

**PDAC 2009**

*“THE RARE EARTHS MARKET:  
CAN SUPPLY MEET DEMAND IN 2014?”*

by

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# What Are Rare Earths?

- ❑ A group of 15 similar elements with unique chemical, magnetic and fluorescent properties.
- ❑ They are essential materials in the components of many items of modern day living such as laptops, hybrids, energy efficient lights and cell phones.

# Summary of Presentation

- The rare earths industry today
- The last 12 months
- China
- Consumption and demand today
- Forecast future demand
- Potential future new suppliers

# Rare Earths: A Short History

**1794:** Rare earths discovered by Johan Gaddin at Ytterby in Sweden

**1903:** First commercial production of rare earth flints at Treibach in Austria

**1953:** Demand ~1,000t REO      Value ~US\$25M

**2003:** Demand 85,000t REO      Value US\$500M

**2008:** Demand 124,000t REO      Value US\$1¼B

**2015:** Demand 200,000t REO      Value US\$2-3B

# The Rare Earths Market Today

- Total demand: 124,000t REO pa (2008)
- Average price: US\$9-11/kg REO
- Total value: US\$1¼ billion pa
- Constraints on Chinese exports are creating opportunities for non-Chinese projects
- Several non-Chinese rare earths projects being evaluated

# The Last 12 Months

- Global financial crisis
- Chinese export quotas reduced
- Chinese export taxes maintained
- Re-start of operations in Sichuan
- Baotou rare earths mineral concentrate stockpile to be established
- Consolidation of rare earths industry (ionic clays) in South China

# China: RE Export Transition

- ❑ 1970s: Rare earth mineral concentrates.
- ❑ 1980s: Mixed rare earth chemical concentrates.
- ❑ Early 1990s: Separated rare earth oxides and metals.
- ❑ Late 1990s: Magnets, phosphors, polishing powders.
- ❑ 2000s: Electric motors, computers, batteries, LCDs, mobile phones.



# China: Export Quota History

## History of Chinese Export Quotas – tonnes REO

<u>Year</u>	<u>Domestic Rare Earth Quotas</u>				<u>Total including Foreign IV Quota</u>	<u>ROW Demand</u>
	<u>Phase 1</u>	<u>Phase 2</u>	<u>Total</u>	<u>Change</u>		
2004	n/a	n/a	48,040t	-	65,600t	57,000t
2005	n/a	n/a	48,040t	0%	65,600t	46,000t
2006	n/a	n/a	45,752t	-5%	61,820t	50,000t
2007	19,600t	23,973t	43,573t	-5%	59,650t	50,000t
2008	22,780t	11,376t	37,189t	-15%	53,150t	50,000t
2009	15,043t	???	???	???	???	50,000t

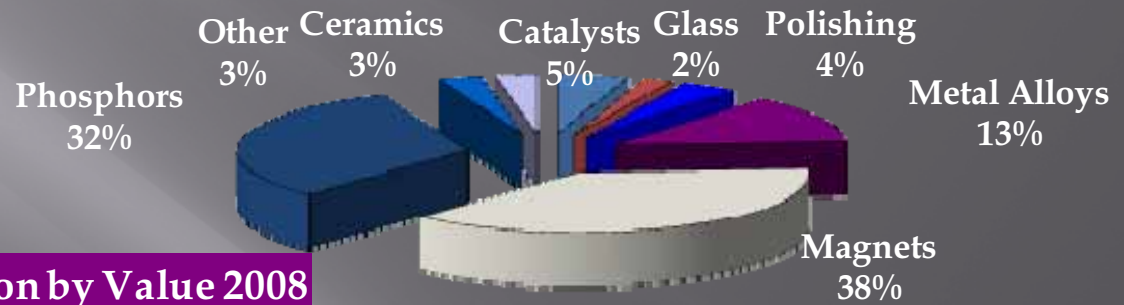
# China: Industry Constraints

- ▣ Mining quotas
- ▣ Export quotas – falling annually
- ▣ Export taxes: 15-25%
- ▣ VAT rebate on exports withdrawn
- ▣ No new rare earth mining licences
- ▣ Environmental legislation enforced
- ▣ Shortage of Tb, Dy and Y

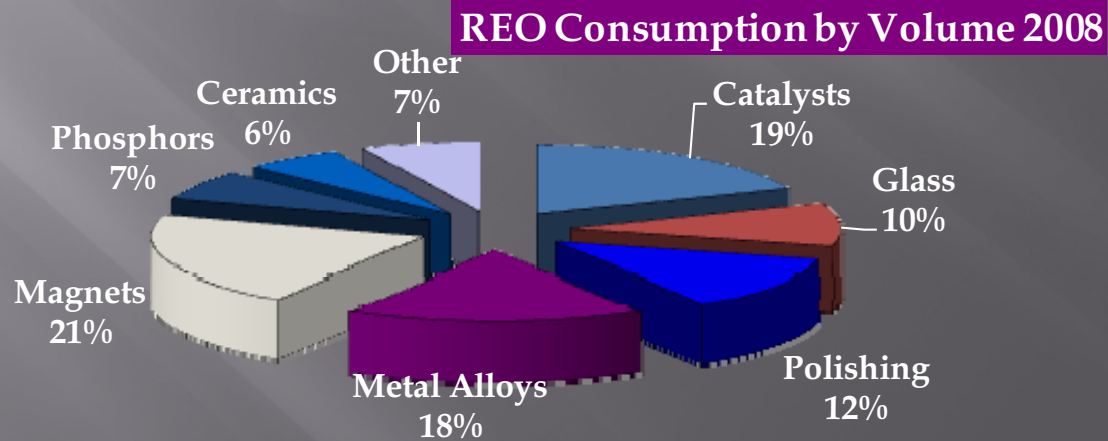
# Global RE Consumption 2008

Estimated Global Rare Earths Demand in 2008 (tREO $\pm 15\%$ )					
<u>Application</u>	<u>China</u>	<u>Japan &amp; NE Asia</u>	<u>USA</u>	<u>Others</u>	<u>Total</u>
Catalysts	7,000	2,000	12,500	1,500	23,000
Glass	8,000	2,000	1,000	1,500	12,500
Polishing	8,000	4,500	1,000	1,500	15,000
Metal Alloys	16,000	4,500	1,000	1,000	22,500
Magnets	21,000	3,500	500	1,000	26,500
Phosphors	5,500	2,500	500	500	9,000
Ceramics	2,500	2,500	1,250	750	7,000
Other	6,000	2,000	250	250	8,500
<b>Total</b>	<b>74,000</b>	<b>23,500</b>	<b>18,500</b>	<b>8,000</b>	<b>124,000</b>

# 2008 REO Consumption



REO Consumption by Value 2008



REO Consumption by Volume 2008

# Forecast Demand in 2014

## Global Rare Earths Demand in 2008 & 2014 (t REO)

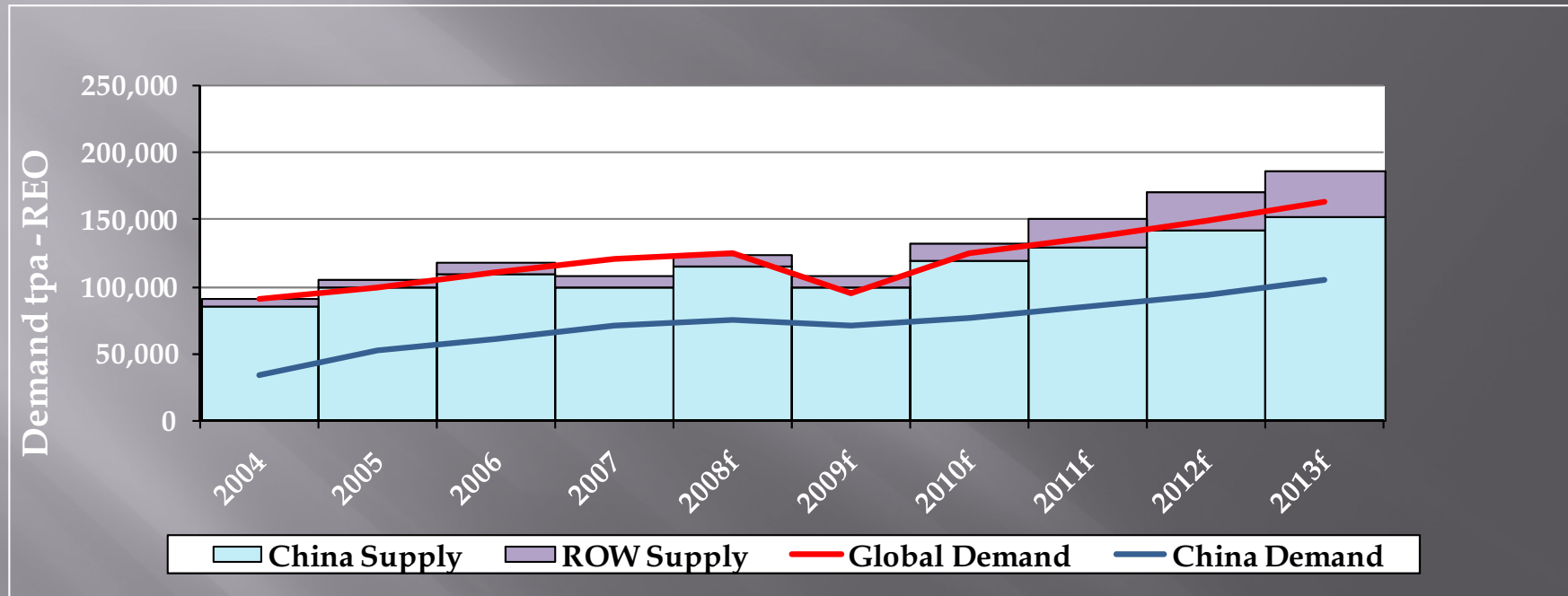
<u>Application</u>	<u>Consumption tpa REO</u>		<u>Market Growth</u>
	<u>2008f</u>	<u>2014f</u>	<u>2011-14</u> <u>%pa</u>
Catalysts	23,000	28-30,000	6-8%
Glass	12,500	12-13,000	negligible
Polishing	15,000	19-21,000	6-8%
Metal Alloys	22,500	43-47,000	15-20%
Magnets	26,500	39-43,000	10-15%
Phosphors & Pigments	9,000	11-13,000	7-10%
Ceramics	7,000	8-10,000	7-9%
Other	8,500	10-12,000	7-9%
<b>Total/Range</b>	<b>124,000</b>	<b>170-190,000</b>	<b>8-11%</b>

# The Issue of 'Balance' in 2014

## Forecast Supply and Demand for Selected Rare Earths in 2014

<u>Rare Earth Oxide</u>	<u>Demand @</u> <u>170-190,000tpa REO</u>	<u>Supply @</u> <u>190-210,000tpa REO</u>
Lanthanum	49-53,000t REO	52-56,000t REO
Cerium	62-66,000t REO	80-90,000t REO
Terbium	400-700t REO	300-500t REO
Dysprosium	1,800-2,200t REO	1,500-2,000t REO
Yttrium	10-14,000t REO	10-12,000t REO

# Rare Earths Supply & Demand



(Assuming current trends continue, new projects are developed and there is a 'balance' in supply and demand for individual rare earths)

# Major RE Source Minerals #1

Rare Earth Content of Major Source Minerals (% total REO)						
Rare Earth Oxide	<u>Bastnaesite</u>		<u>Xenotime</u>		<u>Ion adsorption clays</u>	
	Baiyun Obo, Mongolia, <u>China</u>	Mountain Pass, California <u>USA</u>	Lahat Perak, <u>Malaysia</u>	Guangdong, <u>China</u>	Xunwu, Jiangxi, <u>China</u>	Longnan, Jiangxi, <u>China</u>
La <sub>2</sub> O <sub>3</sub>	23.0	33.2	1.2	1.2	42.0	1.8
CeO <sub>2</sub>	50.0	49.1	3.1	3.0	2.3	0.4
Pr <sub>6</sub> O <sub>11</sub>	6.2	4.3	0.5	0.6	8.8	0.7
Nd <sub>2</sub> O <sub>3</sub>	18.5	12.0	1.6	3.5	30.8	3.0
Sm <sub>2</sub> O <sub>3</sub>	0.8	0.8	1.1	2.2	3.8	2.8
Eu <sub>2</sub> O <sub>3</sub>	0.2	0.1	trace	0.2	0.5	0.1
Gd <sub>2</sub> O <sub>3</sub>	0.7	0.2	3.5	5.0	2.9	6.9
Tb <sub>4</sub> O <sub>7</sub>	0.1	trace	0.9	1.2	trace	1.3
Dy <sub>2</sub> O <sub>3</sub>	0.1	trace	8.3	9.1	trace	6.7
Y <sub>2</sub> O <sub>3</sub>	trace	0.1	61.0	59.3	8.0	65.0
<b>Total</b>	<b>99.6</b>	<b>99.8</b>	<b>81.2</b>	<b>85.3</b>	<b>99.1</b>	<b>88.7</b>



# Major RE Source Minerals #2

Rare Earth Content of Major Source Minerals (% total REO)

Rare Earth Oxide	<u>Monazite</u>			<u>Loparite</u>
	<u>Mt Weld, Australia</u>	<u>India</u>	<u>Guandong, China</u>	<u>Lovozersky Russia</u>
La <sub>2</sub> O <sub>3</sub>	25.1	23.0	23.0	28.0
CeO <sub>2</sub>	48.5	46.0	42.7	57.5
Pr <sub>6</sub> O <sub>11</sub>	5.3	5.5	4.1	3.8
Nd <sub>2</sub> O <sub>3</sub>	16.7	20.0	17.0	8.8
Sm <sub>2</sub> O <sub>3</sub>	2.2	4.0	3.0	1.0
Eu <sub>2</sub> O <sub>3</sub>	0.6	-	0.1	0.1
Gd <sub>2</sub> O <sub>3</sub>	0.9	-	2.0	0.2
Tb <sub>4</sub> O <sub>7</sub>	0.1	-	0.7	0.1
Dy <sub>2</sub> O <sub>3</sub>	0.2	-	0.8	0.1
Y <sub>2</sub> O <sub>3</sub>	0.3	-	2.4	trace
<b>Total</b>	<b>99.9</b>	<b>98.5</b>	<b>95.8</b>	<b>99.6</b>

# New RE Source Minerals

Rare Earth Content of Potential Source Minerals (% total REO)					
Rare Earth Oxide	<u>Trachyte</u>	<u>Apatite</u>		<u>Steenstrapine</u>	Fergusonite
	<u>Dubbo, Australia</u>	<u>Nolans Australia</u>	<u>Hoidas Lake Canada</u>	<u>Kvanefjeld Greenland</u>	<u>Thor Lake Canada</u>
La <sub>2</sub> O <sub>3</sub>	19.5	18.5	19.8	27.4	8.1
CeO <sub>2</sub>	36.7	47.8	45.6	41.2	17.0
Pr <sub>6</sub> O <sub>11</sub>	4.0	6.1	5.8	4.2	3.4
Nd <sub>2</sub> O <sub>3</sub>	14.1	21.4	21.9	12.9	15.6
Sm <sub>2</sub> O <sub>3</sub>	2.5	2.4	2.9	1.6	21.7
Eu <sub>2</sub> O <sub>3</sub>	0.1	0.5	0.6	0.1	0.8
Gd <sub>2</sub> O <sub>3</sub>	2.1	1.2	1.3	1.1	7.1
Tb <sub>4</sub> O <sub>7</sub>	0.3	0.1	0.1	0.2	0.9
Dy <sub>2</sub> O <sub>3</sub>	2.0	0.3	0.4	1.1	5.0
Y <sub>2</sub> O <sub>3</sub>	15.8	1.5	1.3	7.7	14.7
Total	97.1	99.8	99.7	97.5	94.3

# New & Potential North American Suppliers

<u>Factor</u>	<u>Mountain Pass</u> (USA) RCF, Goldman Sachs & Traxys	<u>Hoidas Lake</u> (Canada) Great Western Minerals Group	<u>Thor Lake</u> (Canada) Avalon Ventures Ltd	<u>Bear Lake</u> (USA) Rare Element Resources Ltd
<b>Status</b>	Re-commissioned separation plant. Feasibility study of re-commencing mining and processing underway.	Advanced exploration. Some preliminary test work completed. Could be supplemented by RareCo Project in South Africa	Pre-feasibility study underway. Some preliminary test work completed.	Resource engineering study commenced.
<b>Resource</b>	50Mt @8-9% REO <b>4.3Mt REO contained (a proven reserve)</b>	1.4Mt @ 2.6% REO <b>0.04Mt REO (indicated)</b>	86Mt @1.6%REO <b>1.3Mt REO (inferred)</b>	Not available
<b>Potential Production</b>	Potential 4-12,000t REO pa in 2012.; actual output not disclosed.	3-5,000 tpa REO Start-up post 2012	3-5,000 tpa REO Start-up post 2012	Unknown
<b>Critical Issues</b>	<ul style="list-style-type: none"> <li>■ New owners</li> <li>■ Complete DFS</li> <li>■ Re starting an 'old' plant.</li> </ul>	<ul style="list-style-type: none"> <li>■ Define ore reserve</li> <li>■ Develop process</li> <li>■ Complete DFS</li> <li>■ Approvals</li> <li>■ Customer support</li> </ul>	<ul style="list-style-type: none"> <li>■ Define ore reserve</li> <li>■ Develop process</li> <li>■ Complete DFS</li> <li>■ Approvals</li> <li>■ Customer support</li> </ul>	<ul style="list-style-type: none"> <li>■ Prove ore reserve</li> <li>■ Develop process</li> <li>■ Complete DFS</li> <li>■ Approvals</li> <li>■ Customer support</li> </ul>

# Other New & Potential Suppliers

<u>Factor</u>	<u>Mt Weld</u> (Australia/Malaysia) Lynas Corporation Ltd	<u>Dubbo Zirconia</u> (Australia) Alkane Resources Ltd	<u>Nolans</u> (Australia) Arafura Resources Ltd	<u>Kvanefjeld</u> (Greenland) Greenland Minerals & Energy Ltd
<b>Status</b>	Start-up in late 2009. Project approvals in place. Construction well advanced.	3 <sup>rd</sup> generation pilot plant in 'production' for customer samples. Approvals process well advanced	Pre-feasibility study complete. Pilot plant work started. Approvals process started.	Advanced exploration. Some preliminary test work.
<b>Resource</b>	7.7Mt @ 12.0% REO <b>0.92Mt REO contained (a proven reserve)</b>	73.2Mt @ 0.9% REO <b>0.65Mt REO contained (a proven reserve)</b>	30.3Mt @ 2.8% REO <b>0.85Mt REO contained</b>	334Mt @ 1.2% REO <b>2.6Mt REO contained</b>
<b>Potential Production</b>	10,500t REO pa in 2010/11. Several sales contracts in place. Increase to 21,000t REO in later in next decade.	1,200-1,400tpa REO in 2012/13. REOs (rich in Y) will be by-products to zircon chemical and niobium production.	Target 10,000 tpa REO in 2011. Increase to 20,000tpa REO. Phosphate, calcium chloride & uranium co-products.	TBA. Potential for rare earths carbonate output to exceed 20,000 tpa REO as a co-product to uranium in 2013/14
<b>Critical Issues</b>	<ul style="list-style-type: none"> <li>• Project suspended pending resolution of funding issues</li> <li>• Separation of mining and processing</li> </ul>	<ul style="list-style-type: none"> <li>• Complete DFS</li> <li>• Approvals (started)</li> <li>• Customer support</li> </ul>	<ul style="list-style-type: none"> <li>• Define ore reserve</li> <li>• Confirm process</li> <li>• Complete DFS</li> <li>• Approvals (started)</li> <li>• Customer support</li> </ul>	<ul style="list-style-type: none"> <li>• Define ore reserve</li> <li>• Develop process</li> <li>• Complete DFS</li> <li>• Approvals</li> <li>• Customer support.</li> </ul>

# The Outlook for 2014

- ❑ 'Balance' will still be an issue
- ❑ Supply will be tight, so prices for Tb, Dy and Y should remain strong
- ❑ China will not 'starve' the Rest of the World of rare earths
- ❑ First of new and potential projects should be on-stream
- ❑ Demand of 170-190,000tpa REO – **will be met**

**PDAC 2009**

**“THE RARE EARTHS MARKET:  
CAN SUPPLY MEET DEMAND IN 2014?”**

**YES!**

### Sources of Reference

- Data from Roskill’s 13<sup>th</sup> Edition “The Economics of Rare Earths”  
(published in November 2007)
- China Rare Earths Information Centre
- Company web sites
- Private conversations with producers , explorers and consumers

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