RESEARCH SUMMARY · WESTBECK CAPITAL MANAGEMENT

Everything you need to know about rare earths

An independent reading of Westbeck Capital Management's report on the structural bottlenecks in Western rare earth supply — and where the investable pressure points sit.

TOPIC OF INTEREST

Rare earth magnet economics & technology — what drives demand, why Western supply is structurally constrained, and which segments of the value chain matter for capital allocation.

Source material referenced · Westbeck Capital Management · Geological reports · Company filings · Shanghai Metals Market pricing

01 · OVERVIEW

The four metals that make magnets work

The performance and scalability of modern electric motors, EV drivetrains, and defense technologies depend on high-grade permanent magnets built primarily from four rare earth elements.

Nd
Neodymium
Drives magnetic strength

Pr
Praseodymium
Drives magnetic strength

Dy
Dysprosium
Sustains performance at high temperatures

Tb
Terbium
Sustains performance at high temperatures

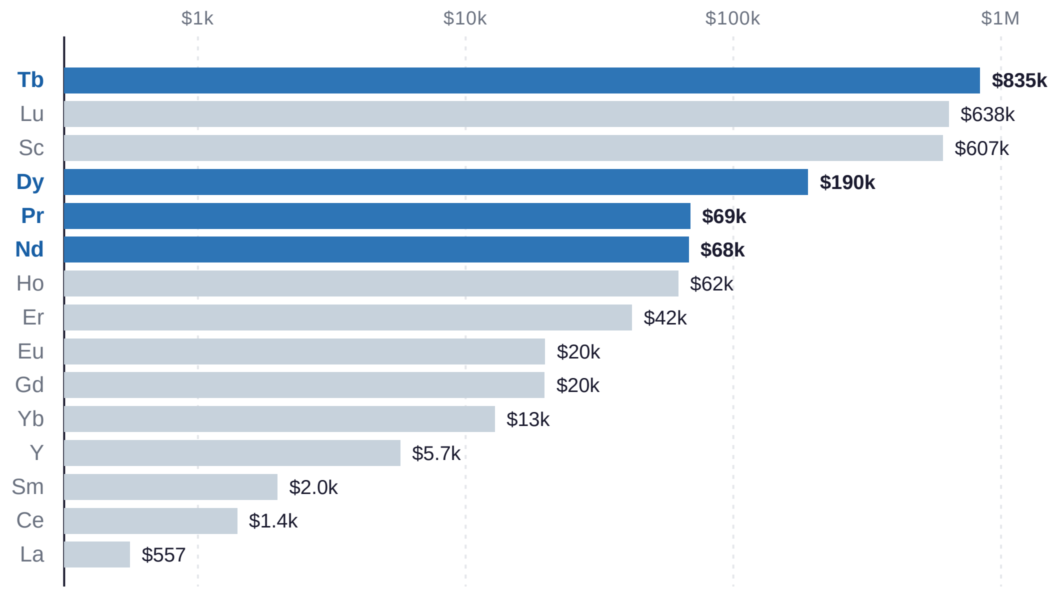
While Nd and Pr drive raw magnetic strength, Dy and Tb are what allow magnets to operate at high temperatures over long periods — making them essential for EV motors, generators, drones, and aerospace systems.

> **KEY TAKEAWAY**
> Neodymium is abundant. The real bottleneck — the structural constraint that drives the investment thesis — is dysprosium and terbium.

02 · ELEMENT ECONOMICS

Where the magnet metals sit

Rare earth element values span three orders of magnitude. The four magnet metals occupy the upper end — but they are not alone there. What makes them different is structural demand, not price.



Element value · USD per metric ton, log scale · magnet metals (Pr, Nd, Tb, Dy) highlighted. Sources: Geological reports, Shanghai Metals Market.

03 · ELEMENT REFERENCE

Why we care, and which elements matter

Lutetium and Scandium are costly but lack the irreplaceable demand that magnet metals carry into EV motors, wind turbines, and defense. The full data underlying the value distribution.

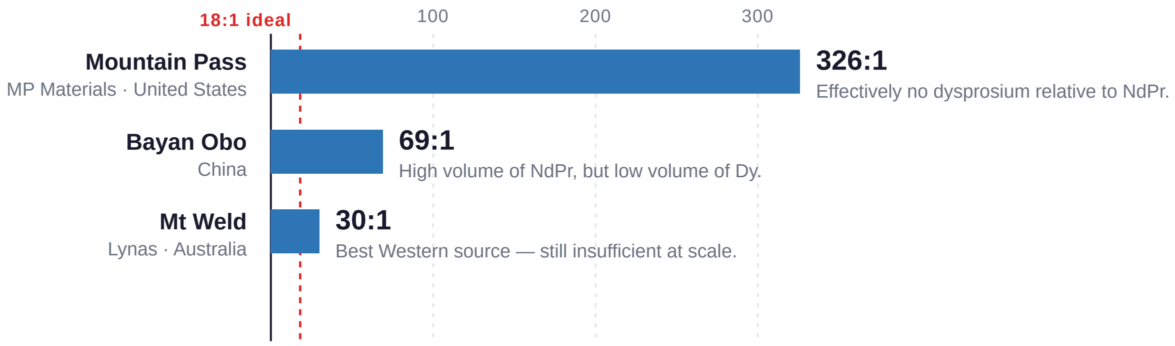
ELEMENT	ATOMIC NO.	PRIMARY USE	VALUE (USD/T)	PREVALENCE (GPT TREO)	RELATIVE VALUE
Lanthanum	57	Catalysts	557	275,944	$154
Cerium	58	Polishing, glass, alloys	1,400	437,967	$613
Praseodymium	59	Magnets	69,056	49,656	$3,429
Neodymium	60	Magnets	68,127	155,561	$10,598
Promethium	61	—	—	—	—
Samarium	62	Magnets, catalysts	1,982	19,922	$39
Europium	63	Phosphors	19,820	3,667	$73
Gadolinium	64	Nuclear, medical imaging	19,695	10,661	$210
Terbium	65	Magnets	834,860	1,589	$1,326
Dysprosium	66	Magnets	190,140	6,061	$1,152
Holmium	67	Magnets, standards	62,243	822	$51
Erbium	68	Fiber optics, medical lasers	41,743	3,156	$132
Thulium	69	Lasers	—	594	—
Ytterbium	70	Radiation sources, atomic clocks	12,836	1,972	$25
Lutetium	71	Medical detectors	637,920	456	$291
Yttrium	39	Phosphors, coatings	5,698	32,050	$183
Scandium	21	Metal alloys	606,950	—	—

Magnet-relevant elements highlighted. Sources: Geological reports, company reports, Shanghai Metals Market pricing.

04 · THE GEOLOGICAL PROBLEM

Western deposits have the wrong ratios

High-temperature magnets require a roughly 18:1 ore ratio of Nd/Pr to Dy. The world's major deposits are extremely unbalanced — Western mines are heavily skewed toward the wrong end of the basket.



NDPR-TO-DY RATIO · LOWER IS BETTER FOR HIGH-TEMPERATURE MAGNETS

The implication: scaling Western magnet supply will overproduce NdPr long before it produces enough Dy/Tb. To increase Dy/Tb output, miners must massively scale total ore production — which floods the market with excess NdPr while still falling short on the heavy rare earths that actually drive performance in EV and defense applications.

05 · WHY DYSPROSIUM MATTERS

The element you cannot engineer around

Dysprosium is essential to several of the most important technology transitions happening right now:

→ Maintains magnetic performance at high temperatures over long periods

→ Essential for EV propulsion motors

→ Required in wind turbines, drones, jets, missiles, and robotics

→ Shortages cannot be engineered around without redesigning the underlying motor

Dy and Tb are not interchangeable inputs. They cannot be swapped, reduced, or replaced with other elements without redesigning the magnet — and often the motor itself — from scratch. That structural rigidity is what makes the supply constraint binding.

06 · THE SUPPLY SOLUTION

Ionic clay deposits — the heavy rare earth source

Unlike hard-rock mines, ionic clay deposits have far better ratios for high-temperature magnet applications, lower waste content, and cheaper extraction economics.

- → NdPr-to-Dy ratios of approximately 9:1 — far better suited to magnet manufacturing
- → Much lower cerium content, which is largely a waste product in this supply chain
- → Low-cost leaching extraction using ammonium sulfate, rather than capital-intensive hard-rock processing

These deposits are the basis of China's dominance in Dy/Tb production. The same geological structures are now being identified in Chile, Brazil, and Southeast Asia. In the West, commercialization is being led by companies like Aclara Resources (ARA.TO).

> **INVESTMENT IMPLICATION**
>
> Ionic clay producers are strategically important because they can supply the exact materials that Western magnet makers are missing. The bottleneck is not light rare earths — it is heavy rare earths in the right ratio at scale.

07 · LONG-TERM DEMAND

Where the market stays structurally tight

Taken together, the supply data points to a rare earth market where heavy rare earths (Dy/Tb) remain the structural constraint. Three forces hold this thesis in place even under different demand scenarios:

- → Even if EV demand slows or shifts toward hybrid models, magnet intensity per vehicle stays high — particularly in series hybrid (SHEV) configurations
- → Western deposits cannot supply enough Dy/Tb without massively oversupplying Nd/Pr first, breaking the project economics
- → New motor technologies like axial-flux designs may gradually reduce reliance on Dy, but they do not eliminate the need for NdFeB magnets altogether

For investors, the asymmetric opportunity sits with companies that produce meaningful amounts of heavy rare earths or that manufacture high-performance magnets — the two genuine bottlenecks of the Western supply chain. Light rare earth miners face oversupply risk if the market shifts or if Western producers are forced to scale inefficient deposits to chase Dy. The market remains structurally tight where it matters most, and capital should follow those pressure points.

08 · TECHNOLOGY SUBSTITUTES

Promising research, but not an immediate threat

Persistent shortages in Dy/Tb have pushed researchers to explore alternative magnet materials and motor architectures. Two emerging categories are scientifically credible but commercially immature.

A · RARE-EARTH-FREE MATERIALS

Tetrataenite & Iron Nitride

Tetrataenite (Fe-Ni alloy) could in theory match NdFeB magnet strength and has been synthesized in laboratories — but has not been commercialized at scale.

Iron Nitride (FeN) has extremely high theoretical strength (143 MGOe), but real-world stability remains unproven. Companies like Niron Magnetics may be overly optimistic on near-term timelines.

Both face open challenges in stability, coercivity, large-scale manufacturing, and reproducibility. Neither is close to displacing NdFeB for industrial applications.

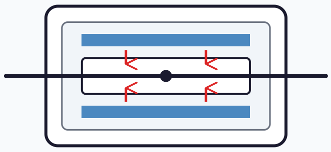
B · ALTERNATIVE MOTOR DESIGN

Axial-flux motors

Rather than replacing the magnet material, this category replaces the motor architecture itself. Axial-flux motors — being commercialized by companies like YASA (Mercedes) — deliver higher power density and improved cooling using less NdFeB material.

If axial-flux gains broader adoption in Western EV platforms, long-term dysprosium demand would cool somewhat — though NdFeB magnets still play a central role.

RADIAL FLUX · CONVENTIONAL

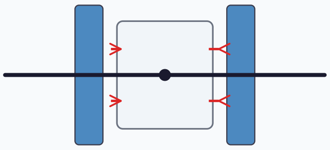


Flux perpendicular to shaft

Cylindrical geometry

Magnetic flux travels radially outward from the shaft. Standard architecture in most current EV drivetrains.

AXIAL FLUX · EMERGING



Flux parallel to shaft

Pancake geometry

Magnetic flux travels along the axis between two rotor discs. Higher power density, less NdFeB per unit output.

Schematic comparison · Radial vs axial flux geometry. Magnets shown in blue, flux direction in red.

BOTTOM LINE

Both alternatives are worth monitoring but neither poses a near-term threat to rare earth demand. In the medium term the bottleneck remains heavy rare earth supply, and the investment focus stays on companies positioned in magnet manufacturing and HREE production.