The Situation Regarding Rare Earth Elements

Ministry of Economy, Trade and Industry
March 2011

- Functions of REEs in Industrial Sectors
- What are Issues on REEs
- Our Measures to Deal with REEs Issues
  - ✓Diversification of Supply Source
  - ✓R&D for Substitute and New Manufacturing Ways
  - ✓Recycling

- Functions of REEs in Industrial Sectors

Principal Uses of Each Rare Earth Element

LREE	Sc	Catalyst
	La	Optical glass, Ceramic condenser, Catalyst & Luminescent Materials
	Ce	Polishing, Catalyst, UV-cut glass & Glass decolorizer
	Pr	Sintered Nd magnet & Ceramic tile color former
	Nd	Nd magnet & Ceramic condenser
MREE	Pm	NA (No stable isotope)
	Sm	Sm-Co magnet
	Eu	Luminescent Materials (Red)
	Gd	Optical glass & Neutron shielding material for atomic reactor
HREE	Tb	Luminescent Materials (Green), Magnetic optical disk target & Sintered Nd magnet
	Dy	Sintered Nd magnet & Giant Magnetostrictive Material
	Ho	Laser component & Magnetic superconductive material
	Er	Crystal grass colorant
	Tm	Laser component
	Yb	Laser component & Visible upconversion
	Lu	Scintillation
	Y	Luminescent Materials, Optical glass & anodic/cathdic material of secondary battery

Examples of Industrial Supply Chains regarding REEs

Hard Disk Drive

Abrasives

Rare earths
Cerium oxide

→ Hard disk platter 

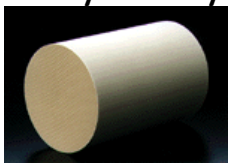
→ Hard disk drive 

→ Personal Computer 

Exhaust Gas Catalyst

Catalyst material

Rare earth
Cerium carbonate

→ 3-way catalyst 

→ Catalytic converter 

→ Automobile 

Phosphor

Phosphor material

Rare earths
Yttrium oxide
Europium oxide
Terbium oxide

→ Phosphor 

→ CCFL (Cold-cathode fluorescent lamp) 

→ Flat Panel Display 

Fluorescent 

Fluid Catalytic Cracking (FCC) Catalyst

Catalyst material → FCC catalyst → Oil refinery

Rare earths
Lanthanum oxide
Cerium chloride

Permanent Magnet

Magnet material → Magnet alloy → Permanent magnet → Motor

Rare earths
Dysprosium metal
Neodymium metal
Samarium metal

Automobile

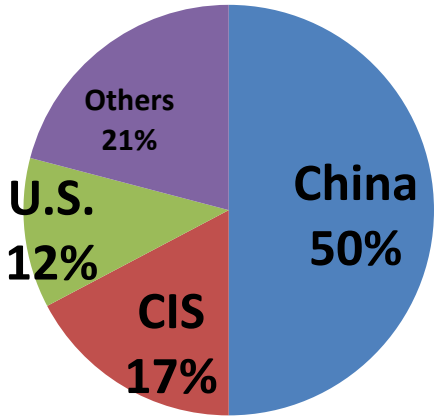
Wind-power generation

Hard disk drive

- What are Issues on REEs

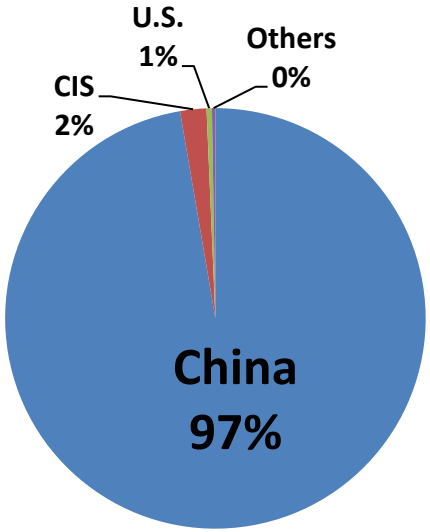
Basic information on rare earths

Worldwide reserves



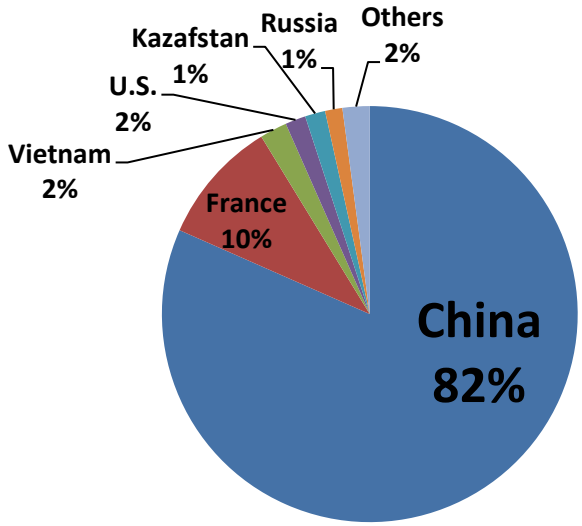
(Source) Mineral Commodity Summaries (USGS)

Annual worldwide production



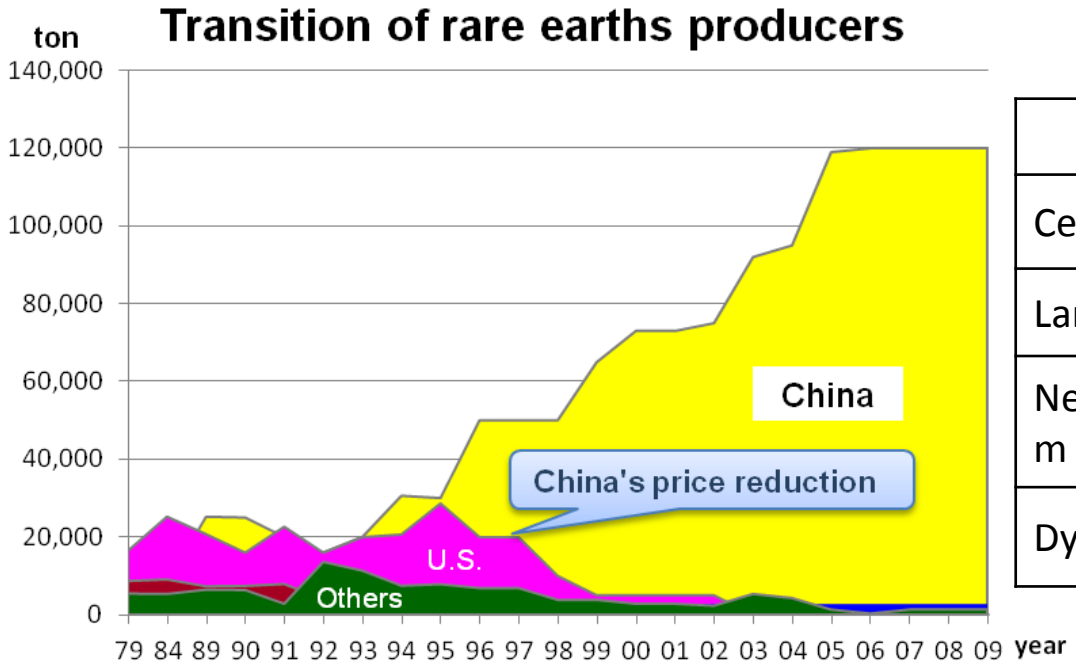
(Source) Mineral Commodity Summaries (USGS)

Japan's import trading partners



(Source) Trade Statistics of Japan(2010)

Change of the position of China as a resource supplier



(Source) Mineral Commodity Summaries(USGS)

Rare earth prices (Unit: US$/KG)

	1990s	2000s	Present
Cerium	$60	$5～10	$95
Lanthanum	$60	$5～10	$90
Neodymium	$60	$8→50	$200～250
Dysprosium	NA	$50→150	$600

(Above “present” prices have been raised after autumn of last year.)

A significant reduction in Chinese rare earth export quotas

China export quotas on rare earths

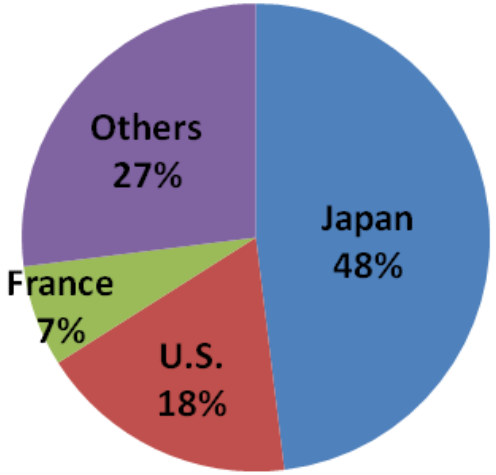
(Unit: ton)

Year	2006	2007	2008	2009			2010			2011
				First	Second	Total	First	Second	Total	First
Export quotas	61,560	60,173	47,449	21,728	28,417	50,145	22,283	7,976	30,259	14,446

- 40%

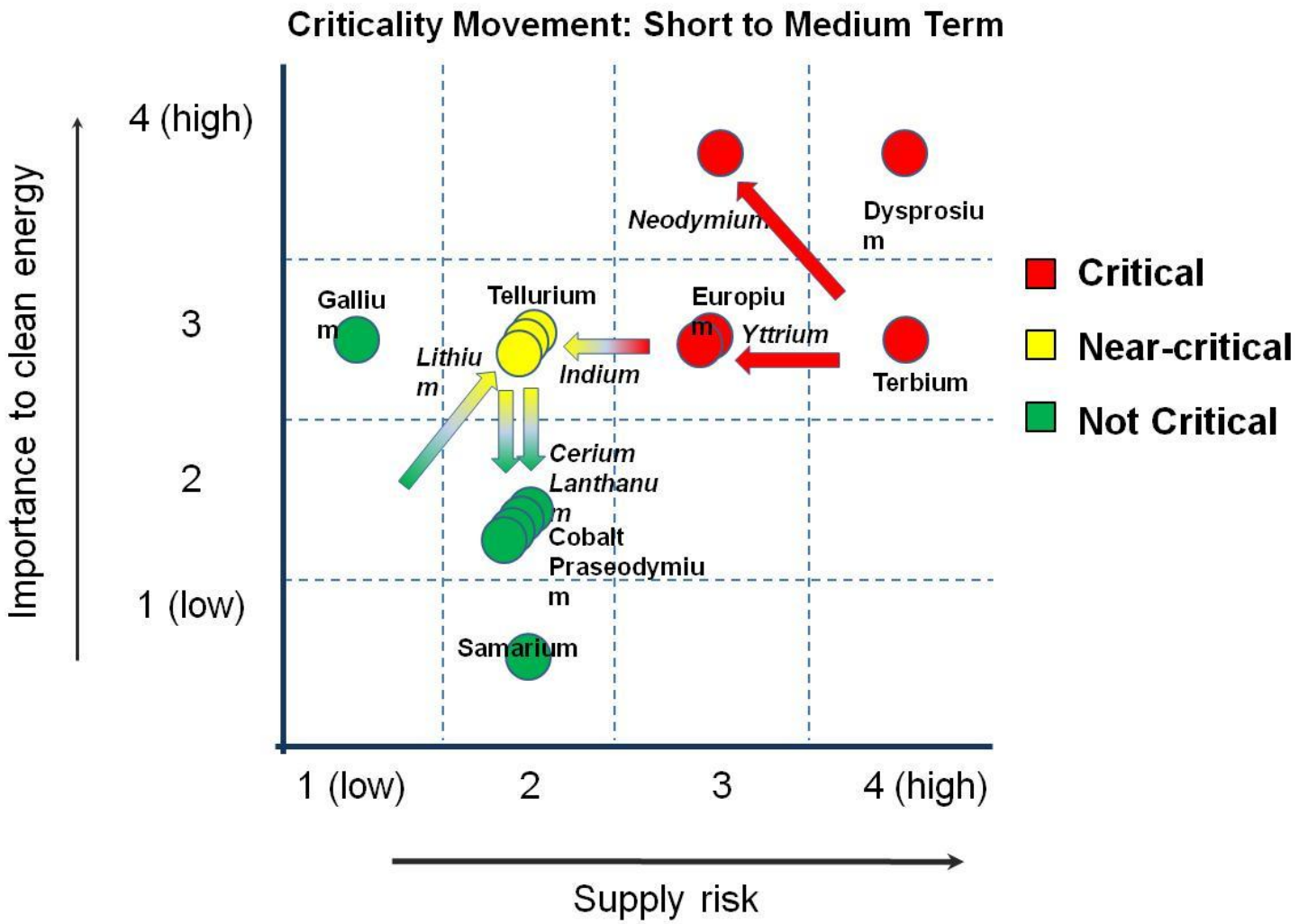
- 35%

China's export tradiing partner



(Source) China Custam(2010)

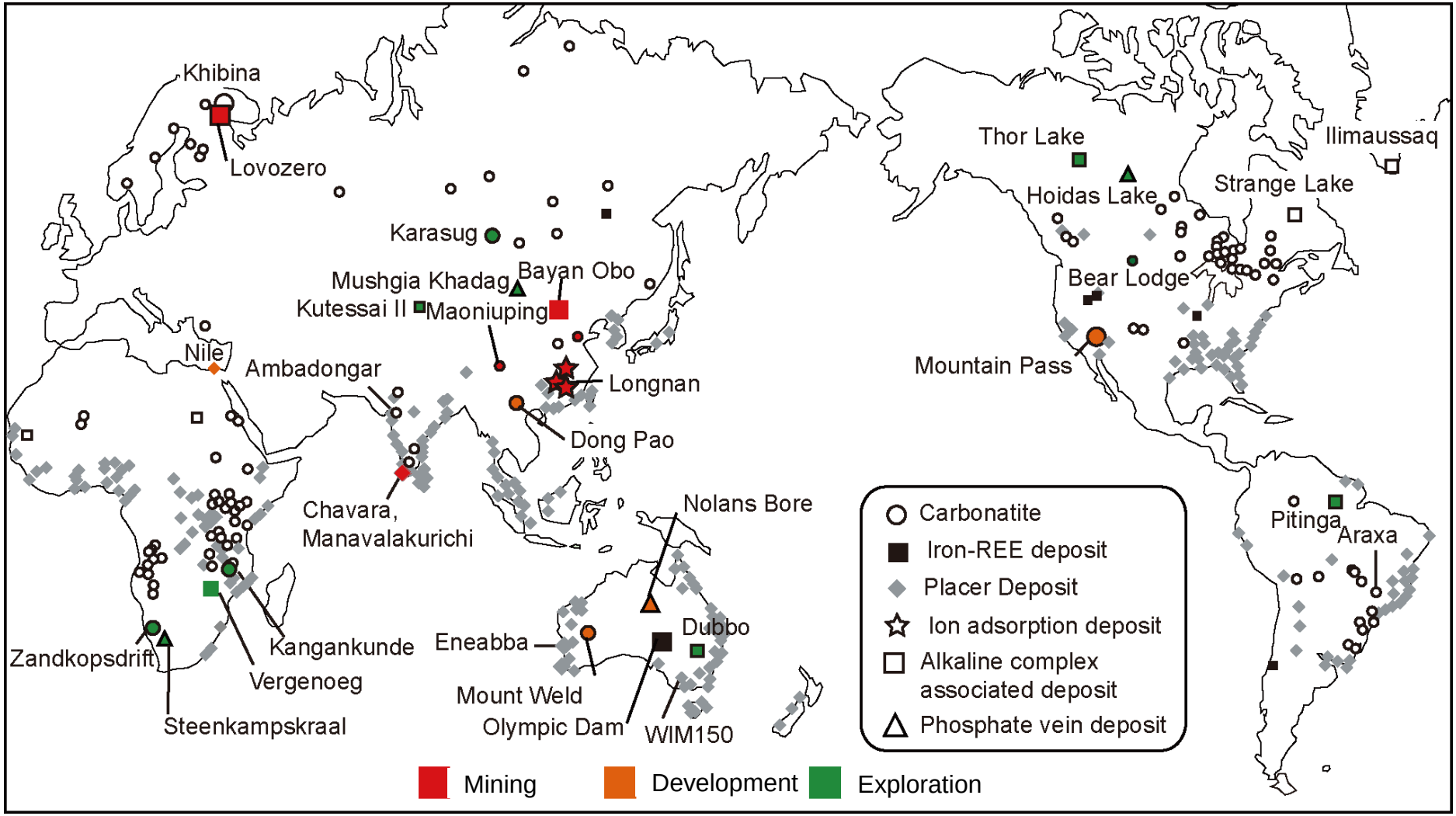
Critical Materials Strategy (by U.S. DOE)



(Source) Critical materials strategy(DOE)

Worldwide Rare Earth Resources

REEs have a wide distribution across the world.



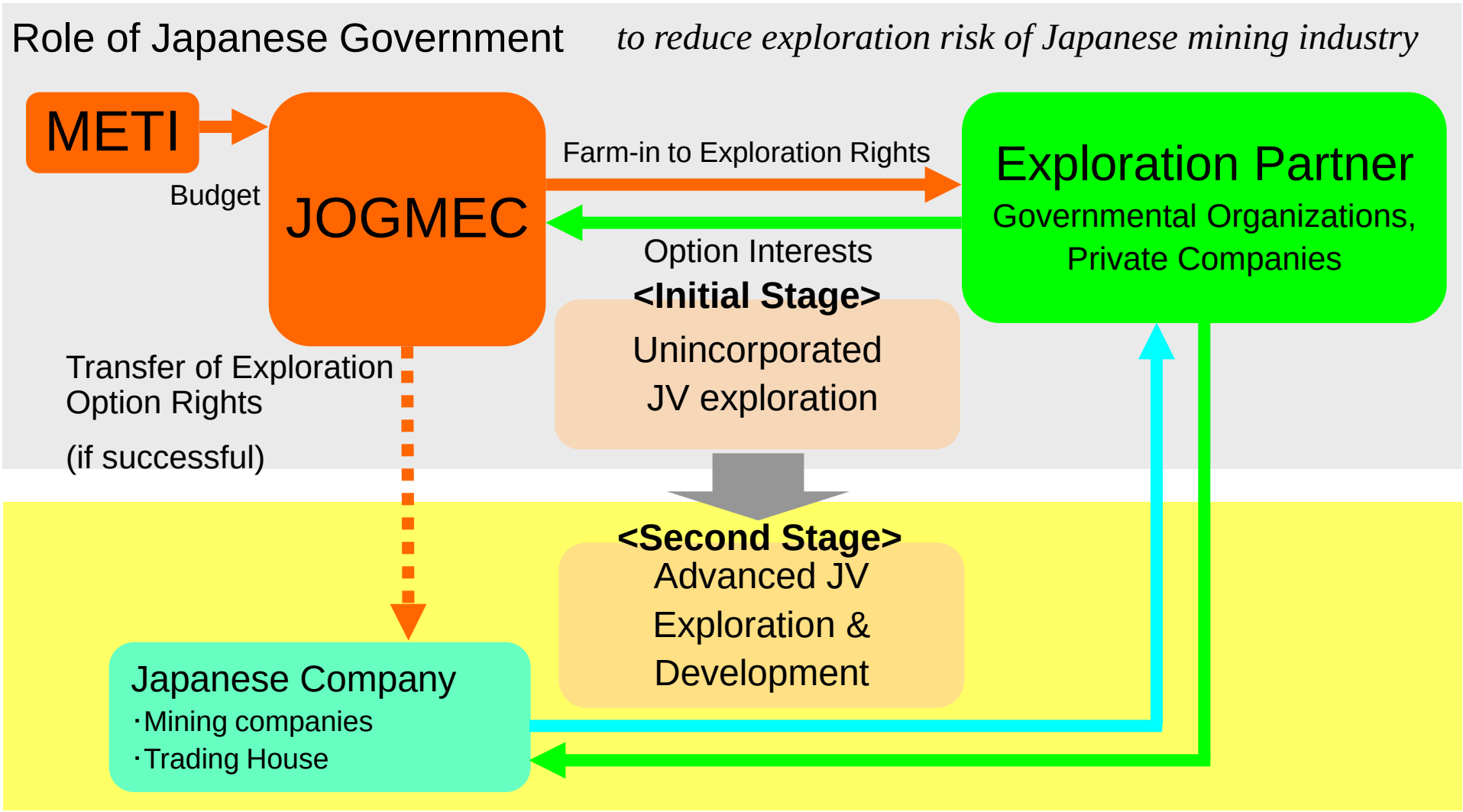
% Distribution of REE in Various Deposits

		China				USA	Australia		Canada
		(Bastnesite))	(Ion-adsorption type)			(Bastnesite))	(Monazite)	(Apatite)	(Xenotime etc.)
		Baiyun %	Longnan %	Xinfeng %	Xunniao %	Mt.Pass %	(Mt.Weld) %	Nolans %	Thor Lake %
Lanthanum	La_2O_3	23.0	0.8	26.5	31.3	33.2	25.1	20.0	0.30
Cerium	CeO_2	50.0	0.2	2.4	3.4	49.1	48.5	48.2	4.40
Praseodymium	Pr_6O_{11}	6.2	0.9	6.0	8.7	4.3	5.3	5.9	1.70
Neodymium	Nd_2O_3	18.5	3.8	20.0	28.1	12.0	16.7	21.5	15.6
Samarium	Sm_2O_3	0.8	2.8	4.0	5.3	0.8	2.2	2.4	10.4
Europium	Eu_2O_3	0.2	0.0	0.8	0.6	0.1	0.65	0.41	1.60
Gadolinium	Gd_2O_3	0.7	5.7	4.0	4.5	0.2	0.90	1.0	14.3
Terbium	Tb_4O_7	0.1	1.20	0.6	0.5	Trace	0.10	0.08	1.80
Dysprosium	Dy_2O_3	0.1	8.40	4.0	1.2	Trace	0.20	0.34	9.80
Holmium	Ho_2O_3	Trace	1.80	0.8	0.1	Trace	Trace	other 0.17	1.20
Erbium	Er_2O_3	Trace	5.10	1.80	0.3	Trace	Trace		4.10
Thulium	Tm_2O_3	Trace	0.80	0.30	0.1	Trace	Trace		0.70
Ytterbium	Yb_2O_3	Trace	4.60	1.20	0.5	Trace	0.10		4.40
Lutetium	Lu_2O_3	Trace	0.60	0.10	< 0.1	Trace	Trace		0.70
Yttrium	Y_2O_3	Trace	62.0	27.5	15.4	0.1	0.40		29.00
	Total	99.6	98.7	91.2	100.1	99.8	100.1	100.0	100.0

In common REEs deposits (bastnesite/ monazite),
La_2O_3/ CeO_2 content in total REO is 70 – 80% (especially 50% of CeO_2).

- Our Measures to Deal with REEs Issues
  - ✓Diversification of Supply Source

JOGMEC JV Exploration Scheme



Japan's Rare Earths Projects
(in which Japanese Companies and/or JOGMEC is involved)

Development

Number	Country	Project	Partners	G-G Arrangement
1	Vietnam	Dong Pao	Vietnamese Private Company	31 Oct. 2010: East Asia Summit @Hanoi
2	India	Orissa	Indian Public Company	25 Oct. 2010: Japan-India summit @Tokyo
3	Kazakhstan	SARECO	Kazakhstan Public Company	29 Spt. 2010: Japan-Kazakhstan Public-Private Joint Economic Committee @Tokyo

Exploration by JOGMEC

Number	Project	Country	Partners
1	Kratz Spring	USA	Gold Canyon Resources
2	Ytterby	Canada	Midland Exploration
3	North Beaty Project	Canada	Titan Uranium
4	South Gobi Region	Mongol	Mongolian Government

[Reference] Foreign companies' development projects

Number	Company	Project	Stage	Partners
1	Lynas (Australia)	Mt. Weld	Development	Sojitz (Japanese Private Company)
2	Molycorp Minerals (USA)	Mountain Pass	Redevelopment	Sumitomo Corp. (Japanese Private Company)

- Our Measures to Deal with REEs Issues
  - ✓R&D for Substitute and New Manufacturing Ways

Rare Metal substitute materials development project

Budget	US$82 million (US$1 = \85)
Term	FY2007-
Targets	**Indium for transparent conducting electrodes, 50% reduction**
	Dysprosium for REE magnets, 30% reduction
	Tungsten for cemented carbide tools, 30% reduction
	PGM for emission control catalysts, 50% reduction
	Cerium for precise polishing, 30% reduction
	Terbium and Europium for fluorescent lamps, 80% reduction

A example of development project

Dysprosium (Dy)

Reducing Dysprosium use in rare earth permanent magnets

Grain refinement and control of interface nanostructure techniques to realize high H_c sintered Nd-Fe-B magnets

Tohoku University, Yamagata University, National Institute for Materials Science (NIMS), Japan Atomic Energy Agency, Santoku Corp., Intermetallics Co., Ltd., TDK Corp., Toyota Motor Corp.

Development of high-performance magnetic materials

Development of new materials for permanent magnets with less or no rare earth element content

Tohoku University, Kyoto University, Chiba Institute of Technology, Kurashiki University of Science and Art, National Institute for Materials Science (NIMS), Toda Kogyo Corp., Teijin Ltd., Toyota Motor Corp.

International cooperation between consuming countries on rare earths

<U.S. and Japan>

◆U.S. – Japan Roundtable on Rare Earth Elements Research and Development for Clean Energy Technologies

Date: November 18-19, 2010 / Venue: Lawrence Livermore National Laboratory, U.S.

◆Next workshop in Japan

Date: TBD / Venue: Japan

<Europe and U.S. >

◆Trans-Atlantic Workshop on Rare Earth Elements and Other Critical Materials for a Clean Energy Future

Date: December 3, 2010 / Venue: the Massachusetts Institute of Technology(MIT), in U.S.

- Our Measures to Deal with REEs Issues
  - ✓Recycling

Structure of Laws relating to 3R

Basic framework law

Basic Law for Establishing the Recycling-based Society

Promotion of systematic undertakings across the entire 3R scope

Law for Promotion of Effective Utilization of Resources

Regulations for the construction of systems for voluntary collection and recycling by manufacturers, etc.

10 industries and 69 products including PCs designated.

Regulations for mandatory recycling of problematic individual items

Measures for containers and packaging that comprises 60% of household refuse

Cost shouldered by manufacturing and distribution companies

- **Containers and Packaging Recycling Law**
  - **Bottles, PET bottles, paper and plastic containers and packaging, etc.**

Measures for bulky waste and refuse

Cost shouldered by person disposing of waste (Consumer)

- **Home Appliance Recycling Law**
  - **Air conditioners, refrigerators, freezers, televisions, washing machines, etc.**
- **End-of-life Vehicle Recycling Law**
  - **Automobiles**

Measures for other bulky, voluminous waste

Cost shouldered by entity disposing of waste (Company)

- **Construction Waste Recycling Law**
  - **Lumber, concrete, asphalt**
- **Food Recycling Law**
  - **Leftover food**

Primary Rare Metals Used in Cell Phones

Cell Phone Net weigh contained	
Metal	g/unit
Nickel	0.623
Chromium	0.235
Manganese	0.037
Cobalt	0.03
Tungsten	0.097
Molybdenum	0.008
Niobium	0.001
Tantalum	0.062
Antimony	0.029
Gold	0.032
Platinum	0.001
Palladium	0.008
Gallium	0.003
Indium	0.003
Rare earth	0.163

Condition and Challenges for Rare Metal Recycling

Example

Rare Metals which are recovered from a cell phone

Gold	0.02 ~ 0.03 g	(\110.0)
Silver	0.1 ~ 0.13 g	(\7.0)
Copper	10.1 ~ 12.8 g	(\7.7)
Palladium	0.003 ~ 0.005 g	(\6.6)

Only approx. \131

Technological development & plant investment for rare metal recycling have been advanced by smelting industry.

Challenges

Establishment of social system for economic recycling

- **Products incl. large amount of rare metals.**
- **Efficient and large-scale scrap collecting.**
- **Technological development for rare metal recycling.**

+ **Design for Recyclability**