MILKEN INSTITUTE

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Innovative Financing for Resilient Critical Mineral Supply Chains

EXECUTIVE SUMMARY

REPORT BACKGROUND

Minerals found in the Earth's crust possess unique properties, including superior magnetic and electrical conductivity rendering them vital in modern economies, technological progress, and defense needs. They enable smartphones to respond to touch, vibrate and glow to alert users. They are found in rechargeable batteries for remote-controlled devices, and their flame-retardant properties are used in industrial thermal suits and children's car seats. Their magnetic stability at extreme temperatures is essential in guided missiles and aircraft. In the renewable energy space, minerals are used extensively in solutions such as wind turbines, and electric vehicles which require between six and nine times the minerals of their fossil fuel counterparts.[1]

Demand has become insatiable across industries, including AI and quantum computing, and is expected to increase exponentially to the extent that the International Energy Agency (IEA) estimates that it could outstrip supply for some minerals, such as copper and lithium, as soon as the 2030s.[2]

However, the supply of these minerals stands in contrast to the growing global demand because of investment disparities between China and the rest of the world since 2013. A strategic multiyear Chinese state investment framework, with financing and insurance alongside policy support, has dominated the global mineral supply chain from cobalt in the Democratic Republic of Congo to nickel in Indonesia. China's Belt and Road Initiative has channeled over $150 billion towards mining and processing over 2013-2025, with a record $24.9 billion just in the first half of 2025, exceeding previous *annual* investment flows.[3] This magnitude of financing, along with state provided insurance, has enabled China's current leadership in key minerals, determining both supply and pricing. Western companies, in the absence of such extensive state-led assistance, have relied far more on the capital markets for fundraising, which has led to volatile investment cycles.

China has also used its control of key mineral supplies to deter competitors. A 2024 Chinese-led oversupply of nickel and lithium, for example, pushed commodity prices below the cost of production for many Western rivals, delaying fundraising and new projects and mothballing some operations. Private capital markets have not been a reliable funding source; private equity and venture capital flows have ranged between $1.9 billion to $10.5 billion annually in the five-year period ending September 30, 2024.[4]

Other investor groups cite long lead times for mines to generate revenues and negative environmental and social risks as key barriers to investing beyond public equities. This fluid private-sector investor landscape impacts fundraising and, hence, future supplies. Finally, new supply risks are emerging as resource-rich countries assert their rights to greater management and economic control of mineral.

The uncertain landscape—China's near-monopolistic advantage, environmental concerns and regulations, surge in demand, and disruptions to supply—is prompting countries to undergo a significant policy review as they evaluate their import dependencies and supply risks. The first reaction has been to identify the minerals considered critical, and while there is no universally accepted definition, they are typically scarce at home, are subject to near-monopolistic supplies, have no known substitutes, and are vital inputs for economic growth and national security. The United States, for example, has identified 50 critical minerals and has determined 100 percent import reliance for 12, and greater than 50 percent import reliance for another 29. These minerals are so designated because they are "essential to the economic and national security of the United States, have a vulnerable supply chain, and serve an essential function in manufacturing a product." [5] Supply risks increased dramatically during trade tensions in 2024–2025, when China increased licensing restrictions on the export of rare earth elements (REEs) vital to US industries.

Across the world, governments are evaluating supply risks and reassessing policies and strategic partnerships. The International Energy Agency (IEA) estimates that half of the 200 critical mineral policies and regulations that it tracks, for 25 countries and regions, were enacted in just the past few years. Recognizing the long lead times for mines to become operational, there is a broad push to diversify and increase supplies. In 2021 the US Department of Energy's Loan Program Office started to fund innovations in critical minerals projects to increase domestic supplies. In 2023, Saudi Arabia's Maa'den mining company formed a joint venture with US-based Ivanhoe Electric to use the latter's Typhoon geophysical surveying technology to identify metals deep below the surface, beyond the capacity of conventional mapping systems. Technology hubs and incubators promoting mining innovations are gaining traction across the world from Canada to Saudi Arabia and Australia.

Strong and rising demand, monopolistic supply chains, geopolitical tensions, and disruption risks and realities are sparking a global interest in investing in critical mineral supply chains. Against this backdrop, the Milken Institute undertook a Financial Innovation Lab project, engaging more than 100 stakeholders through research, interviews, and roundtables to examine the market failures in attracting investment at scale and explore innovative financial frameworks as remedies. *Innovative Financing for Resilient Critical Mineral Supply Chains* discusses the landscape of supply and demand for minerals and the related investment challenges and proposes financing frameworks that would address the key market failures in investing in mineral supply chains and attract diversified, at-scale pools of capital to build the resilience and sustainability required.

SOLUTIONS OVERVIEW

Three frameworks emerged: A syndicated investment model (SIM) to invest in and scale innovations that can prove transformative for the sector; a revolving loan fund (RLF) that includes communities to build stronger partnerships, which would promote best practices and secure the social license to operate; and a blended fund with a public-sector role that focuses on de-risking investments to attract more private-sector capital.

Recommendation 1: Pool existing interested funds into a syndicated investment model managed by an expert team to invest in innovations designed with targeted exposure and transparency.

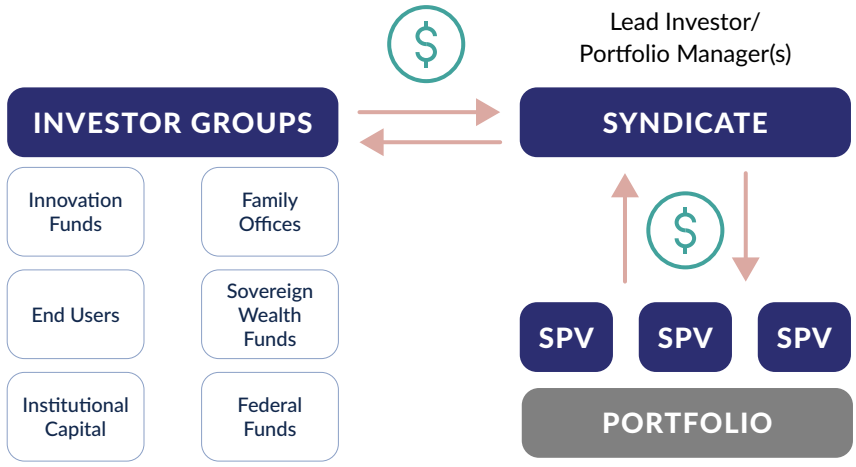
Innovations across the mining supply chain, from exploration of mineral resources to extraction and refining of the ore, can reduce environmental and social impacts, boost efficiency, lower costs, and increase supplies. As one example, AI can be used to detect and quantify mineral deposits and thereby reduce the scale of land disturbance and damage to biodiversity, digitally map mines to reduce accidents, and extract value and minerals from mining waste.

However, financing to navigate the "valley of death" funding gap between concept and proven commercial viability is difficult to secure. Mining companies prefer to use in-house teams for innovation application, and institutional investors are reluctant to invest, citing significant capital (human and financial) needs for due diligence, investment, and management in a field of which they have little knowledge. A SIM could address some of these challenges, elevate investing in innovation and be transformative for the field to attract greater diversity and scale of private capital.

A group of anchor investors would pool capital into a SIM. These investors could be family offices or innovation-focused funds that have a greater risk tolerance than investors new to both mining and innovation. They could also include climate-focused funds with decarbonization and environmental, social, and governance (ESG) mandates. A lead investment team with mining industry expertise would manage the innovation-focused SIM, key to demonstrating early returns and attracting new investor groups.

Investment would be via special purpose vehicles (SPVs), dedicated to a commodity or region, which would increase transparency and provide investors with flexibility to opt out of areas beyond their risk tolerance or mandate. Finally, with demonstrated proof of success in reducing environmental impacts, SPVs could be securitized as green bonds to widen their appeal to a more diversified investor base.

Figure 1: Syndicate Investment Model: A Proposed Version for Mining



Source: Milken Institute (2025)

As investments align with government policies for secure supply chains and spur regional economic activity, the SIM management team could approach authorities for incentives such as tax breaks or physical space for testing innovations. For example, the Australian Automation and Robotics Precinct (AARP), spread over 100 acres, is managed by a state government and shines an international spotlight on the country's largest trial, test, and demonstration ground for robotics and automation.[6]

Recommendation 2: Establish a revolving loan fund to include communities in the economic upside of projects, which would promote best practices and help secure the social license to operate.

The social license to operate a mining project and its supporting infrastructure is critical to success. Mine openings have been delayed for years because of the failure to consult and include host communities. An RLF would include the community in the economic upside of a project and, in addition to regional economic development, would usher in better practices and help secure community support, a top five business risk for C-suites in the mining industry.[7]

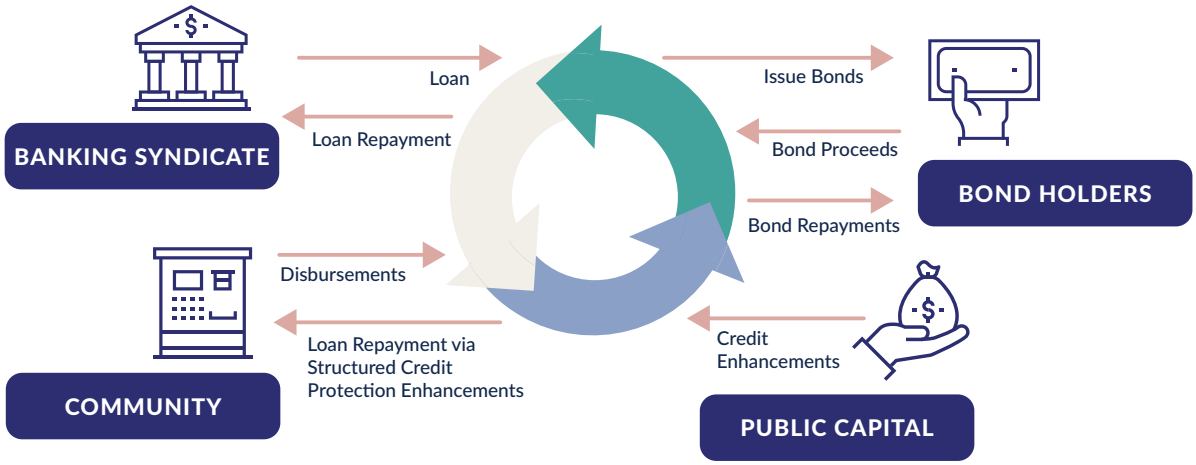
Because mining typically occurs in remote and rural areas, communities need help and incentives to invest in projects. An RLF can help to fill financing gaps for a community interested in co-investing in a project but lacking the financial skills and/or credit score to access capital at terms that work for them and make the investment viable. An initial pool of capital would be provided as a grant or zero-cost loan. This can come from public, philanthropic, or private money. The capital would be used to provide direct loans to the community at terms more favorable than those offered by other sources, such as banks or capital markets. Repayments of the principal and interest would be reinvested into the fund to create a cycle of lending—hence the term "revolving." The fund would be structured to be self-sustaining; over time, it could use capital markets to issue new debt to raise additional capital. If invested in innovation that reduces the environmental impacts of the project, bonds could be marketed as green instruments, increasing the appeal for investors.

In the US, an RLF could be established in the context of onshoring, that is, returning parts of the mineral supply chain home. Tribal Nations are large land-holders, and there is a significant presence of mineral resources and reserves in proximity of reservations.[8] However, despite having a nation-to-nation relationship with the federal government, Tribal Nations are shut out from most public financing tools and face significant credit challenges.[9] This has not improved in 2025, with an uncertain future for federal financing of projects and a White House decision to roll back a prior Executive Order that would have increased funding and consultation pathways (among other goals) for Tribal Nations. However, the Senate has introduced legislation to increase Tribal Nations' access to the bond market, which merits attention.[10]

In a challenging federal policy landscape, the establishment of state-level RLFs would provide Tribal Nations (and other host communities) with access to capital and investment opportunities in projects. In agreement with interested Tribal Nations, land could be used to set up the infrastructure required for nearby projects, test innovations, and process or stockpile minerals. Mining-friendly states keen to capture a piece of the onshoring economic activity could provide the first pool of capital. The RLF could be devised so that different counties or states could host different stages of the supply chain as interests align with Tribal Nations and other communities.

An additional capital pathway is noted in Canada, which utilizes a consortium of financial institutions in an RLF.[11] The First Nations Finance Authority (FNFA), owned completely by First Nations, is the borrowing entity and engages with the consortium on behalf of its members. Once the FNFA has borrowed the funds, it will, based on financial market conditions, use the financial consortium to issue a bond at a lower interest rate to pay off the initial loan. Each bond issuance will have a fund into which the borrower pays to ensure regular repayment.

Figure 2: A Revolving Loan Fund Inclusive of Public and Private Capital



Source: Milken Institute (2025)

In the US, it will be crucial to engage an organization with experience working with Tribal Nations in the establishment and management of the RLF. Once established, the RLF can meet national priorities to onshore parts of the supply chain, uplift economic growth, and secure the social license to operate, de-risking a key component of investing in the sector. These outcomes could catalyze greater private-sector investment. As the fund establishes credibility, it could opt for asset securitization, which could provide host communities with greater options to monetize their investments, or opt for regular bond issuance, which could be recycled into the fund to provide more loans—thereby creating a virtuous cycle for the host community, region, investors, and country.

Recommendation 3: Create a blended finance fund with a public-sector role that focuses on de-risking early investment in the sector to catalyze private capital.

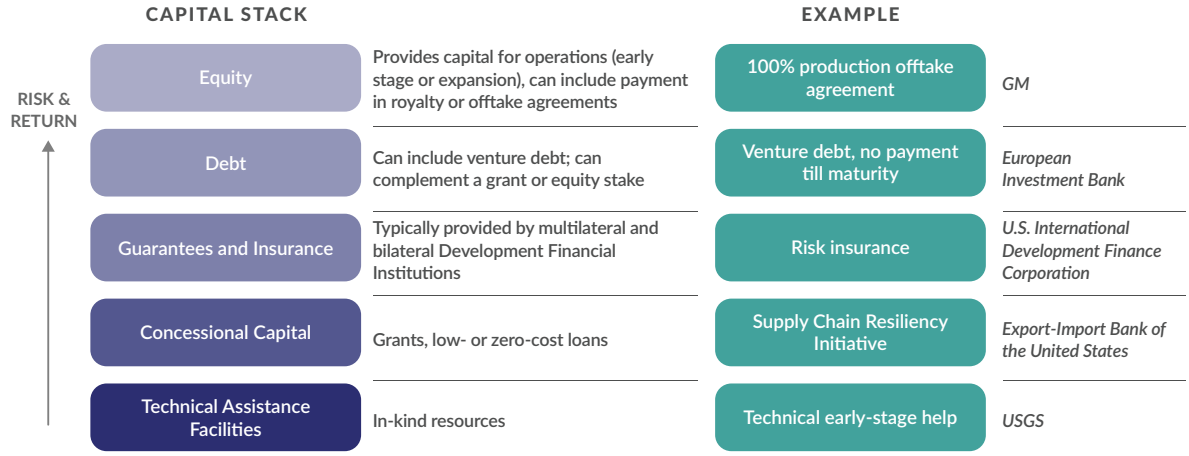
A blended finance fund bridges differing levels of investor appetite for risk and required returns. This approach is popular in sectors that need to lower early-stage risks and can be applied in mining. It would address many of the perceived risks to investing, provide support and guardrails for projects during price volatility, protect projects from Chinese control, and increase the diversity in mineral supplies. There is a role for public-sector engagement in a blended finance fund with greater engagement and innovation.

Key to this structure is the provision of initial capital, either donor or concessional, as a grant or at favorable rates (e.g., low or zero interest rates, flexible repayment schedules). Here, investors usually sacrifice all or some returns for capital preservation and finance the risky development phase while lowering the project costs. Guarantees, insurance, and technical assistance facilities can also be key forces at this stage and are being featured with increasing prominence, accounting for a quarter of recent blended finance frameworks.[12]

Combined, these early forms of support increase the feasibility of projects by financing the early-stage phases, lowering the risk profile and costs. In addition, as typically marquee names, they serve the important function of signaling the project's attractiveness to catalyze private-sector investment. Once this initial capital and support are provided, other institutions such as development financial institutions (DFIs) and the private sector can be engaged via innovative structures with varying degrees of returns, including the following:

- **DFI long-term and low-cost capital** can be game-changing in mining projects and in overseas jurisdictions with high risks. The European Bank for Reconstruction and Development provides equity and long-term debt financing for early stages, and in the US, the Export-Import Bank of the United States expanded its mandate in 2025 to finance overseas mining projects to boost mineral imports.
- **Venture debt financing**, typically done in conjunction with an equity stake or a grant, is popular in high-growth and risky projects. It can take the form of zero repayments until maturity, which preserves the borrower's balance sheet during periods of volatility, increasing the probability of success. Such financing can include the option to convert to a minority equity stake and be a halo effect for private-sector investors.
- **Equity investments** from a broad consortium of end-users tied to offtake agreements will provide the needed early-stage financing, insulate multi-year projects from capital and commodity market turbulence, and provide surety of materials. Large auto makers are financing mine expansions and construction of battery material plants in return for supplies. Given the extensive use of minerals, this group of end-users should be expanded to other industries, including defense, consumer electronics, and biomedical, to name a few.

Figure 3: A Blended Financing Framework for Critical Minerals



Source: Milken Institute (2025)

In the US, at the time of writing this report, the public sector is actively reshaping its approach to funding projects, which could open new opportunities. Reauthorization of the International Development Finance Corporation (DFC) in 2025 may result in an expanded overseas investment mandate and toolkit. The landscape is dynamic, with geopolitical tensions and significant agency and departmental cuts posing challenges. Nevertheless, key actions related to the blended finance fund concept warrant consideration:

- Creating a single entity to provide in-kind and capital support in blended financing frameworks for mining projects. This entity would provide clarity about the policy intent and the toolkit being deployed, which could attract more diversified and at-scale private-sector capital.
- Broadening the DFI toolkit to include financial market instruments such as options to buy investor stakes or output at certain prices or conditions. This tool will provide revenue certainty, increase the attractiveness of the investment for the private sector, and help ensure that supplies survive cyclical or manipulated prices. By purchasing a put option, for example, a mine operator or private investor can sell its equity stake or commodity at a certain price. Because the public sector has longer staying power to ride out a price slump, put options would preserve the project's operability and supply chains.

CONCLUSION

After decades of investment disparities, the understanding of the need for diversified and resilient mineral supply chains is now universal. Governments across the world are actively reshaping policies and pursuing alliances to secure supplies. Private financing in mining and innovations is on the rise. However, neither is on the scale needed to tackle the challenge.

The Milken Institute's Financial Innovation Lab® process has identified three financing frameworks that would address the key challenges deterring the entry of private capital at the scale and diversity required to meet the investment needs. First, a syndicated investment model will elevate the financing of innovations that lower risks and negative impacts of mining, as well as boost yields. Second, a revolving loan fund that includes host communities in projects will promote best practices and secure the social license to operate, reducing delays. Finally, a blended finance fund will address early-stage risks and the impacts of volatile prices and safeguard projects for greater diversity and resilience of supplies. The public sector will play a role, in varying degrees, in all three solutions—vital to efforts to catch up to China and to attract more private-sector capital into this space.

The past four years have seen an increased concentration of mineral supplies to the detriment of the environment, communities, and stability of global supply chains. The Institute believes that the financial solutions proposed are timely and will provide pathways to toward resilient and sustainable critical mineral supply chains, needed for uninterrupted economic progress and national security.

View the full report:

ENDNOTES

1. *The Role of Critical Minerals in Clean Energy Transitions* (International Energy Agency, May 5, 2021), https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

2. *Global Critical Minerals Outlook 2025* (International Energy Association, May 21, 2025), https://www.iea.org/reports/global-critical-minerals-outlook-2025.

3. Christopher Nedopil Wang, *China Belt and Road Initiative (BRI) Investment Report 2025 H1 (Green Finance & Development Center, July 17 2025)*, https://greenfdc.org/china-belt-and-road-initiative-bri-investment-report-2025-h1/.

4. Joyce Guevarra and Shambhavi Gupta, "Sharp Drop in Private Equity Metals and Mining Sector Deals in 2024," S&P Global Market Intelligence, October 24, 2024, https://www.spglobal.com/market-intelligence/en/news-insights/articles/2024/10/sharp-drop-in-private-equity-metals-and-mining-sector-deals-in-2024-85749521.

5. Linda Rowan, "Critical Mineral Resources: The U.S. Geological Survey (USGS) Role in Research and Analysis," Congress.gov, February 21, 2025, https://www.congress.gov/crs-product/R48005.

6. "Welcome to the AARP," Australian Automation and Robotics Precinct, accessed May 30, 2025, https://www.theaarp.com.au/.

7. Paul Mitchell, "Top 10 Risks and Opportunities for Mining and Metals Companies in 2025," EY, accessed May 10, 2025, https://www.ey.com/en_us/insights/energy-resources/risks-opportunities.

8. Samuel Block, "Mining Energy-Transition Metals: National Aims, Local Conflicts," MSCI, June 3, 2021, https://www.msci.com/www/blog-posts/mining-energy-transition-metals/02531033947#.

9. Matthew Gregg, "Separate But Unequal: How Tribes, Unlike States, Face Major Hurdles to Access the Most Basic Public Finance Tools," Brookings, December 3, 2021, https://www.brookings.edu/articles/separate-but-unequal-how-tribes-unlike-states-face-major-hurdles-to-access-the-most-basic-public-finance-tools/.

10. "Overview of the Tribal Tax and Investment Reform Act of 2025," NAFOA, June 18, 2025, https://nafoa.org/policy-alert-overview-of-the-tribal-tax-and-investment-reform-act-of-2025/.

11. "FNFA Borrowing Process," FNFA, accessed May 14, 2025, https://www.fnfa.ca/en/for-first-nations/financing/fnfa-borrowing-process/.

12. "Blended Finance," Convergence, accessed May 10, 2025, https://www.convergence.finance/blended-finance.