Rare earths - an evaluation of current and future supply

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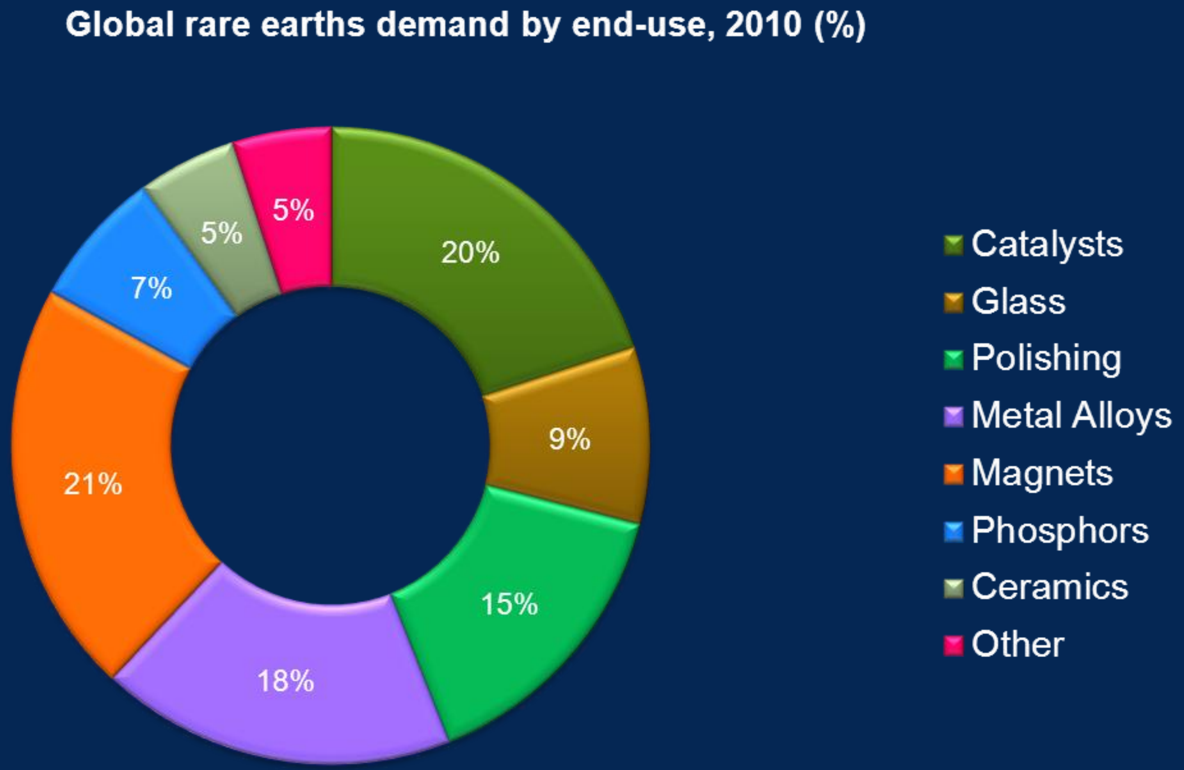
Outline

- Overview of demand
  - Outlook to 2015
- Overview of supply
  - Facets of Chinese supply, including impact of export quotas on shipments to the rest of the world
  - Existing and potential supply from the rest of the world
- Summary
  - Key factors affecting supply
  - China
  - Evolution of supply demand balance

Overview of demand

Estimated demand for rare earths in 2010 by application (in terms of volume)



Source: IMCOA, Roskill

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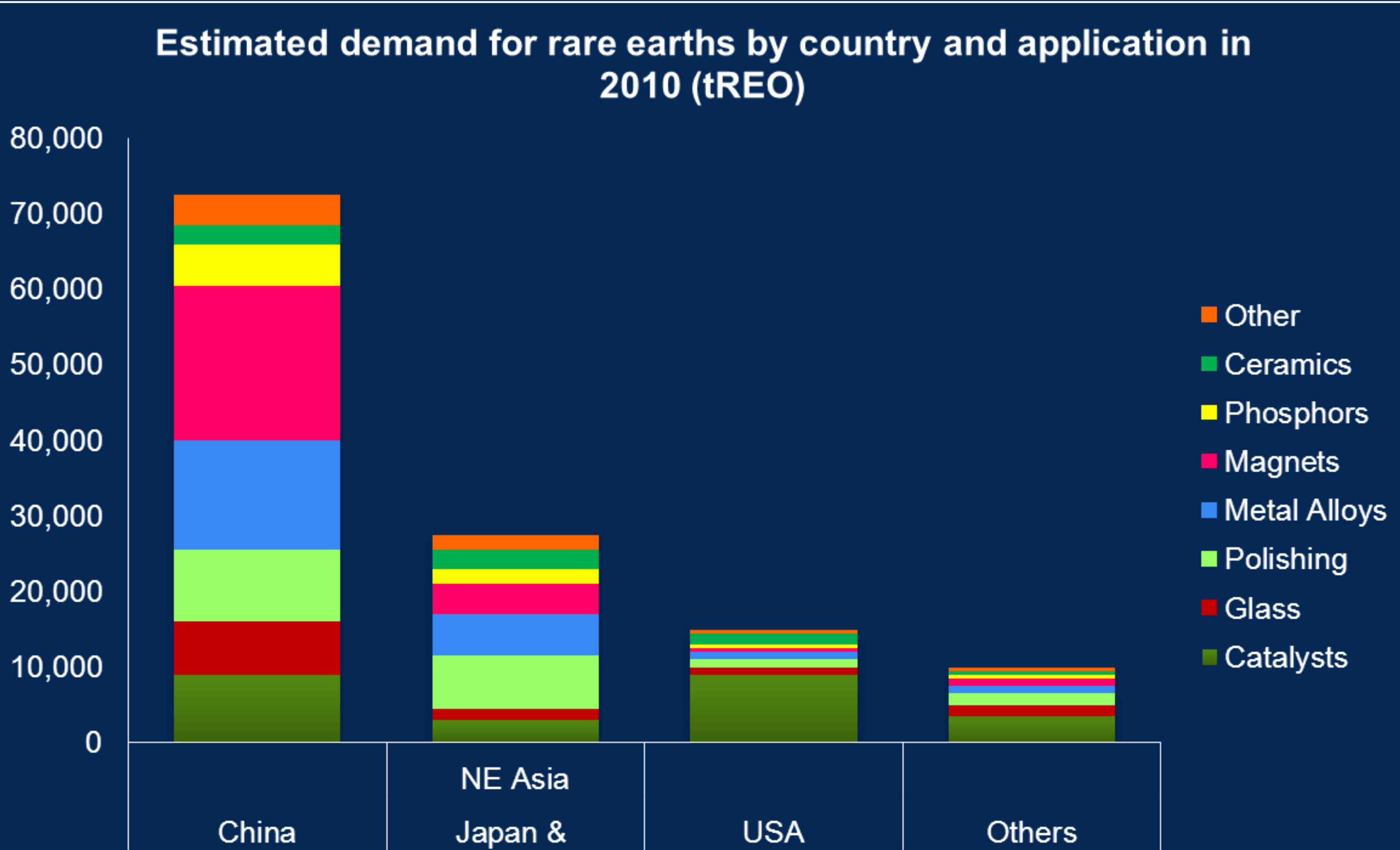
Pattern of demand varies significantly between China (predominance of magnets and battery alloys) and the USA (predominance of catalysts)



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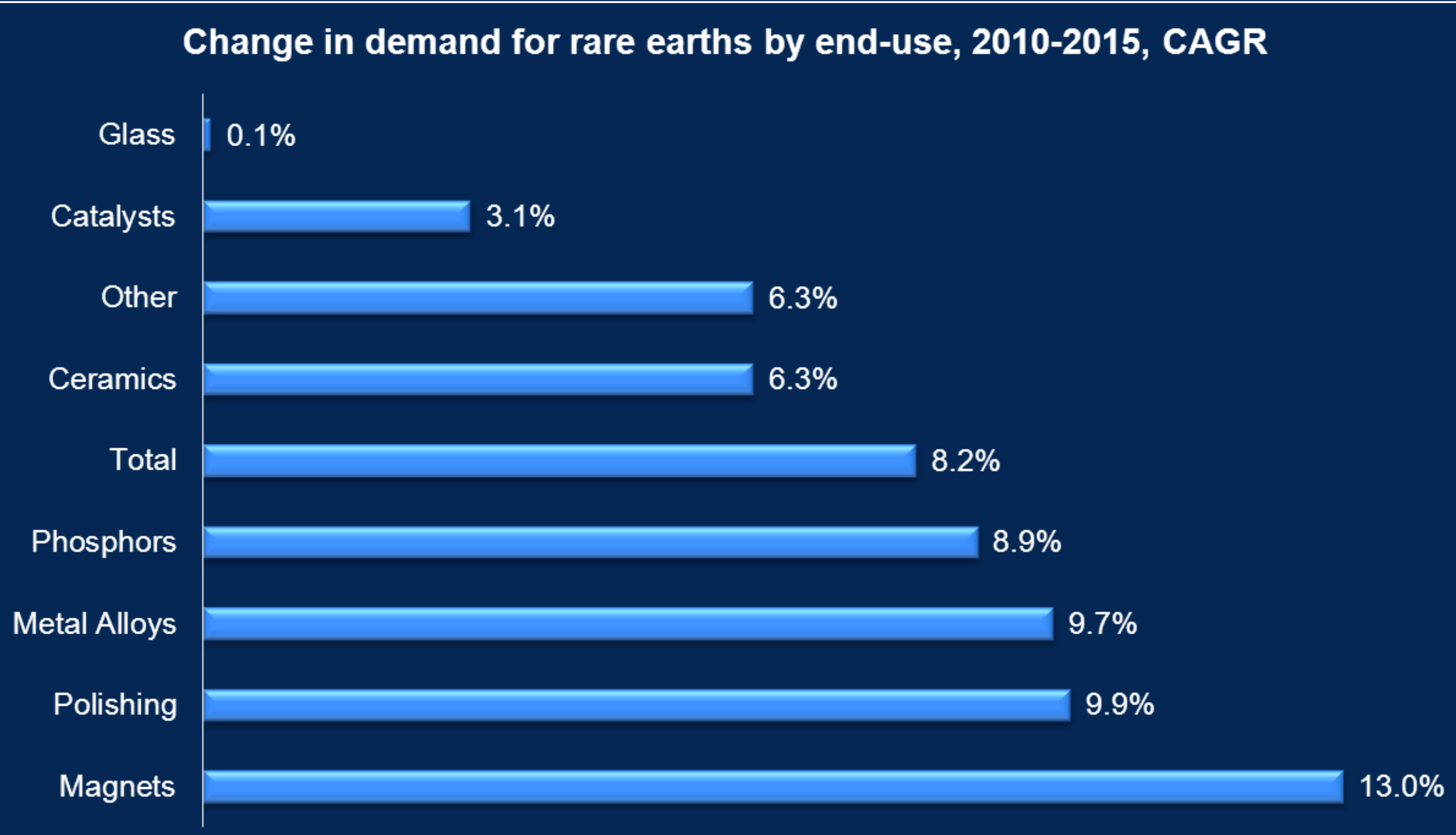
Magnets will continue to show the highest rates of growth in demand in the years to 2015



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Overview of supply

Components of global supply in 2009/10

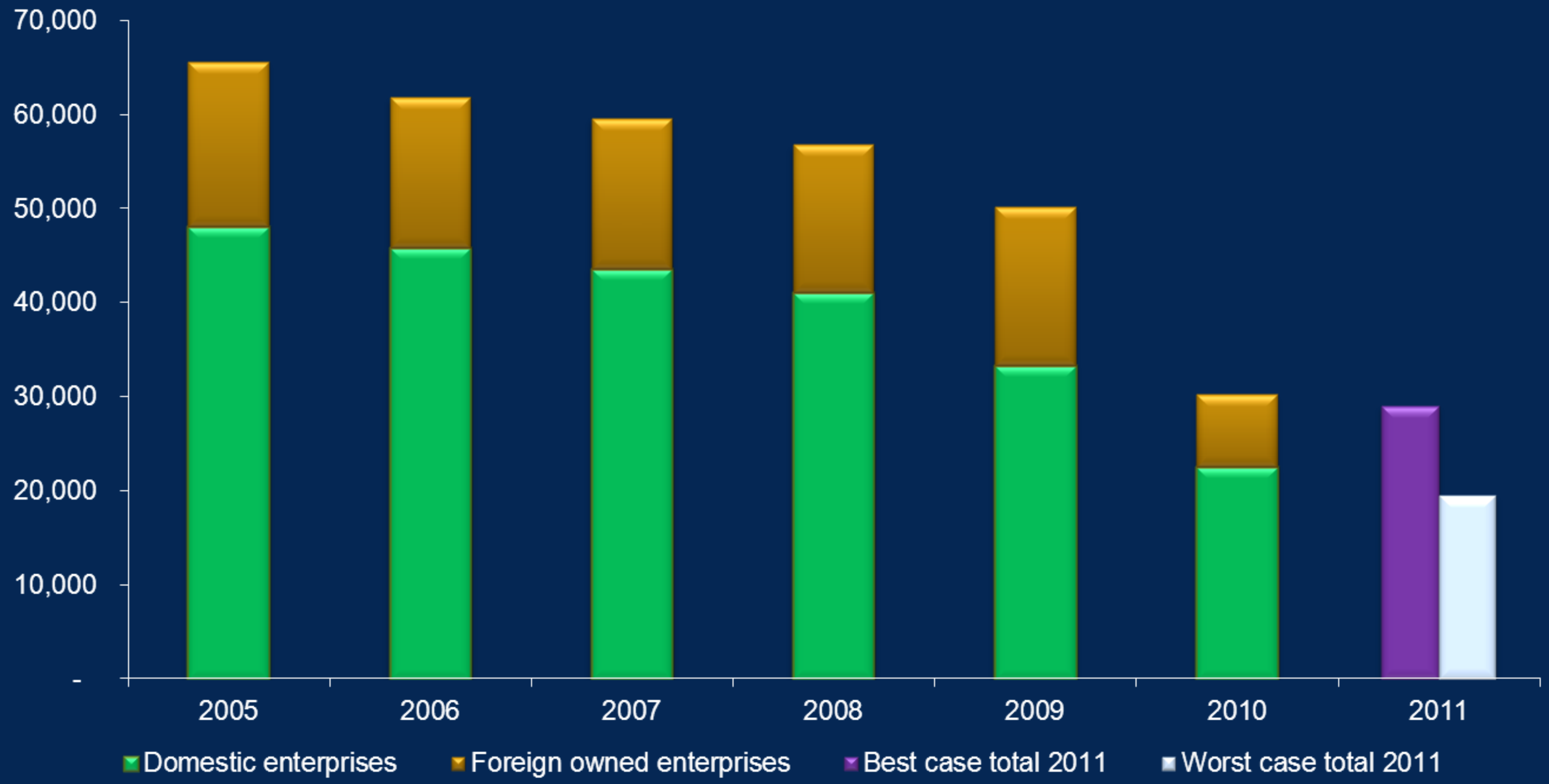
- **China**
  - 129,400t REO in chemical concentrates falling to 120,000t REO in 2010
  - Mainly from bastnaesite from Baotou and ion adsorption clay from southern provinces
  - Around 10,000t REO from stockpiled ore in Sichuan
  - Circa 15,000t REO from “unofficial” sources
- **Russia**
  - 1,898t REO in chemical concentrates from mine output in 2009
- **India**
  - 25- 50t REO in chemical concentrates from tailings
- **USA**
  - Sales of 1,883t REO in 2010 – of which nearly a third was sold in the final quarter
- **Others**
  - Small amounts of monazite and xenotime from south east Asia

Facets of Chinese supply - including the impact of export quotas on shipments to the R-O-W

Facets of Chinese supply

- **Positive impact on supply:**
  - Reserves >55Mt REO
  - Excess secondary processing capacity – but 50% closed
  - Access to relatively low cost processing chemicals
  - Large investment in research and technology
  - Investment in sources of heavy REOs in Fujian province
  - Increasing concentration of organisations controlling supply (could also be negative?)
- **Negative impact on supply of REO and RE metals to R-O-W**
  - Finite heavy rare earth resources (15-20 year mine life)
  - Increasingly rigorous environment legislation
  - Much tighter control of illegal exports
  - Building a stockpile in Baotou
  - No new exploration (exploitation) and mining licences until 2011 (at the earliest)
  - Tighter mining and export quotas and more commodities covered by quotas
  - Export taxes

Evolution of Chinese export quotas from 2005 to 2011 (Note: tonnes of product – not REO)



Source: Chinese Ministry of Commerce

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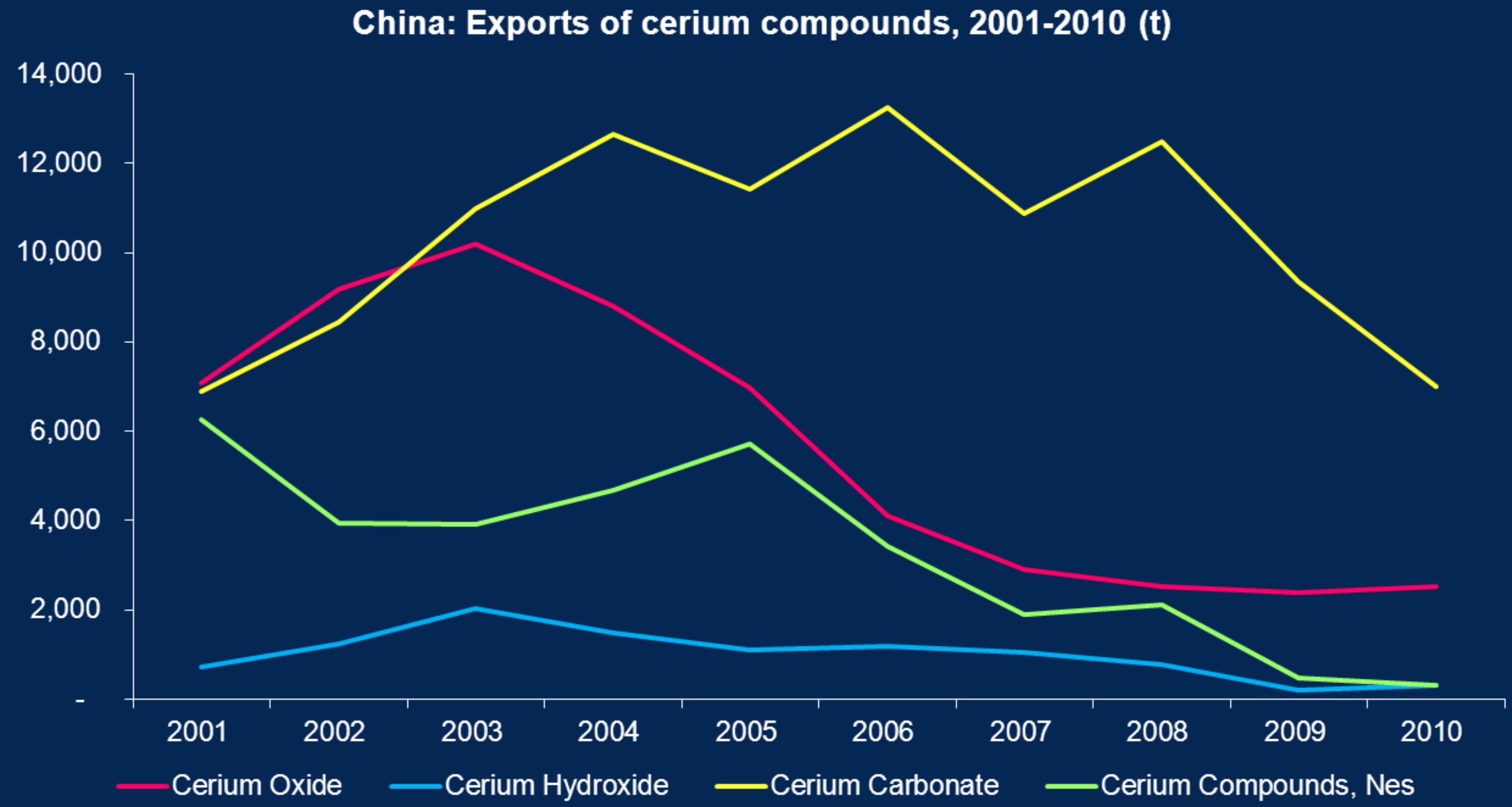
Impact of quotas and other measures on Chinese exports of cerium compounds



Source: Global Trade Atlas

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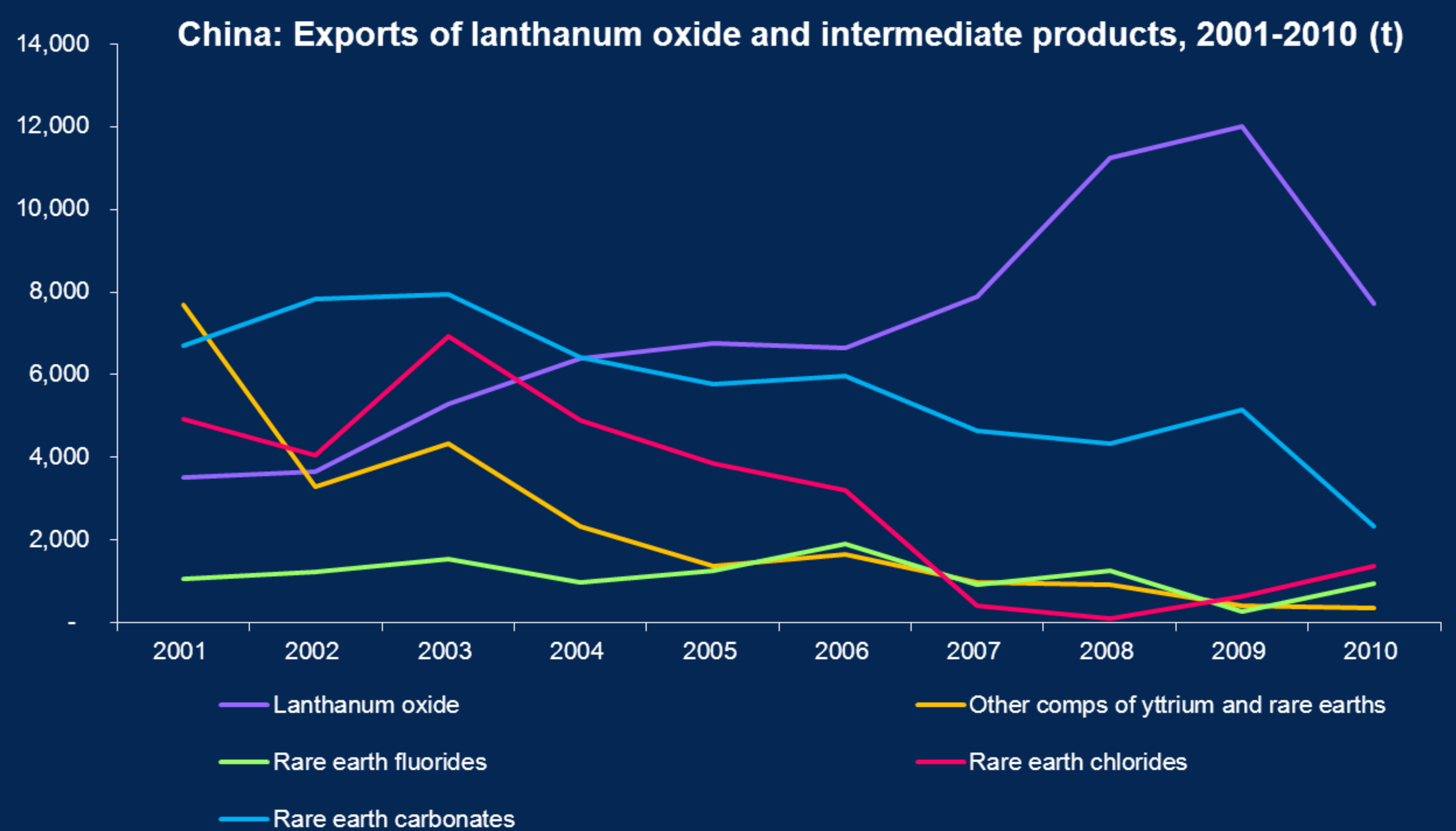
Impact of quotas and other measures on Chinese exports of other (low value) rare earth compounds



Source: Global Trade Atlas

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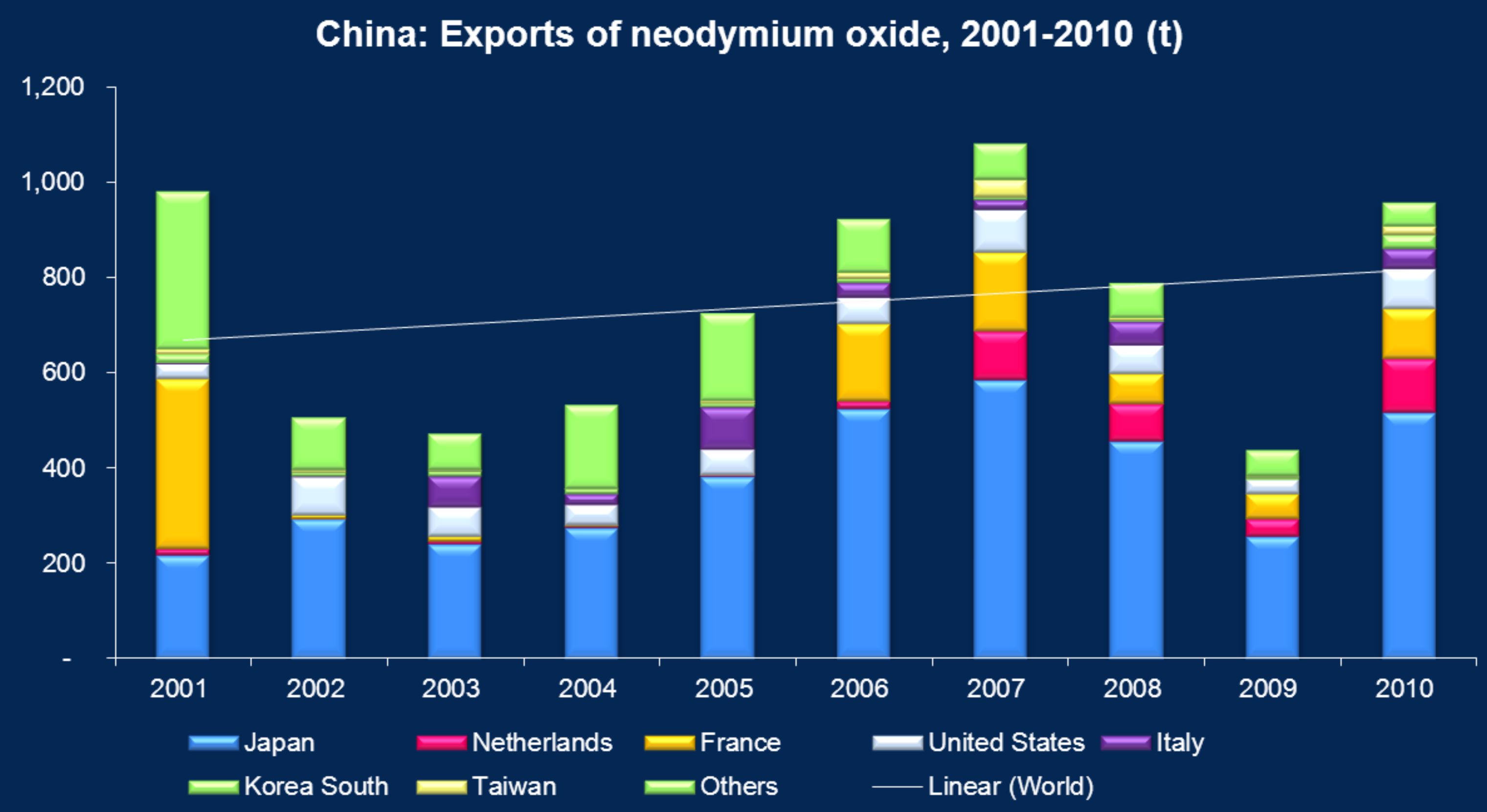
Impact of quotas and other measures on Chinese exports of neodymium oxide – not such a tight supply in 2010 as reports suggested?



Source: Global Trade Atlas

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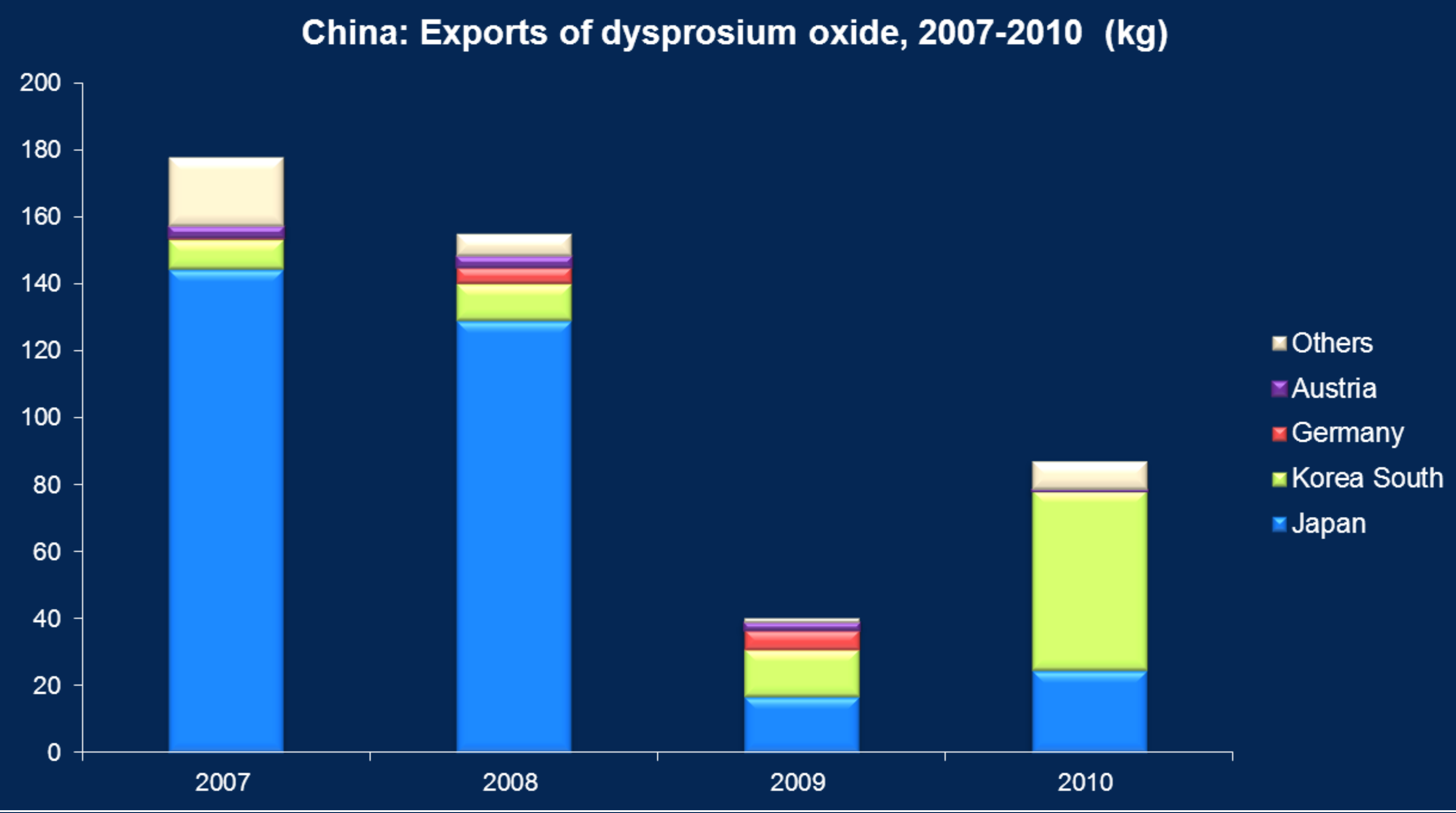
Impact of quotas and other measures on Chinese exports of dysprosium oxide – demand for dysprosium is strong in China so exports are still limited – note increasing exports to South Korea



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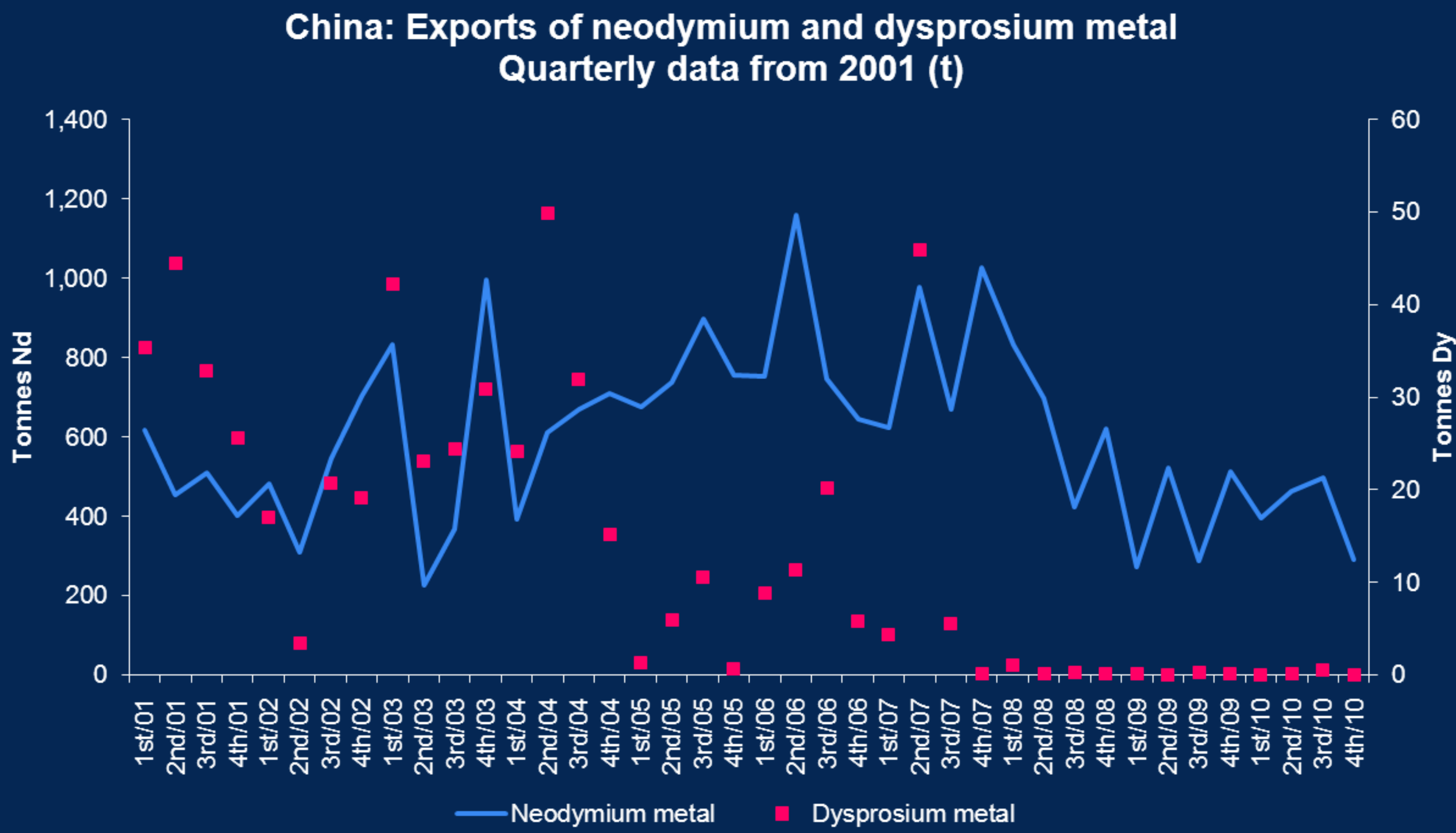
Strong domestic demand and tighter quotas have had a marked impact on Chinese exports of magnetic materials (Nd and Dy metal)



Source: Global Trade Atlas

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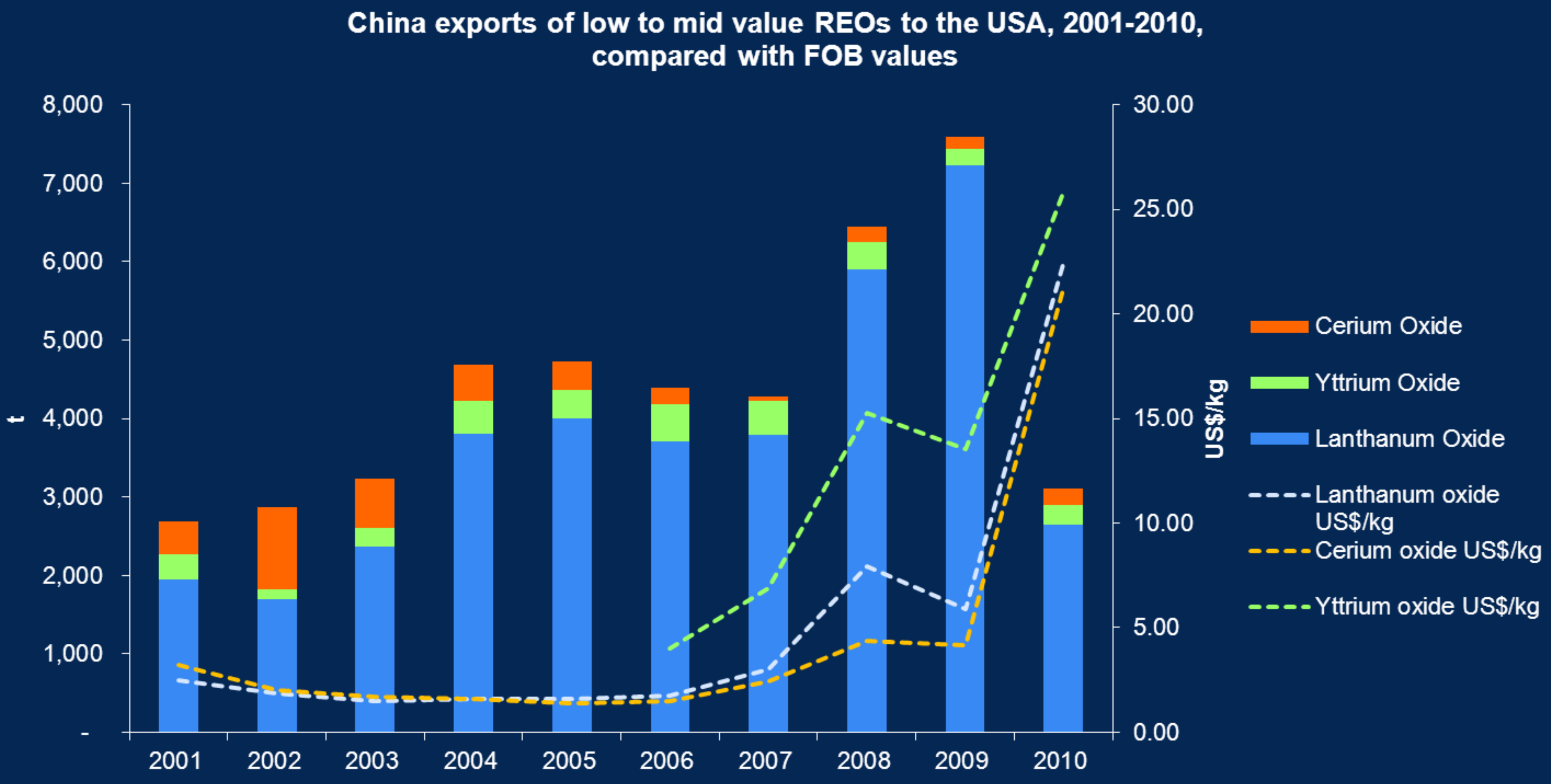
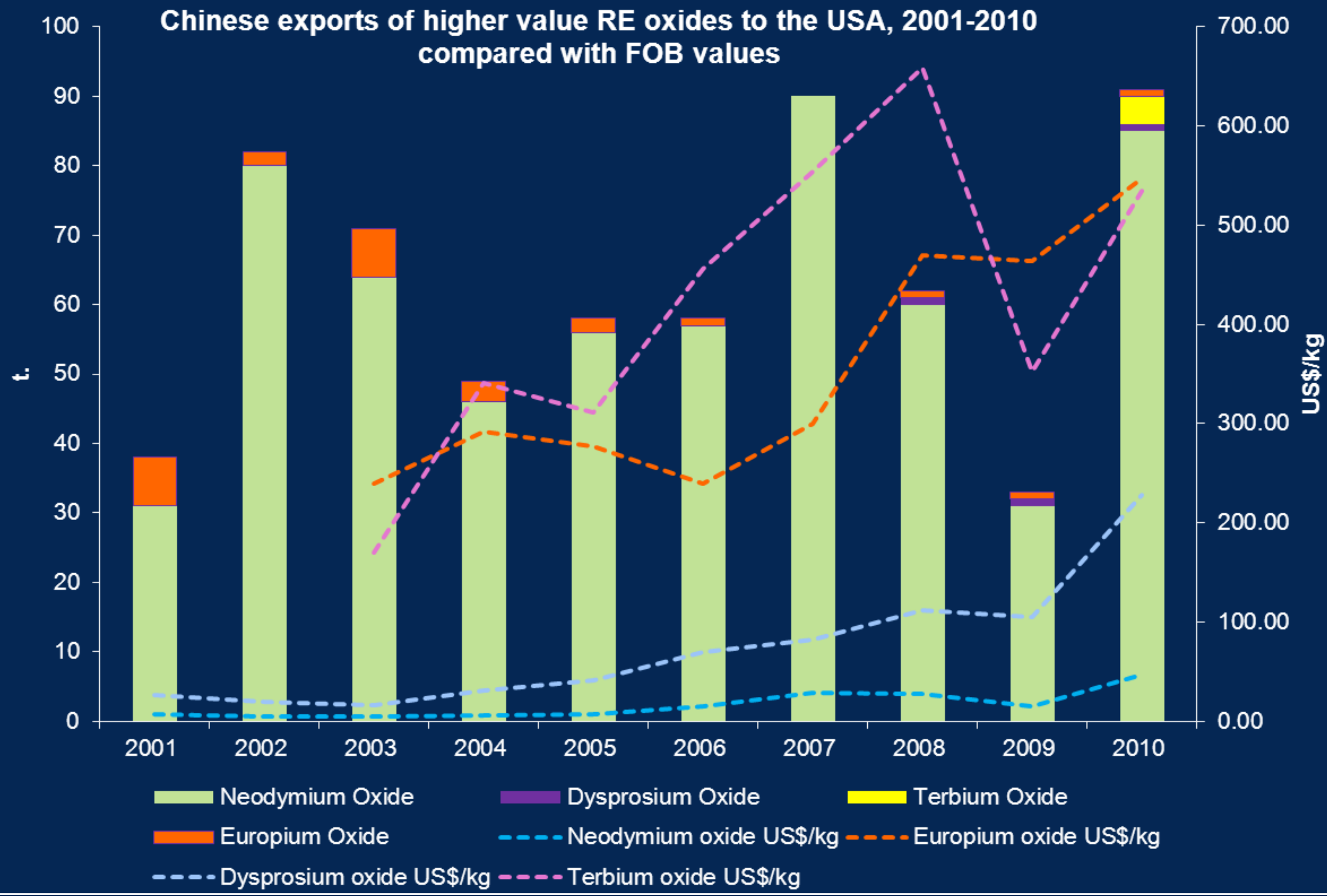
How has this impacted on US supply?

Rising prices and tightening export quotas have had an impact on medium to low value products – for example rare earth compounds used in catalyst manufacture



Source: Global Trade Atlas, Metal Pages, Roskill

But the impact of quotas and rising prices has been much less for the higher value rare earth oxides (discounting the impact of the recession in 2008/9)



Source: Metal Pages, Global Trade Atlas, Roskill

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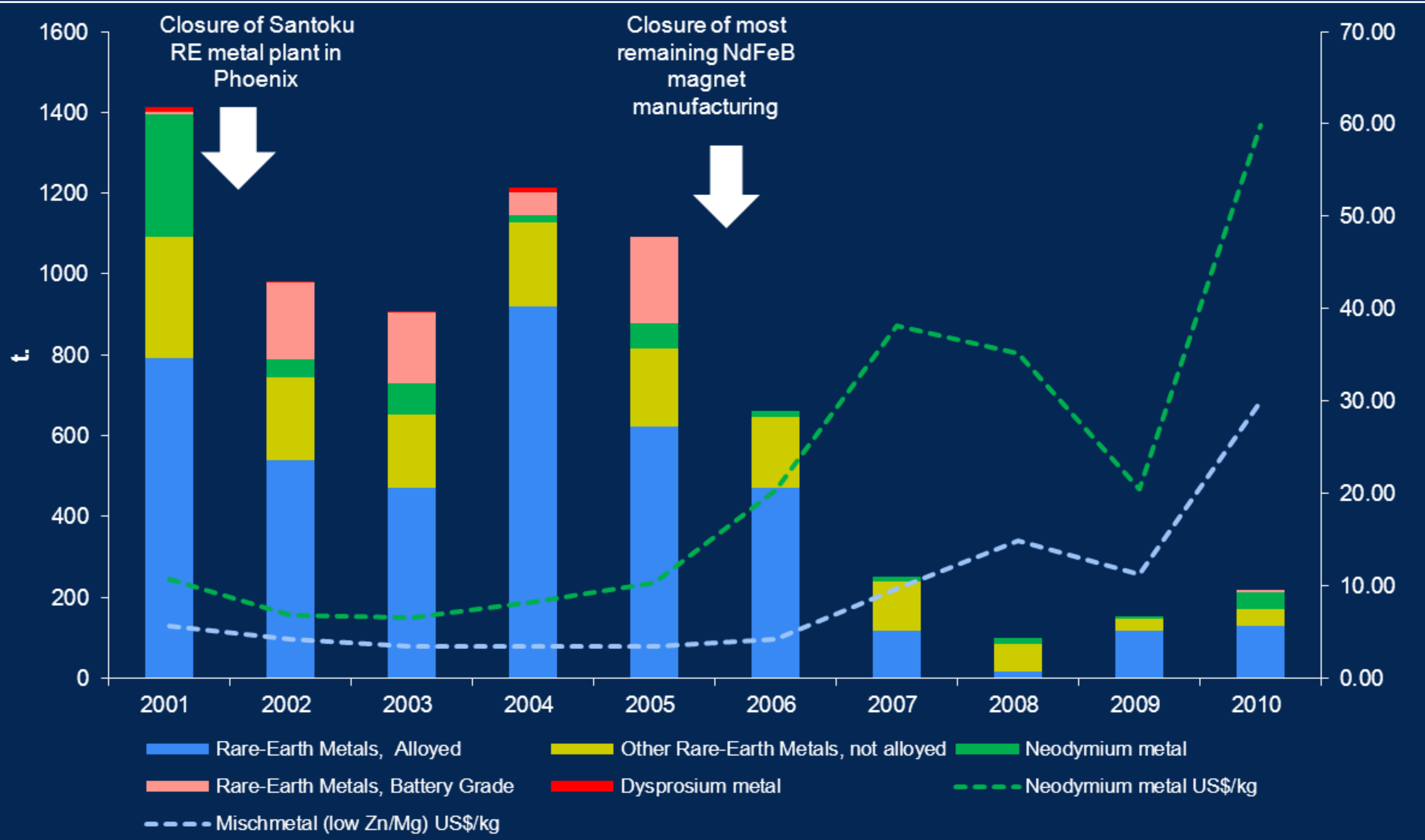
As far as rare earth metals are concerned the changing nature of the rare earth industry in the USA has had more impact than quotas



Source: Metal Pages, Global Trade Atlas, Roskill

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Existing and potential supply from the Rest of the World

Existing R-O-W producers accounted for less than 5% of supply in 2010

Company	Location	Ore type	Capacity (tpy REO)	Notes
Molycorp Minerals	Mountain Pass, CA	Bastnaesite	Current 2,000-3000	Currently processing ore from stockpile, main products are mixed rare earth oxides for FCC catalyst and didymium oxide, lanthanum compounds and SEG concentrate
Lovozersky Mining Company/Solikamsk Magnesium Works	Kamasurt Mine , Kola Peninsula, Russia Solikamsk processing plant, Urals, Russia	Loparite, processed to yield rare earth carbonate, which is shipped to Estonia, Kazakhstan, Austria and China for further processing	Up to 4,400	High level of radioactivity in some zones of the mine
Indian Rare Earths	Mineral sands from Orissa, Tamil Nadu and Kerala have in the past been processed at Udyogamandal, Kerala. Current output from stockpiles of Th rich residues	Monazite from extensive deposits of mineral sands	25-100	Plans for a new monazite processing plant but start-up has been delayed IRE is under the control of the Department of Atomic Energy
Other	Vietnam, Thailand, Malaysia	Monazite	1,800-2,000	Monazite

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Composition of new deposits also vary – which will meet the requirements of the market going forward?

Rare earth content of ore at projects under development (% total REO)							
	Trachyte	**Apatite**	**Alanite and apatite**	**Fergusonite[1]**	**Weathered monazite**	**Monazite**	**Bastnaesite layer**
	Dubbo, Australia	Nolans Australia	Hoidas Lake, Canada	Nechalacho, Canada	Mount Weld	Steenkrams-kraal	Bear Lodge
La_2O_3	19.5	20.0	19.8	16.3	25.1	21.7	29.3
CeO_2	36.7	48.2	45.6	41.4	48.5	46.7	45.0
Pr_6O_{11}	4.0	5.9	5.8	4.8	5.3	5.0	4.8
Nd_2O_3	14.1	**21.5**	**21.9**	**18.7**	**16.7**	**16.7**	**16.8**
Eu_2O_3	0.1	0.4	0.6	0.4	0.6	0.1	0.4
Tb_4O_7	0.3	0.1	0.1	**1.8**	0.1	0.1	0.1
Dy_2O_3	**2.0**	0.3	0.4	**0.7**	0.2	0.6	0.2
Y_2O_3	**15.8**	…	1.3	**7.4**	0.3	5.0	…

Source: Company data
1: Ore, rather than the normally quoted mineral

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Rare earth operations under development – Lynas Corp

- Mount Weld deposit, W. Australia, and a processing plant in Gebeng, Malaysia
- Resource of 17.49Mt at 8.1% REO (equivalent to 1.42Mt REO)
- Capital raising resulted in A$450M which is being used to finance Phase 1 development, completing construction at Mount Weld and Gebeng
- Concentrator will produce 35ktpy of concentrate grading 40% REO – the first feed for the concentrator planed for first week in April
- Phase 1 plant at Gebeng has the capacity to produce 10,500tpy REO
- Possible expansion to 21,000tpy REO (fund raising underway) – decision expected in April 2011
- Start up of Phase 1 planned for Q3 2011, full production by 2012
- Four sales contracts in place – including with Rhodia (now extended to 10 years), plus further letters of intent

Rare earth operations under development – Molycorp Minerals LLC

- Over 50 years of production history at Mountain Pass, California, USA
- Proven reserves 40,000t of REO contained in 0.48Mt ore at average grade of 9.38%
- Probable reserves of 960,000t of REO in 13.8Mt ore at average grade of 8.2%
- Projected mine life of 30 years
- Mining restarted in December 2010
- Production of REOs at the rate of 19,090tpy by 2012/2013
- Possible expansion to circa 40,000t REO
- Plans for conversion of REOs to metal and alloys and then magnet manufacture
- Raised US$394M in August 2010 from IPO and a further US$180M in February 2011 – plan to spend US$511M on modernisation and expansion of mine and processing facilities

Rare earth operations under development – Japanese investments in potential producers of REEs

- **Sumitomo/Kazatomprom**
  - SARECO JV plans to build refinery to treat Y-rich uranium ore tailings, uranium ores and rare earth concentrates to produce REOs and RE metals
  - Output could be 3,000tpy REO by 2011 rising to a possible 5,000tpy REO by 2015
  - However – still the subject of a feasibility study
- **Toyota/Sojitz/Govt. of Vietnam**
  - Dong Pao consists of number of ore bodies with a total reserve of ~9.7Mt REO. The most prospective deposit contains 0.65Mt REO
  - Scheduled to produce 2-3,00tpy REO by 2013, rising to 5,000tpy
  - Mine life of around 20 years
- **Toyota/Indian Rare Earths jv**
  - New monazite processing plant in Orissa with a capacity of 10,000tpy concentrate
  - Previously subject to local opposition
- **Mitsubishi/Neo Material Technologies**
  - Undertaking research to extract HREEs from tailings at Mineracao Taboca's Sn, Ta and Nb mine at Pitinga, Brazil
  - Tailings reported to contain 8.5% REO – with a high grade of Dy

The search for heavy rare earths – but at what cost?

- **Avalon Rare Metals Inc**
  - Nechalacho deposit rich in HREEs in NWT, Canada, low ore grade overall (176Mt at 1.43% REO) but high ratio of heavies
  - BFS could be completed by 2012, construction could start in 2013 resulting in production of 5,000tpy REO by 2015, rising to 10,000tpy REO.
  - Capital costs could be up to US$900M for mine, mill and metallurgical plant
  - Scoping study for separation plant in southern Ontario completed (estimated costUS$346M)
- **Alkane Resources**
  - Proposed production of HREEs as by-product of zirconium production at Dubbo, NSW, Australia
  - Base case of 2,000tpy LREO and 600tpy HREO could be in production by 2013/4 with potential to expand to 6,000tpy.
  - Undertaking definitive feasibility study by early 2011
- **Quest Rare Metals**
  - Strange Lake and others in Quebec/Labrador, Canada. High proportion of HREEs in Strange Lake deposit
- **Ucore**
  - Bokan-Dotson Ridge project, Alaska. Comprehensive suite of HREEs
- **Matamec**
  - Kipawa deposit in Quebec, Canada contains 3 major types of REE mineralisation (eudialyte, yittrio-titanite, and britholite), including LREEs, HREEs and Y

The majority of deposits are rich in LREEs - projects where feasibility studies are underway include:

- **Rareco**, Steenkramskaal, South Africa - reopening and reequipping underground mine, undertaking pre-feasibility study, mining permits received
- **Arafura**, Nolan's project, Australia. Bankable feasibility study underway. Construction could begin in 2012. Traget production of 10,000toy REO by 2013 with possible expansion to 20,000tpy. Processing complex to be built at Whyalla
- **Great Western Minerals Group**, Hoidas Lake, Canada – prefeasibility underway, could produce 3-5,000tpy by 2014. Relatively small resource
- **Rare Element Resources, Bear Lodge, Wyoming, USA** – inferred resource of 17.5Mt at 3.46% REO. Scoping study completed, pre-feasibility and pilot palnt for 2011, possible production from 2015
- **Stans Energy Corp**, studying feasibility of reopening Kutessay II Mine , Kyrgyz Republic, and utilising processing plant at Orlovka (50:50 LREEs and HREEs)

The search continues!

Over 300 rare earth projects identified by mid 2010

But commercial considerations are key:

- Rare earths are not commodities – in many cases they are customer specific
- Most of the rare earth projects that have emerged in the west are single project companies (debt has to be non-recourse project funded)
- Developing a rare earth mine and processing plant is capital intensive (>US$40,000/t capacity, probably more for HREE mine)
- History shows that the development time can be very long (10-15 years)
- Limited technical expertise on mining, cracking and separating outside China
- Percentage REO content is only half the story – REO distribution and amenable mineralogy are important
- Most deposits contain radioactive material that has to be contained and stored
- Projects that rely on shipping low grade concentrate over 100s of km are going to be costly

In summary

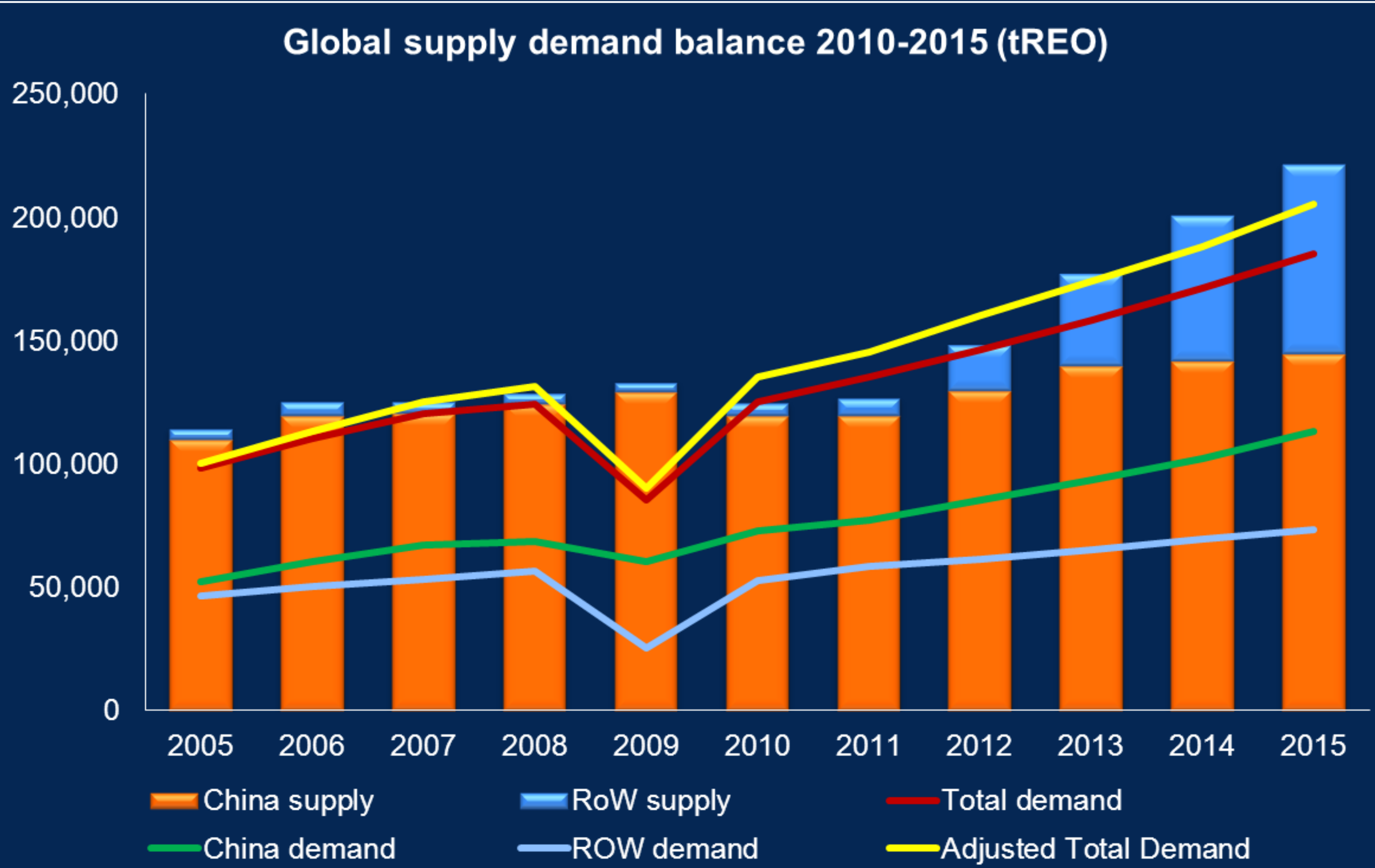
Key factors going forward - supply:

- Over the next four years to 2014 production of rare earths in the rest of the world is scheduled to increase by a factor of 8 or more
- By 2015 ROW production could account for nearly 35 % of world supply
- Forecast demand in 2020 is likely to be 220,000 to 300,000 tREO – this means that ROW supply will need to reach 120,000 to 240,000t – this providing opportunities for more projects to come on stream
- BUT remember that Molycorp and Lynas have first mover advantage and there are still plenty of barriers to entry before junior explorers can become producers

Key factors going forward - China:

- China has at least 30Mt and probably 50Mt of reserves of REO
- It has 200-250,000tpy of processing capacity (some mothballed|)
- The companies associated with consolidating the industry have announced multi-million dollar expansion projects – Fujian Province has announced a US$905M project based on its heavy rare earths reserves
- Recent speeches by Chinese speakers in the west have suggested a maximum production of 100,000tpy in order to conserve reserves – but other sources inside China are predicting production of at least 120,000tpy – remember mine production is not always equivalent to supply, over the last 4 years, we estimate that at least 50,000t of REO in concentrate has been sourced from stockpiled ore in Sichuan
- Mining has now restarted in Sichuan – at the rate of at least 10,000tpy
- Roskill and IMCOA are very wary of the statements that China will not be able to meet its own rare earth needs in the near future

How do we see the supply demand balance evolving over the next four years?



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