

China's REE monopoly renders Western exploration efforts futile. Lessons learned?

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Tallinn 7-8 Oct. 2024



Mismatch between vast REE-exploration budgets spent and new viable operations!

MINING.COM
TOP 50 USA CANADA AUSTRALIA REGIONS - TNM MAPS TNM MARCO POLO
Norra Kärr deposit could help make the EU self-sufficient in rare earth metals – study
MINING.COM Staff Writer | December 17, 2021 | 6:06 am [Battery Metals News Europe Rare Earth](#)

Biggest European rare earth deposit found in Sweden
LKAB is planning to start production of the Geijer deposit this year
January 13, 2023

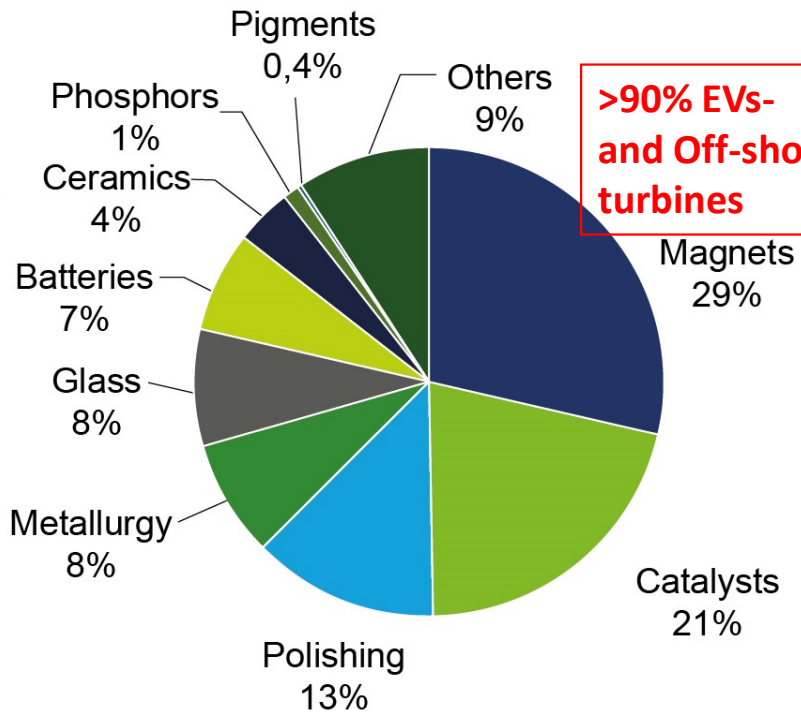
POLITICO
Israel-Hamas war US election Newsletters Podcasts Poll of Polls Policy news
Mining firm: Europe's largest rare earths deposit found in Sweden
NEWS > SUSTAINABILITY
bulk of the EU's supply.

Huge rare earth metals discovery in Arctic Sweden
17 January 2023
Chatterjee

Europe's largest REE discovery made in Norway
The deposit could fulfil 10% of Europe's REE demand
Munira Rajkotwalia

OR MINERALS AND RAW MATERIALS – MiMa

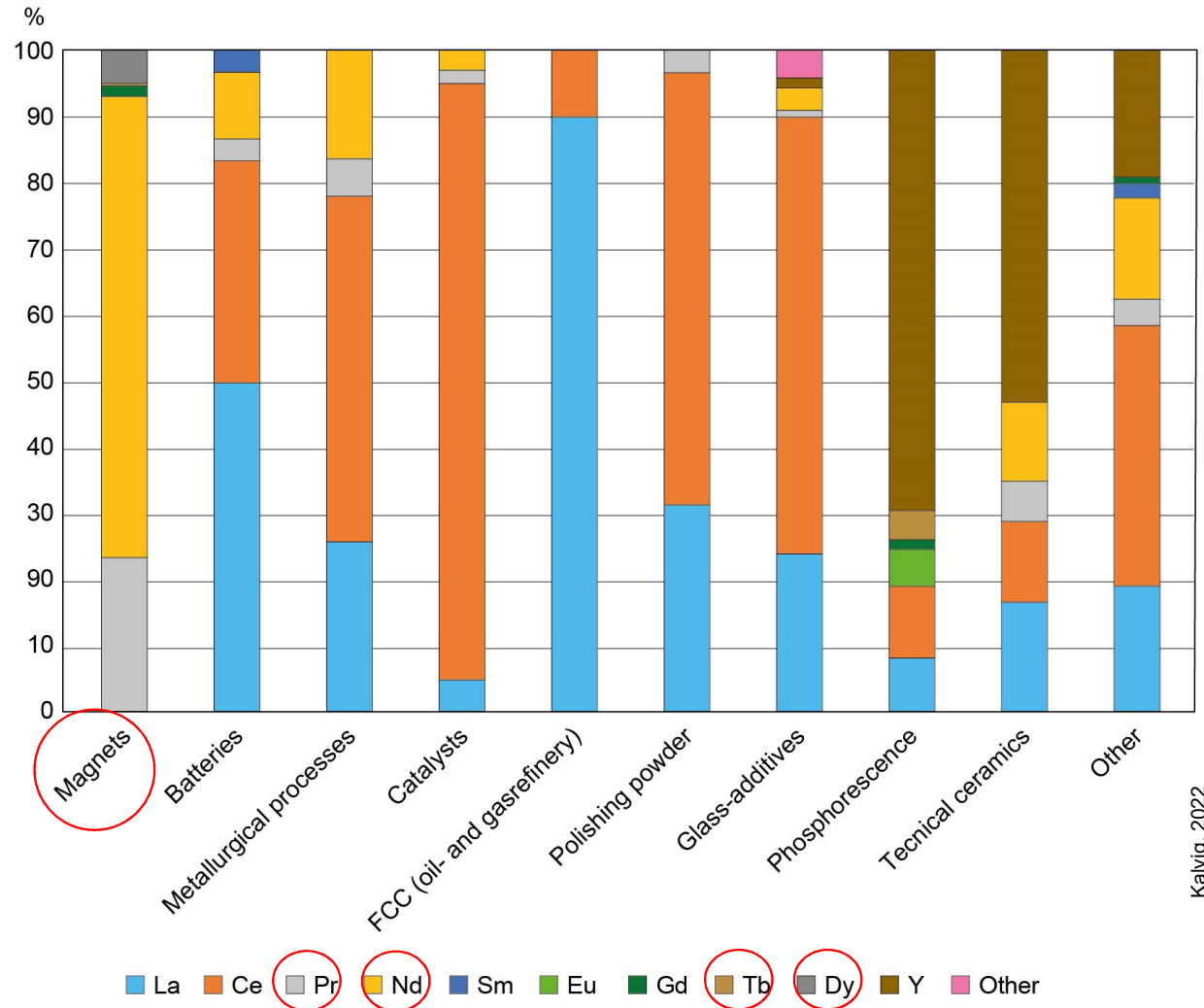
REE end use sectors



**>90% EVs-
and Off-shore
turbines**

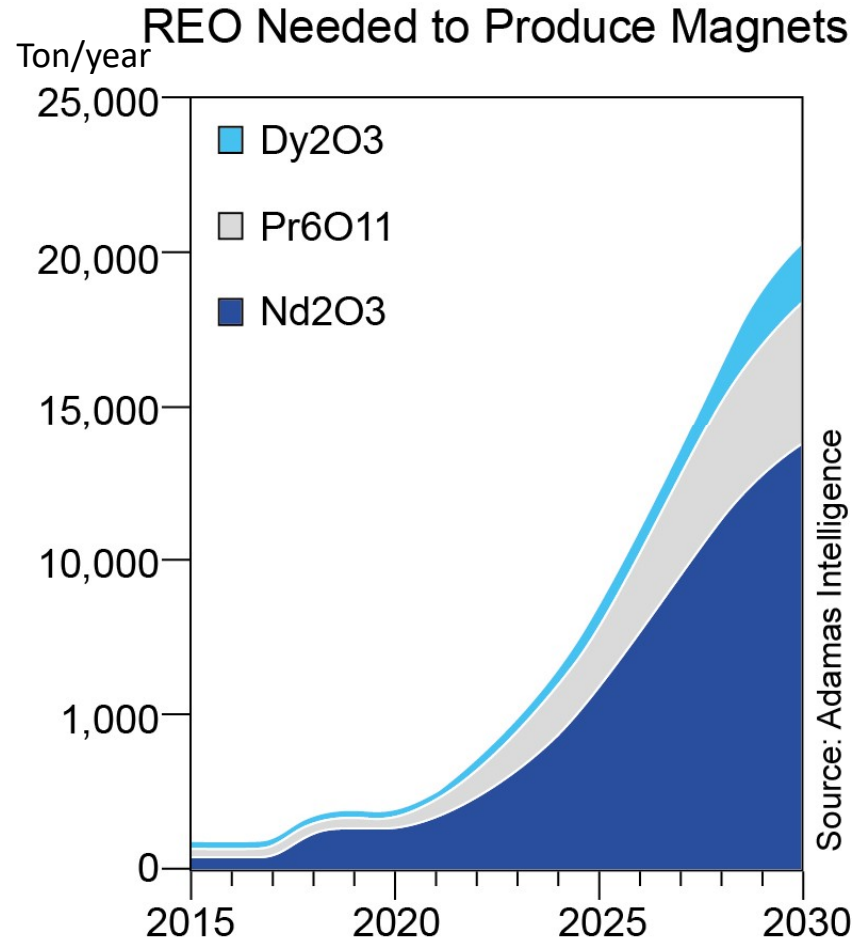
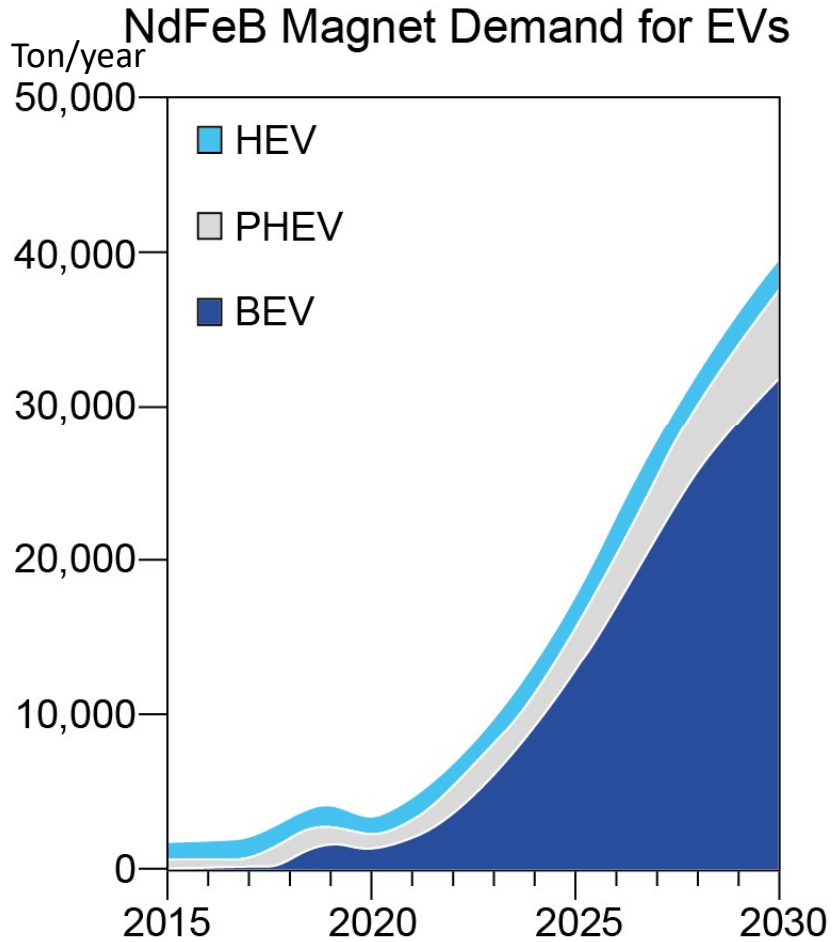
Global consumption of REO: 139,551 t (2019)

No REE-deposit does match the market!



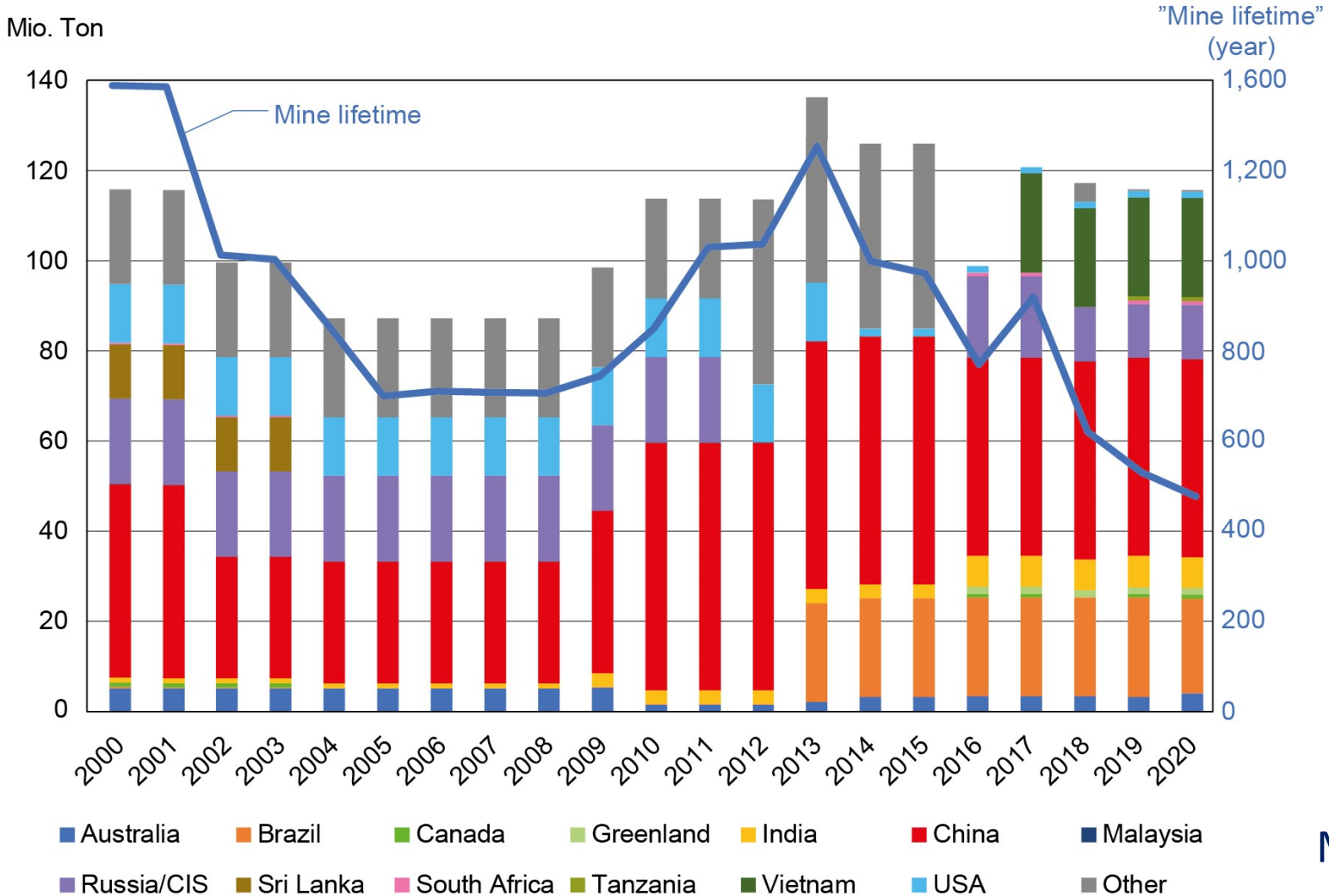
Kalvig, 2022

Magnet demand drives the REE exploration and exploitation



Source: Adamas Intelligence

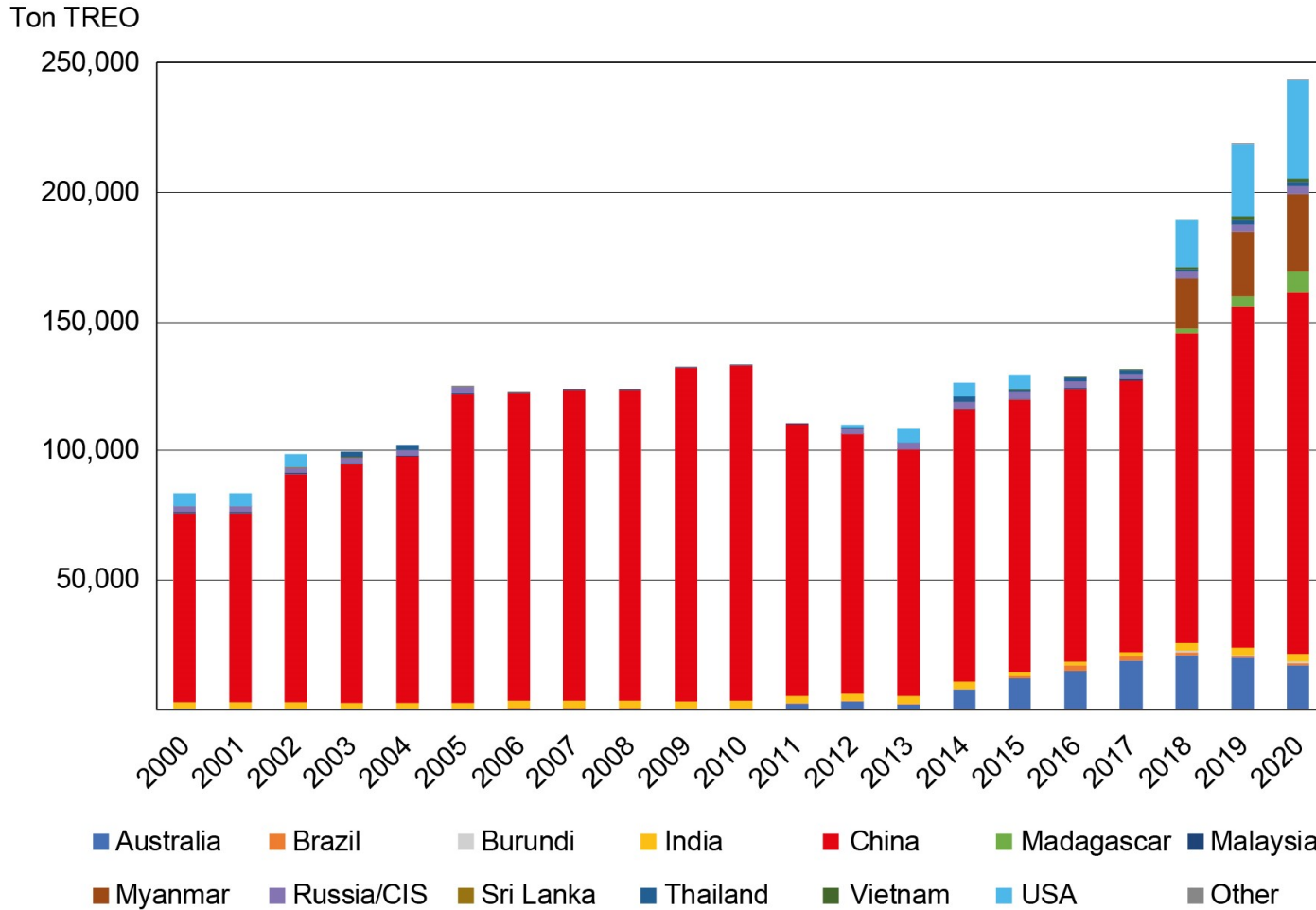
Vast global TReO reserves



USGS Mineral Commodity Summaries 2000-2020

Myanmar?

Mining aligns with growing REE demand



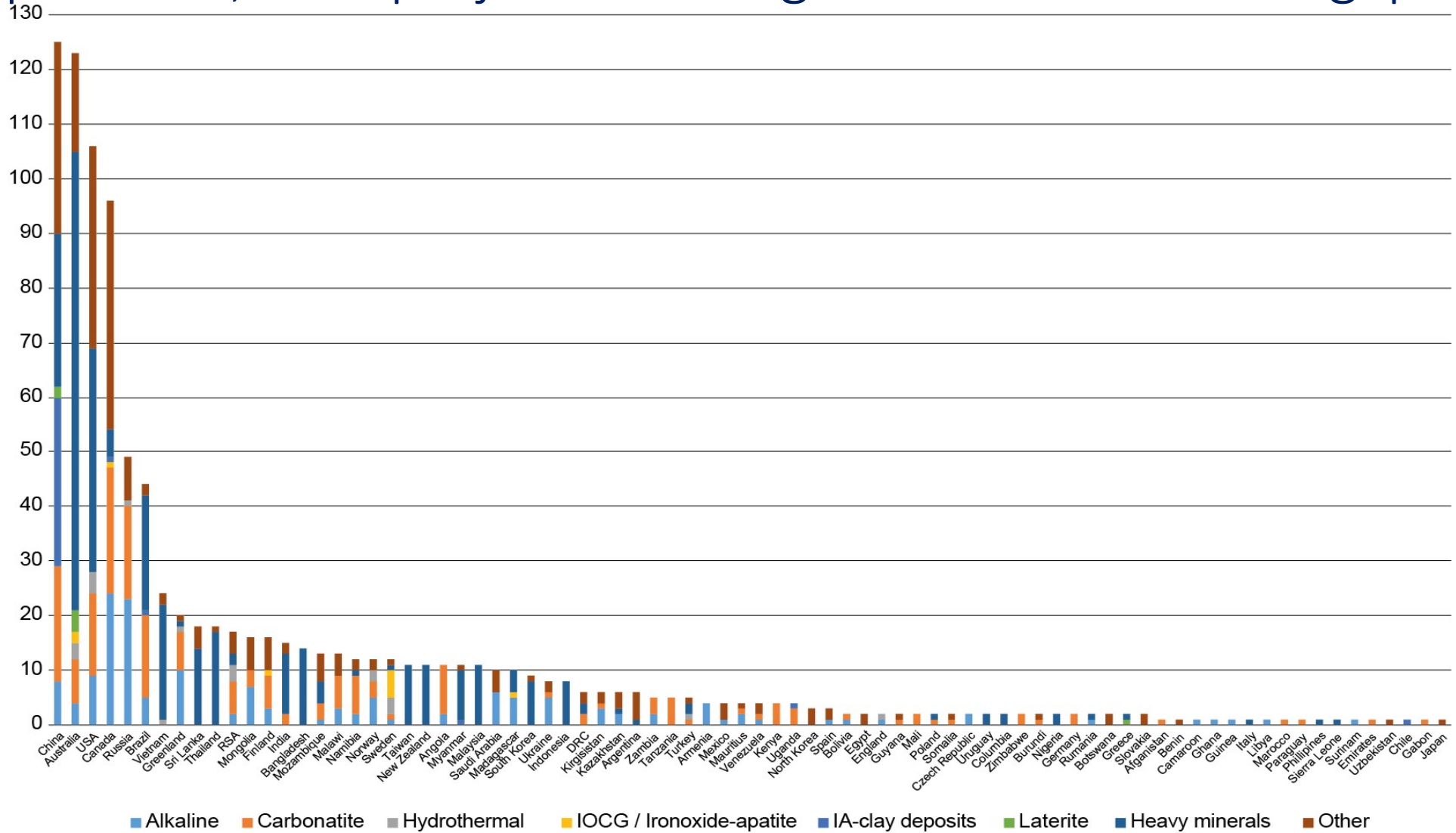
Ton TREO
350,000

The new producers must find their place in the growth.

Supplied by the emergence of new Asian miners (mainly HM and IAC) and the continued resilience of existing supply chains.

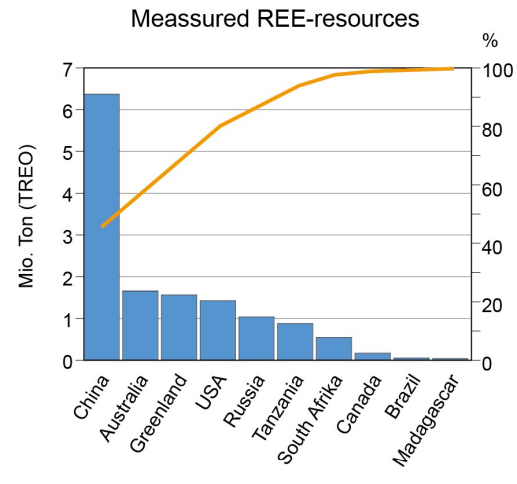
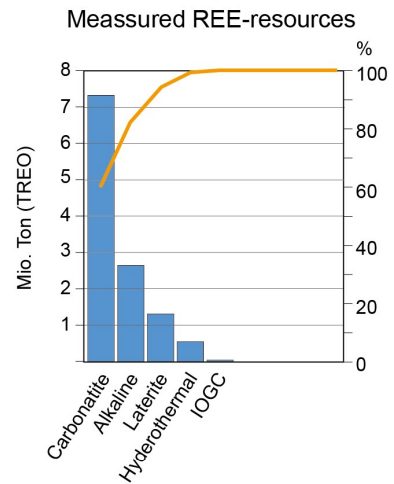
2023

A pool of 1,000+ projects to bridge the 2030-demand gap?

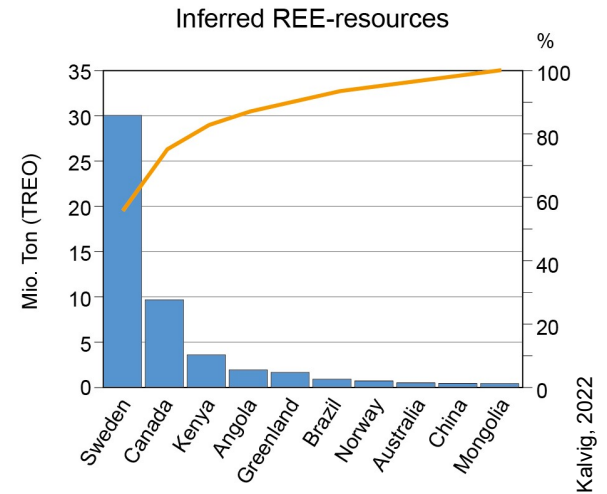
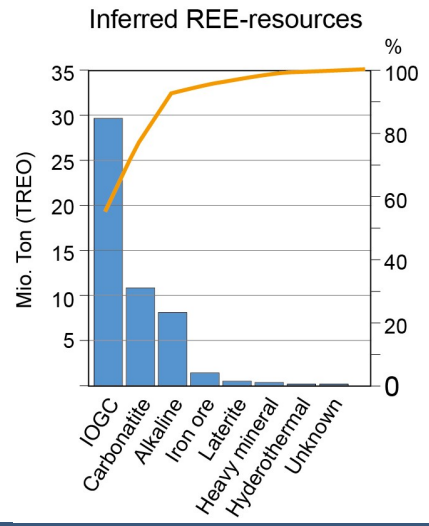
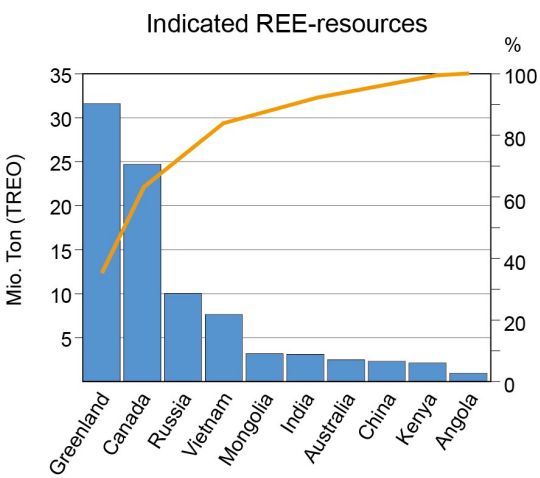
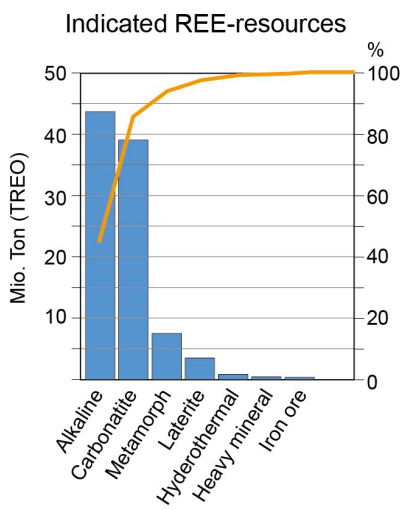


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Categories of resources by geological type and country



Almost no resource data on Heavy Minerals and IAC-types.



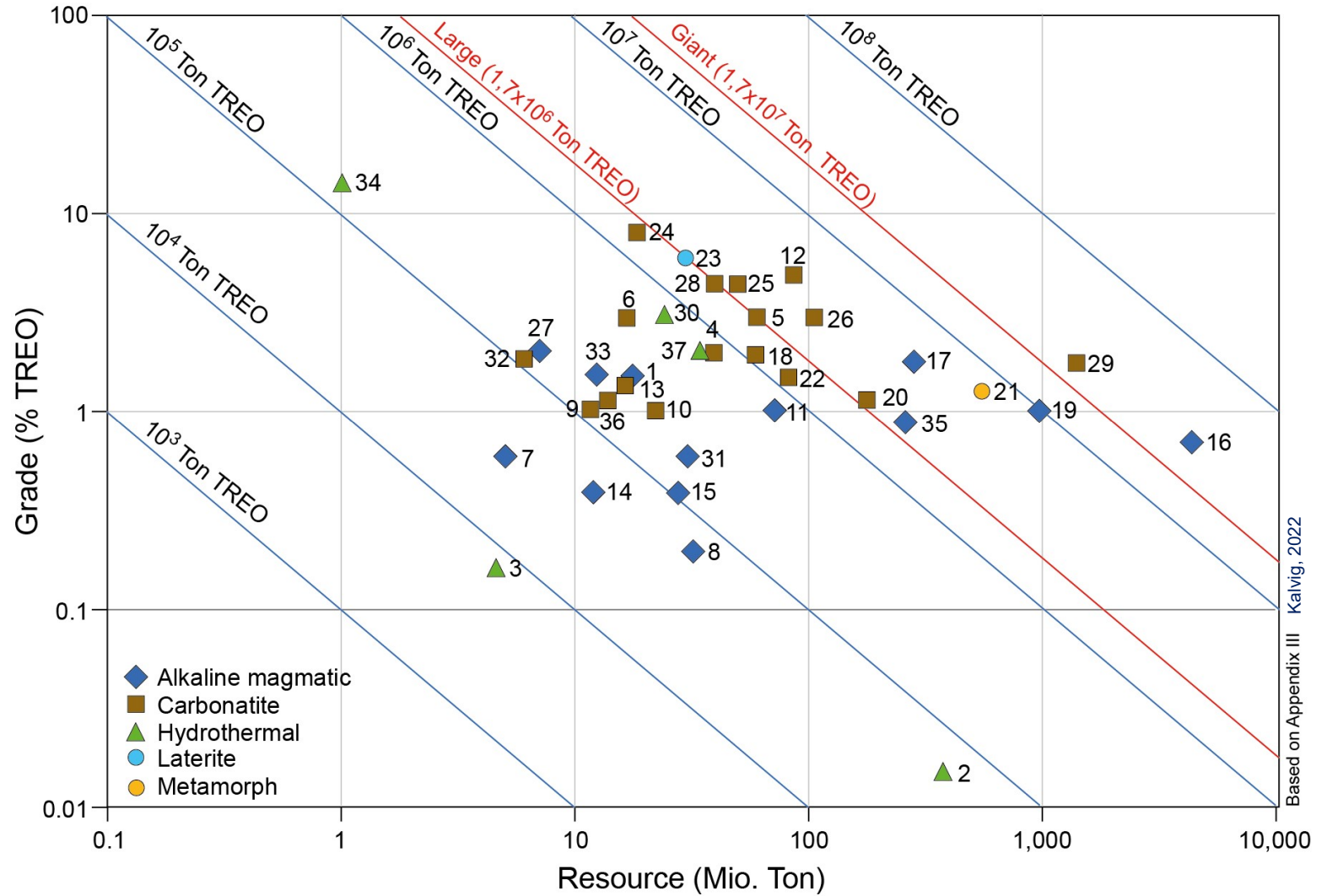
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Vast REE-resources for next many years

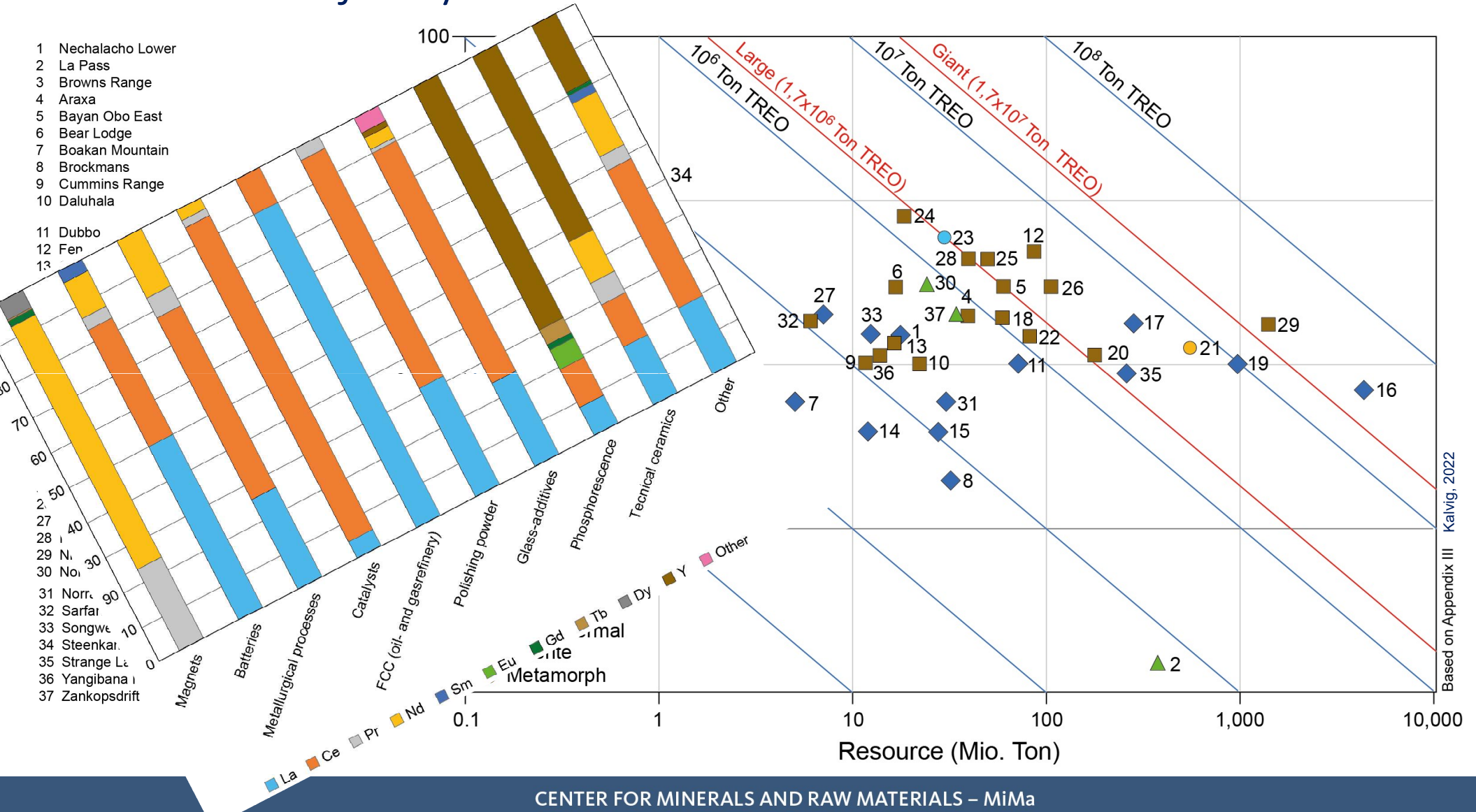
- 1 Nechalacho Lower
- 2 La Pass
- 3 Browns Range
- 4 Araxa
- 5 Bayan Obo East
- 6 Bear Lodge
- 7 Boakan Mountain
- 8 Brockmans
- 9 Cummins Range
- 10 Daluhala

- 11 Dubbo
- 12 Fen
- 13 Glenover
- 14 Khibiny
- 15 Kipawa
- 16 Kringlerne
- 17 Kvanefjeld
- 18 Longonjo
- 19 Lovozero
- 20 Maniuping

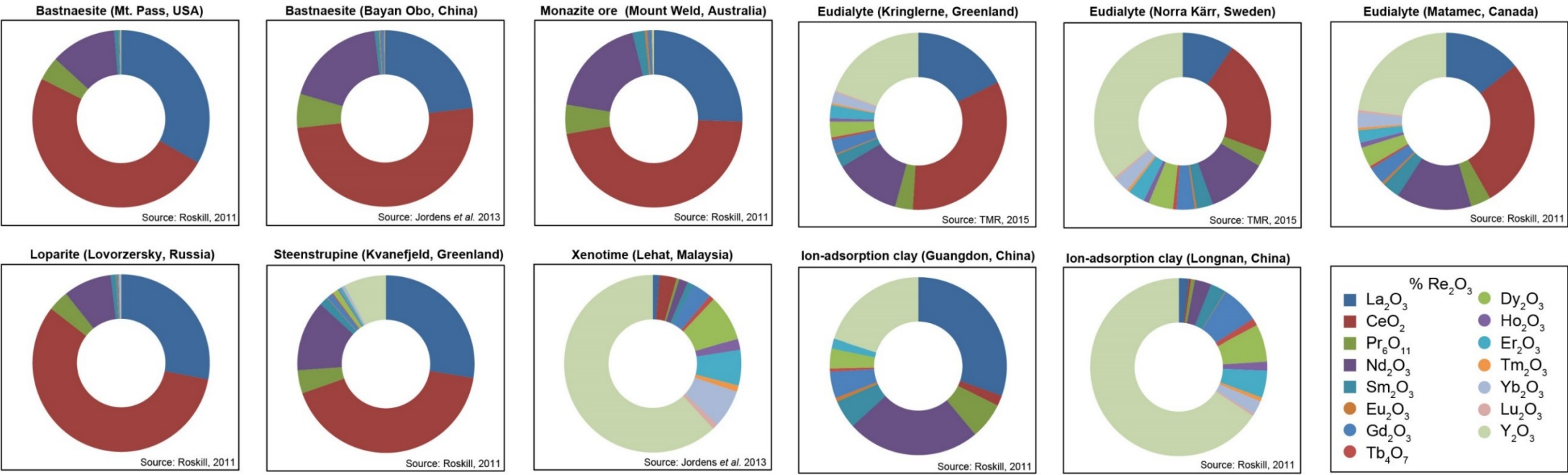
- 21 Mau Xe
- 22 Montviel
- 23 Mount Weld (Duncan)
- 24 Mountain Pass
- 25 Mrima Hill
- 26 Mushgia Khudug
- 27 Nechalacho Upper
- 28 Ngualla
- 29 Niobec
- 30 Nolans Bore
- 31 Norra Kärr
- 32 Sarfartôq
- 33 Songwe Syenite
- 34 Steenkampskrall
- 35 Strange Lake
- 36 Yangibana North
- 37 Zankopsdrift



... but the majority not suitable for the NdFeB markets!



Attractive ore types: Low La+Ce; high Pr+Nd; and high Tb+Dy

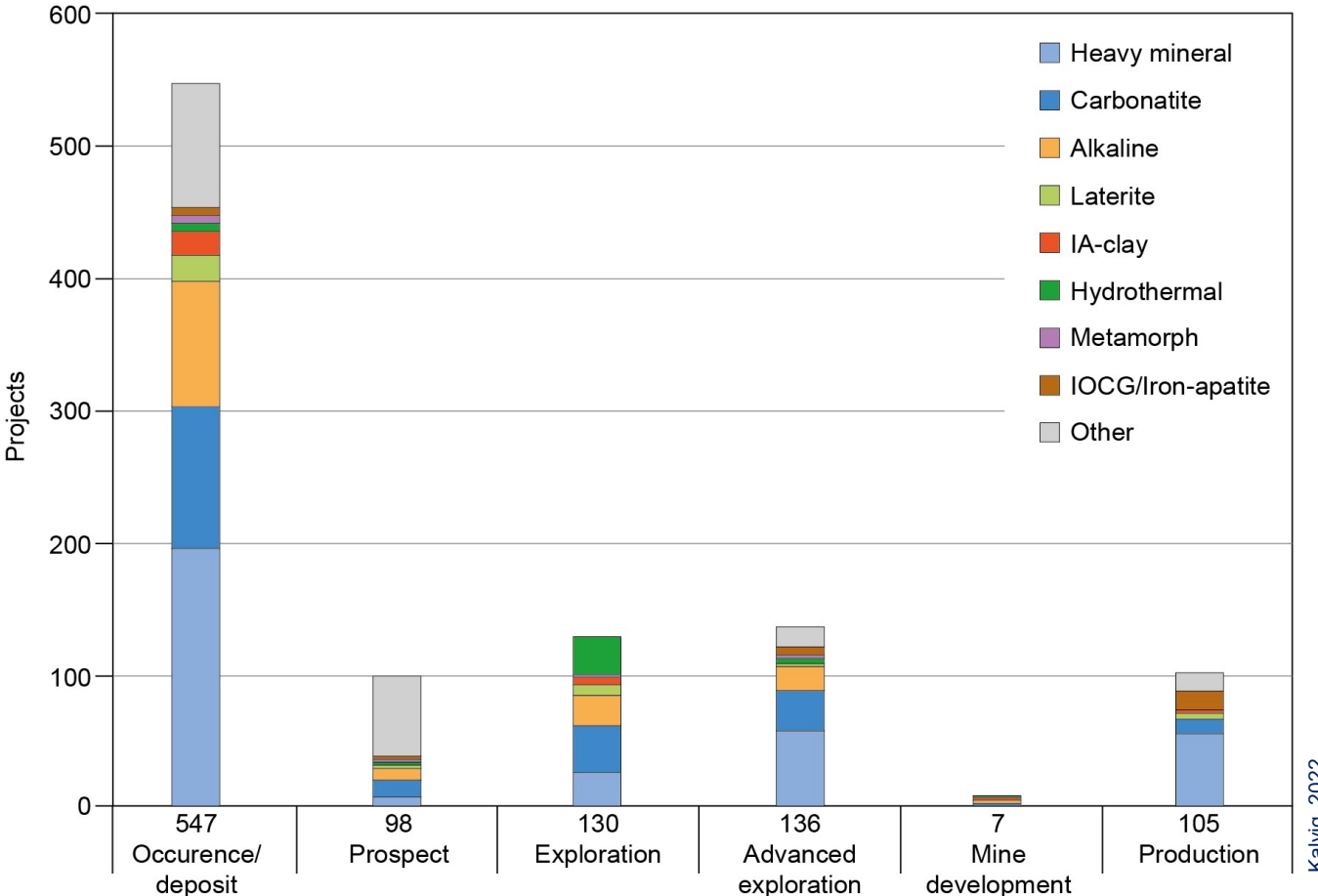


	La-oxide+Ce-oxide	Pr-oxide+Nd-oxide	Tb-oxide+Dy-oxide
	%	%	%
IAC	32	28	4
Alkaline	57	17	3
IOC-apatite	66	17	2
Heavy min. sand	68	21	1
Carbonatite	73	21	1

Kalvig, 2023: Unpublished data

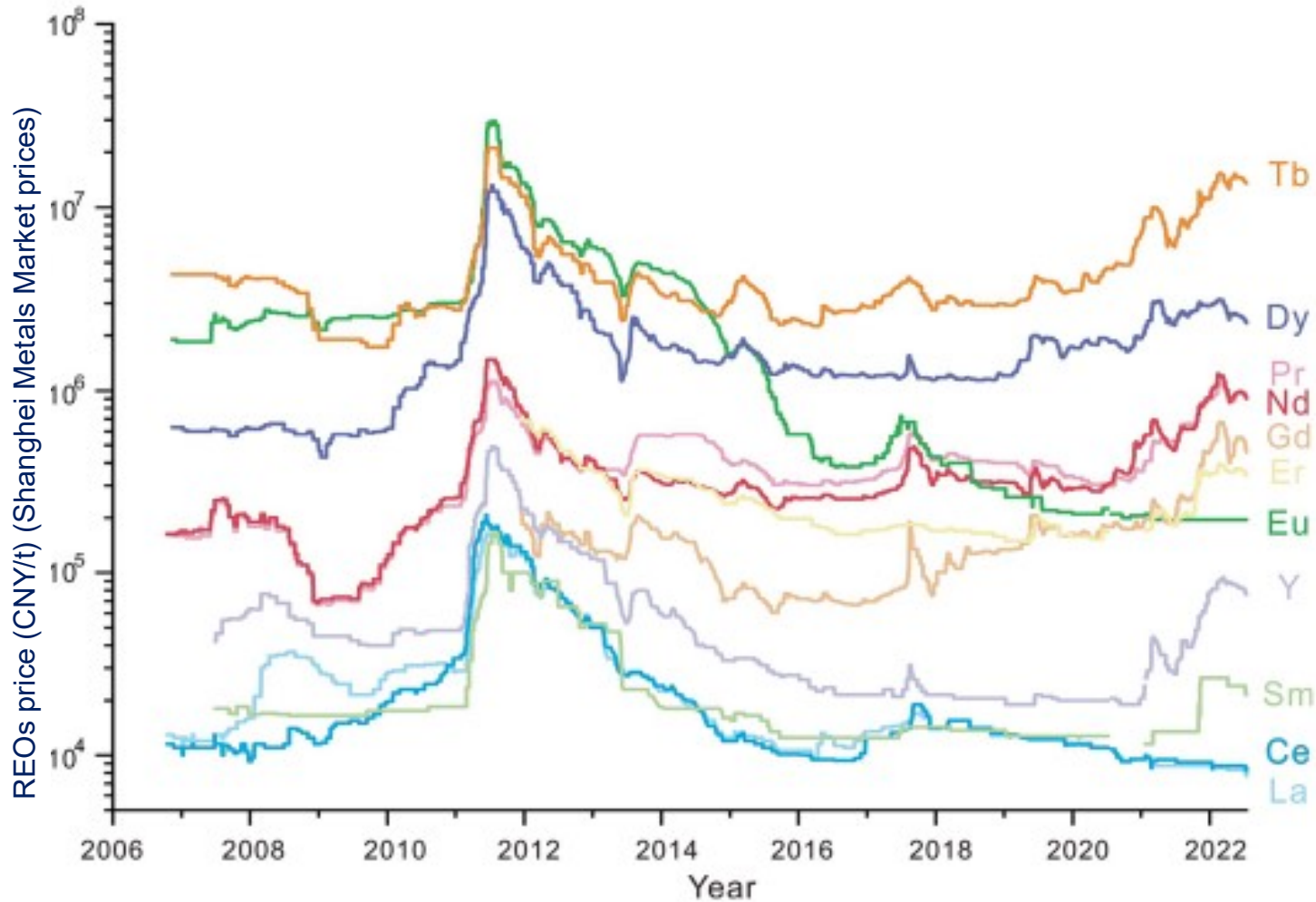
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Only a few are likely to become producers by 2030



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Low prices challenge profitable business models

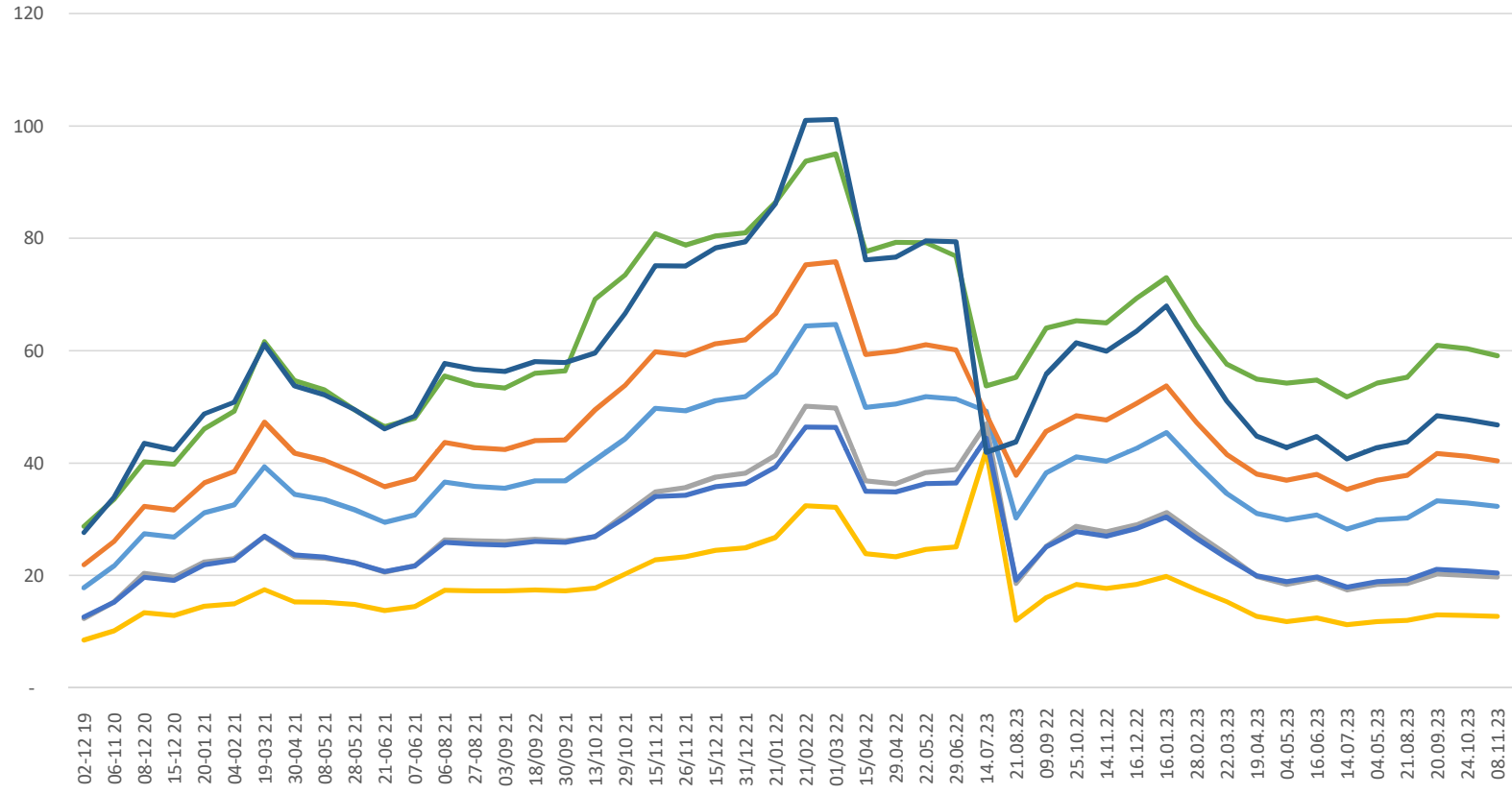


Source: Liu, S.L. et al (2023): Ore Geology Reviews 105428

	USD/kg
Rare earth carbonate	5
Rare earth con c. >70%	8
Lanthanum-oxide	1
Cerium-oxide	1
Neodymium-oxide	61
Praseodymium-oxide	61
Terbium-oxid	800
Dysprosium-oxide	252
Europium-oxide	27
Yttrium-oxide	6
Gadolinium-oxide	26
Erbium-oxide	44
Samarium-oxide	2
Nd-Pr-oxide	60
Lanthan-metal	3
Praseodymium-metal	78
Neodymium-metal	75
Nd-Pr-alloy	75
Mischmetal (La-Ce)	3
Dy-Fe-alloy	242
Holmium-oxide	75
Lutetium-oxide	761
Scandium	797
Thulium-oxide	114
Ytterbium-oxide	14

Source: The Rare Earth Observer 06.09.24

Ore values do not reflect the MREC-price



- Eudialyte -Kringlerne (TANBREEZ)
- Eudialyte Norra Kärr
- Monazite - Mount Weld
- Bastnaesite - Mountain Pass
- Steenstrupine - Kvanefjeld
- Xenotime - Lehat, Malaysia
- IAC - Guangdong

China's toolbox to safeguarding domestic REE supply chains

Policy Type	Sub-group	1975–1990	1991–1998	1999–2009	2010–2015	2016–2018
		Upstream Production for Export	Initial Restrictions on Production & Foreign Investment	Export Quotas & Taxes, Downstream Promotion	Further & Broader Restrictions, WTO Dispute	Post WTO Dispute
REE Office						
	Foreign Investment					
	Production Quota					

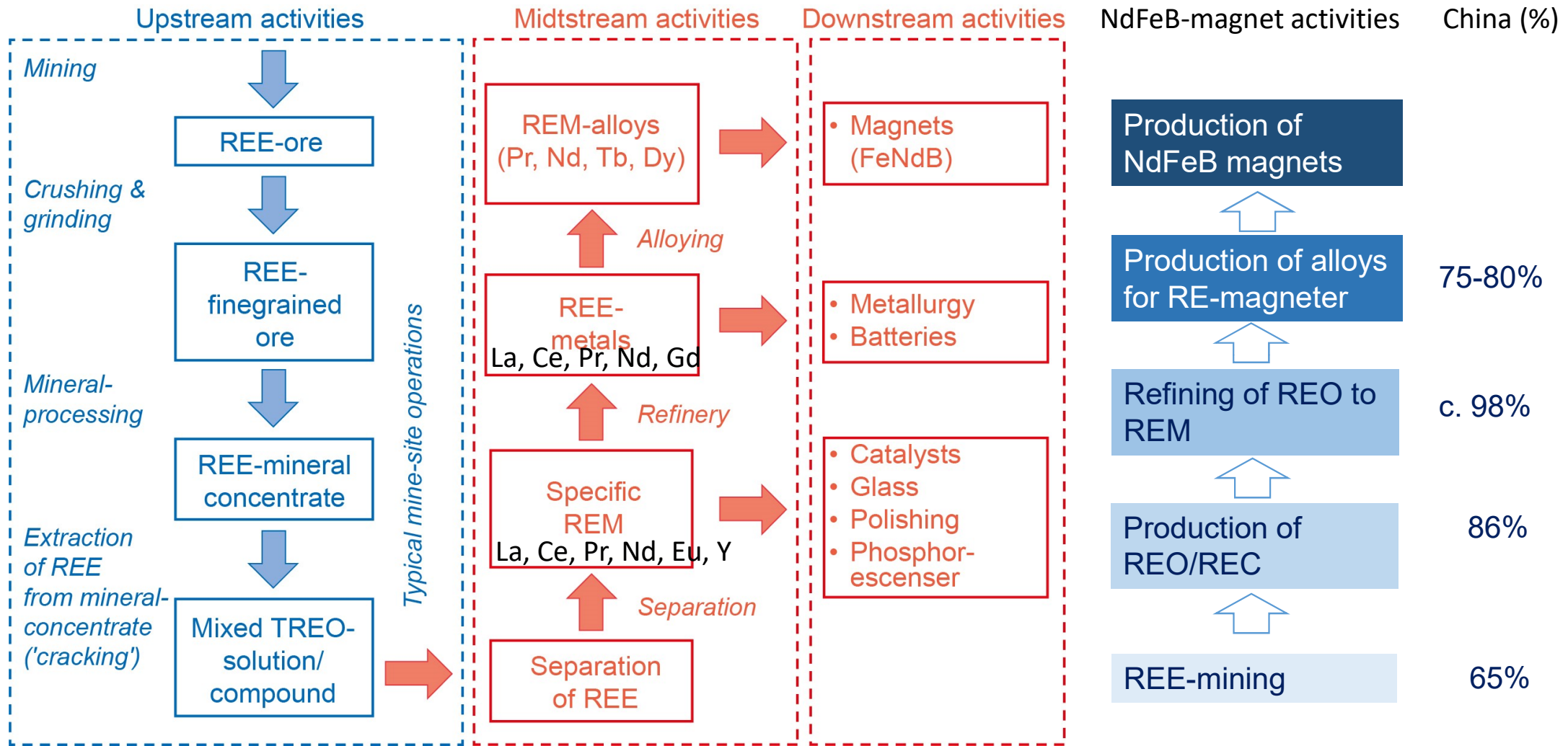
	Mineral products (TREO ton) 2022			Mineral products (TREO ton) 2023			Mineral products (TREO ton) 2024		
	Rock min. (LREE)	IAC (HREE)	Smelting and sep. products for REO	Rock min. (LREE)	IAC (HREE)	Smelting and sep. products for REO	Rock min. (LREE)	IAC (HREE)	Smelting and sep. products for REO
	x 1,000 ton	x 1,000 ton	x 1,000 ton	x 1,000 ton	x 1,000 ton	x 1,000 ton	x 1,000 ton	x 1,000 ton	x 1,000 ton
China Northern Rare Earth Industry Co. Ltd.	140	6	130	177	6	160	188		160
China Rare Earth Group Co. Ltd	50	13	60	57	12	64	62	18	90
Total	190	19	190	234	18	224	250	18	250

China's toolbox to safeguarding domestic REE supply chains

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REE Office						
Industrial policy	Foreign Investment					
	Production Quota					
	Regulations of Production Quota					
	Industrial Consolidation					
	Product Tracing System					
	Exploration and Mining Permit					
	Crackdown on illegal Production					
	Industrial Standard					
	Development Plan					
Export policy	Export Quota					
	Export Tax Rebate					
	Export Tax					
	Export Permit					
Environmental policy	Emission Standard					
	Land Restore					
	Laws and Regulations					
	Qualified REE Firms					
Resource Tax						

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Inadequate REE supply chain infrastructure in the West



Exploration groups compelled to form partnerships with China

Samples:

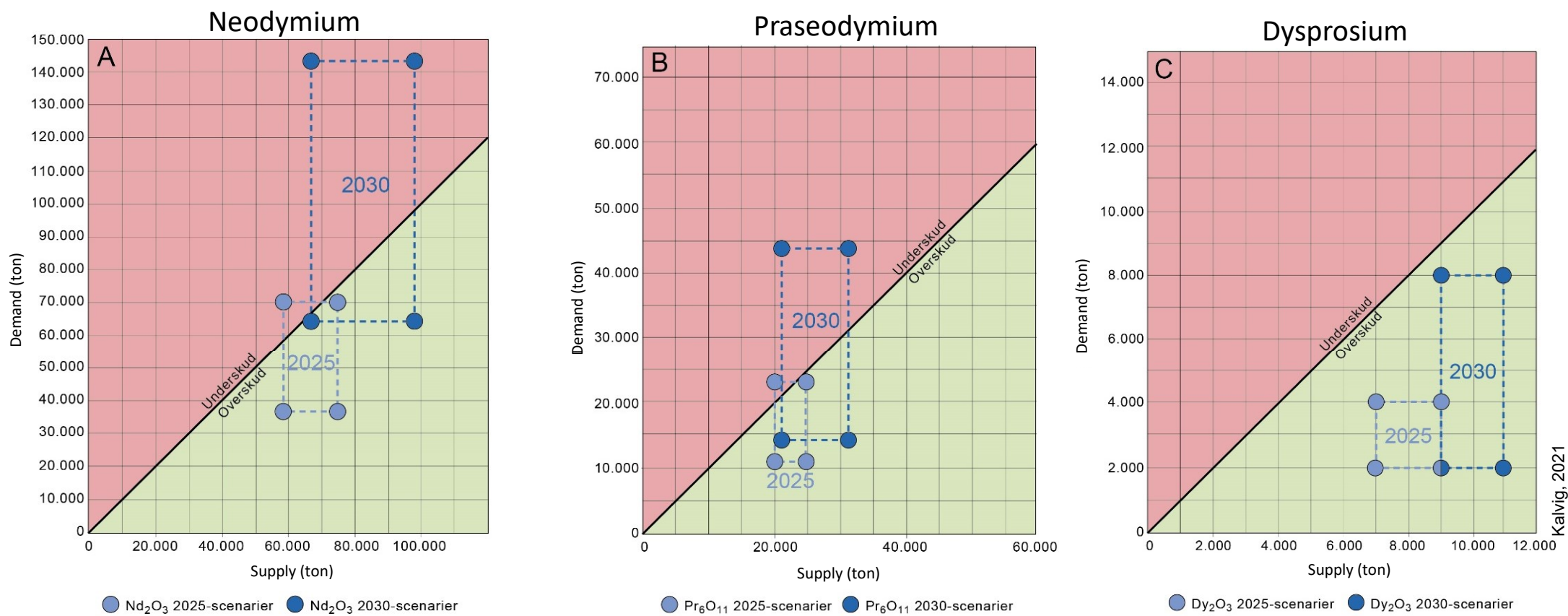
Country	Company	Geological type	Chinese partner
Australia	Yangibana North	Carbonatite / Laterite	Baotou Sky Rock Rare Earth New Materials Co. Ltd (tolling and off-take)
Australia	Banshee (Brown Range)		Guandong Rare Earths Group
Australia	Nolans Bore	Hydrothermal/Carbonatite	Jiangsu Eastern China Non-Ferrous / Shenghe (off-take)
Australia	Eneabba	Heavy mineral sand	Northern Minerals Ltd; JL Mag (9,8% shares)
Australia	Goschen	Heavy mineral sand	Shenghe Resources
Australia	Wedderburn	Heavy mineral sand	Shenghe Resources
Australia	Wolverine	hydrothermal	Zeyu New materials Sales Co (JFMAG) + Sinosteel MECC
Brazil	Matka Zul	?	Roger Li
Canada	Coldwell	Alkaline	Roger Li
Canada	Dory Pond	?	Roger Li
Canada	Nechalacho Upper	Alkaline	Shenghe (9% shareholder)
Canada	Kipawa (Zeus)	Alkaline	Shenghe shareholder
Greenland	Kvanefjeld (main)	Alkaline	Shenghe
Laos	Phaxay district	IA-deposit	Chinese un-identified group
Laos		IA-deposit	Xiamen Tungsten Corp
Madagascar	Tantalus	Carbonatite (IOCG)	Shenghe
Malaysia	Lahat Perak	Heavy mineral sand	?Chinalco
Tanzania	Wigu Hill	Carbonatite	Shenghe (shareholder 10%)
Tanzania	Ngualla Hill	Carbonatite	Shenghe (shareholder) off-take agreement 2024
Uganda	Makuutu	IA-deposit	China Rare Metals and Rare Earth Co Ltd Chinalco (MoU)
Zambia	Nkombwa Hill	Carbonatite	Sinomine Resource Group Co Ltd (jv partner)

IP rights safeguarding Chinese domestic downstream industries

Areas where patents may apply in the NdFeB-magnet supply chains

- **Material composition:**
The specific chemical formulation of NdFeB magnets (alloys or modifications to the basic neodymium-iron-boron composition) to improve e.g. magnetic strength, thermal stability, corrosion resistance.
- **Manufacturing processes:**
The techniques used in melting, casting, and heat treatment to form the magnet material. Advanced processes for shaping the magnets (like sintering or hot pressing).
- **Coatings and treatments:**
Special coatings to prevent oxidation and corrosion of the magnets.
- **Innovations in magnet design:**
The design of NdFeB magnets for specific applications (e.g., motors, generators, medical devices)

Lessons learned



I underestimated the IAC and chain-resilience!

Lessons learned?

A personal take:

- **Chinese dominance over global REE supply chains and consuming sectors remains firmly entrenched, and China has the capacity to stay in this position and to meet the demand**
- **The Western strategy of developing REE supply chains from mine to magnet has failed!**
 - Huge investments are poured into exploration projects with little chance of becoming commercially viable.
 - The need to address supply chain gaps —starting with magnets, followed by metals and separation, and ultimately developing the mining industry—is overlooked by investors, government officials (including Geological Survey Organizations?), and politicians.

Is the Western strategy too shortsighted?

- **Are emerging technologies replacing NdFeB-magnets in wind and EV's in 2030?**
 - Ferrite magnets
 - Rare-Earth-Free induction motors and synchronous reluctance motors)
 - Iron-Nitride (FeN) magnets
 - Halbach Array Motors (optimizing performance with fewer or weaker magnet
 - Superconducting motors
 - Magnetless motors: switched reluctance motors (SRMs)
- **A thorough analysis of potential next-wave REE-demanding technologies is essential,**
 - along with development of strategies to prevent past mistakes!

Thank you!

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<http://www.geus.mima.dk>