

The 400-Kilogram Secret Inside Every F-35

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Key Takeaways

- China's control of rare earth processing, representing 91% of global supply, turns the 400 kilograms of critical minerals inside every F-35 into a strategic vulnerability and a long-term case for the [WisdomTree Efficient Rare Earth Plus Strategic Metals Fund \(WDIG\)](#).
- As Beijing tightens export restrictions on gallium, antimony and rare earths, U.S. and allied governments are accelerating domestic mining and processing investments that could reshape strategic metals over the next decade.
- The defense mineral shortage is a structural investment theme, with rising demand from military systems, EVs and AI colliding with long permitting timelines and constrained global supply.

A modern fighter jet is, among other things, a mineral supply chain problem. America's most advanced weapons systems depend on elements most defense analysts have never heard of, and most of them run through China.

There is a version of the F-35 Lightning II story that gets told as a triumph of American engineering.

- The most advanced fighter jet ever built.
- Stealth geometry that confounds radar.
- Sensors that see further than any system that came before.

Essentially, a single aircraft that can outfly, outthink, and outlast almost anything in the sky.

There is another version that almost never gets told. Before any of that engineering becomes possible, more than 400 kilograms of rare earth elements must be mined and processed for each aircraft.¹ Neodymium and praseodymium for the motors that actuate flight control surfaces. Terbium and dysprosium to keep those magnets functional at the extreme temperatures of combat operations. Europium and erbium in the display systems and laser rangefinders. Samarium in the guidance systems. The F-35 is, among other things, a monument to the periodic table, and most of what it is built from comes from China.²

This is the story of the defense mineral basket: fourteen elements that sit at the intersection of national security and supply chain vulnerability, and the slow, expensive, often agonizing effort to understand what that exposure actually means.

What the Basket Actually Contains

The defense basket, as defined by the U.S. Geological Survey's critical minerals framework, groups minerals whose primary economic significance is military.³ But the category is, if anything, an understatement. Several of the fourteen minerals have dual-use applications that make the supply chain problem substantially worse:

The same mineral that goes into an EV motor also goes into a missile guidance system, which means civilian demand and military demand compete for the same constrained supply.

Tungsten, atomic number 74, is perhaps the most straightforward case. Its melting point of 3,422 degrees Celsius—the highest of any element—makes it irreplaceable for armor-piercing munitions, where the penetrator rod must maintain structural integrity under the heat and pressure of impact. It is also used in jet engine components and cutting tools. China mines approximately 83% of the world's tungsten and controls 85% of processing. U.S. import reliance exceeds 50%.⁴

Beryllium is the exception that proves the rule. The United States is one of the few cases in this landscape where America actually leads: the U.S. accounts for roughly 50% of global beryllium production. The F-35 and most advanced aerospace platforms rely on beryllium alloys for critical electrical and mechanical components, exploiting the metal's extraordinary stiffness-to-weight ratio. The complication is berylliosis, a serious and sometimes fatal lung disease caused by beryllium exposure, which limits how aggressively the U.S. can expand production even when it holds the resource advantage.⁵

The ore is global. The processing is Chinese. And America has limited capabilities for most of it. One export ban, one licensing restriction, or one escalation could trigger a supply crisis.

The Rare Earth Problem Is Structural

To understand why the defense mineral problem is so difficult to solve, you have to understand rare earth processing, specifically, why the chemistry that transforms rare earth ore into separated, usable metals is so hard to replicate.

Rare earth elements are, despite their name, not particularly rare in the earth's crust. They are rare in concentration. Unlike copper or iron, which form discrete mineral deposits, rare earths tend to occur together in low-grade, geologically complex deposits, and separating them from each other requires a specialized form of chemistry called solvent extraction, which translates to hundreds of stages of mixing, settling, and separation that must be calibrated precisely for each deposit's unique mineralogy. The knowledge required is deep, site-specific, and accumulated over decades.

The United States had that knowledge. The Mountain Pass mine in California's Mojave Desert was, through the 1980s, the world's leading source of rare earth elements.⁶ Then, attracted by lower labor costs and fewer environmental restrictions, Western manufacturers began shifting production to China. China classified rare earth elements as protected strategic resources in 1990.⁷ Two years later, Deng Xiaoping made his now-famous declaration: the Middle East has its oil, China has rare earths.⁸ What followed was a

15-year consolidation. By 2010, China owned the industry. The U.S. had walked away from both the mines and the chemistry.

Today, China mines approximately 69% of the world's rare earth elements and processes 91% of them.⁹ Among the defense-critical rare earths are:

- Neodymium
- Praseodymium
- Dysprosium
- Terbium
- Samarium

China's export restrictions are not hypothetical. The USGS model assigned a 100% probability of Chinese supply disruption to 17 minerals, because China had already imposed bans or export licensing requirements on them. Samarium, critical for the SmCo permanent magnets used in jet engines and precision-guided missiles, carries a probability-weighted GDP impact of \$4.5 billion under the model, and carries a 100% probability because the restriction is already in place.¹⁰

Defense Risk Doesn't Stay in the Defense Basket

One of the most important insights in the critical minerals literature is also one of the least intuitive:

The defense basket, as a category, is a convenient fiction. Weapon systems don't draw from one basket. They draw from all of them simultaneously.

Consider a single weapons platform in full operational context. The airframe uses titanium, which comes from the defense basket, where China controls 69% of mining. The magnets in its electric actuators are neodymium-iron-boron, which is from the magnet basket, where China controls 91% of processing. The radar and electronic warfare systems depend on gallium arsenide chips, which is from the chip and display basket, where China controls 99% of gallium production. The batteries in backup power systems use cobalt and lithium, which are from the battery basket. The targeting display is indium tin oxide, which is, again, from the chip basket, where China controls 70% of indium production.¹¹

The Department of Defense's own risk assessment maps this cross-basket exposure explicitly. Antimony trisulfide ties to military primers, cartridges, and missile items. Gallium and germanium feed semiconductors, infrared lenses, and electronic warfare systems. The NdPr and dysprosium in permanent magnets run through aircraft, missiles, submarines, UAVs, radar, and tank navigation. The DoD has specifically flagged Chinese restrictions on gallium, germanium, and antimony as supply-chain disruption risks, all three of which China has now acted on.¹²

The same dysprosium in an electric vehicle motor is in a missile guidance system. Civilian demand and military demand compete for the same constrained supply from the same Chinese processing facilities.

The Response: Faster Than Anyone Expected, Slower Than Anyone Hoped

The U.S. government has not been idle. The response to mineral vulnerability has, in fact, been both bipartisan and concrete, in part because the military implications are difficult to argue with in the abstract, and in part because the exposure has become impossible to ignore as China has begun selectively acting on it.

The Department of Defense awarded more than \$439 million under the Defense Production Act to companies working on rare earth processing and separation. One recipient, Noveon Magnetics, is working to establish domestic rare earth magnet manufacturing. Another critical investment: in 2025, the DoD made a \$400 million equity investment in MP Materials, which operates the Mountain Pass mine in California, the same facility that was the world's rare earth center before the industry moved to China. Starting in July 2025, MP ceased all sales to China and began pivoting its supply entirely toward the U.S. defense industrial base.¹³

Lynas Rare Earths, an Australian company operating through a U.S. subsidiary, received \$120 million to build the first commercial heavy rare earth separation facility on American soil. In March 2026, Lynas signed a new \$96 million supply agreement with the DoD, the kind of binding, long-term commitment that makes it possible to justify the capital expenditure of rebuilding an industry from the ground up.¹⁴

The antimony case is instructive for what it reveals about speed. In early 2024, the U.S. had no domestic antimony production at all. China controls roughly 60% of global mining and announced export licensing requirements in August 2024, then escalated to a full ban on U.S. exports by December. The DoD responded with an \$80 million award to Perpetua Resources in Idaho. Construction began in late 2025. Production is expected to begin in 2028. The four-year gap between the export ban and the first domestic ounce of production is considered a fast timeline.¹⁵

The 29-Year Problem

The deepest structural challenge is not funding or political will. It is time. In the United States, the average elapsed period from mineral discovery to commercial production is 29 years, which is the second-longest timeline in the world.¹⁶ Permitting a new mine takes 7 to 10 years. In Canada and Australia, countries with comparable environmental standards, permitting takes two years. The difference is not environmental rigor—it is overlapping jurisdictional review, National Environmental Policy Act requirements that can generate environmental impact statements taking a decade to complete, and litigation exposure that creates uncertainty even after permits are granted.

China faces none of these constraints. Its centralized approval process can move in months. The World Health Organization (WHO) estimates that more than one million Chinese citizens die prematurely each year from the pollution generated by mineral mining and processing.¹⁷ That is, in the most direct sense, the price China has decided to pay for supply chain dominance. The strategic calculation embedded in that trade-off is not one the United States can or should replicate. But the time asymmetry it creates is real, and the consequences compound.

A processing plant for critical minerals takes between 18 months and five years to build after permits are in hand, and then requires separate permits and construction timelines for each downstream processing

stage. The accumulated delay means that policy decisions made today about rare earth processing will not produce domestic supply until the early 2030s at the earliest. Meanwhile, the demand curve for defense systems, EVs, and AI infrastructure continues rising.

What the F-35 Actually Tells Us

The 400-kilogram figure is not a design flaw. It is a feature. The F-35's capabilities, the sensors, the magnets, the guidance systems, the display technology, require those specific elements because no other materials produce the same properties. There is no engineer's workaround that replaces dysprosium in a high-temperature permanent magnet, or samarium in a SmCo guidance system, or beryllium in an aerospace structural component. The physics are what they are.

What the F-35 tells us, and what the broader defense mineral basket tells us, is that the line between economic competition and military readiness has effectively dissolved. Export restrictions on gallium are not just trade policy—they are a decision about whether American radar systems can be manufactured and maintained. An export ban on antimony is not just a commodity play—it affects military primers and munitions production. The minerals in that aircraft are not separate from the geopolitical contest over who builds and supplies them. They are the contest.

The uranium story from 1939 ended with the United States finding the world's purest deposit in the Belgian Congo and using it to end the war. The critical mineral story of the 2020s has no such tidy resolution available. There is no single deposit that solves the problem. There is only the slow, expensive, unglamorous work of rebuilding supply chains that were handed away over 30 years of shortsighted cost optimization, and the question of whether enough of that work can be completed before the next export ban makes the answer matter.

Conclusion: One Strategy with Two Types of Strategic Metal Exposure

The 400 kilograms of rare earth elements inside every F-35 are not an anomaly. They are a precise illustration of how completely advanced military capability has become inseparable from mineral supply chains, supply chains that, for the most critical materials, run almost entirely through Chinese processing facilities.

The defense basket is the sharpest version of a problem that runs across all seven critical mineral categories. The ore is global. The processing is concentrated. And the timeline to rebuild domestic alternatives is measured in decades, not years.

For investors, that structural reality has a mirror image. The same supply constraint that creates national security vulnerability also creates a long-term investment signal. The companies mining, refining, and securing these materials are building infrastructure the modern economy cannot function without, and the commodities themselves sit at the intersection of accelerating demand and deliberately constrained supply.

The [WisdomTree Efficient Rare Earth Plus Strategic Metals Fund \(WDIG\)](#) was designed for exactly this environment, combining equity exposure to global producers navigating these supply chains with direct commodity exposure through a diversified metals futures basket in a single capital-efficient structure.

The minerals inside the F-35 are not going to be replaced by something more convenient. Neither is the investment case for owning the companies and commodities that supply them.

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Important Risks Related to this Article

There are risks associated with investing, including possible loss of principal. The Fund is actively managed and invests in commodity metals futures contracts from an eligible exchange, and equity securities issued by global companies primarily involved in strategic metals and rare earths mining activities.

The value of metal commodities, such as various mined metals and commodity-linked derivative instruments, such as commodity metals futures contracts, typically is based upon the price movements of the physical commodity or an economic variable linked to such price movements. Price movements in metals and commodity metals futures contracts may fluctuate quickly and dramatically, have a historically low correlation with the returns of the stock and bond markets, and may not correlate to price movements in other asset classes.

By investing in the equity securities of metal miners, the Fund may be susceptible to financial, economic, political, or market events that impact the metal mining industry. Derivatives are used by the Fund to gain exposure to strategic metals and rare earth mining activities. Derivative investments can be volatile and may be less liquid than other investments. As a result, the value of an investment in the Fund may change quickly and without warning you may lose money. A fund that has a portfolio that is concentrated in the securities of issuers in a particular industry or group of related industries, may be adversely affected by the performance of those securities, and more susceptible to adverse economic, market, political, or regulatory occurrences affecting that industry or group of related industries.