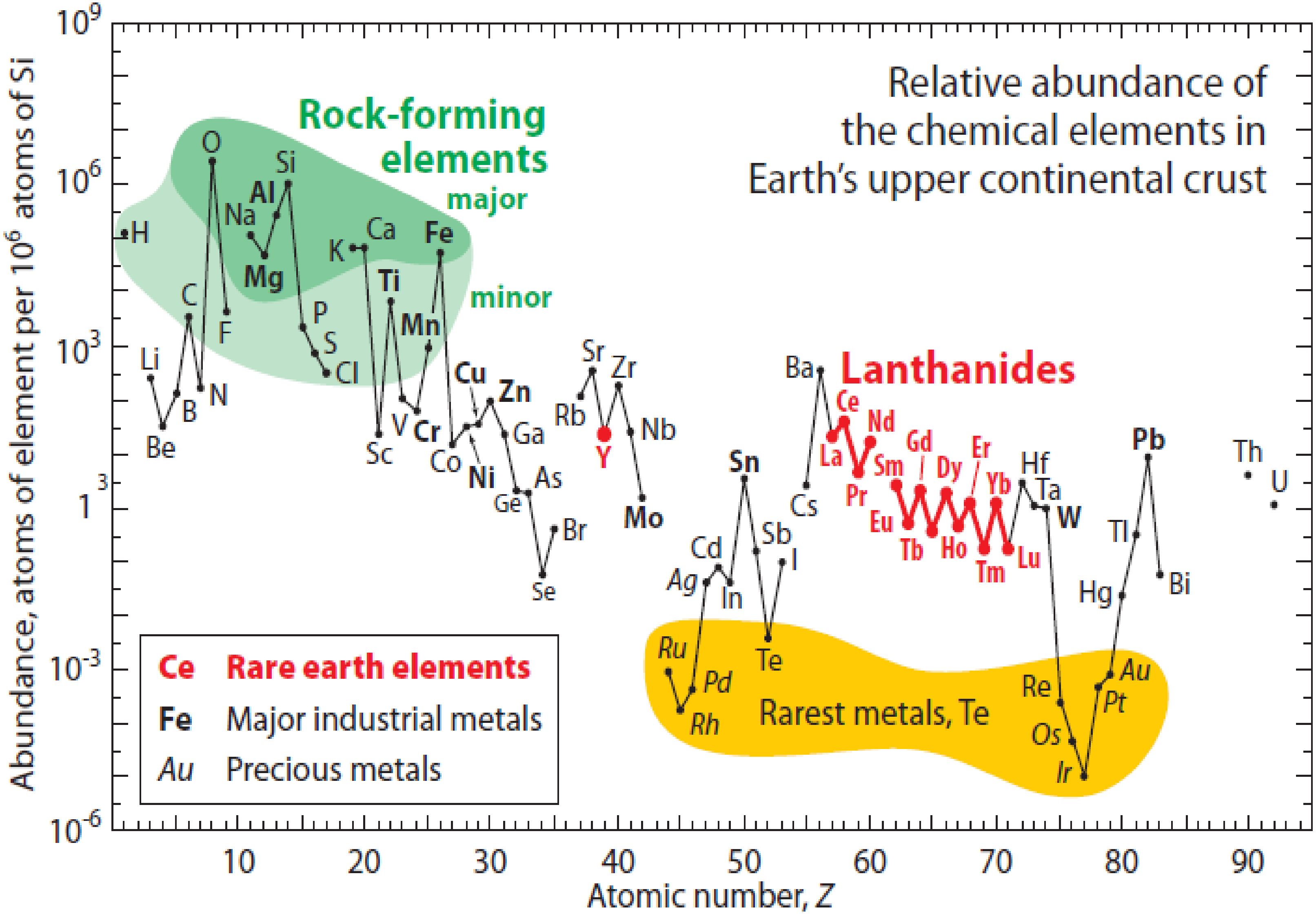
None are Really Rare: However Many Have become Increasingly Critical, Strategic and Indispensable



Imports (%) of These Metals Increased Between 2009 and 2010

	2009	2010		
ARSENIC (trioxide) 100	100	100		Morocco, **China**, Belgium
ASBESTOS 100	100	100		Canada
BAUXITE and ALUMINA 100	100	100		Jamaica, Brazil, Guinea, Australia
CESIUM	100	100		Canada
FLUORSPAR 100	100	100		Mexico, **China,** South Africa, Mongolia
GRAPHITE (natural)	100	100		**China**, Mexico, Canada, Brazil
INDIUM	100	100		**China**, Canada, Japan, Belgium
MANGANESE 100	100	100		South Africa, Gabon, **China**, Australia
MICA, sheet (natural)	100	100		**China**, Brazil, Belgium, India
NIOBIUM (columbium) 100	100	100		Brazil, Canada, Germany, Estonia
QUARTZ CRYSTAL (industrial)	100	100		**China**, Japan, Russia
RARE EARTHS	100	100		**China**, France, Japan, Austria
RUBIDIUM	100	100		Canada
STRONTIUM	100	100		Mexico, Germany
TANTALUM	100	100		Australia, **China**, Kazakhstan, Germany
THALLIUM	100	100		Russia, Germany, Netherlands
THORIUM	100	100		United Kingdom, France, India, Canada
YTTRIUM	100	100		**China**, Japan, France
GALLIUM	99	99		Germany, Canada, **China**, Ukraine
BISMUTH	90	94	4.444%	Belgium, **China**, United Kingdom, Mexico
PLATINUM	89	94	5.618%	South Africa, Germany, United Kingdom, Canada

ANTIMONY	92	93	1.087%	**China**, Mexico, Belgium
GERMANIUM	90	90		Belgium, **China**, **Russia**, Germany
RHENIUM	79	86	8.861%	Chile, Netherlands
DIAMOND (dust, grit and powder) 85	82	85	3.659%	**China**, Ireland, **Russia**, Republic of Korea
POTASH	73	83	13.699%	Canada, Belarus, **Russia**
COBALT	75	81	8.000%	Norway, **Russia**, **China**, Canada
TITANIUM MINERAL CONCENTRATES 81	72	81	12.500%	South Africa, Australia, Canada, Mozambique
ZINC	76	77	1.316%	Canada, Peru, Mexico, Ireland
TUNGSTEN	63	68	7.937%	**China**, Canada, Germany, Bolivia
SILVER	63	65	3.175%	Mexico, Canada, Peru, Chile
PEAT	50	59	18.000%	Canada
PALLADIUM	47	58	23.404%	**Russia**, South Africa, United Kingdom, Belgium
CHROMIUM	39	56	43.590%	South Africa, Kazakhstan, **Russia**, **China**
BERYLLIUM	2	47	2250.000%	Kazakhstan, Kenya, Germany, Ireland
NICKEL	18	43	138.889%	Canada, **Russia**, Australia, Norway
ALUMINUM	18	38	111.111%	Canada, **Russia**, **China**, Mexico
MICA, scrap and flake (natural)	11	27	145.455%	Canada, **China**, India, Finland
PERLITE	21	25	19.048%	Greece
SALT	19	24	26.316%	Canada, Chile, Mexico, The Bahamas
SULFUR	4	17	325.000%	Canada, Mexico, **Venezuela**
IRON and STEEL SLAG	8	10	25.000%	Japan, Canada, Italy, South Africa
PUMICE	3	7	133.333%	Greece, Turkey, Iceland, Mexico

Four Domestic Case Studies of Critical Metals

- The Case of U.S. Manganese
- The Case of U.S. Cobalt
- The case of U.S. Graphite
- The case of U.S. Vanadium

China’s REE Policy is the “Tip of the Iceberg”

Increased export restriction and price volatility as China continues its military and domestic economic development.

China controls production of manganese, moly, tungsten, antimony and graphite – soon to be strategic and critical metals.

Her Natural Resource policy is both Economic and Strategic.

China's View: Germanium = Industrial Gold

Chen Jianheng of the Chinese Society of Rare Earths

*“**Germanium and rare earth metals are widely called "industrial gold" but the volume of Germanium is even less than rare earths ….***

China has 3,500 tons in germanium reserves, the second largest in the world. However, the total amount of global reserves -- estimated at 8,600 tons -- may not last more than 40 years.”

The planet's remaining germanium reserves are much less than the gold reserves of 86,000 tons … its price is not even 6% of the price of gold.

Even **China is running out** of “Industrial Gold” critical metals.

The Cyclical Failure of U.S. Supply Chain Development:
The Need for Extractive Domestic Natural Resource Legislation

Sub Par domestic NR exploration leads to

Sub Par discovery which leads to

Insufficient U.S. natural resource production means

Lost supply chain infrastructure (due to economics)

Insufficient advanced IP development

– **IMPAIRED STRATEGIC CAPABILITY AND**
– **ULTIMATELY A LOWER QUALITY OF LIFE**

Intellectual Property Development

IP development is an ongoing process of 10 to 20 years

Someone said this was a short term – 2 year problem.

Really!!!

Countries with surplus critical resources, few environmental barriers and developing IP can control the commodity market and encumber high tech development.

The GAO Says

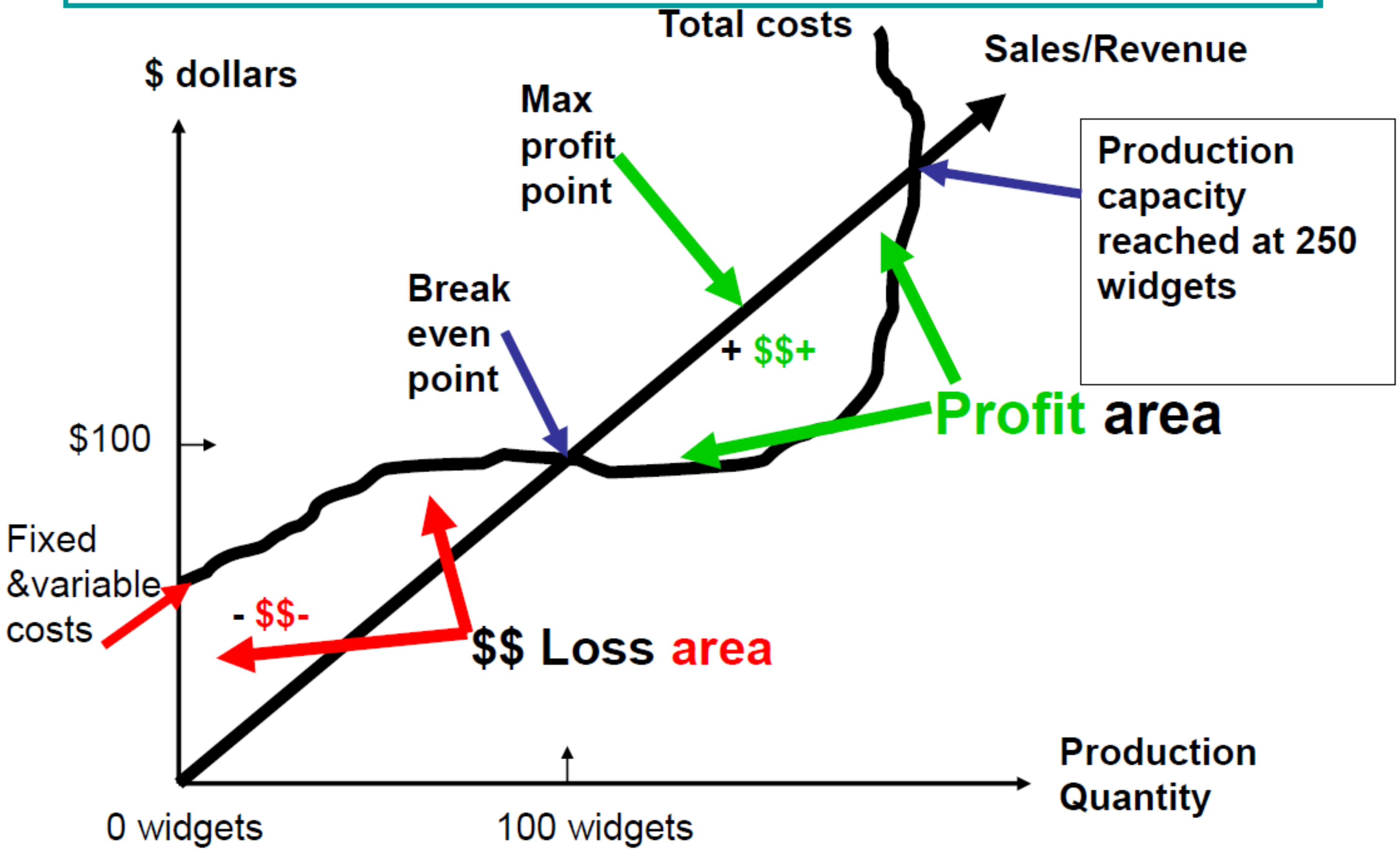
- A GAO report emphasizes the lack of U.S. capability in the rare earth mineral global supply chain at each of the stages:

  1) mining,
  2) separation,
  3) refining oxides into metal,
  4) fabrication of alloys and
  5) manufacture of magnets and other products.

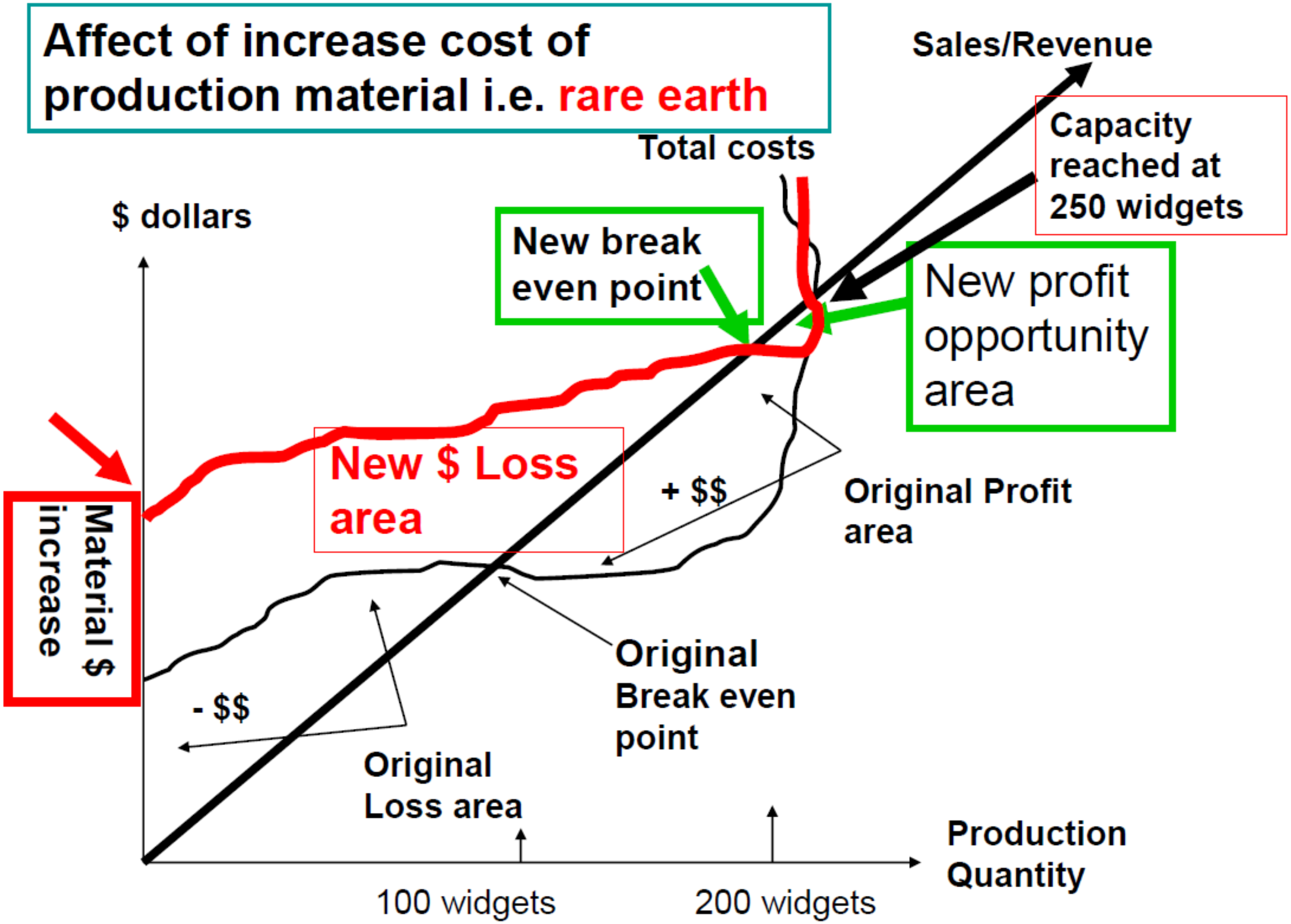
Case Study of a U.S. High Temp REE Magnet Developer

- Access to appropriate raw material flow.
- Necessity to Engineer away from Rare Earth Elements.
- Depend on research from Materials Scientists.
- Difficulty in supply chain vertical integration – time.
- Difficulty and timeframe in hiring and training capable engineers.
- Economics of the process (Mystery / History cycle).
- Necessity for multiple sources of supply.

Normal Magnet manufacturing business profit & Loss (**before** rare earth $ increases)



Economics: Achilles Heel of the American HT Magnet Supply Chain



Major Economic and National Security Catalysts in the Race for IP and Supply Chain Dominance?

- Asia's New Arms Race, 2009, Makes **Critical** Metals **Strategic**

- The Great Convergence of QOL to 2030:

China 9% to 24% Global GDP
India 2% to 10%
US 24% to 12%