The Geopolitics of Critical Minerals

Some Provocations

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The Big 3 Ideas

- Not all critical minerals are as critical in the same way.
- We overestimate China's geopolitical *leverage* on account of its dominant position in critical mineral supply chains.
- We underestimate the substitutes and alternatives being developed.

Understanding National Definitions

- Critical Minerals: non-fuel minerals that are
  - essential in use
  - subject to supply risks (geologic, technical, environmental and social, political, economic)[1]
  - US, EU, India, etc., use this terminology.
- Strategic Minerals:
  - important for strategic industries
  - May also indicate if they can be used as foreign policy levers[2]
  - Russia & China use this nomenclature.

[1] National Research Council (NRC), *Minerals, Critical Minerals, and the U.S. Economy*, 2008

[2] J. Zhou and A. Månberger, Critical Minerals and Great Power Competition: An Overview, SIPRI, October 2024, https://doi.org/10.55163/WEMJ9585.

An illustration

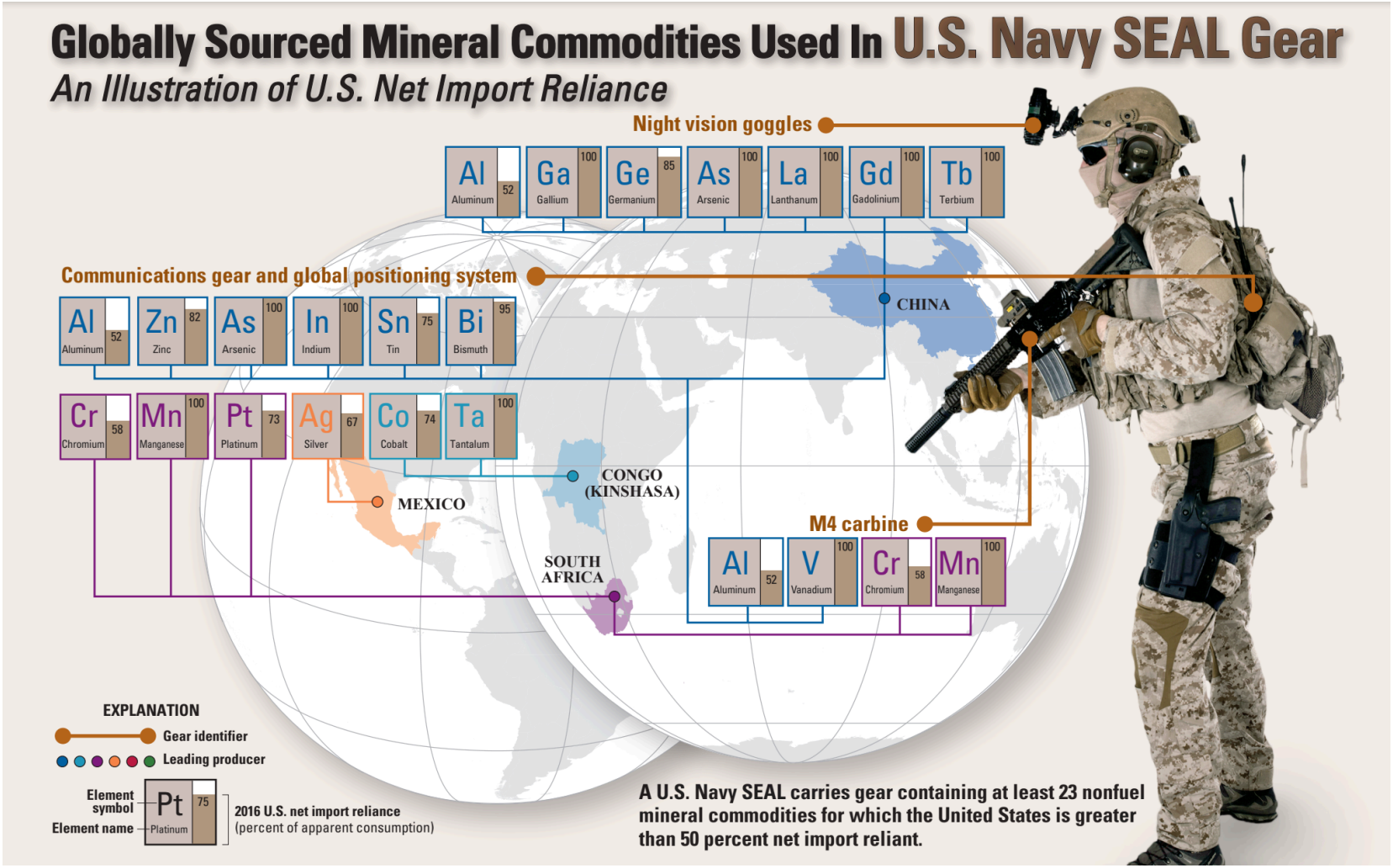

Figure 1: Source: USGS

Weaponisation of Everything is not New

- 'Geopolitics of the 1930s was partly rubber politics'[3]
- Mercury was critical in the 1950s because it was used in walkie-talkies during the Korean War
- 'Materials Myopia' of the 1980s.
  - Cobalt (97%), Manganese (98%), Chromium (91%), and Platinum (87%) were the big four.
  - Cobalt was used in jet engine superalloys. DRC Rebels occupied region with cobalt mines.
  - But no oil shock: military stockpiles, substitutes (Molybdenum & composites, high prices), alternatives (new mines)

When a nation-state enjoys a state of creative insecurity, its rate of innovation will tend to accelerate.[4]

[3] Baums, Ansgar, and Nicholas Butts. 2025. *Tech Cold War: The Geopolitics of Technology.*

[4] Taylor, Mark Zachary. 2016. *The Politics of Innovation*

The Latest Version of MineralPolitik

- In 2002, Spain came up with a "priority" minerals list
- After the 2010 Senkaku Islands dispute and China's use of export restrictions, several countries started defining critical mineral lists
- Today, 20+ countries have such a list.
  - 2022 CML in the US had 50 elements
  - India's CML has 46 elements (~40% of the periodic table)

Critical Minerals are not Oil - Feature 1

- Oil is a fuel; critical minerals are materials
- Oil blockades cause economy-wide inflation
- Quantities of some critical minerals required is tiny; making stockpiling and recycling an option
- Critical mineral embargoes are not as effective as oil blockades

The Supply Chain - Feature 2

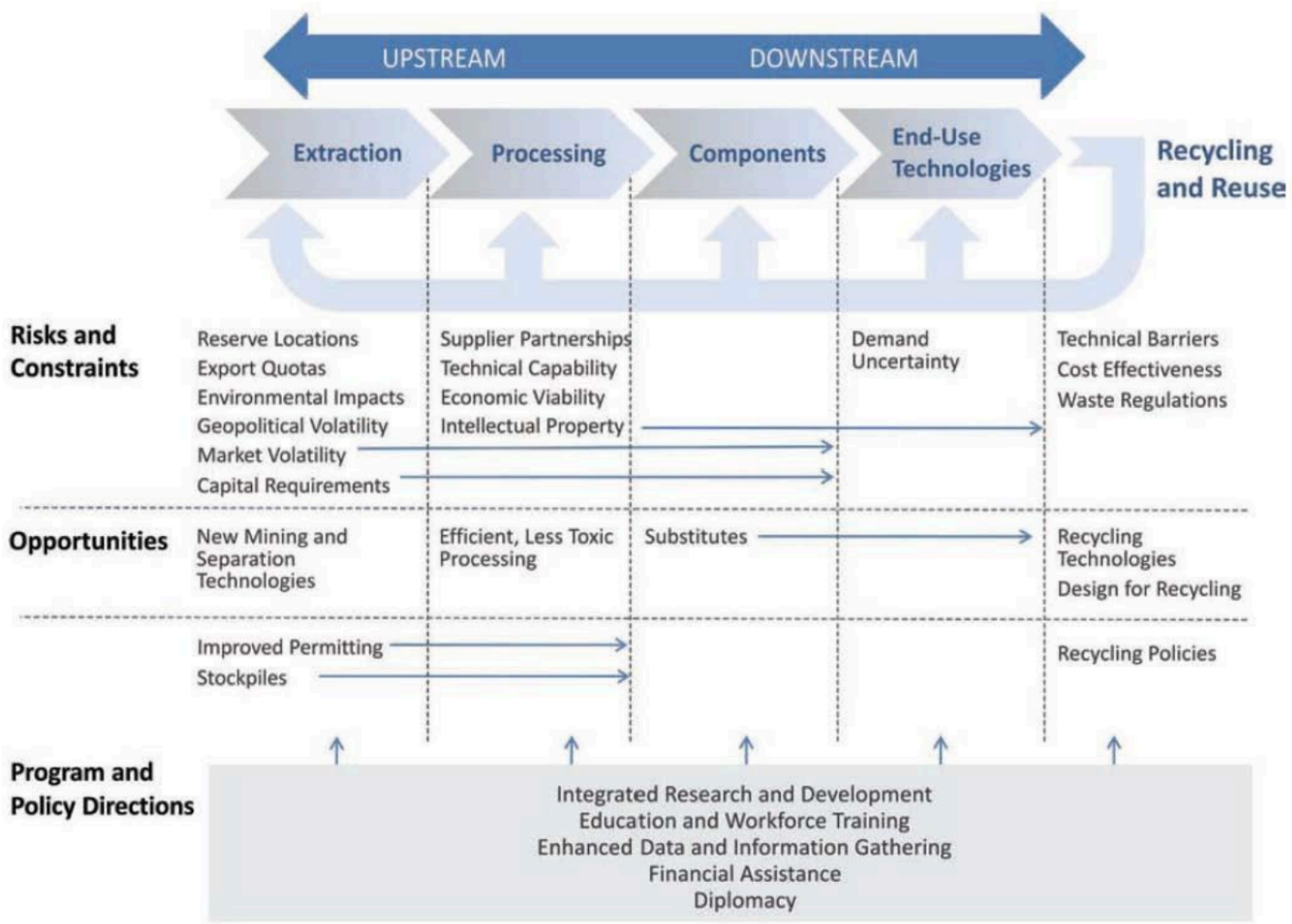

Figure 2: Source: USGS

China's Dominance

1. As a process, quite like Taiwan becoming a force in semiconductor manufacturing
2. Over two-thirds of the production of rare earths; over 80% share of processing
3. Over 70% import dependence on Copper, Lithium, Nickel, Titanium, and Cobalt; also an importer of REE concentrates
4. Developed refining and processing of REEs once the West left the field open even though the tech was developed in the West
5. SOEs and overseas investments in recent years

Low prices, dumping, high investment, and structural overcapacity (not geopolitical).

China's Weaponisation. It's Different from 2010. I

- July 2023: Export Control Licenses for Gallium and Germanium, requiring permits and end-use verification
- Dec 2023: A ban on the export of rare earth processing technologies (extraction and separation) comes into force
- Sep 2024: Export controls on antimony take effect, covering ores, metals, oxides, and processing technologies
- December 2024: Export Licenses for the US denied on Gallium, Germanium, and Antimony.
- April 2025: Special Licenses needed for export of seven rare earth elements and magnets used in the defense, energy, and automotive sectors.

China's Weaponisation. It's Different from 2010. II

- Oct 2025: Seven new controls, six are materials-related
  - any high-end battery technology must get Chinese government approval for exports.
  - export of rare earth elements and products meant for advanced semiconductor (<=14 nm logic, >=256-layer memory) production or for defence applications. These elements are used in minute quantities and hence there is a *de minimis* clause. So if *Applied Materials China* makes some of these products, it can't sell outside China without the CPC's blessing.
  - licensing requirements on exporters who have anything to do with "technologies related to rare earth mining, smelting and separation, metal smelting, magnetic material manufacturing."

China's Weaponisation. It's Different from 2010. III

- licensing requirements are in place for the export of superhard materials like specified synthetic diamond micropowder, single crystals, wire saws, grinding wheels.
- extraction systems, kilns, furnaces, electrolytic setups, magnet manufacturing lines, and rare earth raw materials and reagents also come under licensing requirements.
- controls expanded to **twelve rare earth elements** (adding Ho, Er, Tm, Eu, and Yb to the list)

- Jan 2026: targeted bans on the export of dual-use items to Japan, such as Indium compounds, Antimony, Graphite, Tungsten.

Others Are Preparing in Four Ways

1. Material-for-Material Substitution: for example, using iron or manganese (LFP) instead of cobalt in batteries.
2. System-for-System Substitution: Replacing lithium-ion batteries with hydrogen fuel cells.
3. Process-for-Process Substitution: Recycling critical minerals from old electronics instead of mining new ones.
4. Efficiency Improvements: Using less rare earths in magnets and wind turbines through better design.

Technology dependence does not necessarily imply strategic vulnerability

The case of Gallium & Germanium vs US export controls is not comparable. Think about:

- Substitutability,
- Supply chain dominance, and
- Acquired capability/technological gap

A Framework

Strategic Objective	Instruments Used	Underrated Repercussions
Denial	Secondary Sanctions	Difficult to sustain; incentives for backdoor deals with adversary
	restrictions on movement of high-tech labour	Can slow down technical progress
	Export controls, End-use restrictions	Encourages adversary to build local capacity in a focused manner
	Outgoing Investment restrictions	Can slow down technical progress
Outpace adversary	industrial espionage to steal secrets, targeted poaching	Invites stricter controls on professionals from the stealing country
	Build partnerships for resilience, like the Mineral Security Partnership	Self-sufficiency is a myth
	Indigenisation and industrial policy via offtake guarantees, equity investments, upfront capital support, price-risk mechanisms, or PLIs	Difficult to sustain.
	Encourage substitutes	Takes time for the supply chains to adjust
	Increase dependence and control by running down prices	Hurts domestic producers
Remove major bottlenecks	Increase pace of approvals for mining, refining, recycling projects	New mining projects take longer
	Build partnerships	Self-sufficiency is a myth
	Stockpiling	Works for a short duration and for minerals required in smaller quantities

Figure 3: Source: Author

Recent Diplomatic Rearrangements

- Mineral Security Partnership (32) to catalyse investments
  - 19 projects on upstream mining/extraction,
  - 15 on midstream processing, and
  - 3 on recycling and recovery.
- Critical Raw Materials Club by the EU
- Joint stockpiles
  - To mitigate immediate risks of denials
- Joint Research
  - For long-term substitutions

Lessons from the 2010 Rare Earth Restrictions

- This forced Japan to look for substitute sources, build stockpiles, invest in urban mining, and partner with other countries.
- The net result is that Japan is less dependent on China's rare earths today than in 2010 (down to 60 per cent from 90 per cent) and consumes half the rare earths it did in 2010.

Rare-earth Re-industrialisation in the US I

1. MP Materials - price-floor guarantee + offtake guarantee + equity + Apple's support for magnets
2. ReElement Technologies, based in Indiana, plans to produce 400 tons of yttrium oxide per year by March 2026
3. Vacuumschmelze announced the prodution of the first US rare earth magnet facility in 25 years.
4. Vulcan Elements completed a facility with 10,000 metric tons magnet production capacity after just 18 months, bolstered by a ten-year offtake agreement with GM. This agreement enabled Vulcan to raise $335 million via banks and secure a $620 million direct loan from the Pentagon.

Rare-earth Re-industrialisation in the US II

5. American company REAlloys and Japan's JOGMEC entered into an MoU through which JOGMEC will license its magnet processing technology to REAlloys, which has mines in Canada. REAlloys, in turn, is guaranteeing Japan access to its scandium and yttrium output from Hoidas Lake. There is a structured offtake arrangement in this deal too.
6. A Belgian firm, Solvay, will begin supplying an American magnet-making firm, Noveon Magnetics, with rare earth oxides recycled from electronic waste, starting in 2026.
7. Flash Metals USA will be productising a new technique to recycle critical minerals from electronic waste, starting in the first quarter of 2026. This technique, known as Flash Joule Heating, is more environmentally friendly than the alternatives.

A Modern Approach to Critical Minerals I

- A composite criticality score is not helpful. Copper is critical in a different way than Terbium.
- Criteria[5]:
  - global demand + projected demand till 2030
  - diversity of current suppliers
  - Global (untapped) Reserves
  - end-use applications
  - substitutability and recyclability
  - India's own resources
- This gives pathways:

A Modern Approach to Critical Minerals II

- Terbium - small demand + strategic end-use applications + lack of global reserves = stockpiling
- Copper - large demand + broad industry use + lack of domestic resources = diversify
- Lithium - large demand + broad industry use + some domestic resources = fast-track mining + diversify + recycling innovation

[5] Forthcoming Takshashila paper by Tannmay Kumarr Baid and Shobhankita Reddy

Don't Fall for Alarmist Accounts - China has not played a geopolitical masterstroke I

- Critical minerals (including REEs) aren't like oil.
- Dependence on China will not go away soon, but we don't need complete independence from China either
- China's overuse of export controls has driven other countries to find alternatives and work together. It's already overplayed its hand. China is making China+1 happen.
- Rising prices of these materials are not a problem but a pathway to a solution.
- If Chinese companies can build a DeepSeek without the most advanced GPUs, automakers across the world can definitely build electric motors without Chinese rare earth magnets.

Don't Fall for Alarmist Accounts - China has not played a geopolitical masterstroke II

- We need more focus to identify what's truly a strategic vulnerability
- Keep track of substitution. Rare earth *magnets* are vital but not indispensable.

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