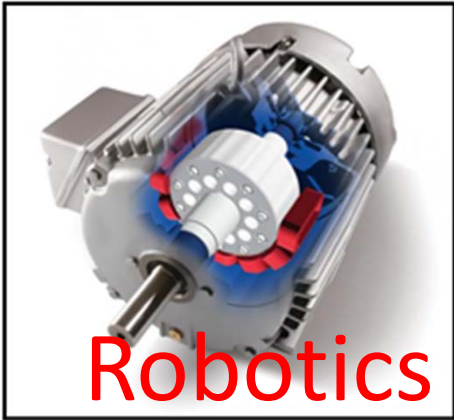
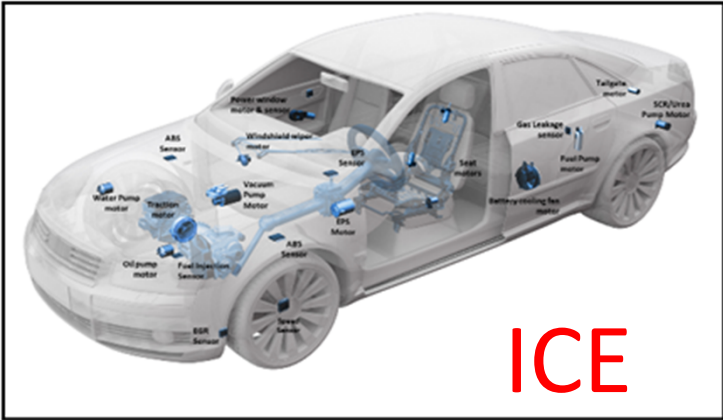
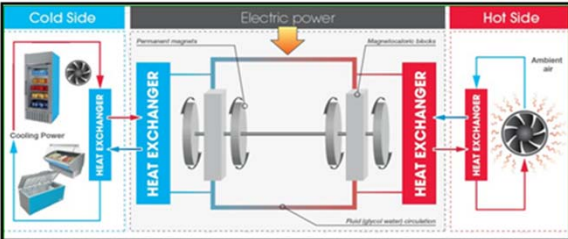


Introduction - John Ormerod

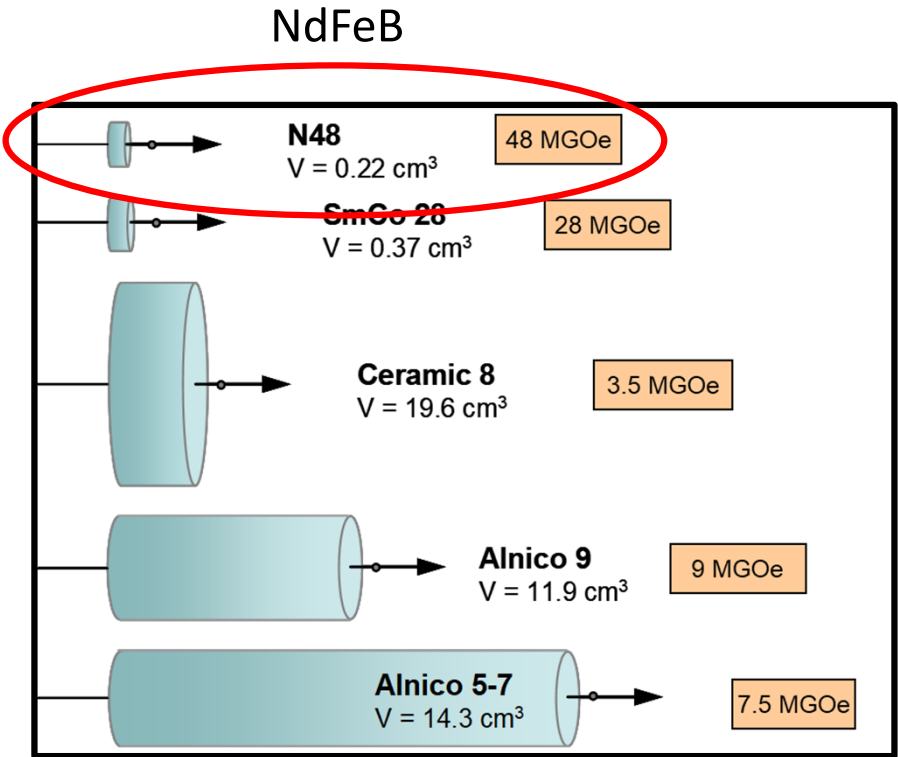
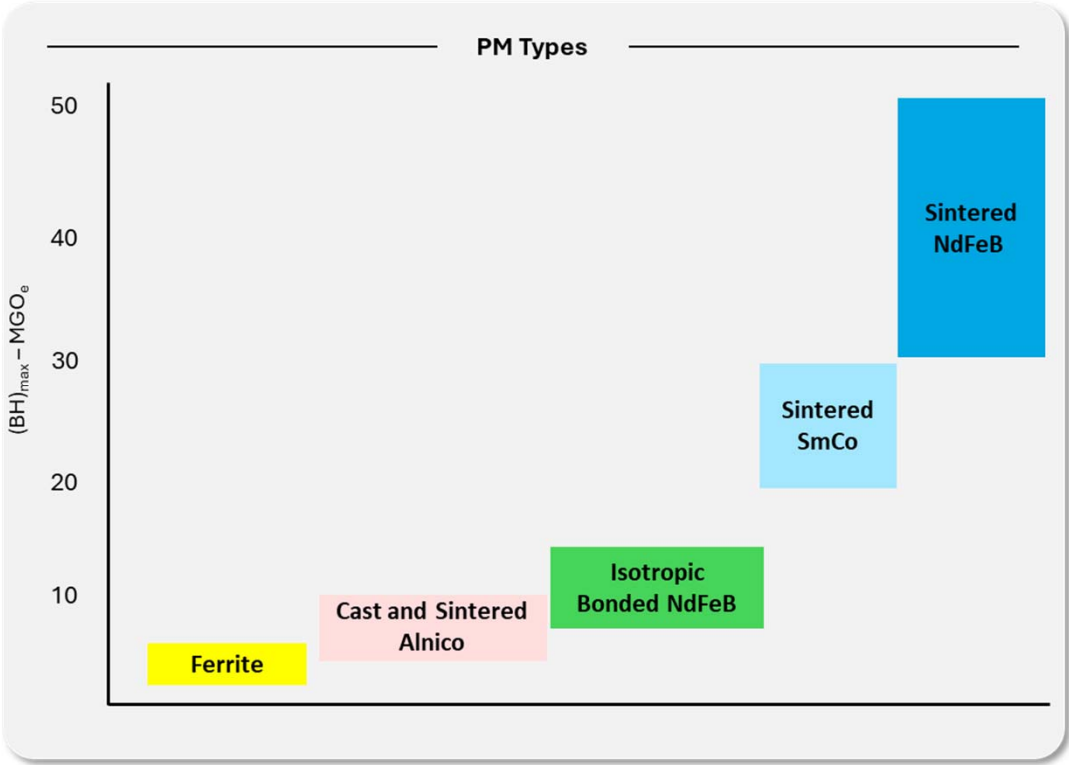
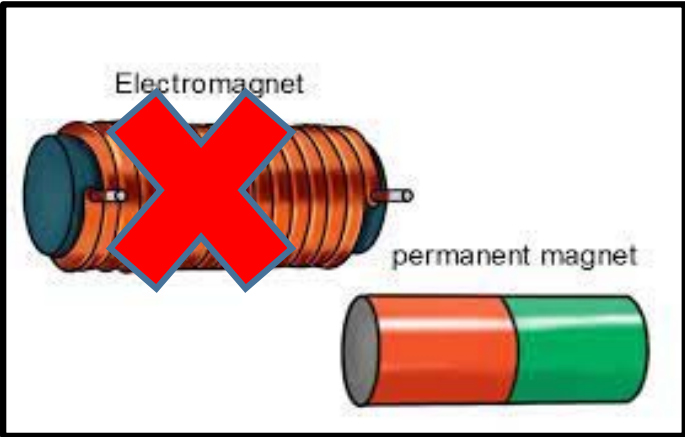
- BSc, MSC and PhD in Metallurgy from the University of Manchester (1972 – 1978).
- Magnetics career began for Philips (UK and Holland) – 1979 – 1990.
- Developed and commercialized SmCo5, 2:17 and NdFeB magnets.
- Joined Arnold Magnetic Technologies (US) responsible for soft and hard magnetic materials 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).

Introduction To Permanent Magnets – Hidden But Essential!



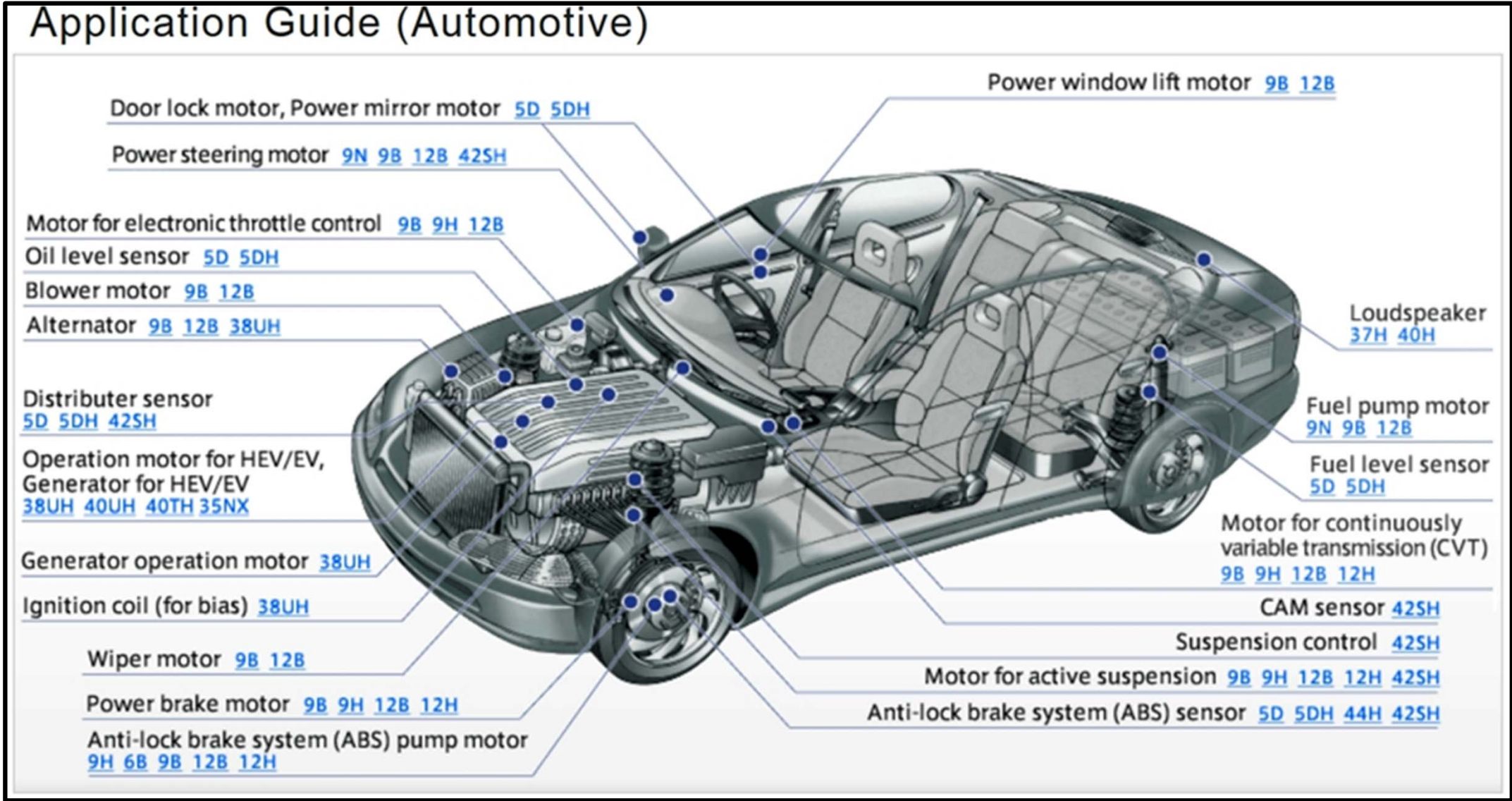
What Is A Rare Earth (NdFeB) Magnet?

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



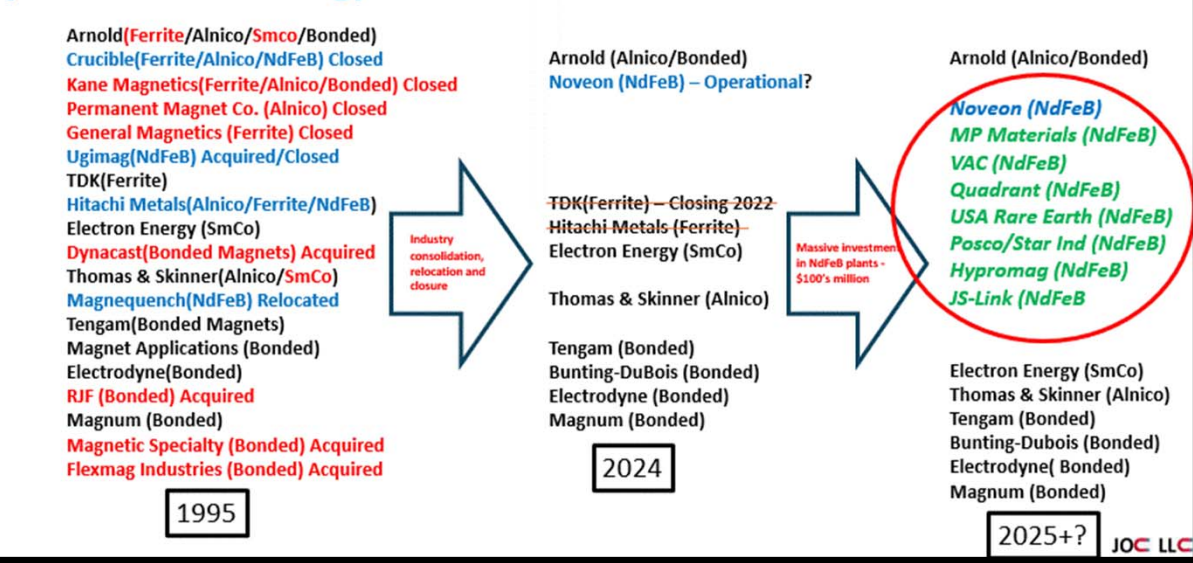
NdFeB magnets are used where weight or space is a constraint and magnetic field levels cannot be achieved by other material options.

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



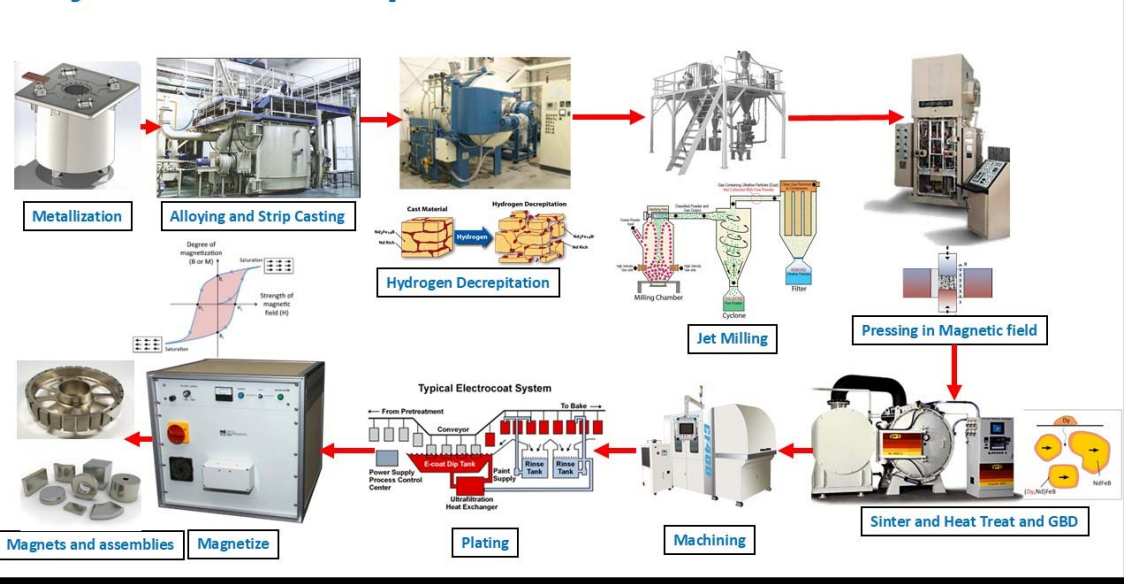
Who Makes Permanent Magnets?

US Permanent Magnet Industry From 1995 to Today to 2025+ (US Manufacturing)



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

Major Process Steps for Sintered NdFeB

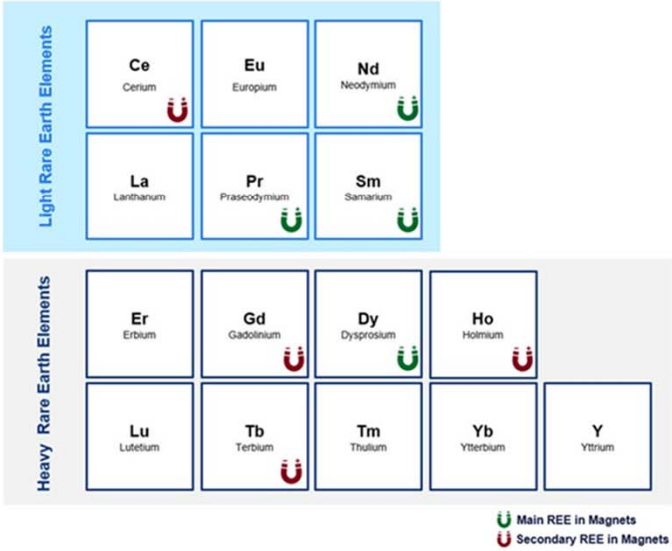


What Are The Rare Earth Elements?

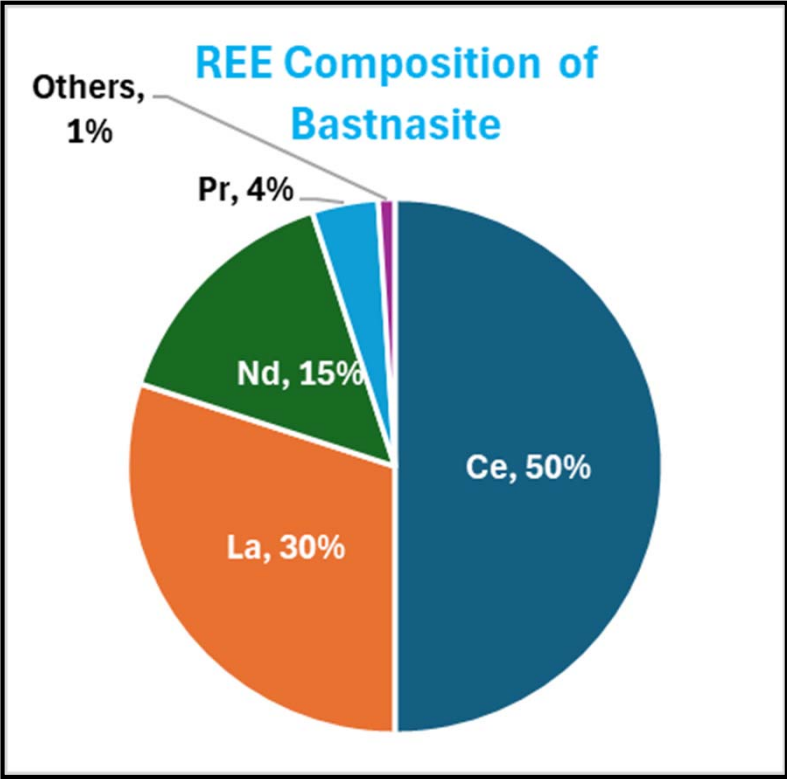
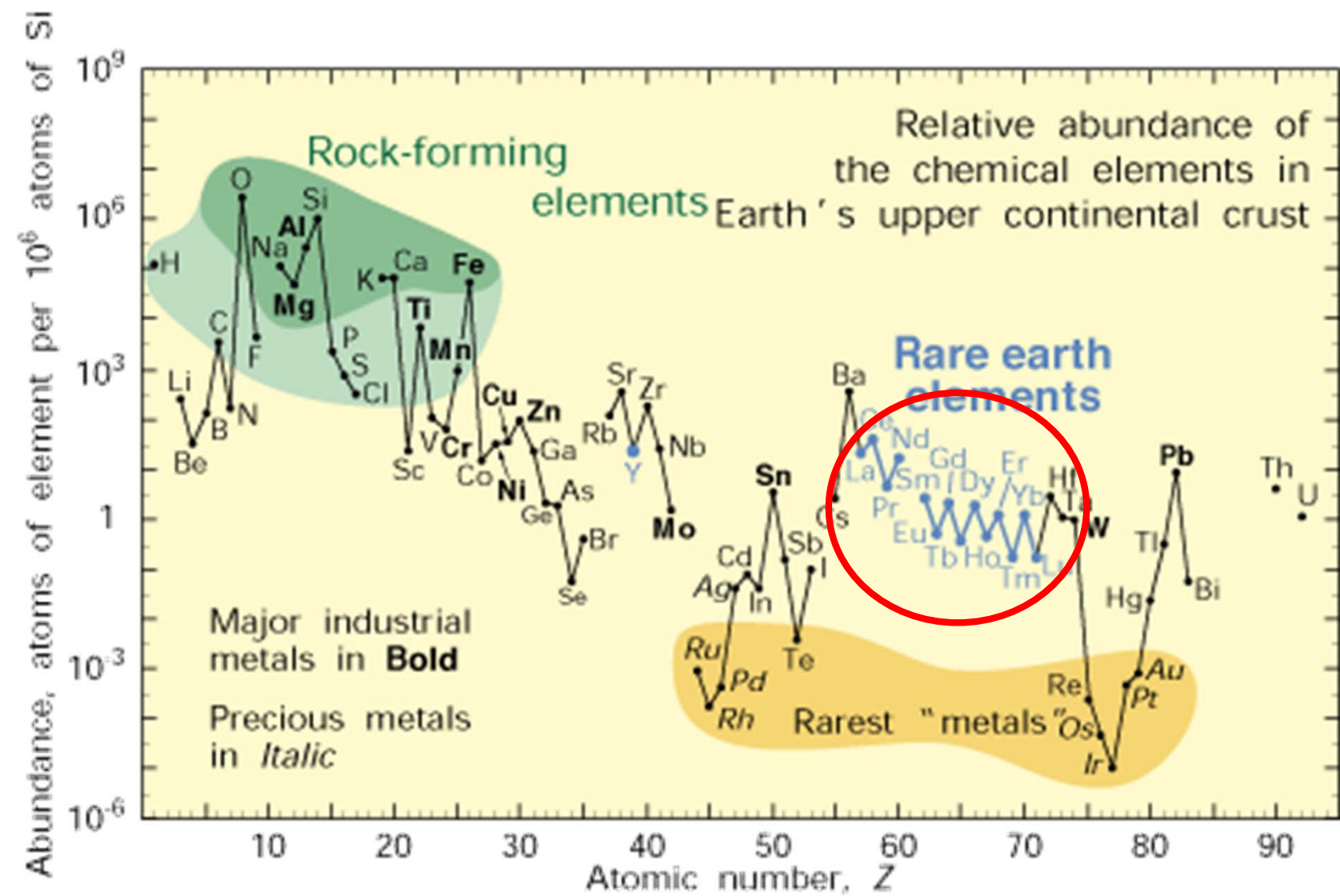
Rare Earth Elements
(21, 39, and 57-71)

H 1																	He 2
Li 3	Be 4	Rare Earth Elements (21, 39, and 57-71)										B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	57-71	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	89-103	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Uub 112	Uut 113	Uuq 114	Uup 115	Uuh 116	Uus 117	Uuo 118
Lanthanide Series		La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71	
		Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103	

Classification of REEs based on their application in magnets

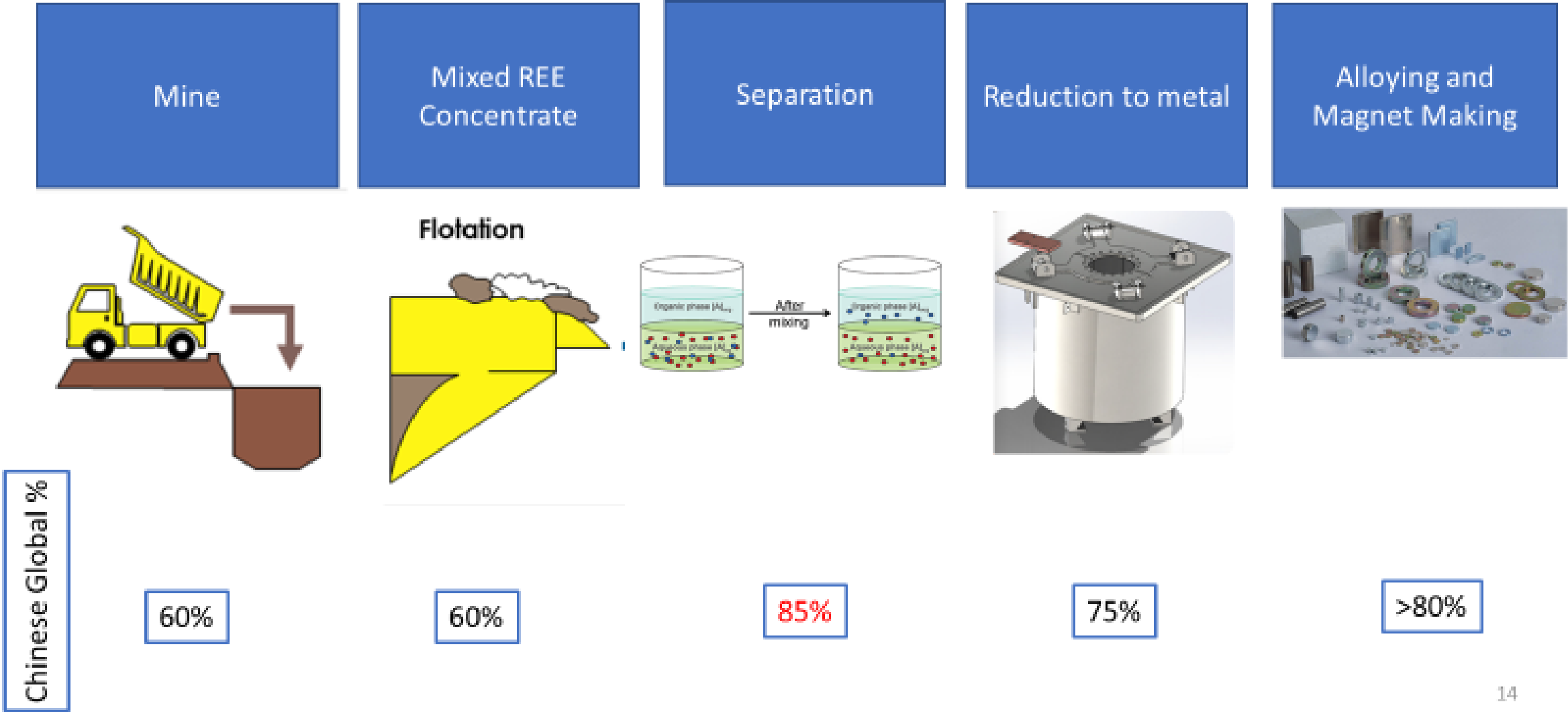


The Rare Earths – Not Really Rare!

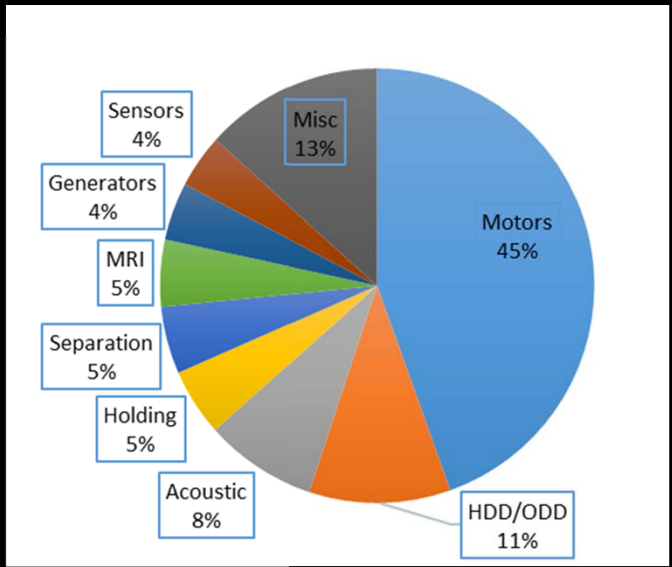
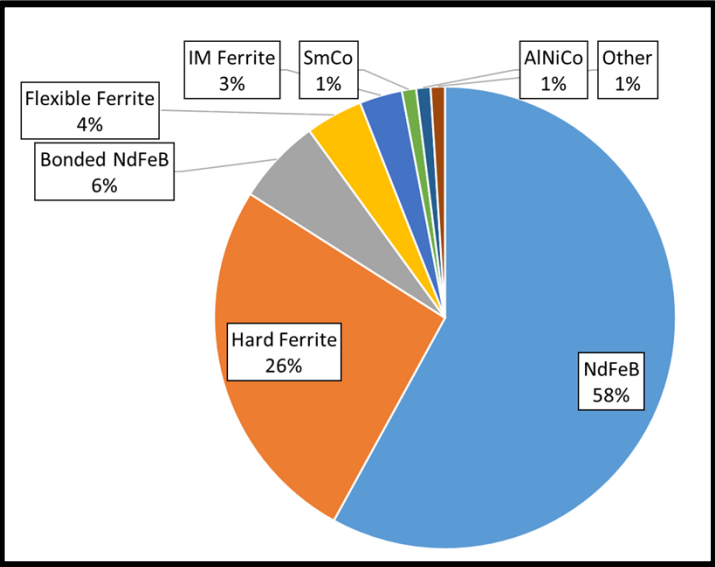


Issue is the relative REE content in the mineral deposit and the supply-demand balance

Integrated Rare Earth Magnet Supply Chain



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

