Critical Minerals of Peril and Power: The Five-Element Spine of the Modern Arsenal

written by Tracy Hughes | July 6, 2025

The pilot slides his thumb across the F-35's throttle and the jet answers with a whiplash of thrust, airframe flexing like a living blade. Hidden beneath that carbon-fiber skin is a cathedral of metals the color of dusk and midnight: magnets that refuse to demagnetize in a nuclear storm, alloys that laugh at 3,000-degree infernos, atoms that turn silent radiation into radar and radios into whispers. Strip them away and the fighter becomes a hollow shell, a sculpture of ambitions never realized. Keep them flowing—day after day, shipment after shipment—and you have the **backbone of deterrence** in the twenty-first century….**critical minerals**.

Ask our Critical Minerals Institute (CMI) Co-chair and world-renowned critical minerals expert **Jack Lifton** why these elements matter and he doesn't reach for poetry. "**The issue is not the properties of these chemical elements, it's their uses,**" he tells me, voice gravelly from decades spent stalking mine heads and defense plants. In that single sentence lies the brutal calculus of modern strategy: weapons win wars, but **materials determine whether the weapons can be built in the first place**. The metals that follow—**rare earths, tungsten, titanium, gallium, beryllium**—form the unbreakable chain linking geology to geopolitics, quarry dust to combat power. Break any link and the chain snaps.

1. Rare-Earth Elements: The Invisible Engines

Neodymium-iron-boron and samarium-cobalt magnets make the impossible routine: fins that twitch in hypersonic slipstreams, gimbals that aim radar beams with surgeon precision, actuators that drop a JDAM exactly where a lieutenant in a distant trailer wants it. Lifton leans forward when he speaks of them. "**Those magnets run the controls that let an aircraft live through a nuclear electromagnetic pulse.** " Samarium-cobalt, stubborn as prophecy, keeps its magnetism even when a thermonuclear flash saturates the sky with radio fury. Neodymium magnets, meanwhile, pack a warhorse's strength into a hummingbird's weight—*one* reason a modern fighter carries nine hundred pounds of rare earths, more mass than its entire weapons bay.

Yet the supply line is a tightrope strung over a chasm. **China refines nearly nine out of every ten kilograms of these elements**, and the magnets themselves are manufactured in factories ringing the South China Sea. Western engineers dream of "mine-to-magnet" corridors in Canada, Australia, even Greenland, but ore bodies take a decade to permit and another to bankroll; magnets need sintering plants, not press releases. Until those dreams harden into furnaces, the arsenal's beating hearts come stamped "Made in Ganzhou" or "Baotou."

2. Tungsten: The Gravity of Destruction

If rare earths are the nerves of the arsenal, **tungsten is its iron fist**. At 19.3 grams per cubic centimeter it is heavier than despair—denser than uranium, minus the radiological aftertaste. Lifton doesn't mince words: "**If you want to manufacture any munitions—from artillery shells down to small-caliber bullets—you need tungsten for the penetrators.**" A discarding-sabot round traveling a mile each second depends on tungsten's weight to punch clean through a main-battle tank's Chobham armor; anti-armor missiles rely on tungsten-cum-copper liners to generate molten jets that punch through thick armor plate as if it weren't there.

Here, too, the supply ledger casts a long shadow. **China controls more than half the world's mining output and most processing capacity**. The West keeps modest strategic stockpiles, but munitions plants consume metal by the car-load, not the kilogram. Should Beijing ever slam the export gate, NATO's guns would eventually click on empty chambers. "We can produce the finest military equipment in the world," Lifton warns, "**but without tungsten, we cannot produce anything.**"

3. Titanium: The Bone of Flight

Watch a submarine knifing under polar ice or a hypersonic glide body clawing at the edge of space and you are watching **titanium inside a crucible of stress**. Lighter than steel yet strong as an oath, titanium resists corrosion in salt, shock in combat, and temperatures that make ordinary alloys sag. It frames the spine of every Western fighter, wraps the hull of deep-diving subs, and forms the casings of classified weapons that travel Mach 5 with no margin for melting.

Unlike tungsten or rare earths, titanium ore lies under friendlier flags: Australia, South Africa, the United States. But ore is just rock; defense programs run on billet and forgings. The alchemy that transforms ilmenite into certified aero-grade parts involves vacuum arc remelting, electron-beam melting, and decades of metallurgical folklore. **Russia once provided a third of the world's aerospace-quality sponge**, and sanctions after 2022 forced Western primes into frantic restructuring. New sponge plants are rising in Utah and Quebec, yet lead times stretch into 2027. Until then, every rivet of titanium holds a whisper of supply doubt in its shine.

4. Gallium: The Quiet Pulse of the Electromagnetic Frontier

Gallium can melt in your palm, but alloy it with arsenic or nitrogen and it becomes the beating heart of the electromagnetic spectrum. **GaAs and GaN transistors amplify radar waves, route gigahertz drones, and harden electronic-warfare suites against jamming**. The AN/TPY-2 radar that watches for hypersonic threats relies on tens of thousands of gallium nitride T/R modules; the F-35's Distributed Aperture System bathes the pilot in a near-panoramic IR view fed by gallium-rich detector stacks.

It is here that supply risk borders on farce: **China refines roughly 98 percent of the world's gallium**, most of it scraped from bauxite refineries as an afterthought. In July 2024 Beijing flexed its muscles, slapping export permits on gallium compounds. Western defense firms felt the sting within weeks—back-orders, price spikes, whispers of redesign. Alternative recovery from coal fly ash or European zinc plants remains pilot-scale. Lifton shakes his head: "**Gallium's measured in tons, but its importance is immeasurable. Lose it and the entire radar chain collapses.**"

5. Beryllium: Precision in the Void

Stand inside a missile silo and look up: the inertial-navigation gyroscope staring back is built on **beryllium's ghostly rigidity**. The metal is lighter than aluminum yet six times stiffer than steel, refusing to warp even at launch-g forces. Inside optical targeting mirrors, beryllium scatters heat so quickly that images stay sharp through relentless dogfights. It fortifies X-ray windows, guides satellites, and—in oxide form—insulates power transistors in space probes orbiting Jupiter.

But the element is double-edged. **Beryllium dust is toxic**, scarring lungs with incurable disease; machining must occur in sealed cells, respirators clamped to faces. Ore comes chiefly from a single U.S. mine in Utah's Spor Mountain and from stockpiles of the Defense Logistics Agency. Should that mine falter, substitutes are scarce. The Pentagon's own material baseline lists beryllium as irreplaceable for high-g seekers and strategic optics—a single-point vulnerability hiding in plain sight.

Convergence of Scarcities

Taken one by one, each metal tells a story of geochemistry and engineering; taken together, they reveal an uncomfortable pattern. **Not one of the five is both abundant in allied territory and easy to process without years of capital and licensing**. Rare earths and tungsten lie beneath Chinese soil or Chinese capital; gallium and beryllium depend on single-thread supply lines; titanium's forge chain still bears Russian fingerprints. The calculus of risk multiplies, not adds. A single diplomatic rupture, earthquake, or factory fire can cascade through the arsenal like an EMP of scarcity.

Yet there is resilience in recognition. The United States is reopening dormant mines in Texas and Wyoming, Canada is courting Greenlandic molybdenum and REE ventures, Australia is fast-tracking tungsten and scandium deposits. Allied engineers are recycling rare earth magnets from wind turbines, extracting gallium from coal ash, designing jet engines that sip rather than gulp titanium. Strategy, after all, is the art of options.

Lifton remains blunt: "**Supply chain risk—that's the metric that matters. Everything else is commentary.**" He reminds me only seven nations truly build military aircraft, and two of them—America and China—dominate the sky. In such a narrow arena, the fight for materials is already the opening skirmish of the next war. Trucks hauling REE oxides through outback deserts, barges stacked with concentrate in the Yellow Sea, railcars of sponge titanium rolling across the Rockies—all are pieces on a board where logistics equals leverage.

So, count the rivets, weigh the tungsten cores, trace the gallium from refinery to wafer. **Behind every sonar ping and every missile streaking through the upper stratosphere is a quarry, a smelter, a trader's ledger.** We win or lose long before the first trigger is pulled—out where geology meets strategy, in the quiet dominion of metals that make physics obey our will.

In that dominion, these five elements stand like cosmic sentinels: **rare earth**s for motion, **tungsten** for impact, **titanium** for backbone, **gallium** for sight and speech, **beryllium** for the precision of the gods. Protect their supply, and the arsenal breathes. Neglect them, and the mightiest army becomes a beautifully painted shell, empty of force.

Jack Lifton signs off with a final, unornamented warning: **"Without secure access to these critical minerals, the phrase 'full-spectrum dominance' is just ink on a briefing slide."** One suspects future historians will decide whether we listened.