



Critical Minerals Consortium

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Scandium and Vanadium: Two Critical Metals the United States Cannot Afford to Ignore

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The United States leads the world in aerospace, defense, energy, and advanced manufacturing. Yet two critical metals—largely unknown outside technical circles—have become increasingly important to maintaining that leadership.

The numbers tell a story that should command attention.

Scandium and vanadium are performance multipliers. Used in fractions of a percent, they make aircraft lighter, steel stronger, batteries longer-lasting, communications systems more capable, and advanced manufacturing more efficient. As competition for leadership in aerospace, defense, energy, artificial intelligence, and advanced manufacturing intensifies, demand for these performance gains will continue to grow.

Yet the supply picture tells a very different story.

Global production of scandium oxide totals only about 30–40 tonnes per year. China accounts for roughly 80–90% of that supply, with most of the remainder coming from Russia, Kazakhstan, Ukraine, and the Philippines. The United States produces essentially none commercially.¹

China, similarly, produces roughly 65–70% of the world's vanadium, while Russia, South Africa, and Brazil account for most of the remainder. The United States has no significant primary vanadium mine.²

Those supply chains matter because remarkably small additions of scandium and vanadium can unlock disproportionately large performance gains.

Small Additions, Outsized Effects

The strategic value of both metals lies in a simple engineering principle: tiny additions produce outsized performance gains.

Scandium

Scandium is a lightweight transition metal with a density of 2.99 g/cm³—roughly one-third that of steel. Its value emerges when engineers add just 0.1–0.5% scandium to aluminum.³

Those trace additions improve strength, weldability, fatigue resistance, and thermal stability while increasing an alloy's weight by less than 0.5%.

Those performance gains are not merely theoretical—they have already found practical applications across military, commercial, and industrial products. The Soviet Union incorporated aluminum-scandium alloys into the MiG-29,⁴ while Airbus later commercialized the technology through Scalmalloy® for additive manufacturing. A 3D-printed A320 cabin partition demonstrated a 45% weight reduction—approximately 30 kilograms—compared with the conventional design.⁵ Smith & Wesson's Model 340PD similarly weighs roughly 45% less than a comparable steel revolver.⁶ Aluminum-scandium nitride (AlScN) is also emerging in RF electronics, where scandium increases the piezoelectric response by roughly 4–6×, enabling higher-performance 5G and future 6G communications.⁷

Vanadium

While scandium creates value by improving lightweight, high-performance components, vanadium delivers a similar effect at an entirely different scale. Adding only 0.05–0.15% vanadium can increase the yield strength of steel by roughly 30–100%, depending on the alloy and application, while simultaneously improving toughness, wear resistance, and fatigue life. Approximately 90% of global vanadium demand still comes from steel.

China has embraced vanadium on an industrial scale. Its experience demonstrates how small additions to steel can deliver substantial engineering advantages at minimal cost. Revised rebar standards increased vanadium content, enabling production of higher-strength rebar with yield strengths increasing from 400 MPa to 500 MPa (25%) and up to 600 MPa (50%) in higher-grade applications.⁸ The result is stronger, more earthquake-resistant infrastructure. Chinese rebar now accounts for roughly 40% of global vanadium demand, illustrating how relatively small changes in engineering standards can reshape demand for a critical mineral.⁹

Vanadium is also a key ingredient in Ti-6Al-4V—the world's most widely used aerospace-grade titanium alloy (6% aluminum, 4% vanadium, balance titanium).¹⁰ Its exceptional strength-to-weight ratio enables engineers to build aircraft, missiles, spacecraft, and gas turbines that are lighter without sacrificing strength, improving fuel efficiency, payload capacity, maneuverability, and component life.

Beyond aerospace, vanadium is the active energy-storage material in vanadium redox flow batteries (VRFBs). Unlike the lithium-ion batteries used in electric vehicles, which gradually lose capacity over time and are typically expected to last about a decade, VRFBs are designed for stationary electrical grids, where durability matters more than weight. They can operate for more than 20 years, withstand 20,000–30,000 charge-discharge cycles with minimal degradation, and provide 4–12+ hours of energy storage, making them well suited for integrating intermittent solar and wind generation.¹¹

Although they serve very different markets, both metals demonstrate the same principle: tiny additions can produce disproportionately large improvements in performance. Those engineering advantages have limited strategic value if they cannot be produced at scale.

The Problem Is Not Geology. It Is Industrial Capacity.

The United States produces essentially no commercial scandium and has no significant primary vanadium mine. In an era when governments are moving beyond the lowest-cost supply chains and prioritizing resilient domestic and allied industrial capacity, that reality carries growing strategic significance. For critical minerals such as scandium and vanadium, the challenge is not simply geology—it is the ability to mine, process, refine, and manufacture at commercial scale.

Scandium is not exceptionally rare in the Earth's crust—it occurs at roughly 22 parts per million, comparable to lead.¹² What is rare are deposits concentrated enough to support a standalone mine.

Instead, scandium is recovered primarily as a byproduct of titanium, nickel, uranium, rare-earth, and alumina processing. That creates a structural constraint: higher scandium demand does not automatically produce higher scandium supply. Producers often must expand an entirely different mining operation to recover additional scandium.

Vanadium benefits from more production pathways—including titanomagnetite ores, steel slags, petroleum residues, and spent refining catalysts—but production remains heavily concentrated geographically.

The result is an uncomfortable reality:

The United States can design and build the world's most advanced aircraft, missiles, satellites, power systems, and electronics, yet it remains dependent on foreign suppliers for many of the critical materials those technologies require.

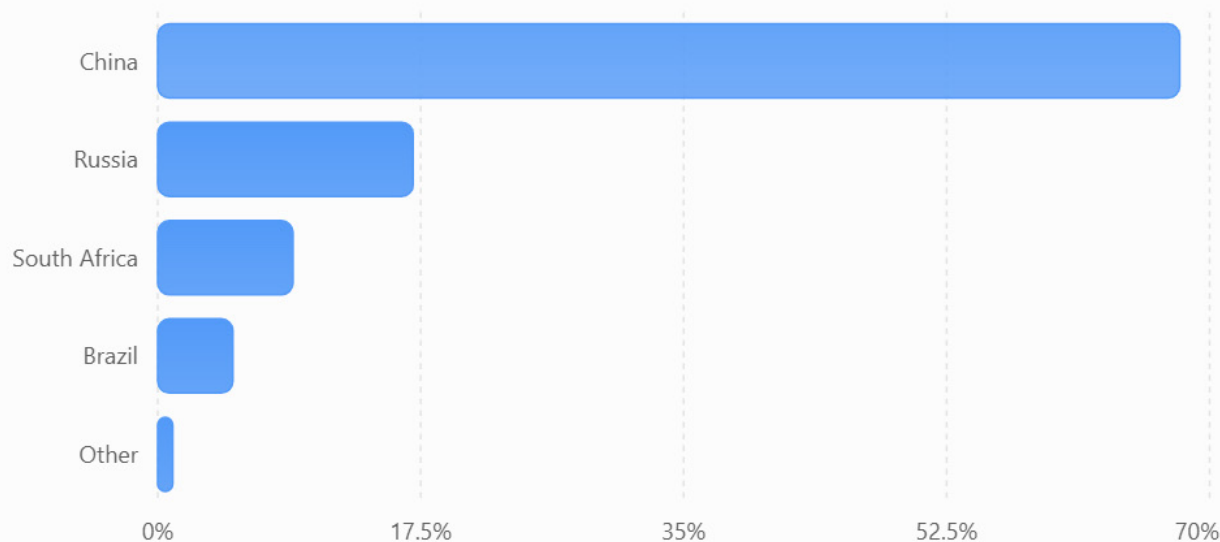
If the United States has the resources, why hasn't it built these supply chains?

The answer is not geology. The United States possesses significant mineral resources but has struggled to convert them into commercial production. New mining projects often require 10–20 years to move from discovery to operation because of permitting requirements, environmental reviews, financing challenges, infrastructure needs, and litigation risk.²³ During the same period, countries such as China invested aggressively across the entire mining, processing, refining, and manufacturing value chain, building the industrial capacity that increasingly underpins today's critical mineral supply chains.

Closing that gap will require more than recognizing the problem. It will require rebuilding the industrial capacity needed to compete. Trusted allies such as Canada and Australia—which have already made significant progress in developing commercial critical mineral projects—will remain indispensable partners. However, resilient supply chains require more than diversified imports. They require domestic mining, processing, refining, and manufacturing capacity capable of supporting long-term industrial demand.

Global vanadium production is heavily concentrated

Approximate production shares using midpoints of commonly cited ranges.



Shares are approximate; figures are intended to show concentration, not exact annual tonnage.

China Holds the Stronger Hand Today

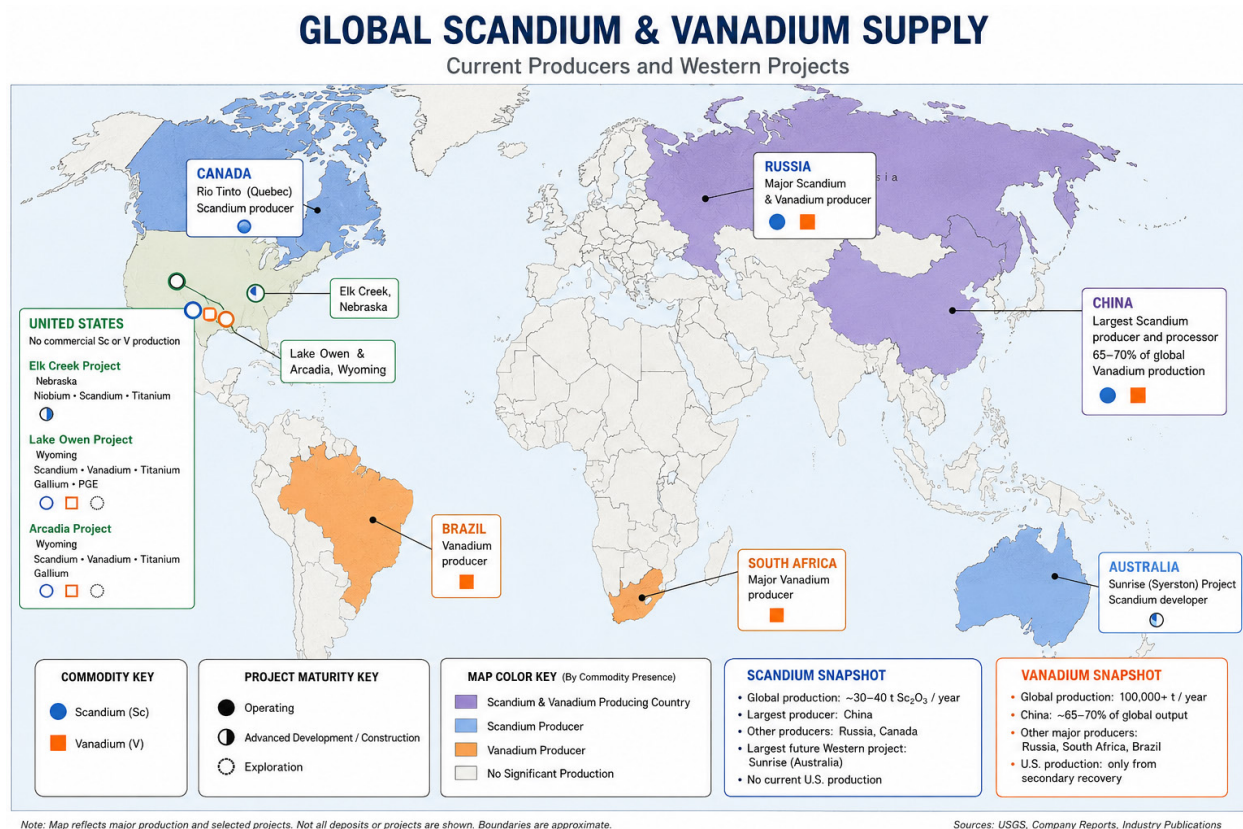
China dominates scandium production and refining while producing roughly 65–70% of global vanadium output.² Russia remains another major supplier, giving a small number of countries significant influence over materials increasingly essential to aerospace, defense, energy, and advanced manufacturing. This concentration gives relatively few countries significant influence over supply chains that support critical industries worldwide.

Outside China, Canada currently provides North America's only commercial scandium production through Rio Tinto's Quebec operations,¹³ while Australia's Sunrise (Syerston) Project is expected to become the world's first large-scale primary scandium mine, representing an important opportunity to diversify Western supply.¹⁴

The United States, by contrast, has no commercial scandium production and no significant primary vanadium mine. Instead, it relies largely on imports and limited secondary recovery despite possessing significant domestic mineral resources. Advancing promising projects from exploration to commercial production will be essential to strengthening domestic supply.

The most advanced is NioCorp's Elk Creek Project in Nebraska, a proposed 38-year niobium-scandium-titanium operation supported under the Defense Production Act.¹⁵ In Wyoming, Lake Owen and Arcadia, both controlled by Meta Critical Minerals, target scandium, vanadium, titanium, gallium, and other critical minerals.¹⁶ Although still in the exploration stage, they represent some of the few domestic opportunities to develop multiple strategically important minerals from a single district.

The United States has the geology. What is needed is converting geological potential into dependable production through exploration, processing, financing, and commercial development.



Washington Has Started Moving

Recognizing the strategic importance of scandium and vanadium, the federal government has begun treating critical minerals as an industrial-base issue rather than simply a commodity issue. Rather than relying solely on market forces, agencies including the Department of Defense (DoD), Defense Logistics Agency (DLA), and Office of Strategic Capital (OSC) are using procurement, strategic stockpiling, cost-share funding, and non-dilutive financing to strengthen domestic and allied supply chains.

The Defense Logistics Agency (DLA) launched a roughly \$1 billion critical minerals acquisition initiative to rebuild the National Defense Stockpile.¹⁷ By purchasing critical minerals before they are urgently needed, DLA strengthens strategic reserves while providing producers with the long-term demand needed to justify new mining, processing, and refining capacity. For scandium, DLA proposed purchasing up to 6.4 tonnes of scandium oxide from Rio Tinto, valued at up to \$40 million over five years.¹⁸ Against annual global production of only 30–40 tonnes, that single procurement could represent roughly 16% of one year's worldwide supply, demonstrating how government procurement can influence even the world's smallest critical mineral markets.

DoD is also reducing technical risk. Through Title III of the Defense Production Act (DPA), it committed \$29.9 million in cost-share funding to ElementUSA to demonstrate domestic recovery of scandium and gallium from alumina-processing waste.¹⁹ Rather than purchasing minerals, the government is helping prove a new extraction process that industry can later commercialize. Meanwhile, OSC is reducing financial risk through non-dilutive financing. In 2026, it announced a conditional \$400 million, 25-year loan commitment to Sunrise Energy Metals Limited (ASX: SRL) to expand its scandium operations at the Syerston Scandium Project in New South Wales, Australia, providing long-term capital without requiring the company to give up equity.¹⁴

For vanadium, the government paired procurement with policy. The FY2026 National Defense Authorization Act (NDAA) expanded sourcing restrictions on covered materials—including vanadium—from foreign entities of concern,²⁰ while DLA's Strategic Materials team awarded US Vanadium LLC, majority owned by TechMet USA Inc., an eight-figure, three-year contract—the largest in the company's history—to supply high-purity vanadium pentoxide (V₂O₅) flake for the National Defense Stockpile. US Vanadium is the only current domestic producer of high-purity vanadium pentoxide, operating two facilities in Arkansas, in Benton and Hot Springs.²¹

Together, these initiatives represent a broader shift in industrial policy. Procurement creates demand. Stockpiles provide strategic reserves. Cost-share funding helps commercialize new technologies. Non-dilutive financing helps move major projects toward production. Together, these tools reduce private-sector risk and encourage the investment needed to expand mining, processing, and refining capacity. They also underscore an important reality: resilient supply chains cannot be created through procurement and sourcing restrictions alone. They ultimately depend on building the domestic and allied industrial capacity needed to produce these critical materials at scale.

The Opportunity Is Bigger Than Defense

Although national security has driven much of the recent attention, the commercial opportunity extends far beyond defense. Scandium and vanadium support industries that collectively represent trillions of dollars in global economic activity, from aerospace and energy to advanced manufacturing, transportation, electronics, and infrastructure.

Scandium already supports aerospace, additive manufacturing, solid oxide fuel cells, advanced electronics, communications, transportation, and high-performance materials.

In 2026, Bloom Energy stated that its scandium supply chain could support 25 GW of annual fuel-cell manufacturing capacity—enough generating capacity to serve approximately 15–20 million U.S. homes under typical electricity demand.²² More importantly, the statement was intended to demonstrate that the company had secured sufficient scandium supply to support industrial-scale growth rather than being constrained by material availability.

Vanadium already underpins steel, infrastructure, aerospace, chemicals, and grid-scale energy storage, where demand is expected to grow alongside investments in resilient infrastructure and electricity systems.

The opportunity therefore extends well beyond securing wartime stockpiles or reducing supply-chain risk.

It is an opportunity to build an American industrial ecosystem that transforms mineral resources into advanced materials, manufacturing capacity, intellectual property, high-value companies, skilled jobs, and long-term economic and strategic advantage.

The Bottom Line

The strategic question is no longer whether scandium and vanadium matter.

It is whether the United States can build the domestic industrial capacity to turn geological potential into long-term economic and strategic advantage.

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