Introduction - John Ormerod

- BSc, MSC and PhD in Metallurgy from the University of Manchester (1972 – 1978).
- Magnetics career began for Philips (UK and Holland) – 1979 – 1990.
- Developed and commercialized SmCo5, 2:17 and NdFeB magnets.
- Joined Arnold Magnetic Technologies (US) responsible for soft and hard magnetic materials development and GM for permanent magnets (1990 – 2002).
- 2002 - 2014 President of Res Manufacturing in Milwaukee.
- Co-editor of recently published The Global PM Industry Report and Modern Permanent Magnets
- Principal of JOC LLC a business and technology consultancy for magnetics and metals related industries (www.jocllc.com).

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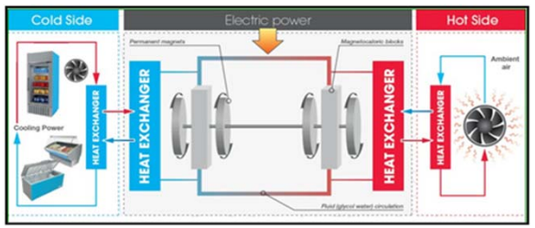
Introduction To Permanent Magnets – Hidden But Essential!

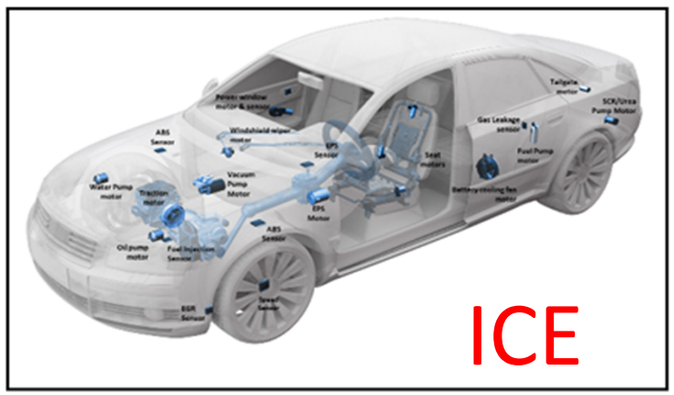
AI

Tiny

HEV

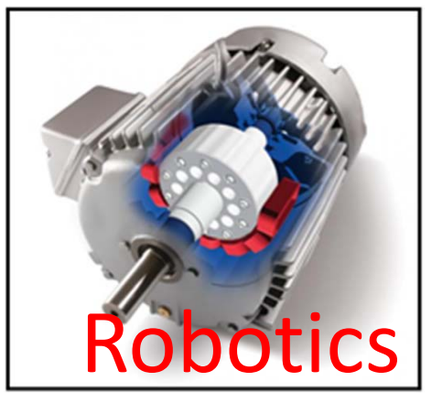


DD



ICE

Robotics



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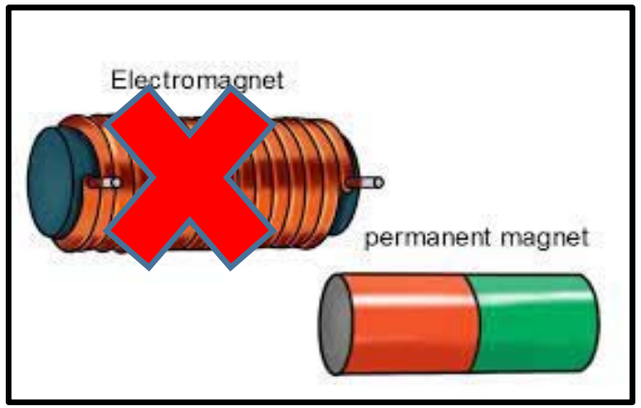
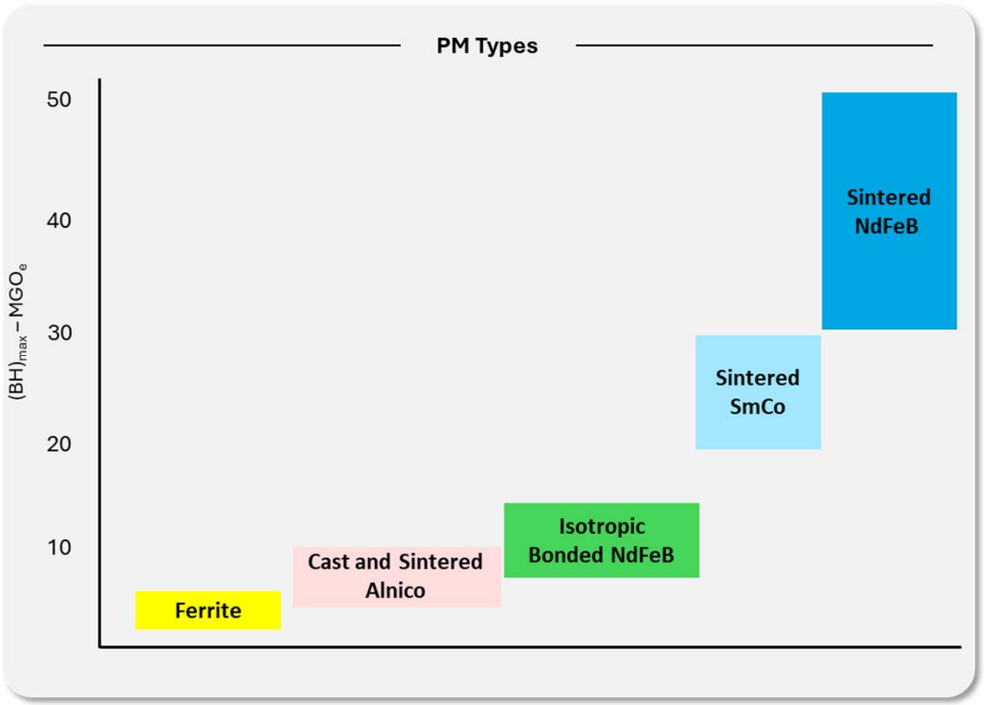
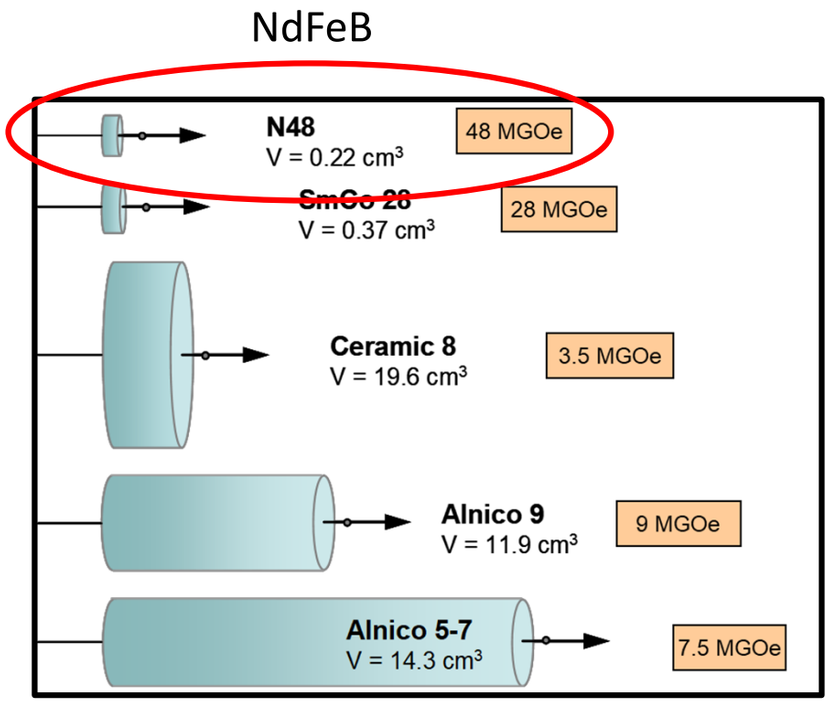
What Is A Rare Earth (NdFeB) Magnet?

Permanent magnets are used in a device for only one reason, and that is to provide a magnetic field with no energy input.







NdFeB magnets are used where weight or space is a constraint and magnetic field levels cannot be achieved by other material options.

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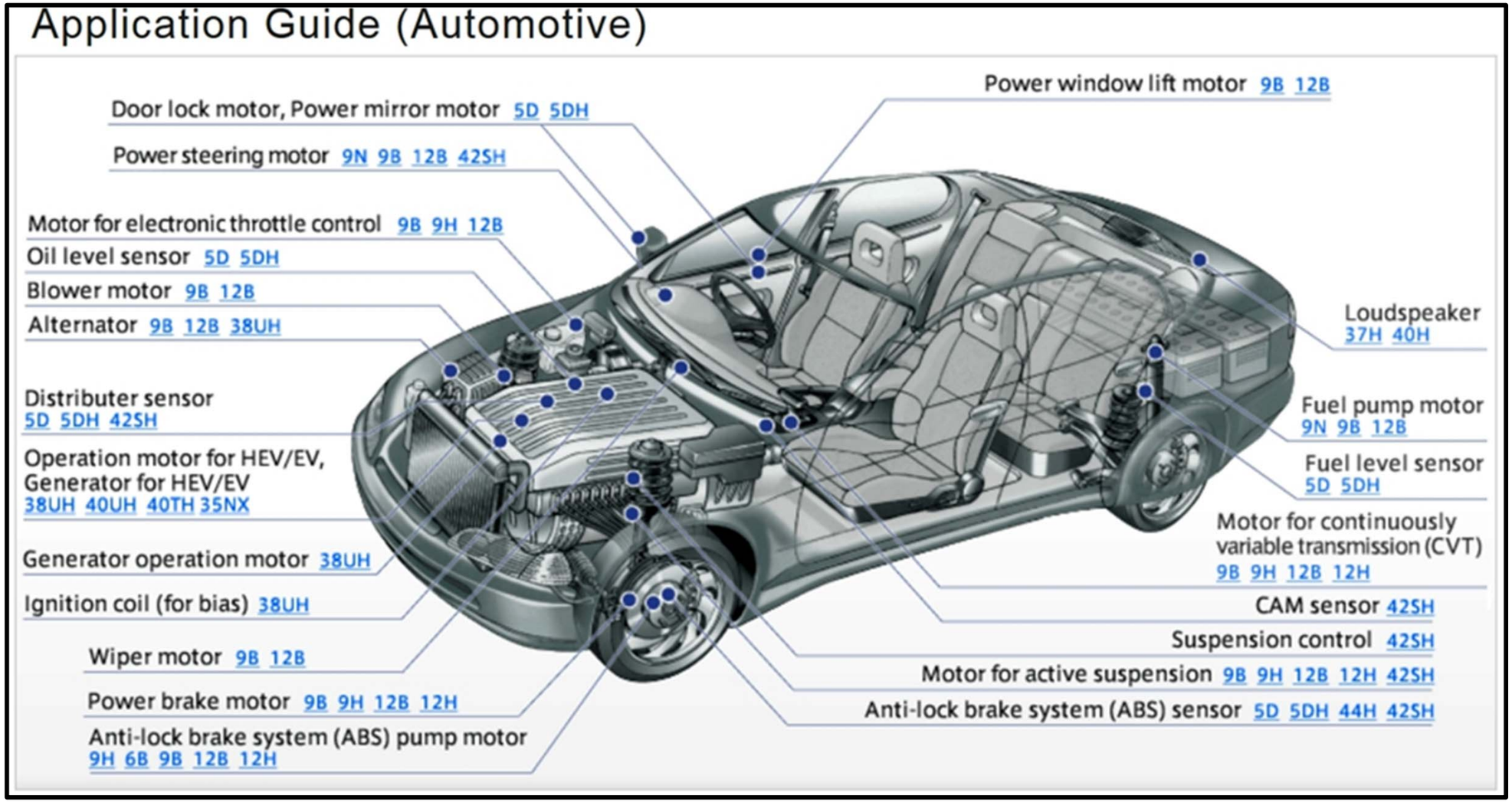
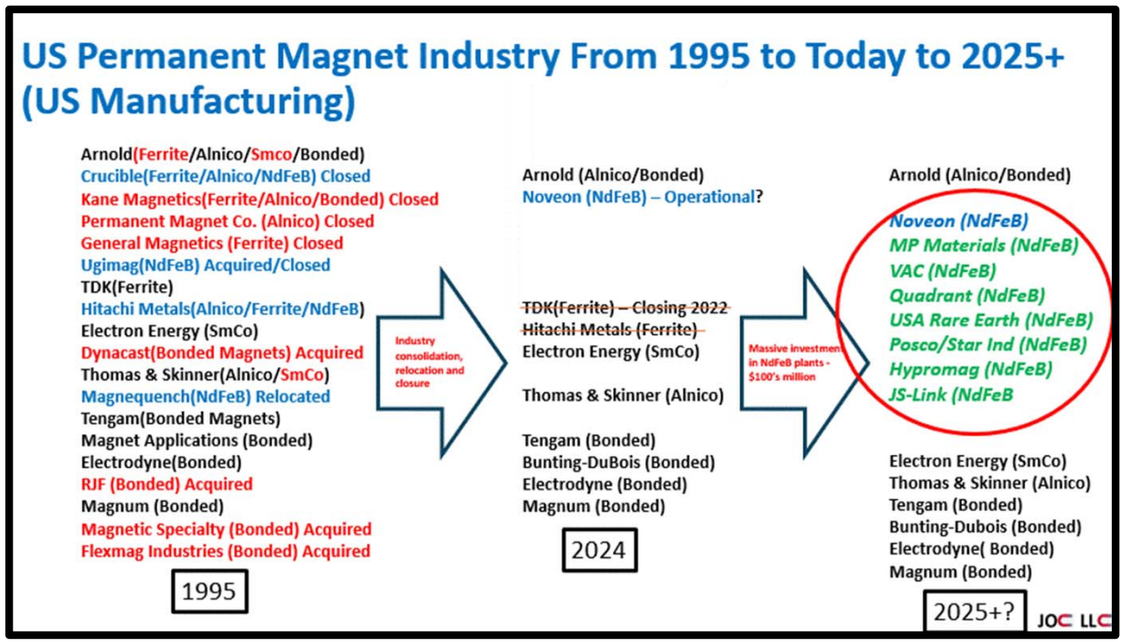
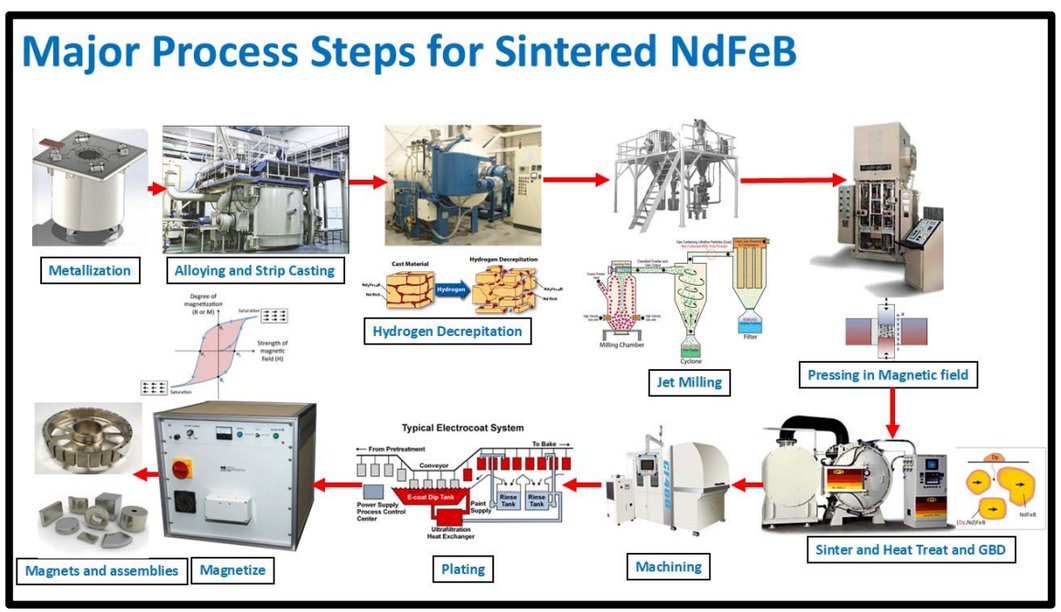
Automotive (ICE and EV) Is The Largest Market For Permanent Magnets



Who Makes Permanent Magnets?





Country or Region	2005	2010	2015	2020	2025	2030
China	36.1	48.8	51.4	57.0	62.7	66.1
Japan	29.7	23.4	20.3	16.4	13.3	10.1
USA	4.3	2.8	2.5	2.3	1.8	1.7
Europe	6.4	4.6	4.1	3.5	2.9	2.2
India	5.4	4.9	5.6	5.1	5.2	5.3
SE Asia	6.5	5.9	6.5	7.2	6.6	6.5
South America	4.4	3.6	3.5	3.1	2.7	2.4
All Others	7.2	6.0	6.1	5.5	4.7	5.6
Totals	100.0	100.0	100.0	100.0	100.0	100.0

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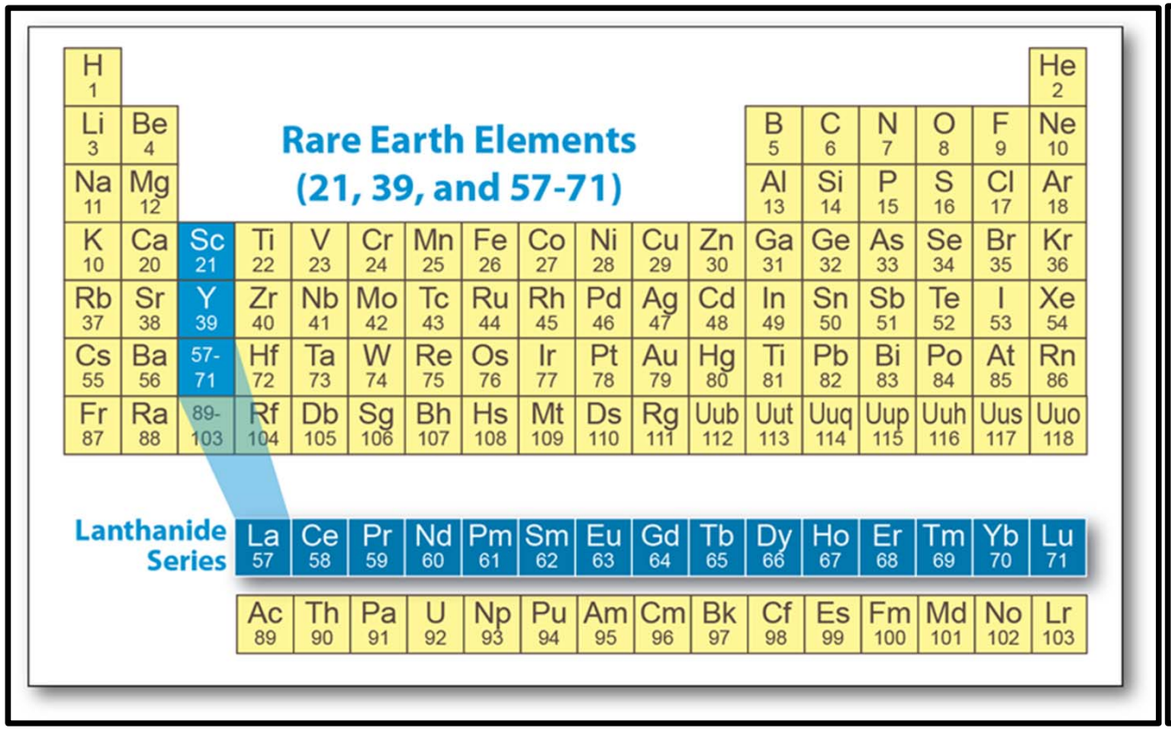
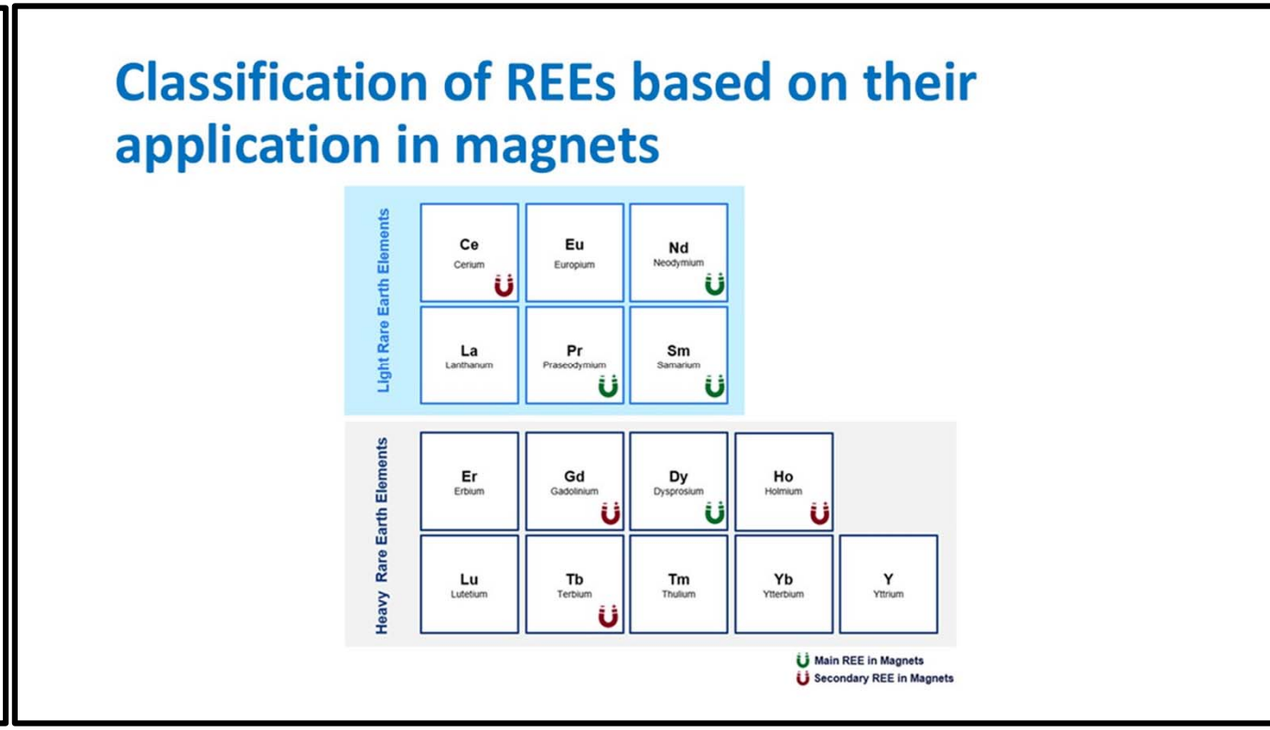
What Are The Rare Earth Elements?





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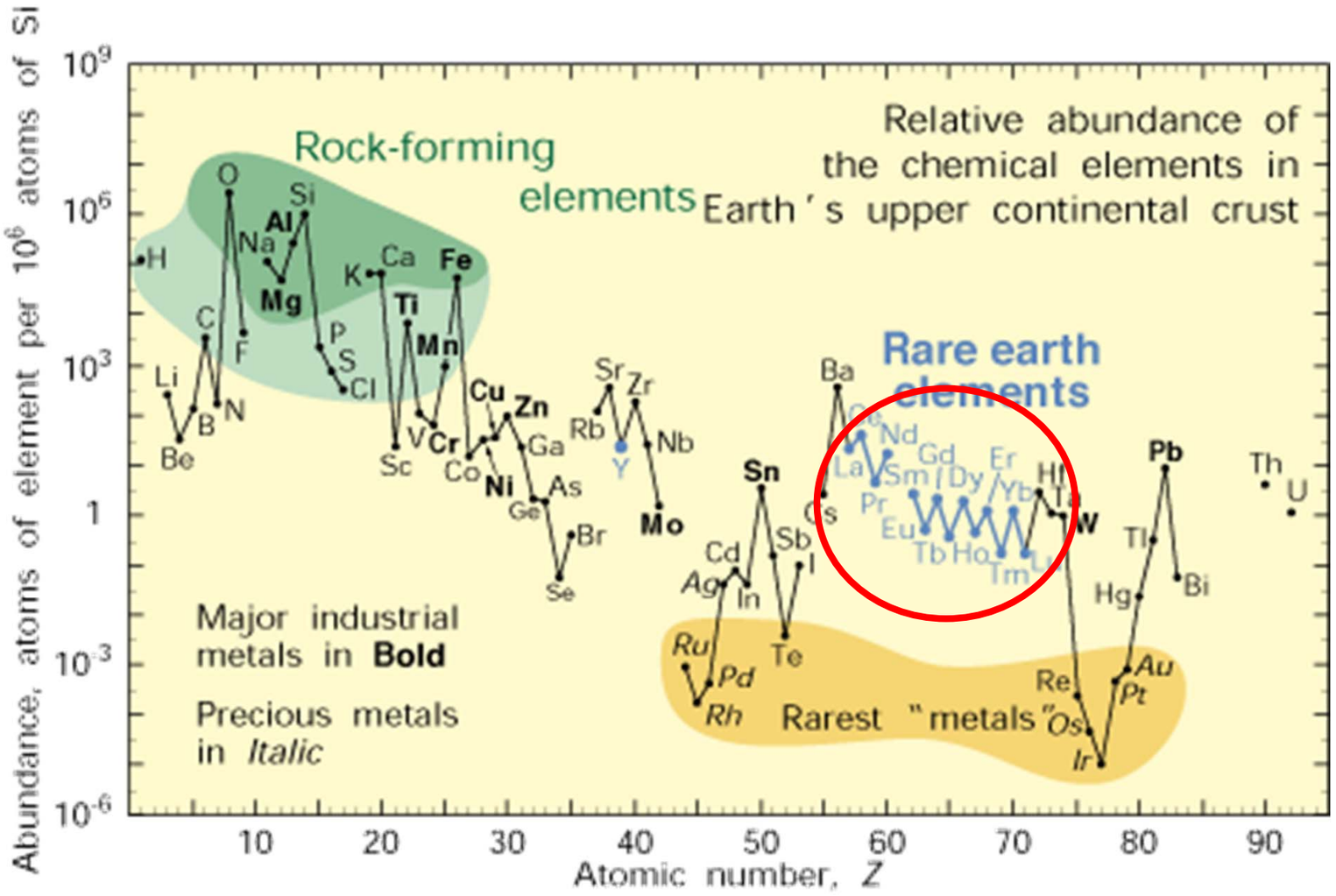
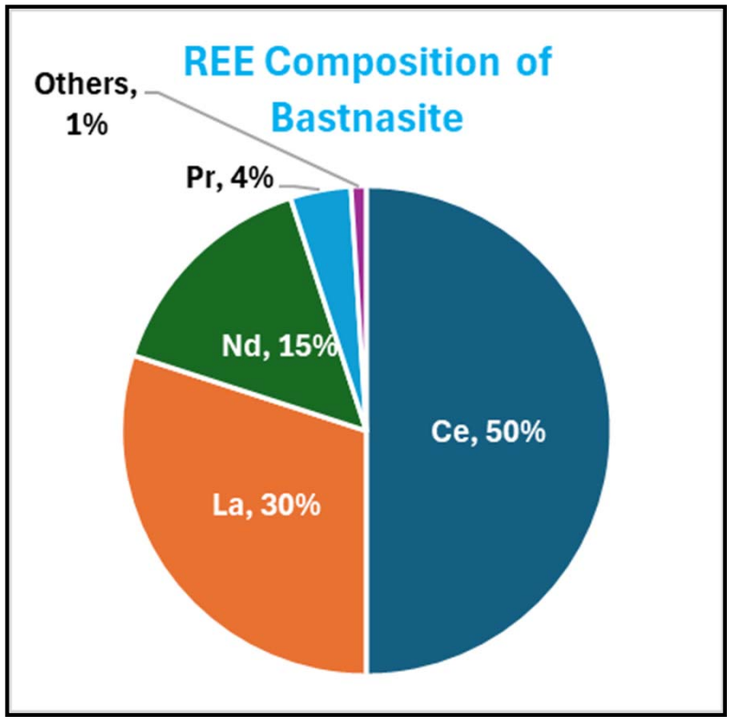
The Rare Earths – Not Really Rare!





Issue is the relative REE content in the mineral deposit and the supply-demand balance

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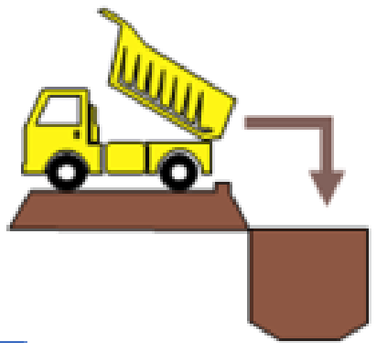
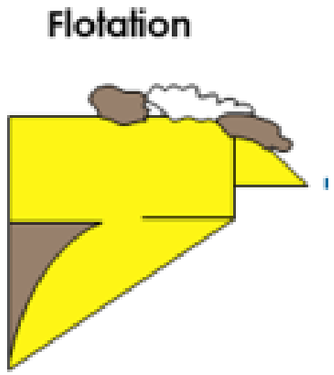
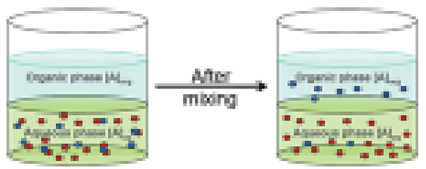
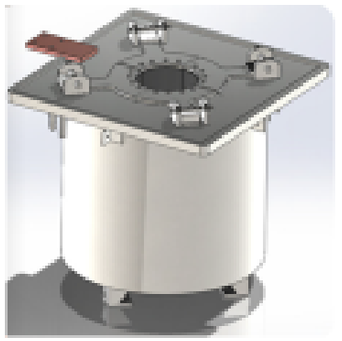
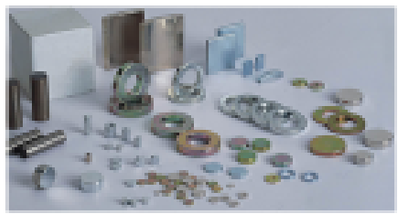
Integrated Rare Earth Magnet Supply Chain

Mine	Mixed REE Concentrate	Separation	Reduction to metal	Alloying and Magnet Making
				
Chinese Global %	60%	60%	85%	75%	>80%

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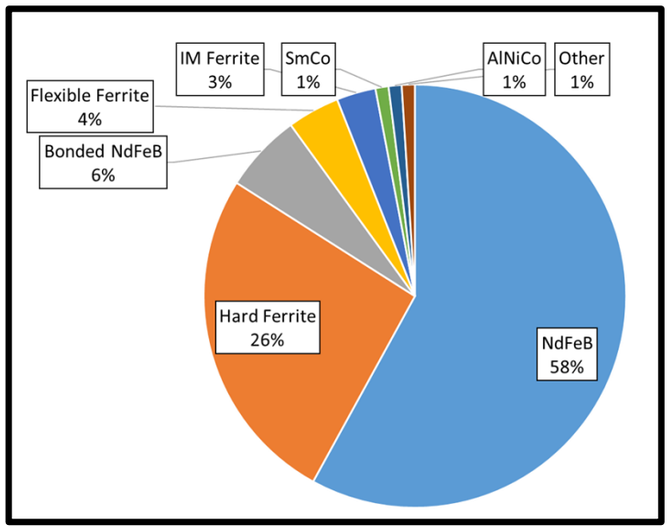
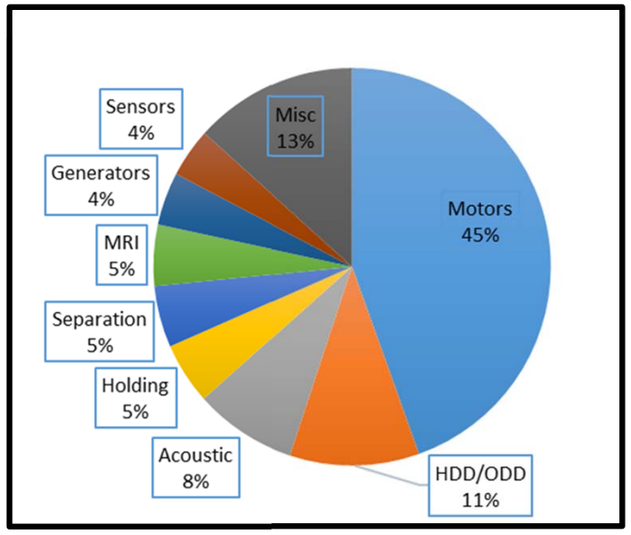
What Are The Markets And Applications?





	2020	2030	2040
Material	**Weight (000's kg)**	**Weight (000's kg)**	**Weight (000's kg)**
NdFeB	190,000	450,000	600,000
Ferrite	900,000	950,000	1,000,000
Bonded NdFeB	12,000	24,000	34,000
SmCo	4,400	4,700	5,000
Alnico	6,750	6,850	7,000
Other	2200	2,500	3,000