

*“Rare Earths: Facing New Challenges  
in the New Decade”*

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# Summary of Presentation

- Introduction
- Demand today
- China
- Forecast future demand
- 10 steps to commercial production
- Potential future new suppliers

# Rare Earths: Type & Symbols

Element	Type	Symbol	Atomic Weight
Lanthanum	'Light' or 'Ceric'	La	138.92
Cerium		Ce	140.13
Praseodymium		Pr	140.92
Neodymium		Nd	144.27
Samarium	'Medium'	Sm	150.43
Europium		Eu	152.00
Gadolinium		Gd	156.90
Terbium	'Heavy' or 'Yttric'	Tb	159.20
Dysprosium		Dy	162.46
Holmium		Ho	163.50
Erbium		Er	167.20
Thulium		Tm	169.40
Ytterbium		Yb	173.04
Lutetium		Lu	174.99
Yttrium	Y	88.92	

# The Last 18-24 Months

- Global financial crisis
- China declares 'heavy' rare earths resources are finite (approx. 15 years)
- Chinese export quotas reduced
- Chinese export taxes maintained
- Stockpiles of REs established in China
- Consolidation of rare earths industry started in Southern China (ionic clays)
- Lynas & Molycorp announce they will move their projects to 20,000tpa REO quickly

# Rare Earths – Commercial Concepts

- Rare earths are not commodities – customer specific
- Western rare earths enterprises are single project companies (debt has to be non-recourse project funded)
- Capital intensive (>US\$40/kg annual capacity)
- Long start-up; limited expertise outside China
- Supply and demand for individual REOs is not in balance
- Used in small quantities:
  - REO price has negligible impact on final product price
  - Limited recycling

# Rare Earths – Technical Concepts

- Rare earths have unique chemical, magnetic and luminescent properties
- Each orebody is different; so the process route is project specific
- Pilot plant studies are an essential element of a Bankable Feasibility Study
- Rare earths are chemically similar so they are difficult to separate

# The Rare Earths Market Today

- Estimated demand in 2008: 124,000t REO
- Estimated demand in 2009: 80-85,000t REO
- 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



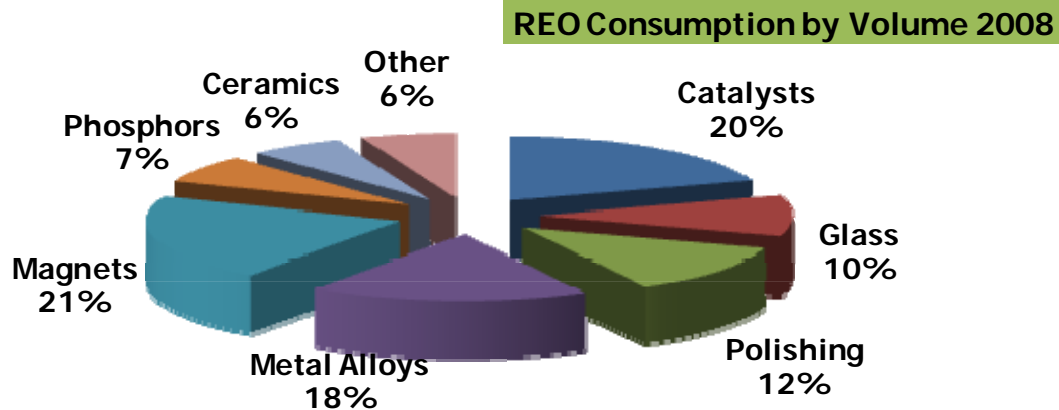
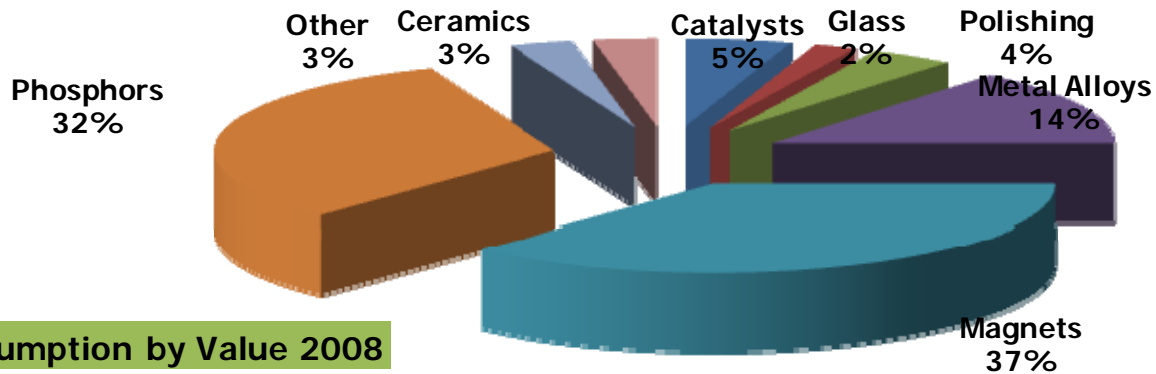
# Global RE Consumption 2008

Estimated Global Rare Earths Demand in 2008 (t REO ±10%)

(Source: Roskill, IMCOA)

Application	China	Japan & NE Asia	USA	Others	Total
Catalysts	9,000	3,000	9,500	3,500	25,000
Glass	7,500	2,000	1,000	1,500	12,000
Polishing	8,000	4,500	1,000	1,500	15,000
Metal Alloys	15,500	4,500	1,250	1,000	22,250
Magnets	21,000	3,500	750	1,000	26,250
Phosphors	5,500	2,500	500	500	9,000
Ceramics	2,500	2,500	1,250	750	7,000
Other	5,000	2,000	250	250	7,500
<b>Total</b>	<b>74,000</b>	<b>24,500</b>	<b>15,500</b>	<b>10,000</b>	<b>124,000</b>

# 2008 REO Consumption



# China: Industry Constraints

- Production quotas – reserves limited
- Export quotas – falling annually
- Export taxes: 15-25%
- VAT rebate on exports withdrawn
- No new rare earth mining licences
- Environmental legislation enforced
- Potential shortage of Tb, Dy and Y

# China: Export Quota History

## Chinese Export Quota History 2004-2010 (Tonnes REO)

<u>Year</u>	<u>Rare Earth Quotas</u>				<u>ROW</u>
	<u>Domestic Companies</u>	<u>Foreign Companies</u>	<u>Total</u>	<u>Change</u>	<u>Demand</u>
2005	48,040t	17,659t	65,609t	0%	46,000t
2006	45,752t	16,069t	61,821t	-6%	50,000t
2007	43,574t	16,069t	59,643t	-4%	50,000t
2008	Actual: 34,156t Adjusted: 40,987t*	Actual: 13,293t Adjusted: 15,834t*	Actual: 47,449t Adjusted: 56,939t*	-5½%*	50,000t
2009	33,300t	16,845t	50,145t	-12%	25,000t
2010	Quota for 1H2010 is 16,304t compared with 15,043t for 1H2009	Quota for 1H2010 is 5,978t compared with 6,685t for 1H2009	n/a	n/a	48,000t

Note: \* Quotas adjusted to an equivalent 12 month quota as there was a change in the dates for which they were issued; so that now they are for a calendar year

# Chinese Rare Earths Production

## Chinese Production of Rare Earth Chemical Concentrates 2004-14 (tpa REO $\pm 10\%$ )

<u>Year</u>	<u>Bayan Obo Bastnasite</u>	<u>Sichuan Bastnasite</u>	<u>Ion Adsorption Clays</u>	<u>Monazite</u>	<u>Total</u>	<u>NDRC Quotas</u>
2004	42-48,000	20-24,000	28-32,000	-	90-100,000	n/a
2006	45-55,000	22-26,000	40-50,000	8-12,000	125-140,000	n/a
2008	60-70,000	10-15,000	45-55,000	8-12,000	125-140,000	127,280
2010	55-65,000	10-15,000	35-45,000	4-8,000	110-130,000	122,000
2014	80-100,000	20-40,000	40-50,000	8-12,000	160-170,000	140-160,000

Note: Illegal or uncontrolled mining and processing is not included. It has amounted to 10-20,000t pa REO over the last 3-5 years

Source: IMCOA, CREIC, Baogang Rare Earth Hi-Tech, Sichuan REAssociation, GRIREM.

# Forecast Demand in 2014

## Global Rare Earths Demand in 2008 & 2014 (tpa REO) ± 15%

(Source: IMCOA, Roskill, Private Discussions with Industry Stakeholders)

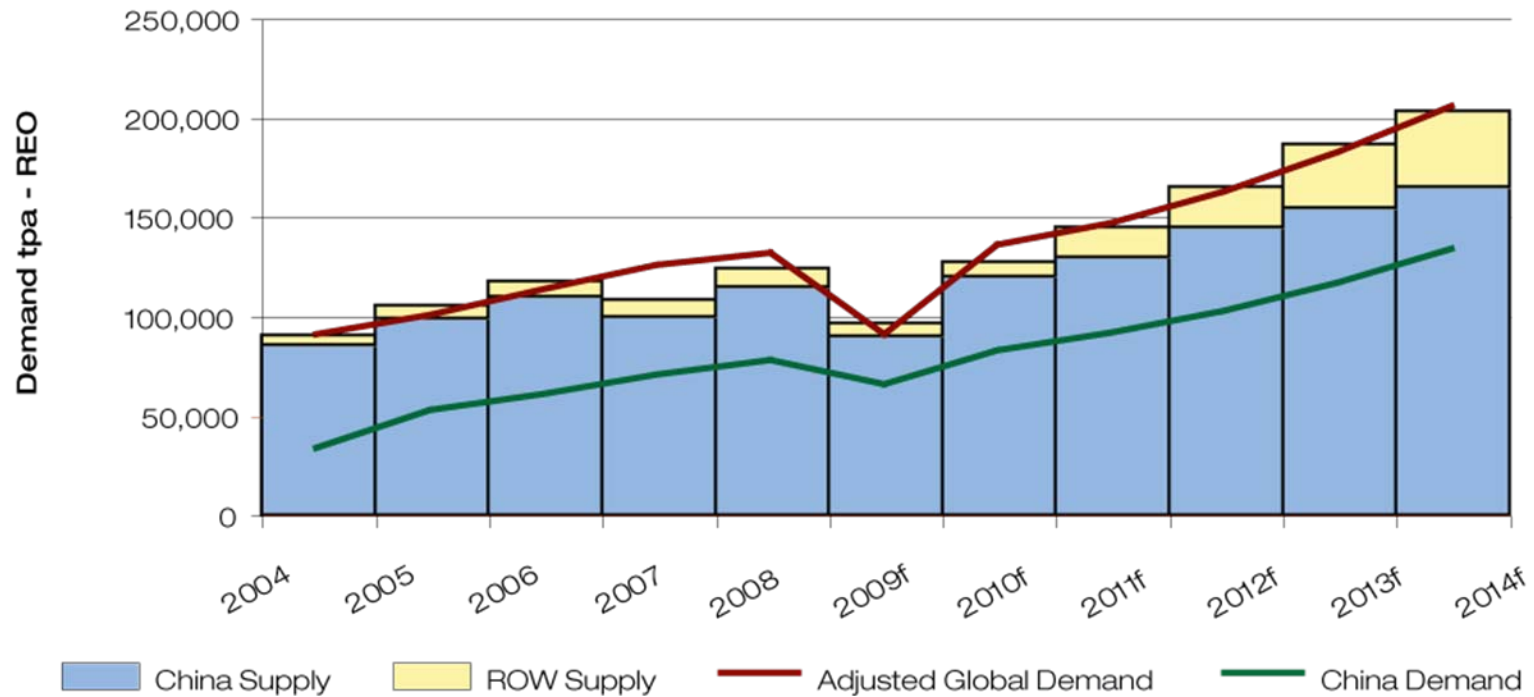
<u>Application</u>	<u>Consumption tpa REO</u>		<u>Market Share</u>
	<u>2008</u>	<u>2014f</u>	<u>2014</u>
Catalysts	25,000	30-33,000	17%
Glass	12,000	12-13,000	7%
Polishing	15,000	19-21,000	11%
Metal Alloys	22,250	42-48,000	25%
Magnets	26,250	38-42,000	22%
Phosphors & Pigments	9,000	11-13,000	7%
Ceramics	7,000	8-10,000	5%
Other	7,500	9-12,000	6%
<b>Totals</b>	<b>124,000</b>	<b>170-190,000</b>	<b>100%</b>

# The Issue of 'Balance' in 2014

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

<u>Rare Earth Oxide</u>	<u>Demand @ 170-190,000tpa REO</u>	<u>Supply @ 190-210,000tpa REO</u>
Lanthanum	50-55,000t REO	52-57,000t REO
Cerium	60-65,000t REO	80-85,000t REO
Terbium	400-500t REO	400-500t REO
Dysprosium	1,900-2,300t REO	1,800-2,000t REO
Yttrium	10-14,000t REO	9-13,000t 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 through extra supply. Source: IMCOA, Roskill, CREIC and Rare Earths Industry Stakeholders. )



# The Road to Commercial Rare Earths Production: Steps 1 to 3

1. Prove Resource/Reserve:
2. Define Process – Bench Scale (each orebody is unique)
  - Beneficiation (increase rare earths mineral concentration; goal is a minimum of 25% REO)
  - Extraction (concentration of rare earths into a pure solution)
  - Separation of individual rare earths
3. Pre-Feasibility Study (including raising funds for pilot plant and bankable feasibility study)

# The Road to Commercial Rare Earths Production: Steps 4 to 6

The Demonstrate Plant is often the most important step to commercialisation – **not to be underestimated**

Demonstrate that the chosen processes are technically and commercially viable through continuously operated pilot plant(s) to produce samples to customer (future) specification(s); to collect data for the Bankable Feasibility Study (BFS) and for the Environmental Impact Assessment :

4. Beneficiation
5. Extraction of rare earths
6. Separation of individual rare earths

# The Road to Commercial Rare Earths Production: Steps 7 to 10

7. Obtain Project Environmental Approval(s)
8. Negotiate Sales Contracts
9. Complete Bankable Feasibility Study
10. Construction and Start-up

# 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>Nechalacho</u> (Canada) Avalon Ventures Ltd	<u>Bear Lodge</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 underway. Process development commenced
<b>Resource</b>	20Mt @9.2% REO 1.8Mt REO contained (a proven reserve)	2½Mt @ 2.4% REO 0.06Mt REO (inferred)	69Mt @2.0%REO 1.3Mt REO (inferred)	9 Mt @ 4.1% REO 0.4 Mt REO (inferred)
<b>Potential Production</b>	Target: 18,000t pa REO; start-up in 2012	3-5,000 tpa REO Start-up post 2014	3-5,000 tpa REO Start-up post 2014	Unknown
<b>Critical Issues</b>	<ul style="list-style-type: none"> <li>■ New owners</li> <li>■ Completing 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>■ Define ore reserve</li> <li>■ Develop process</li> <li>■ Complete DFS</li> <li>■ Approvals</li> <li>■ Customer support</li> </ul>

# Other 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>Kvanefield</u> (Greenland) Greenland Minerals & Energy Ltd
<b>Status</b>	Start-up in late 2010. Project approvals in place. Construction well advanced but suspended	3 <sup>rd</sup> generation pilot plant in 'production' for customer samples. Approvals process well advanced	Pre-feasibility study complete. Pilot plant well advanced. Approvals process started.	Advanced exploration. Some preliminary test work.
<b>Resource</b>	12Mt @ 9.7% REO 1.2Mt REO contained (a proven reserve)	73Mt @ 0.9% REO 0.65Mt REO contained (a proven reserve)	30Mt @ 2.8% REO 0.85Mt REO contained	215Mt @ 1.0% REO 2.6Mt REO contained
<b>Potential Production</b>	10,500t REO pa in 2011. Several sales contracts in place. Increase to 21,000t REO in 2012/13	2,500tpa REO in 2013/14. REOs (20% M&HREEs) will be by-products to zirconium chemical and niobium production.	20,000 tpa REO in 2013/14. 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 post 2014
<b>Critical Issues</b>	<ul style="list-style-type: none"> <li>■ Funding issues now resolved - no debt.</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 Ten Steps to Rare Earths Commercial Production

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7	STEP 8	STEP 9	STEP 10
Prove Resource	Process Defined	Pre-Feasibility Study	PILOT PLANT(S)			EIS Approval	Letters of Intent (LOI)	BFS & Funding	Construction & Start-up
			Beneficiation	Extraction	Separation				
<b>Mt Weld</b> (Lynas)									
<b>Mountain Pass</b> (Molycorp Expansion)									
<b>Nolans</b> (Arafura)									
<b>Dubbo</b> (Alkane)									
<b>Nechalacho</b> (Avalon)									
<b>Hoidas Lake</b> (GWMG)									
<b>Bear Lodge</b> (Rare Element Resources)									
<b>Kvanefjeld</b> (Greenlands Minerals & Energy)									

# The Challenges for 2014

- Supply will be tight.
- 'Balance' will still be an issue; so prices for Tb, Dy and Y will remain strong.
- China: Can the rare earths industry be successfully controlled?
- Will the first of the new non-Chinese projects have been successfully built and commissioned?.

# *“Rare Earths: Facing New Challenges in the New Decade”*

## Sources of Reference

- Data from Roskill's 13<sup>th</sup> Edition “The Economics of Rare Earths & Yttrium” (November 2007).
  - China Rare Earths Information Centre
    - Prices from *metal pages*©
    - Company web sites
- Private discussions with producers and consumers