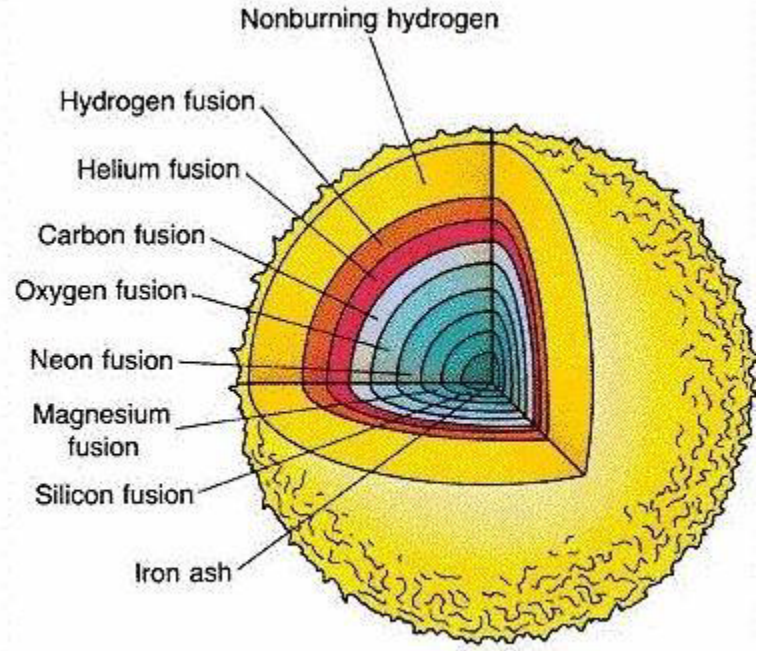
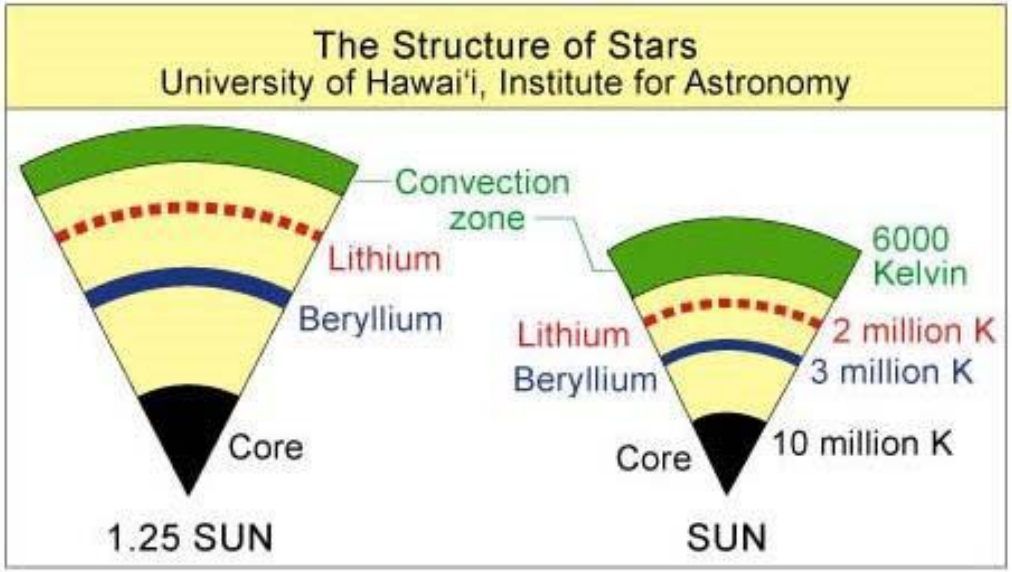
# Material Sourcing Challenges & Strategies

4th Ceramic Leadership Summit
April 9, 2014  Baltimore, Maryland

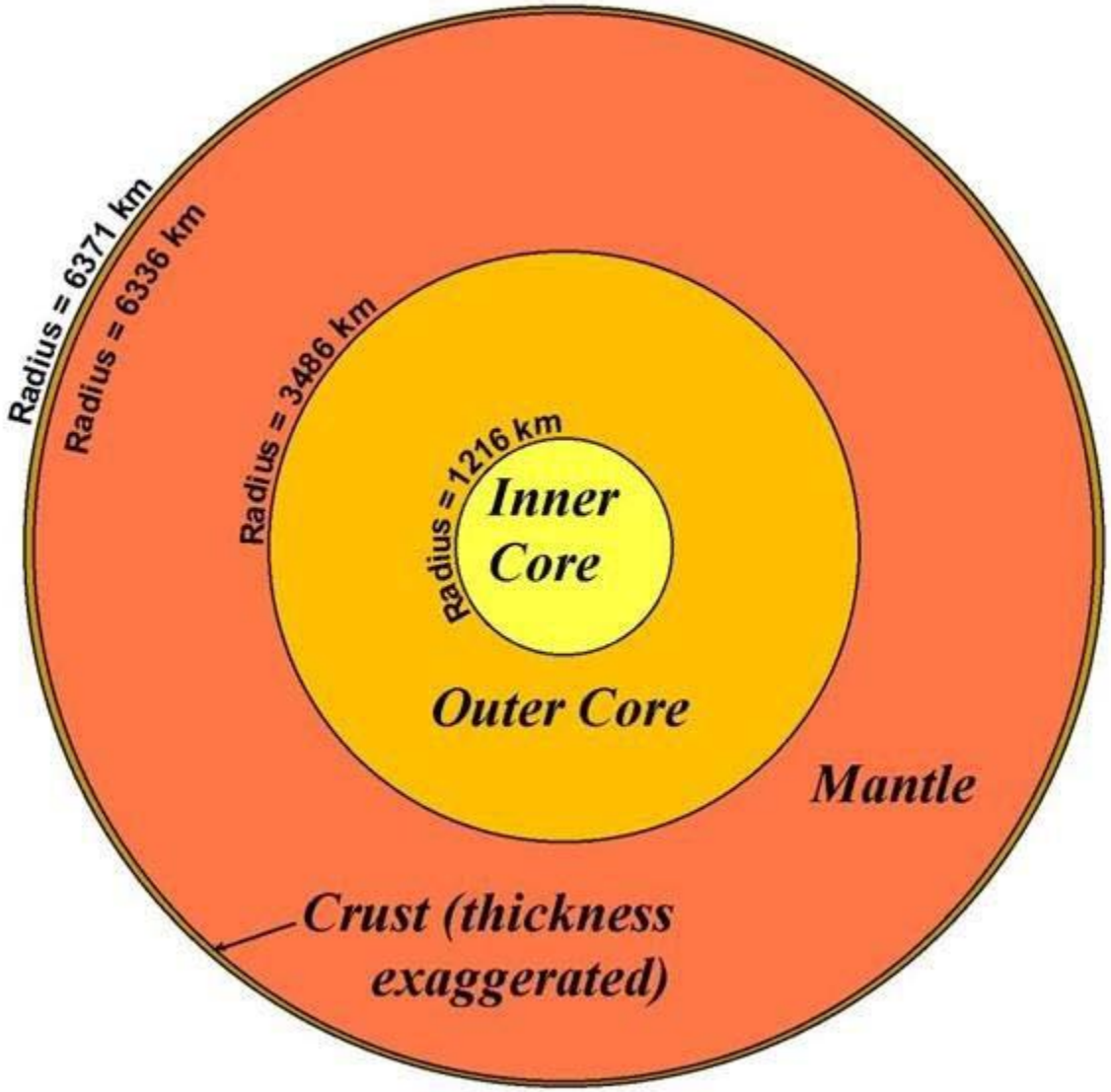
Michael N. Silver, President & CEO
American Elements

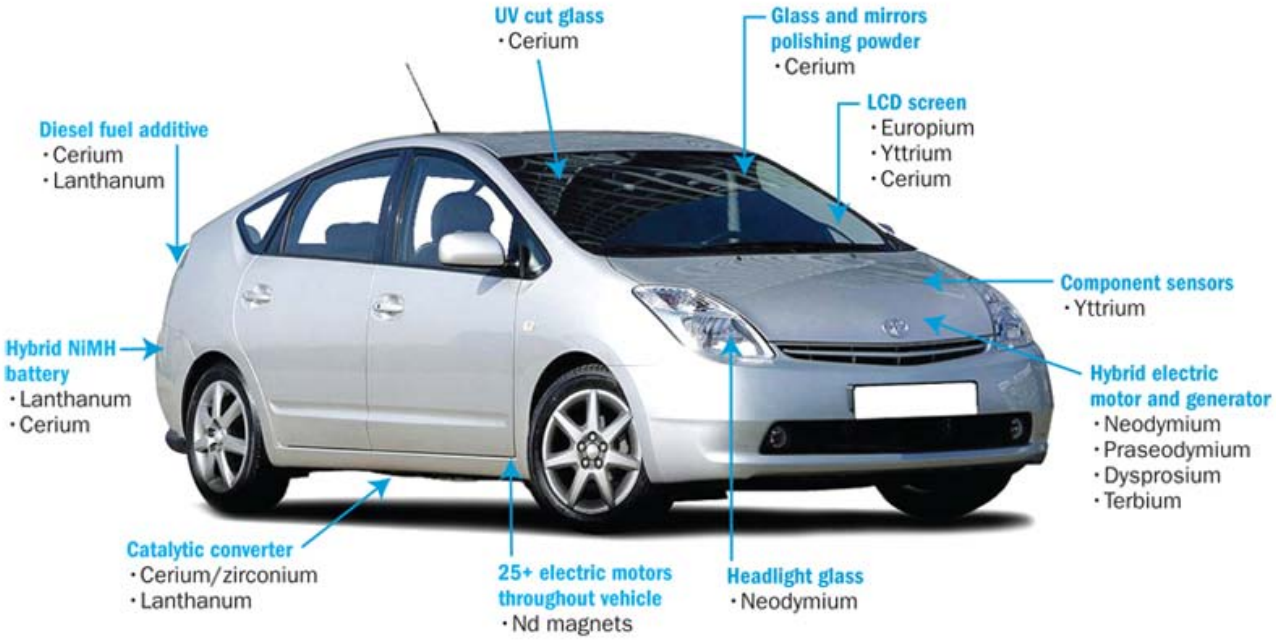
AMERICAN ELEMENTS

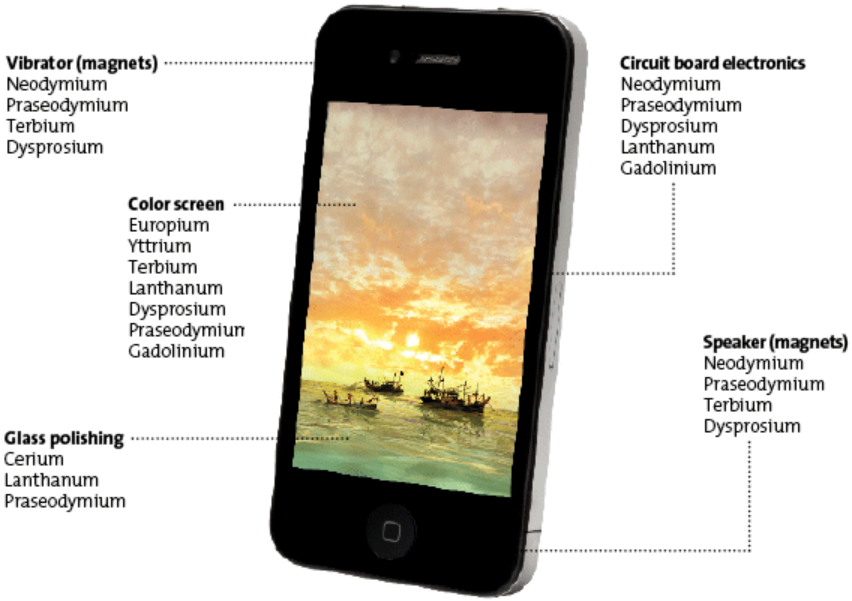

Nonburning hydrogen
Hydrogen fusion
Helium fusion
Carbon fusion
Oxygen fusion
Neon fusion
Magnesium fusion
Silicon fusion
Iron ash


The Structure of Stars
University of Hawai'i, Institute for Astronomy
Convection zone
Lithium
Beryllium
Core
1.25 SUN
6000 Kelvin
Lithium
2 million K
Beryllium
3 million K
Core
10 million K
SUN

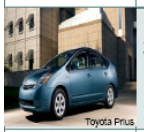
# Structure of Earth

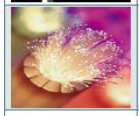
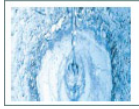


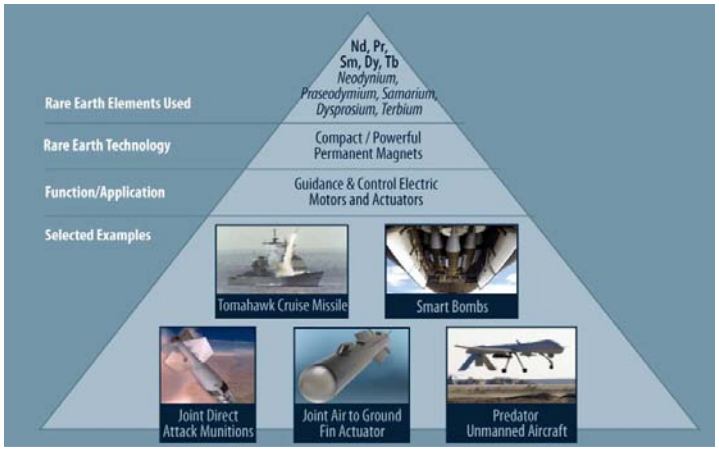

UV cut glass
• Cerium
Glass and mirrors polishing powder
• Cerium
LCD screen
• Europium
• Yttrium
• Cerium
Diesel fuel additive
• Cerium
• Lanthanum
Component sensors
• Yttrium
Hybrid NiMH battery
• Lanthanum
• Cerium
Hybrid electric motor and generator
• Neodymium
• Praseodymium
• Dysprosium
• Terbium
Catalytic converter
• Cerium/zirconium
• Lanthanum
25+ electric motors throughout vehicle
• Nd magnets
Headlight glass
• Neodymium

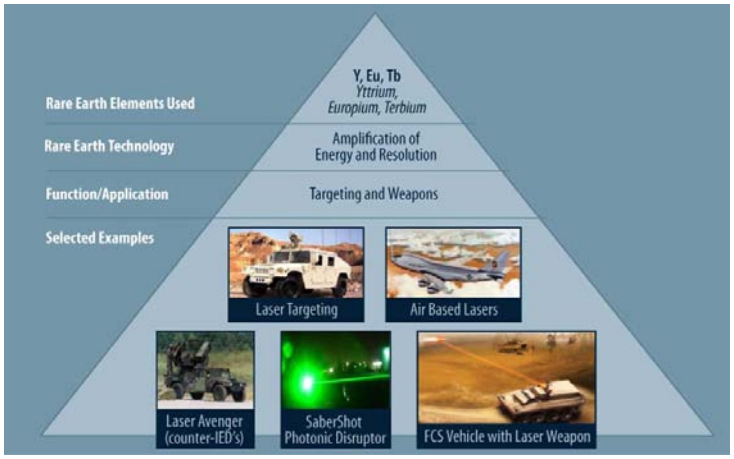

Vibrator (magnets)
Neodymium
Praseodymium
Terbium
Dysprosium
Color screen
Europium
Yttrium
Terbium
Lanthanum
Dysprosium
Praseodymium
Gadolinium
Glass polishing
Cerium
Lanthanum
Praseodymium
Circuit board electronics
Neodymium
Praseodymium
Dysprosium
Lanthanum
Gadolinium
Speaker (magnets)
Neodymium
Praseodymium
Terbium
Dysprosium

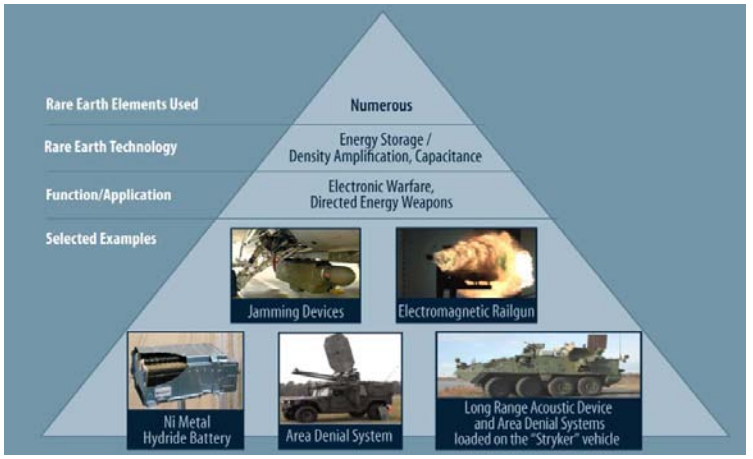
# Industries Impacted

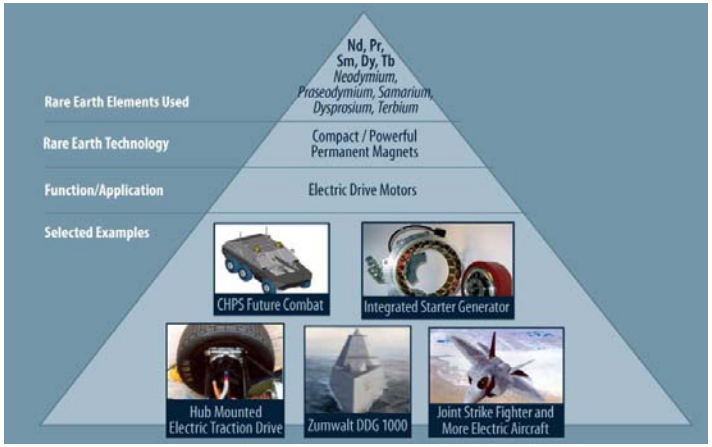
| | Application | Rare Earth (RE) Technology | Enabling Functionality | RE Elements Required |
|---|---|---|---|---|
|  Toyota Prius | Hybrids, Plug-In, and Electric Vehicles | RE Permanent Magnets | Electric Traction Drives replacing or supplement-ing internal combustion engines | Nd, Pr, Dy, Tb |
|  Bosch Electric Power Steering System | Electric assist motors in conventional and advanced vehicles | RE Permanent Magnets | Higher MPG by taking significant loads off power trains | Nd, Pr, Dy, Tb |
|  | Wind and Hydro Power Generation | RE Permanent Magnets | Gearless generators for better reliability and online performance | Nd, Pr, Dy, Tb |
|  | Compact and Linear Fluores - cent Lamps, LEDs, etc. | RE Phosphors | Ability to match color and bright-ness of incan-descents with 70% less energy | Y, Eu, Tb |
|  High power Ni-MH Battery from Toyota Prius | Ni Metal Hydride Batteries | Energy Storage | Proven and Cost Effective compared to Li Ion Battery alternatives | La |
|  | Capacitors with High Energy Density | Rare Earth-doped ceramic , tantalum and other types of capacitors | High Energy Density compared to conventional capacitors | Various |
|  Black & Decker Cordless Drill | Cordless Power Tools | RE Permanent Magnets | Compact, Light Weight and Powerful Motors | Nd, Pr, Dy, Tb |
|  | Integrated Starter / Generator for Improved MPG | RE Permanent Magnets | Shuts off engine when stopped and instant restart when accelerator is pressed | Nd, Pr, Dy, Tb |

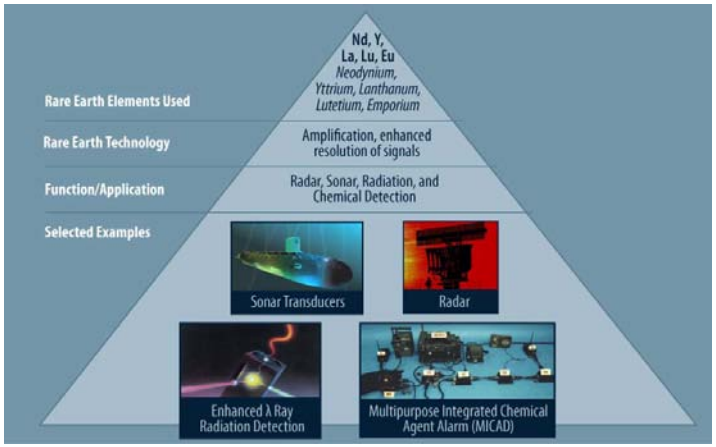
| | Application | Rare Earth (RE) Technology | Enabling Functionality | RE Elements Required |
|---|---|---|---|---|
|  | Computer Disc Drives | RE Permanent Magnets | Compact, Light Weight and Powerful Motors | Nd, Pr, Dy, Tb |
|  | Handheld Wire-less Devices | RE Permanent Magnets<br><br>RE Phosphors | Compact, Light Weight and Powerful Motors<br><br>Flat Screen Displays | Nd, Pr, Dy, Tb, Y, Eu<br><br>Y, EU, Tb, Gd, Ce |
|  | Fiber Optics | Signal Amplification | RE doped optical fibers | Y, Eu, Tb, Er |
|  | Flat Screen Displays | Low Pressure UV Excitation of RE Phosphors | Brilliant colors: red, green and blue in large flat panel displays | Y, Eu, Tb, Gd, Pr, Ce |
|  | Fluid Catalytic Cracking (FFC) for making gasoline | Provides Brønsted acid sites to the catalyst matrix | Higher activity and stability than other Brønsted acid sources | La, Ce |
|  | Catalytic Converters and other emission reduction technologies | Ability to oxidize CO and ozone to $CO_2$ and $O_2$ | Significantly less expensive than Pt metal group alternatives | Ce, La |
|  | Medical Imaging – MRI<br><br>X-ray Imaging | RE Permanent Magnets<br><br>Wavelength shift | Produce magnetic field<br><br>To collect scintillation light | Nd, Pr, Dy, Tb,<br><br>Y, Eu, Tb |
|  | Water Treatment | Selective adsorption | Ability to selectively remove contaminants from water | Proprietary RE technology from Molycorp Minerals, LLC |


Rare Earth Elements Used
Nd, Pr, Sm, Dy, Tb
Neodynium, Praseodymium, Samarium, Dysprosium, Terbium
Rare Earth Technology
Compact / Powerful Permanent Magnets
Function/Application
Guidance & Control Electric Motors and Actuators
Selected Examples
Tomahawk Cruise Missile
Smart Bombs
Joint Direct Attack Munitions
Joint Air to Ground Fin Actuator
Predator Unmanned Aircraft

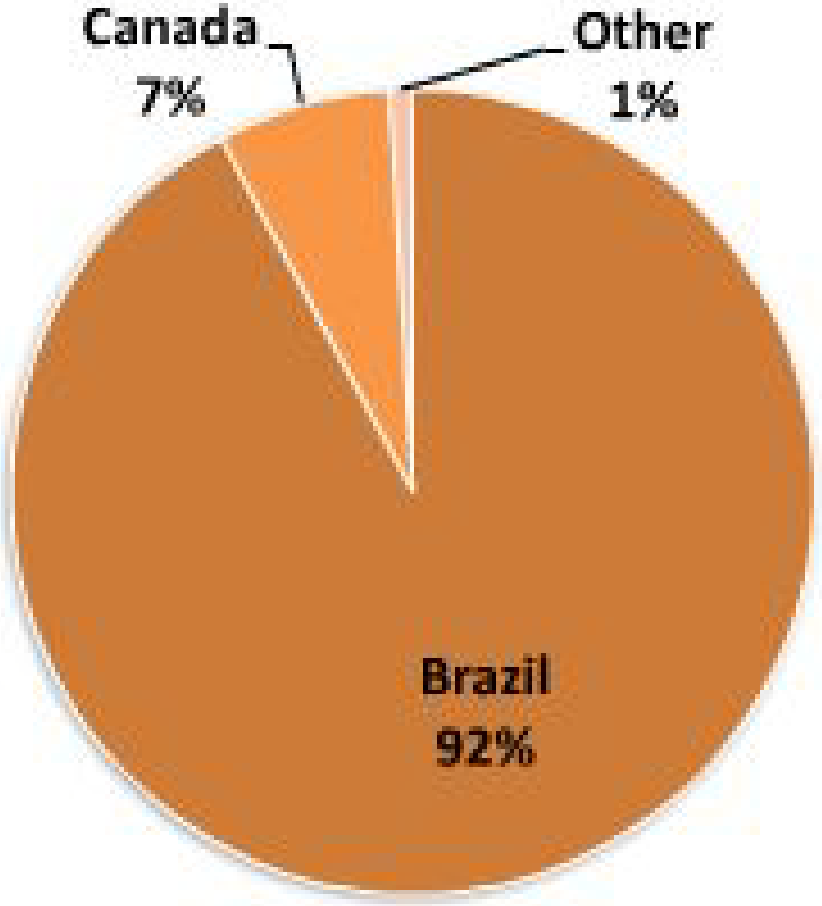

Rare Earth Elements Used
Y, Eu, Tb
Yttrium, Europium, Terbium
Rare Earth Technology
Amplification of Energy and Resolution
Function/Application
Targeting and Weapons
Selected Examples
Laser Targeting
Air Based Lasers
Laser Avenger (counter-IED's)
SaberShot Photonic Disruptor
FCS Vehicle with Laser Weapon


Rare Earth Elements Used
Numerous
Rare Earth Technology
Energy Storage / Density Amplification, Capacitance
Function/Application
Electronic Warfare, Directed Energy Weapons
Selected Examples
Jamming Devices
Electromagnetic Railgun
Ni Metal Hydride Battery
Area Denial System
Long Range Acoustic Device and Area Denial Systems loaded on the "Stryker" vehicle

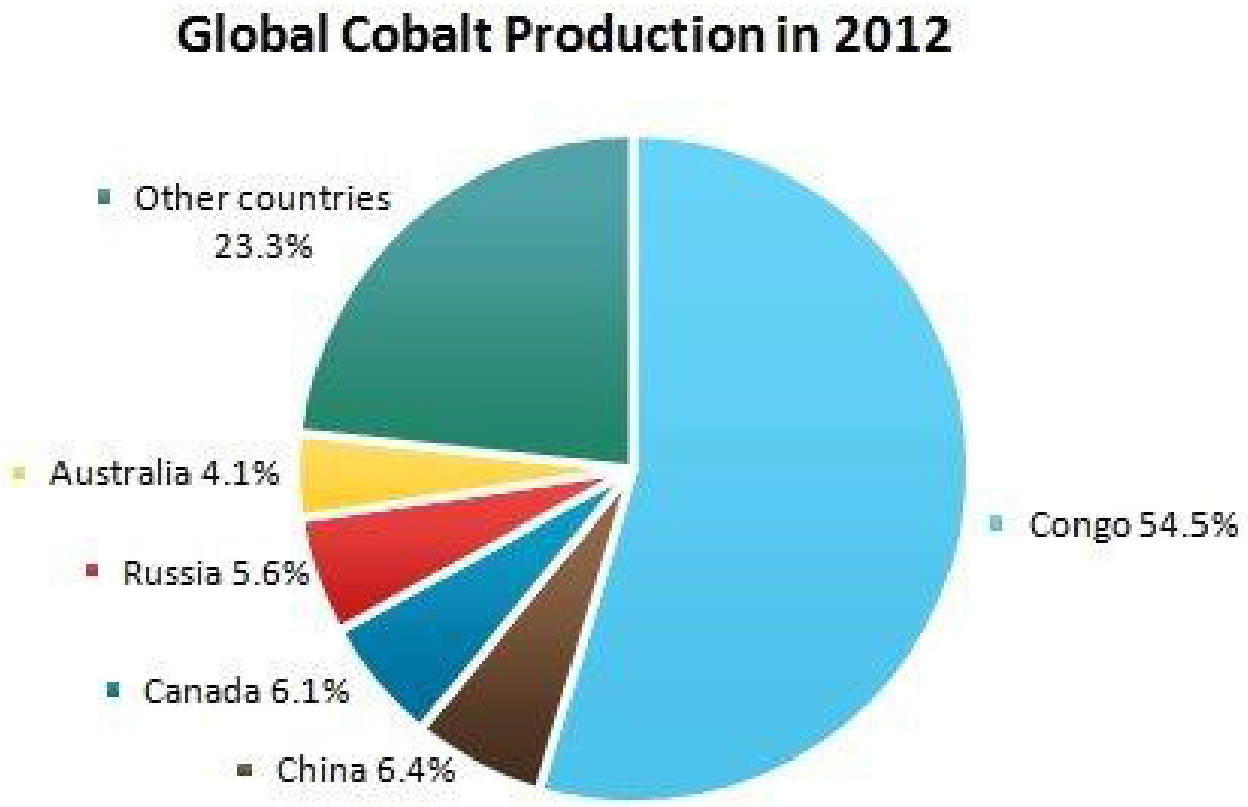

Rare Earth Elements Used
Nd, Pr, Sm, Dy, Tb
Neodymium, Praseodymium, Samarium, Dysprosium, Terbium
Rare Earth Technology
Compact / Powerful Permanent Magnets
Function/Application
Electric Drive Motors
Selected Examples
CHPS Future Combat
Integrated Starter Generator
Hub Mounted Electric Traction Drive
Zumwalt DDG 1000
Joint Strike Fighter and More Electric Aircraft


Rare Earth Elements Used
Nd, Y, La, Lu, Eu
Neodymium, Yttrium, Lanthanum, Lutetium, Emporium
Rare Earth Technology
Amplification, enhanced resolution of signals
Function/Application
Radar, Sonar, Radiation, and Chemical Detection
Selected Examples
Sonar Transducers
Radar
Enhanced A Ray Radiation Detection
Multipurpose Integrated Chemical Agent Alarm (MICAD)

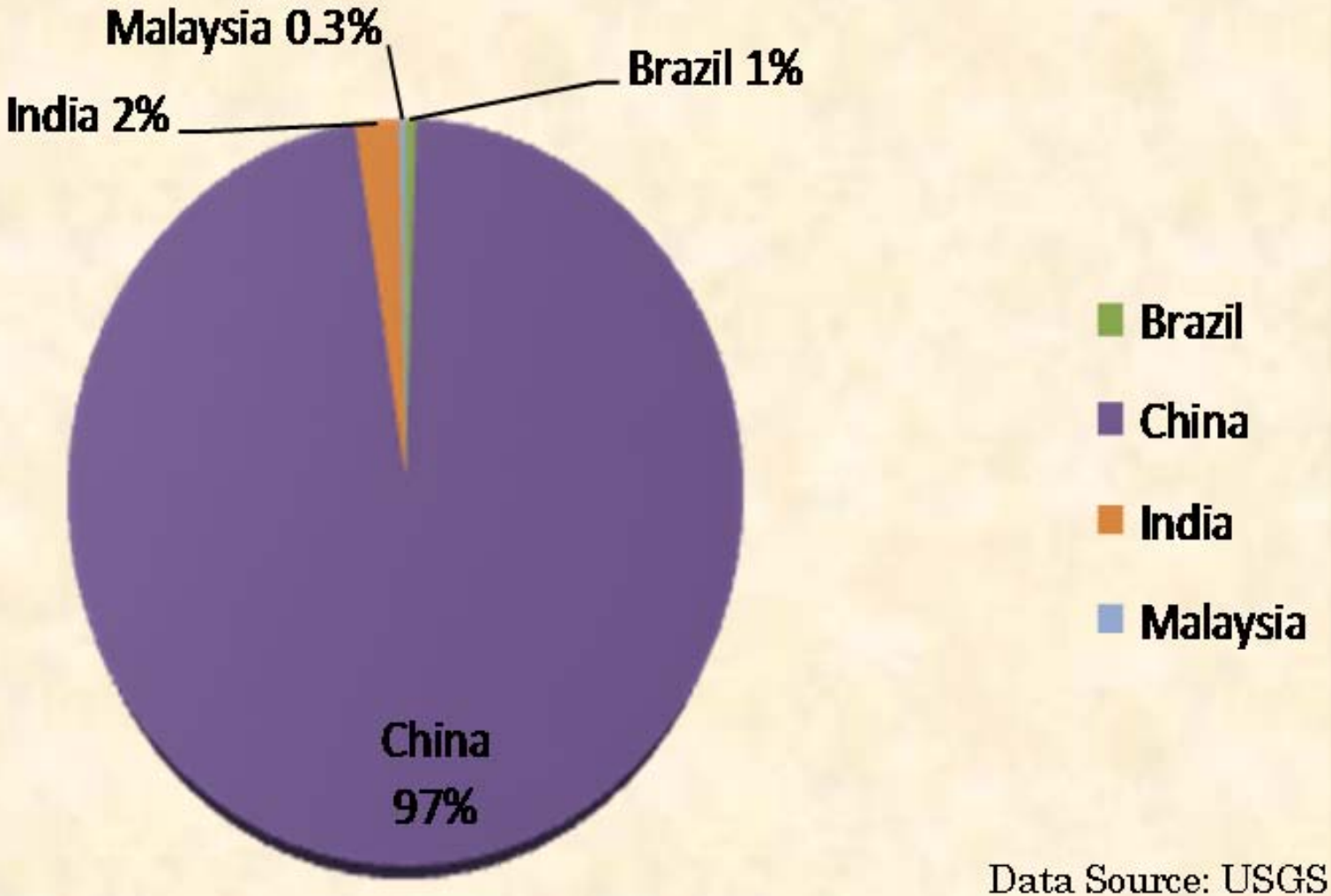
## Exhibit 11: Niobium Producers




Souce: USGS

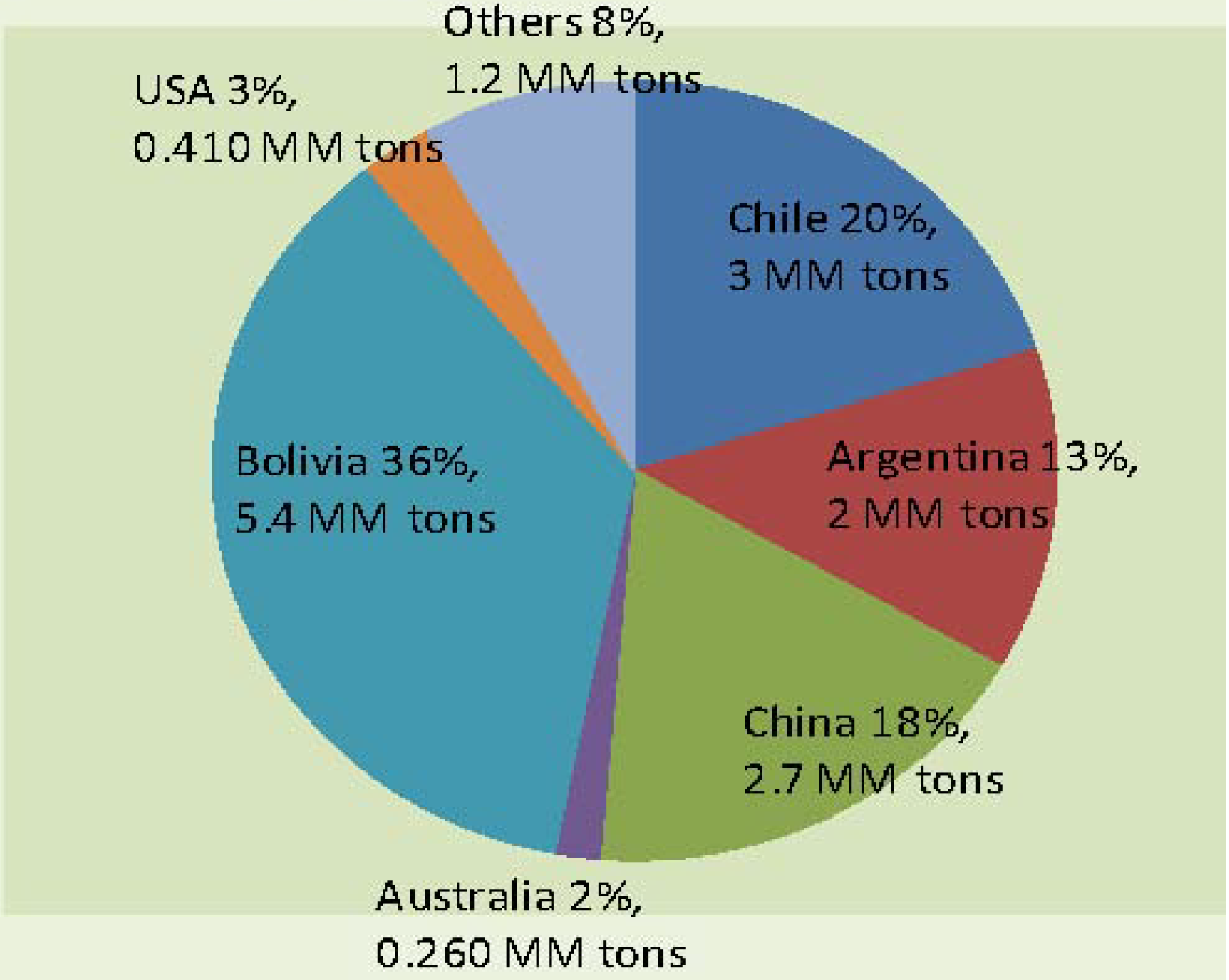

Global Cobalt Production in 2012
Other countries 23.3%
Australia 4.1%
Russia 5.6%
Canada 6.1%
China 6.4%
Congo 54.5%

# Global Rare Earths Production - 2009



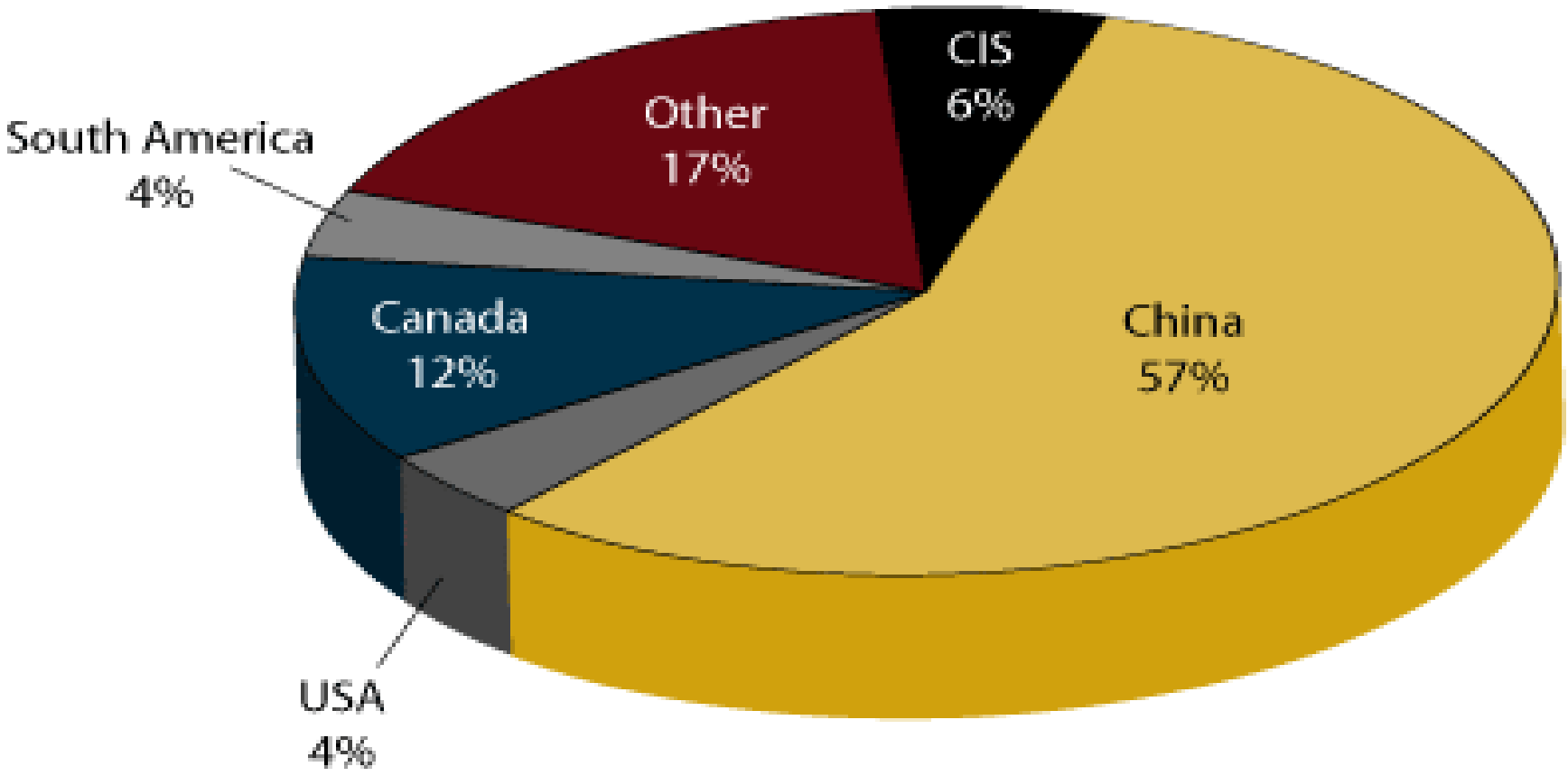

Data Source: USGS

# Lithium Reserve Base



# Advantage China

***Estimated world tungsten reserves 7.0 million tons (W Content).***




*Source: Energy & Scarcity Investor*

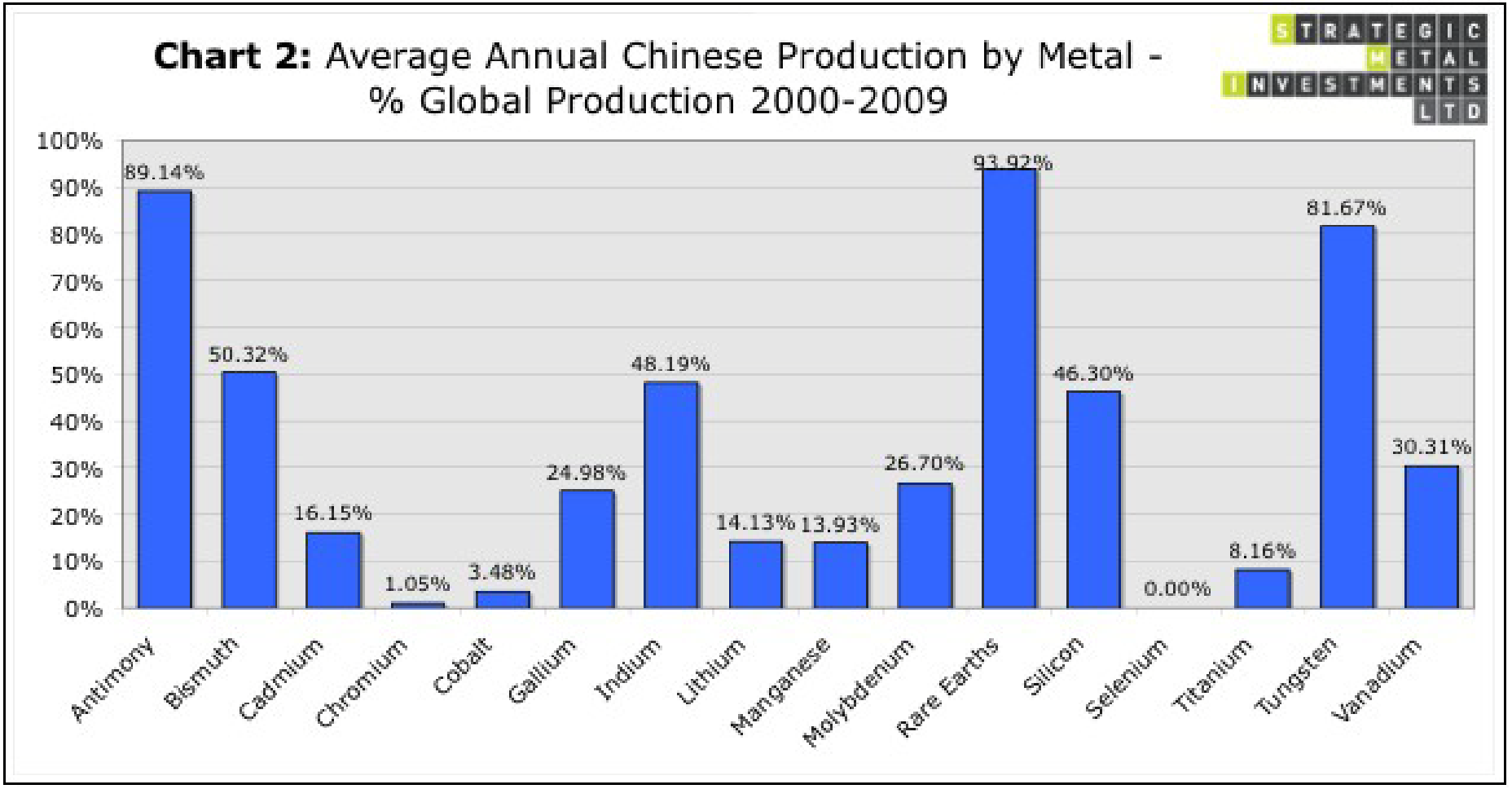
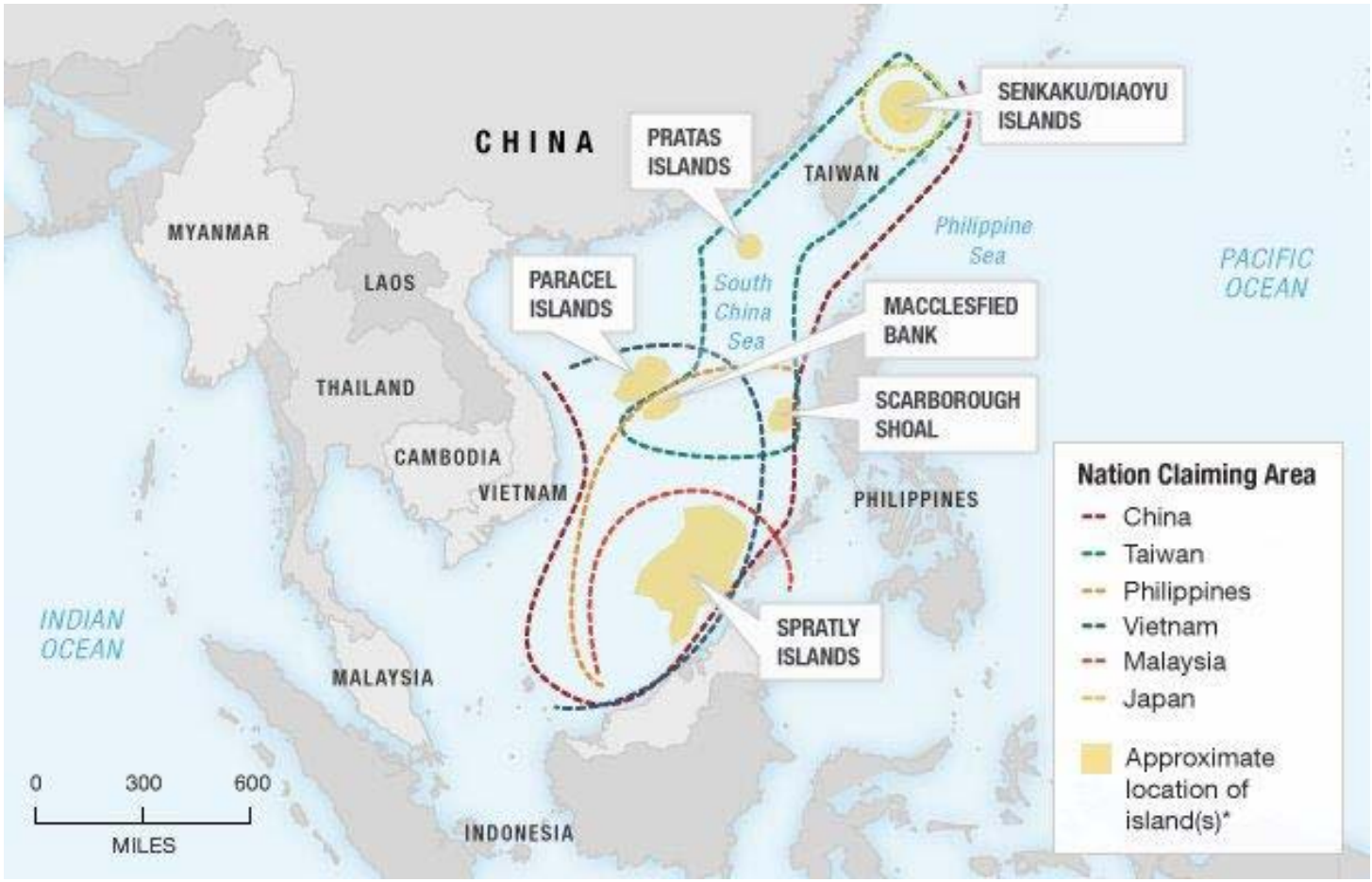


Chart 2: Average Annual Chinese Production by Metal - % Global Production 2000-2009
STRATEGIC METAL INVESTMENTS LTD
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
89.14%
50.32%
16.15%
1.05%
3.48%
24.98%
48.19%
14.13%
13.93%
26.70%
93.92%
46.30%
0.00%
8.16%
81.67%
30.31%
Antimony
Bismuth
Cadmium
Chromium
Cobalt
Gallium
Indium
Lithium
Manganese
Molybdenum
Rare Earths
Silicon
Selenium
Titanium
Tungsten
Vanadium


FLITE-FUEL
SORRY
NO
GAS


GE全球研发中心·上海
China Technology Center, Shanghai
隆重开幕 Grand Opening


CHINA
SENKAKU/DIAOYU ISLANDS
PRATAS ISLANDS
TAIWAN
Philippine Sea
PACIFIC OCEAN
MYANMAR
LAOS
PARACEL ISLANDS
South China Sea
MACCLESFIED BANK
THAILAND
SCARBOROUGH SHOAL
CAMBODIA
VIETNAM
PHILIPPINES
INDIAN OCEAN
SPRATLY ISLANDS
MALAYSIA
0 300 600
MILES
INDONESIA
Nation Claiming Area
China
Taiwan
Philippines
Vietnam
Malaysia
Japan
Approximate location of island(s)*

# South China Sea Holds 80% As Much Oil As Saudi Arabia's Reserves



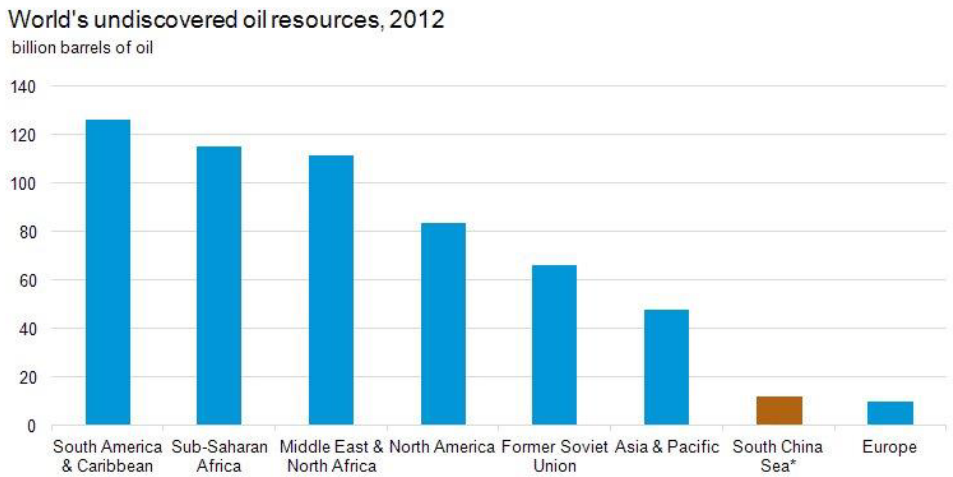
November 12, 2011 4:14 pm



We spotted this today:

"The South China Sea may hold 213 billion barrels of oil, or 80 percent of Saudi Arabia's reserves, according to Chinese studies cited in 2008 by the U.S. Energy Information Agency. The world's second-largest economy claims "indisputable sovereignty" over most of the sea, including blocks off Vietnam that Exxon Mobil Corp. (XOM) and Russia's Gazprom OAO (GAZP) are exploring. "

Statistics Source: NextBigFuture



# Back in Asia, Hagel Pursues Shift to Counter China's Goals in Pacific

Pool photo by Jacquelyn Martin

Defense Secretary Chuck Hagel arrived Wednesday at Yokota Air Base, outside Tokyo, after four days in South Korea.

By JENNIFER STEINHAUER
Published: October 2, 2013

SEOUL, South Korea — In the four years since he announced a shift in American foreign policy and defense strategy to counter China's ambitions in Asia, President Obama has found himself perpetually sidelined from his goals by a series of escalating conflicts in the Middle East and budget crises at home. A long-planned trip to the area has been cut back because of the government shutdown that began Tuesday.

But Defense Secretary Chuck Hagel is forging ahead with a military agenda that reflects the Obama


**Related**

Listening Post: Another Shutdown Victim: U.S. Efforts to Offset China

# Russia's leading role in the Indonesian mining revolution

BY RANDY FABI AND FERGUS JENSEN
JAKARTA | Sun Mar 23, 2014 10:46pm EDT



A worker poses with a handful of nickel ore at the nickel mining factory of PT Vale Tbk, near Sorowako, Indonesia's Sulawesi island, in this January 8, 2014 file photograph.
CREDIT: REUTERS/YUSUF AHMAD

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(Reuters) - Russia's two metal giants have emerged as big winners from Indonesia's new mining law, after leading a drive to get Jakarta to stick to its controversial mineral ore export ban in the face of opposition from miners and Asian buyers.

In its six-month lobbying campaign last year, United Company Rusal and Norilsk Nickel delivered a blunt message to Indonesian officials: We will only invest billions of dollars in smelters if you ban bauxite and nickel ore exports.

The effort seemed to have paid off, despite a denial by Indonesia that it was influenced. When the law came into effect this year, Indonesia enforced a water-tight export ban for only two major minerals - nickel ore and bauxite.


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Campaign Kazakhstan
Campaign for democratic, social & workers rights in Kazakhstan

Monday, June 18th 04:38 PM IST

# China sees Greenland as potential rare earth competitor

# REE # Greenland rare earths # China rare earth monopoly



**Greenland has some of the world's biggest deposits of rare earth elements, strategically important metals in which China has a near monopoly.**

**LONDON(BullionStreet):** World's rare earths monopoly China sees a potential competitor in Greenland as far as mineral trade is concerned, analysts said.

They said, the dragon nation already started talking to Danish authorities about possible alliances in the trade.

Chinese President Hu Jintao's three-day visit to Denmark is in line with this aim in mind, they said. That may explain why the leader of the world's most populous country decided to devote three days to visiting Denmark, a nation of just 5.6 million

Greenland, a self-governing dependency of Denmark, has some of the world's biggest deposits of rare

# China makes $15b direct investment in Africa – Statement

Page last updated at Friday, November 9, 2012 8:08 AM // Leave Your Comment


Statistics show that about 18,000 Chinese companies have invested overseas, mainly in the developing world.

By the end of 2011, China has executed more than 2,200 projects for less-developed countries to the benefit of local people.

A statement signed by Mr. Shao Haijun, Bureau Chief of Xinhua News Agency Accra Bureau, copied to the Ghana News Agency (GNA), said with direct investment in Africa totaling nearly $15 billion, less-developed countries have been exempted from the re-payment of 4.8 billion dollars debts.

It said, a decade ago, in 2000, the Forum on China and Africa Cooperation was established and since then, there has been rapid development in the economic relations between China and Africa.

The statement said in June, this year, Ghana signed a $3 billion Chinese Master Facility Agreement with the China Development Bank.

"Looking back, one can see that burgeoning development of China has brought huge vigour and vitality to world peace and development over the past decade, as a number of facts and statistics prove it," it said.

The statement said African countries were eager to reduce poverty, create jobs and increase economic growth.

It said Mr Hu Jintao, President of China, has pledged to offer 20 billion US dollars as loans to African countries to support infrastructure, industries and small-scale businesses to boost the continent's development agenda.

"China is already playing an increasingly helpful role in Africa's developmental process," the statement said.

# Philips Reduces Dependence on Rare Earths for LEDs

Posted 4/23/2012 11:13 PM by Esther Tanquintic-Misa from International Business Times in Investing, Commodities

0 comments | Like it Don't like it

In Europe

Royal Philips Electronics has started working on a technology that will significantly reduce its dependence on rare earth minerals for creating its light emitting diode (*LED*) lighting products.

"We have launched some innovation projects in order to become less dependent on rare earths," SmartPlanet quoted Frans van Houten, CEO of Royal Philips Electronics, as saying in a conference call with analysts on Monday.

Mr van Houten explained creating the LED lighting products will remain dependent on rare earths, it being a vital component to its efficiency. But such dependence can be lessened.

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# Hitachi spins up 'leccy fan motor sans rare earths

## Where's your monopoly now, China?

By **Phil Muncaster** • **Get more from this author**

Posted in Hardware, 13th April 2012 08:15 GMT

Japanese electronics giant Hitachi has unveiled what it claims to be a highly efficient mid-sized electric motor built without using the rare earth minerals which have become essential to the production of much of modern technology.

The 11kw motor is designed to power pumps or fans in factories and tunnels and should be ready for commercial production by 2014, said Hitachi.

The key design challenge the firm had to overcome was to build a magnet synchronous motor with the requisite energy efficiency and performance without using the rare earth minerals neodymium and dysprosium.

Hitachi said it achieved this thanks to developing its own "iron-based amorphous metal core", which it has been working on since 2008.

The main drivers for the project were improving energy efficiency to counter global warming and move away from a reliance on rare earth materials which China has a virtual monopoly on.



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GREENTECH

# A Push to Make Motors With Fewer Rare Earths

By JIM WITKIN
Published: April 20, 2012

FOR much of the last century, the straightforward solution to making a car perform better has been to install a bigger engine. In the hybrids and electric cars of coming years, however, the answer might be installing motors with more powerful magnets.

Enlarge This Image

Until the 1980s, the most powerful magnets available were those made from an alloy containing samarium and cobalt. But mining and processing those metals presented challenges: samarium, one of 17 so-called rare earth elements, was costly to refine, and most cobalt came from mines in unstable regions of Africa.



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What's Popular Now

Those Revolting Europeans

The Great Pulitzer Do-Over

# Critical materials issues cut both ways

Chris Cann
Contributing editor

The market shortfall of critical materials has caught the attention of business and government in recent years. And while the most publicised challenges relate to the demand side of the equation, there is a growing issue for countries with critical material monopolies.

Last week, Worcester Polytechnic Institute was named the lead institution on a US$7.4 million, multi-university award from the US Army that will support the development of metallurgical methods and lightweight alloys for more effective and durable vehicles and systems.

Part of the brief is to develop magnesium alloys that require fewer rare earth elements (REE), or which use more readily available REEs, in the goal to reduce the military reliance on a group of metals largely dependent on Chinese supply.

REE avoidance measures such as this have been in play since the Chinese restricted the supply of REEs to high-tech Japanese industry in 2011 during a dispute over the Senkaku Islands in the East China Sea.

China's export policy on its REEs (more than 90% of world supply) continued to concern the international manufacturing community and military groups, which have increasingly sought work around using REEs wherever possible.

Royal Philips Electronics has been working on lessening the need for REEs in light-emitting diode products (LED lights); Hitachi has developed its own iron-based amorphous metal core for mid-sized electric motors to by-pass REEs; while the car industry in general has been working on ways to develop powerful magnets without samarium or cobalt (cobalt is not an REE but is a critical metal because of its mining base in politically

*Worcester Polytechnic Institute in Worcester, Massachusetts, was lead institution in a multi-university research award from the US Army supporting development of new metallurgical methods and new lightweight alloys*

unstable African countries, principally the DRC).

Many manufacturers and governments are concentrating their efforts on these-steering REEs, but this research is likely to spread to any other material considered critical*.

Cobalt is one example. Another is niobium, which is largely restricted to Brazil and is vital to the aerospace industry.

Michael Silver, chief executive of high-end minerals supplier American Elements, has described this phenomenon as "innovation distortion" and believes that it is inefficient.

"There really is no scarcity issue with respect of these metals," he told *Mining Journal*. "The sole issue is a fear that geopolitics will hold back the use of these metals.

"Instead of looking for interesting new ways to use available materials, we're looking for ways to work around certain materials and calling that innovation. To me, that's a distortion of the whole concept of innovation."

American Elements sits between the producers and consumers of these critical materials and Silver believes this puts him in a position to see the issue from both sides of the fence.

"We don't make money out of this debate – we're objective on the matter," he says. "It's not the restrictions, transparent growth of the industry that everyone should be striving toward. It creates a kink in the innovation process and that will have a cost.

"It's a waste – we're creating a situation where the brightest people are focusing their efforts on moving sideways."

While Western governments and manufacturers spin their wheels waiting [illegible] to use REEs, other strategic or critical metals, countries such as China with a natural near monopoly over certain materials could be doing themselves a disservice by limiting their availability.

When China initially held Japan's REE supply to ransom in 2011 it was a purely political move. Since then, however, restrictions have been economically motivated.

Currently, China offers a tiered pricing system for its REEs, which sees local, Chinese manufacturers receive a very competitive price, while overseas, foreign manufacturers have to pay a vastly higher rate.

The idea is that manufacturers will be forced to set up Chinese manufacturing bases to ensure secure and reasonably priced raw material supply.

This is designed to help China move its manufacturing sector up the value chain as it moves toward a domestically supported economy. It stands to reason that other developing nations with critical materials, such as Brazil, may follow suit.

But this is uncharacteristically short-sighted on the part of the Chinese, according to Silver, who was recently in Beijing speaking to a mixed audience of industry and government.

"I asked the Chinese why they would convey, through their geopolitics, the message that the rest of the world needs to stay away from these elements," he said.

"If China hadn't created that environment then there would be billions of bright minds all over the planet looking for ways to use minerals that they control – instead they're looking for ways not to use them."

Silver said innovation distortion in response to restricted supply of materials is unavoidable. It is [illegible] countries such as China to [illegible] their ability to think long-term and change tack.

**American Elements released its third annual Endangered Elements list recently, which ranks the top-five most geopolitically threatened elements in terms of supply. Both the EU and US have issued their own lists of strategic or critical metals, of which there are around 14 (REEs are generally classed as one material on the US and EU lists).*

DISPUTE SETTLEMENT: DISPUTE DS431

# China — Measures Related to the Exportation of Rare Earths, Tungsten and Molybdenum

This summary has been prepared by the Secretariat under its own responsibility. The summary is for general information only and is not intended to affect the rights and obligations of Members.

See also:
> The basics: how disputes are settled in WTO
> Computer based training on dispute settlement
> Text of the Dispute Settlement Understanding

Other disputes involving:
> Export Restrictions
> Rare Earths
> United States
> China
> General Agreement on Tariffs and Trade 1994
> Protocol of Accession

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Panel report circulated on 26 March 2014 ⓘ

## Key facts back to top

| | |
|---|---|
| Short title: | China — Rare Earths |
| Complainant: | United States |
| Respondent: | China |
| Third Parties: | Brazil; Canada; Colombia; European Union; India; Japan; Korea, Republic of; Norway; Oman; Saudi Arabia, Kingdom of; Chinese Taipei; Viet Nam; Argentina; Australia; Indonesia; Turkey; Peru; Russian Federation |
| Agreements cited: (as cited in request for consultations) | GATT 1994: Art. VII, VIII, X, XI, XI:1, X:3(a) Protocol of Accession: , , Part I, para. 1.2, Part I, para. 5.1, , , Part I, para. 11.3, Part I, para. 5.2, Part I, para. 8.2, Part I, para. 7.2 |
| Request for Consultations received: | 13 March 2012 |
| Panel Report circulated: | 26 March 2014 |

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# INNOVATION MATERIALS TREATY

1. Defines what materials are deemed by signators as **“Innovation Materials”.**

2. Any country with 35% or more of production of a given Innovation Material is defined as a **“Sovereign Monopoly”**.

3. Signators are made up of (!) all Sovereign Monopolies and (2) all Industrial Nations that use Innovation Materials.

4. KEY PROVISION I: NO COSTS OR RESTRICTIONS on removal of Innovation Materials from Sovereign Monopoly once purchased within the country whether for personal use or distribution AND non-citizens and foreign corporations can purchase freely.

5. KEY PROVISION II: Country may still enact limitations on production due to environmental concerns such as pollution or limited resources. [Cf. WTO rules]

6. Penalty: Automatic Global Import Duty by Signators on any products produced by the Sovereign Monopoly that incorporate that Innovation Material.


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