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AI Governance and the Geopolitics of Extraction

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Key Points

- The infrastructure of artificial intelligence (AI) depends on critical minerals and rare earth elements, making their supply chains a central factor in national security, economic stability, and global technology competition and governance.
- Overreliance on supply chains characterized by limited geographic diversification exposes AI commercial and defence industries to trade disruptions, cyber sabotage and strategic leverage.
- Diversifying supply chains requires international cooperation that accounts for sustainability, labour standards and transparency to balance national security with environmental and human security concerns.

Introduction

In April 2025, China's Ministry of Commerce imposed export controls on seven rare earth elements in response to US President Donald Trump's tariffs on Chinese goods (Baskaran and Schwartz 2025a). These elements are part of a broader set of critical minerals that are not only essential for advanced technologies, including defence applications such as advanced missile systems (Lopez 2024), but also for the hardware that powers AI technologies. While AI is often imagined in terms of algorithms and data, it is also material, requiring rare earth elements and other critical minerals (such as silicon, cobalt and germanium) for faster and more efficient computation. The ongoing struggle to secure access to these resources not only reflects the broader strategic rivalry between the United States and China over AI dominance, but it also reveals the deep political and material dimensions of AI's design, governance and implementation — dimensions that extend into the often-hidden worlds of resource extraction, environmental security and global supply chains.

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The massive computing power required by AI systems would not be possible without the specialized physical components that power them. Made out of critical minerals and rare earth elements, these components play an important role in the development of microchips, data servers and high-speed networking equipment. For example, neodymium is used in the powerful magnets that drive cooling fans and hard disks (Zorpette 2023) and scandium is used to improve semiconductor performance, while other elements such as erbium are used to amplify fibre-optic data transmission (King, n.d.). Critical minerals such as silicon enable microchip production, cobalt powers batteries and germanium supports the high-bandwidth fibre-optic cables that AI systems require. While most people might have never heard of many of these elements, they form the physical backbone of AI that enables massive computation.

Critical minerals and rare earth elements have become central to the power competition intensifying between the United States and China, as both nations vie for AI supremacy. One major challenge that arises in this AI-race is that the United States and other Western allies are heavily dependent on China for these materials. China currently dominates the global rare earth elements supply chain, controlling approximately 60–70 percent of worldwide mining and as much as 90 percent of the processing capacity (Aggarwal 2025). China also exercises control over the global AI-relevant CM supply chain. For example, China produces 98 percent of the world's gallium; this dominance comes largely from countries' reliance on Chinese refinement technology (Baskaran and Schwartz 2024a). In recent years, Beijing has increasingly demonstrated its willingness to weaponize this dominance by imposing export restrictions on rare earth elements, highlighting vulnerabilities in Western markets that lack immediate alternative sources (Baskaran and Schwartz 2025a). The fact that critical minerals and rare earth elements are also critical components in US defence capabilities has intensified Washington's interest in overcoming China's dominance.

Beyond geopolitics, the role of critical minerals and rare earth elements in AI also exposes a host of hidden environmental security issues, including ecological degradation, exploitative labour practices and political instability. Technology companies have long cultivated an image of "the cloud" as clean and sustainable, often obscuring the environmental and human costs that underpin modern computing

(Ensmenger 2018). Despite marketing campaigns that emphasize renewable energy and corporate responsibility, the extraction and processing of critical minerals and rare earth elements is frequently associated with toxic waste, water contamination, hazardous working conditions and political instability in mining regions (Crawford 2021). The stakes are high for leading in AI governance and innovation, and while these opportunities can bring significant growth to economies and societies around the globe, there are also significant extractive costs that are often invisible to the end users of technology. These hidden costs will shape not only the global balance of power, but also the prospects for a more sustainable digital future.

What Are Critical Minerals and Rare Earth Elements?

Critical minerals are naturally occurring elements and materials that are essential for advanced technologies, and whose supply chains are vulnerable to disruption due to geological scarcity or production concentration. Examples of critical minerals include silicon, lithium, cobalt and the 17 rare earth elements, all of which underpin sectors from renewable energy to defence applications as well as modern computing.

As a subset of critical minerals, rare earth elements are a group of 17 metallic elements with an atomic structure that allows them to produce much stronger magnetic fields than conventional materials such as iron. These unique magnetic properties make them indispensable for a wide range of modern technologies. Despite their name, rare earth elements are actually relatively abundant in the Earth's crust (Rowlatt 2014). However, they are rarely found in concentrated deposits and instead are mixed in with other elements, including radioactive substances (Calderon 2021). As a result, extracting and refining rare earth elements can be costly, labour-intensive and environmentally hazardous, requiring a significant up-front investment and careful management of waste.

While rare earth elements represent one of the larger groups of minerals tied to AI infrastructure, they are only a part of the broader category of AI-critical minerals, which also includes non-rare earth elements such as gallium and germanium. Because these materials are crucial for semiconductors, AI hardware and data centres, they are frequently grouped alongside rare earth elements in both policy discourse and export control measures. Like rare earth elements, gallium and germanium are increasingly subjected to geopolitical tensions due to China's dominance in their production and refinement.

Up until the 1980s, the United States led the world in rare earth production, but this dominance waned as China began heavily subsidizing its own rare earth industry (Aggarwal 2025). By leveraging low-cost labour, relaxing environmental regulations, providing state subsidies and securing key refinement patents, China quickly gained a competitive advantage (Seth 2024). As a result, the United States and Europe gradually reduced their rare earth production, which paved the way for China to become the world's main supplier. Today, this near-monopoly continues to shape the global market for high-tech materials, showing how these elements connect environmental, political and economic issues around the globe.

The Race for Securing Critical and Rare Earth Minerals for AI

Given the growth opportunities AI and other advanced technologies can bring, critical minerals are increasingly being recognized as strategic assets that can shape national security, economic competitiveness and global influence depending on who is in control of them. However, growing geopolitical tensions with China have prompted several Western countries to reassess how they secure and process these materials. From the extraction to the refinement of critical minerals, every stage of the supply chain can now be viewed as a strategic pressure point in the global race for AI and technological dominance.

Vulnerabilities in the AI-critical mineral supply chain exist on two levels: the first challenge is the material acquisition of the minerals and the second is the refinement capacity. When it comes to the material acquisition of critical minerals and rare earth elements, Australia, Canada, the United States and several African and South American nations have access to stockpiles as well as mining sites that could produce rare earth elements (Martínez 2025). However, these resources have been underdeveloped due to high production costs, stringent environmental and labour protections and political constraints. In contrast, China's aggressive investments in overseas mining, combined with its less restrictive environmental regulations, have allowed it to largely dictate the market for AI-relevant rare earth elements and critical minerals (Aggarwal 2025).

A second and equally significant vulnerability lies in refinement capacity. Even when Western countries control raw mineral supplies, they often lack the specialized, capital-intensive facilities needed to process these materials. Refining these minerals is expensive and environmentally intensive, and Western producers have struggled to justify investments in costly and technically demanding refinement facilities. By providing refinement companies with large subsidies and lowering production costs through reduced environmental and social safeguards, the Chinese government has allowed domestic firms to undercut foreign competitors. This has left nations dependent on China for processing materials, even when those nations mine the materials themselves.

Recognizing these risks, a growing number of countries have begun to focus their policies on reducing their reliance on Chinese refinement. Currently, many national and multilateral efforts have largely focused on structural solutions. The United States has focused on enhancing domestic production and supply chain resilience by shifting federal funding allocations (Lopez 2024) and encouraging public-private partnerships. These initiatives include the Stargate Project, a $500 billion private investment in AI infrastructure led by OpenAI, Oracle and Softbank, and pledges by Nvidia, Apple and the Taiwan Semiconductor Manufacturing Company to boost investment in US-based AI manufacturing (OpenAI 2025; Apple 2025; The White House 2025b). President Trump also issued an executive order instructing relevant US agencies to pursue domestic mineral production projects (The White House 2025a). Overall, these efforts have aimed to restructure the critical mineral and rare earth element supply chains and ensure that the United States can meet the demands of both defence and commercial markets.

Canada has also taken steps to increase the supply of responsibly sourced critical minerals and support the development of domestic and global value chains. The government's Critical Minerals Strategy has identified several Canadian regions with high potential for mineral exploration and development in the near future (Government of Canada 2023). Objectives in this strategy include expanding research and exploration activities; developing sustainable infrastructure and strategies for extracting and producing critical minerals; increasing government financial assistance and facilitating private sector investment in exploration and innovation; and balancing innovation with environmental and social obligations. The strategy also recognizes the necessity of collective action at the international level in developing global value and supply chains for critical minerals and rare earth elements.

Under Canadian leadership, in June 2025, Group of Seven (G7) leaders also released a Critical Minerals Action Plan to diversify global production and supply chains, encourage investments in new projects, and promote innovation (G7 Leaders 2025). The plan emphasizes closer collaboration with the private sector, international organizations and local communities, while also pledging to help African and Latin American partners build their own processing capacities. This initiative builds on earlier multilateral efforts such as the 2022 Global Minerals Security Partnership and a Canada-Germany research project to expand gallium production outside of China (Mining Technology 2025).

Security Implications

The failure to diversify supply chains carries far-reaching security implications. As geopolitical tensions rise, overreliance on a single supplier can create vulnerabilities that extend across national defence, economic stability and global technological competitiveness. This section explores how concentrated supply chains heighten risks related to military readiness, cyber sabotage, trade wars and shifting economic alliances, while also complicating efforts to align security strategy with sustainable development goals.

National Security and Infrastructure Integrity

The use of critical minerals and rare earth elements in AI infrastructure, as well as advanced military applications, makes access to these materials inseparable from national security priorities. Thus, supply chain security issues are also national security issues. In the event of a prolonged trade war, access to these crucial materials could be denied or delayed, threatening countries' military readiness, global chip production and the broader AI industrial base. This could, in turn, hinder research, innovation, and the development of frontier AI models that rely on high-performance chips and massive computational power. Fears over restricted access may lead countries to pursue stockpiling strategies that could also increase the risk of conflict over control of mineral-rich regions, particularly in Africa and South America, where US and Chinese interests increasingly overlap (Solar 2025).

Efforts by the United States and its allies to reduce dependence on Chinese-controlled mineral and rare earth supply chains may also introduce new vulnerabilities. As countries invest in alternative mining operations and refining facilities, these assets could become targets for cyber-enabled sabotage and intelligence gathering. New mining operations and refining facilities outside of the existing supply chain could be targets of cyberattacks aimed at disrupting alternative AI development pipelines. Indeed, an Australian rare earth element mining company that divested from China was later targeted in a cyberattack by a cybercriminal group (Greene 2024). China has been known to use cybercriminal groups as proxies to achieve various strategic objectives (Mauer 2017). As geopolitical competition over critical materials intensifies, safeguarding emerging supply chains from cyber threats will be essential to ensuring both technological resilience and national security.

Escalating Geopolitical Tensions

As the United States and China compete for control over AI-critical materials, export restrictions have become a central tool of geopolitical leverage. In August 2023, China imposed licensing requirements and volume caps on exports of gallium and germanium, driving up prices by more than 70 percent, in direct response to US-led chip export controls enacted throughout 2022 and 2023 (Baskaran and Schwartz 2024b; Pessarlay 2023; Allen 2024; US Department of Commerce Bureau of Industry and Security 2022). By late 2024, the United States had expanded these controls further, restricting semiconductor-making equipment and sanctioning 140 Chinese companies (US Department of Commerce Bureau of Industry and Security 2024), prompting Beijing to halt exports of critical minerals to the United States (Lawal 2024). A short-lived truce in mid-2025 briefly restored some exports, but this agreement broke down when US companies continued to suffer rare earth element shortages (Baskaran and Schwartz 2025b).

In parallel, Washington has pressed its allies to follow suit by restricting exports of AI-relevant materials and technology to China. The United States, the European Union and allies including Australia, Canada and Japan have established the Minerals Security Partnership (MSP) to reduce dependence on Chinese-controlled minerals. While African, Latin American and Eastern European countries are not members of the MSP, the MSP has pursued partnerships and engagement with select countries that have minerals and rare earth elements of interest, including those critical for AI development. Partnerships with African countries in particular conflict with China's Digital Silk Road initiatives and its broader Belt and Road Initiative, making AI development the new dimension of geopolitical conflict in Africa.

As these tensions intensify, parallel AI-critical mineral strategies may divide the world into new technology-driven political and economic blocs. Distinct supply chains could produce separate AI ecosystems, with countries aligning around either Chinese or Western-centred networks. This fragmentation risks undermining international collaboration on emerging technologies and complicating the interoperability, standardization and scalability of AI infrastructure across different geopolitical spheres.

Environmental Security as National Security

In the digital era, material infrastructure has undergone a significant transformation where the large-scale factories, machinery and manual production that characterized the Industrial Revolution have dematerialized into data, bits and clouds (Ensmenger 2018). Because it is easy to overlook the material aspects of digital assets that are fundamental to the production and application of AI, it is also easy to overlook the ecological footprint that marks the digital era. In addition to concerns over AI's energy output (Taft 2025) or water usage (Mytton 2021), the mining and purifying of critical minerals and rare earth elements raise significant concerns for AI governance. Since these materials are mined, purified and processed long before they are integrated into AI hardware, the environmental and ethical impacts are often obscured (Crawford 2021). Despite many organizations and government legislators now focusing on AI ethics, most of this attention has focused on fairness and representation in data and models, rather than questions about environmental justice and sustainability.

Mining has historically been an environmentally destructive practice, often carrying significant consequences for the ecosystems and communities around it. There are two methods of mining for rare earth elements, which both release toxic chemicals into the environment. One method involves stripping topsoil and soaking the extracted earth, while the other pumps chemicals directly into the ground through PVC pipes, which are sometimes abandoned and never cleaned up (Nayar 2021). One of the largest rare earth element mines in the world, Baiyun Obo, a Chinese-owned mine located in Inner Mongolia, has an 11 km^2 waste pond with toxic sludge that contains elevated levels of radioactive thorium (Ives 2013). Media investigations into the mine have found that livestock and crops surrounding the mine frequently die off, and numerous residents have fallen ill with a range of ailments (Bontron 2012).

Rare earth element mining is not only environmentally destructive but can also drive political instability. In Myanmar, which has recently undergone a violent military coup, the rare earth element mining sector has expanded dramatically. According to Global Witness (2024) the number of mining sites in militia-controlled areas has grown by more than 40 percent. With the rare earth elements trade valued at US$1.4 billion in 2023, there are concerns that this industry risks financing further conflict and devastation in an already volatile region, especially as much of the extraction is illegal, operated by militias aligned with the illegitimate military regime and carried out without environmental oversight or regulation (ibid.).

Diversifying AI Supply Chains While Promoting National, Economic and Environmental Security

Critical minerals and rare earth minerals essential to AI development remain a significant point of contention in national security and geopolitics. Without a stable and diverse supply chain, countries risk falling behind and becoming more vulnerable to trade disruptions and strategic dependencies. One of the biggest vulnerabilities in the existing production supply chain that Canada, the United States and other partners face is the lack of refinement capabilities. Thus, offering incentives, such as tax credits, to encourage Western-controlled refining capabilities could help close the supply chain gap.

Despite growing military and commercial demand, increased domestic production in any one country is unlikely to meet national needs. Thus, international cooperation is required between states that share common values related to national, economic and environmental security. Currently, bilateral and multilateral agreements between states to diversify supply chains could be bolstered by engagement with multilateral organizations such as the Organisation for Economic Co-operation and Development (OECD), the G7/Group of Twenty, the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), the Extractive Industries Transparency Initiative, and the Energy Resource Governance Initiative (ERGI). These organizations have already developed frameworks for sustainable practices, capacity building and policy development for critical mineral extraction. The IGF, for example, supports countries in developing sustainable mining practices through technical assistance and capacity building programs, as well as assistance in establishing laws and policies (IGF 2023). Meanwhile, ERGI has convened a coalition, led by Australia, Botswana, Canada, Peru, and the United States, to share best governance practices and encourage transparent and ethical mineral sourcing. Leveraging these existing platforms could help coordinate investment, harmonize environmental and labour standards, and support supply chain diversification efforts.

Working with international partners and existing frameworks is important for also addressing supply chain diversity holistically. While most of the efforts made by governments thus far have looked to make structural changes to supply chain systems by improving access, these efforts should be paired with environmental and labour standards, including promoting clean refinement technologies or traceability and auditing mechanisms. These provisions have been identified as crucial to building resilient critical mineral supply chains by organizations such as the OECD, the IGF and ERGI, which emphasize transparency, environmental safeguards and economic incentives in providing an environment that attracts investment and ensuring that agreements benefit producing countries in addition to Western interests (IGF 2023, 2025; OECD 2016). For example, the OECD's due diligence guidance report encourages auditing and traceability to prevent corruption and labour violations, while IGF tool kits argue that clean technology and community benefit agreements act as mechanisms for sustainable development. Embedding these provisions would help distinguish Western-led initiatives by emphasizing higher standards for environmental protection and labour practices, in contrast to models that prioritize low-cost extraction and processing.

AI governance efforts should also begin to recognize the ethics embedded into AI's material components. Beyond the data and algorithms that shape how we use these technologies, the physical materials that build them also carry important ethical considerations for environmental justice, fair labour and political stability. While there are important national security considerations for diversifying supply chains and access to critical minerals and rare earth elements, this should be balanced with the environmental and human security concerns that come alongside mining and refinement efforts. AI companies and their Silicon Valley investors have a clear economic interest in amplifying and exacerbating a global arms race for AI dominance, especially if this race relaxes regulations to encourage shareholder growth over safety, security and environmental justice. AI governance and the material infrastructure that underpins its development is especially vulnerable to this exploitation because of its invisibility to the everyday user. Recognizing and addressing the ethical, environmental and geopolitical dimensions of AI's material foundations is essential to ensuring that responsible AI development is not just about how technologies function, but also about how, and from what, they are made.

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