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Critical Minerals Supply Chains and U.S. National Security: The Geopolitical Vulnerability of West African Sourcing in the Gulf of Guinea

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Abstract
The United States confronts a profound strategic vulnerability in critical minerals supply chains, particularly for minerals essential to clean energy technologies and defense systems. While West Africa and the Gulf of Guinea possess approximately 30 percent of global mineral resources including dominant reserves of cobalt, manganese, graphite, and bauxite, China's dominance of midstream processing capabilities, controlling 50 to 95 percent across key minerals, constrains U.S. access despite raw material abundance. This article examines how governance challenges, geopolitical competition, and supply chain concentration risks threaten U.S. manufacturing resilience and national security interests. Through qualitative analysis of regional governance structures, institutional capacity, and bilateral partnerships, we find that while Africa presents critical opportunities for supply chain diversification, substantial implementation gaps persist in infrastructure development, mineral processing localization, and institutional coordination between U.S. partners and African governments. U.S. strategy must shift from raw material acquisition toward midstream processing development and integrated value chain partnerships, a transition requiring sustained political commitment and fundamental restructuring of mineral development frameworks.

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1. Introduction

The global energy transition underpins contemporary strategic competition between the United States and China, with critical minerals emerging as the decisive battleground. Electric vehicles require approximately 50 to 100 kilograms of graphite per unit compared to minimal amounts in conventional vehicles, and lithium-ion battery production demands cobalt, nickel, manganese, and graphite in precise stoichiometric ratios (DOE, 2021). Defense systems including permanent magnets in military motors, semiconductor components in advanced weaponry, and grid stabilizing batteries for forward operating bases depend on rare earth elements and critical minerals concentrated in geographic regions where China maintains structural advantages.

The scale of emerging demand is extraordinary. The International Energy Agency projects that global lithium demand will increase fivefold from 2024 to 2040, graphite and nickel demand will double, and cobalt demand will triple under the Stated Policies Scenario (IEA, 2025). This exponential growth coincides with a period of accelerating U.S. China strategic competition, wherein Beijing has weaponized its control of mineral processing to exact geopolitical concessions. In December 2024, China imposed stringent export restrictions on gallium, germanium, and graphite, materials essential to semiconductors and battery anodes, signaling willingness to constrain U.S. manufacturing capabilities. This restriction pattern emerged as China responded to U.S. escalation of technology export controls targeting Chinese semiconductor manufacturing, establishing a precedent for supply chain warfare in critical technology domains (Perera, 2025; Chia, 2025) [5, 24].

West Africa and the Gulf of Guinea represent a critical opportunity to decentralize global mineral supply chains away from China's dominance. The region accounts for approximately 30 percent of global mineral resources, including over 70 percent of global cobalt reserves in the Democratic Republic of Congo adjacent to the Gulf, 60 percent of manganese production through South Africa, Gabon, and Ghana collectively, and the world's largest bauxite reserves in Guinea. Yet structural constraints undermine the translation of resource abundance into operational supply chain resilience. Weak governance, limited processing capacity, inadequate infrastructure, and competition from Chinese investors impede the transition from theoretical opportunity to operational reality. This paradox of abundance constrained by absence of institutional capacity, processing infrastructure, and financing mechanisms defines the contemporary challenge in U.S. Africa minerals strategy.

2. China's Processing Dominance and Strategic Leverage

Understanding U.S. vulnerability requires precise characterization of China's competitive advantages, which extend far beyond raw material possession. China's dominance spans the entire mineral value chain from mining and beneficiation through separation, metallurgy, and advanced material production. This vertical integration creates multiple leverage points unavailable to alternative suppliers and enables China to exercise geopolitical influence through supply disruption (Shiquan & Xu, 2023).

China controls processing at the midstream and downstream stages at concentrations that define strategic vulnerability. In lithium, China controls 71 percent of global processing capacity. For cobalt, China controls 73 to 75 percent of global processing capacity, with over 61,000 metric tons annually processed from Congolese ore. Graphite processing reveals particularly acute concentration, with China processing 77 percent of global production and 90 percent of natural graphite globally. Rare earth elements demonstrate even more extreme concentration, with China controlling 92 percent of processing capacity and implementing export controls since 2024. Manganese refining provides substantial processing capacity enabling China to control cathode material supply chains across the battery sector (Tang et al., 2025; Nassar et al., 2025; Muller & Pippart, 2025) [18, 23].

This processing concentration is not accidental but reflects deliberate strategic investments spanning three decades. Chinese government policy since the 1980s has systematically incentivized investment in mineral processing through state backed financing, tax exemptions, low interest loans, and environmental cost externalization unavailable to Western competitors. The governance structure enabling Chinese dominance combines state controlled enterprises with preferential financing mechanisms and strategic trade policies that concentrate processing capacity regionally, creating structural competitive advantage (Tang et al., 2025; Shang, 2025) [25].

China's processing dominance translates into geopolitical leverage exercised through export restrictions and supply disruptions. In August 2023, China announced export licensing requirements for antimony, gallium, and germanium. By December 2024, it imposed blanket restrictions or severe limitations on graphite sales to the United States and its allies, framing these measures as national security actions and establishing precedent for weaponizing mineral access. The timing of restrictions coincided with U.S. escalation of technology export controls targeting Chinese semiconductor manufacturing, signaling tit for tat supply chain warfare. However, China's restrictions target chokepoint minerals where alternative processing capacity does not exist domestically in the United States, whereas U.S. technology restrictions target manufacturing capabilities where alternatives exist. According to analysis by security specialists, gallium and germanium restrictions alone could impose over 1 billion dollars in costs on U.S. semiconductor manufacturers, while broader graphite and rare earth restrictions could halt vehicle assembly within weeks if alternative supplies do not materialize (Perera, 2025; Hoskins & Bicker, 2025; Liang & Marsh, 2023) [13, 17, 24].

China's control extends beyond processing to mining operations themselves. Chinese companies have systematically acquired mining assets across Africa, particularly in the Democratic Republic of Congo. China Molybdenum's Kisanfu copper cobalt mine in the DRC produced 61,073 metric tons of cobalt in the first half of 2025, a 13 percent year on year increase, demonstrating China's capacity to scale production rapidly. Additional Chinese acquisitions span multiple nations: in Zimbabwe, Zhejiang Huayou Cobalt acquired the Arcadia Lithium Project for 422 million dollars in 2021, while Sinomine Resource Group acquired Bikita Minerals in 2022 and subsequently announced a 400 million dollar processing facility expansion. In Mozambique, Shandong Yulong Gold acquired 70 percent of the Ancuabe graphite project in February 2025, targeting 60,000 metric tons per year of graphite concentrate, and DH Mining Development operates the Nipepe graphite project with 100,000 metric tons per year initial capacity and expansion plans to 200,000 metric tons per year (Tang et al., 2025) [18]. This strategy creates an integrated supply chain from resource extraction in Africa through processing in China to advanced material manufacturing and electric vehicle production in China, generating Chinese control over price setting, supply allocation, and technology development across the entire value chain.

3. U.S. Manufacturing Supply Chain Vulnerability

Critical minerals supply chains penetrate deeply into U.S. manufacturing, particularly electric vehicle production and semiconductor dependent defense systems. Understanding specific vulnerability requires mapping mineral dependencies across industries and quantifying the scale of emerging demand relative to announced supply capacity.

Electric vehicle production exemplifies mineral supply chain complexity and vulnerability. A single large format electric vehicle battery pack with 100 kilowatt hour capacity, typical for mid-range vehicles, requires 8 to 10 kilograms of lithium for anode and cathode material, 5 to 10 kilograms of cobalt for cathode stabilization in nickel cobalt manganese chemistries though reduced in lithium iron phosphate chemistries, 10 to 20 kilograms of nickel for cathode material increasingly substituted by cobalt reduction, 3 to 5 kilograms of manganese for cathode stabilization and operational performance, and 50 to 100 kilograms of graphite for anode material representing the single largest mineral requirement by mass. U.S. battery manufacturing has expanded to 2 gigawatt hours of announced capacity through 2030, with projections reaching 3 to 4 gigawatt hours including Inflation Reduction Act stimulated investment. This manufacturing expansion creates corresponding mineral demand that at 2

gigawatt hours annual capacity with 100 kilowatt hour packs would exceed 16,000 metric tons annual lithium demand from U.S. production alone, over 100,000 metric tons graphite demand, and over 10,000 metric tons cobalt demand (IEA, 2025; Correa et al., 2023; Michalek et al., 2025) [7, 21].

Despite global raw material abundance, Correa and colleagues identify critical shortfalls in announced mining and processing capacity relative to projected demand. For Inflation Reduction Act compliant supply sourced from U.S. and Free Trade Agreement partner countries, sufficient lithium processing capacity exists to meet U.S. demand through 2030, though global supply outside China proves insufficient to meet combined U.S., European, and allied demand by 2035. For cobalt, announced mining capacity appears sufficient, though announced processing capacity falls short by 15 to 20 percent relative to demand. Graphite reveals the critical shortage projected by 2030, with natural graphite mining capacity sufficient but processing capacity concentration in China at 77 percent of global production capacity creating acute vulnerability. Nickel announced mining capacity appears adequate, but high purity nickel processing for battery grade material faces capacity constraints with Chinese processors dominating (Correa et al., 2023; IEA, 2025).

The bottleneck is not ore availability but processing and value-added manufacturing capacity outside China. This distinction is critical to understanding vulnerability. Possessing raw materials is insufficient if processing occurs in geopolitically hostile jurisdictions. Defense applications require mineral specifications exceeding battery sector purity and consistency standards. Permanent magnets using rare earth elements power electric motors in military vehicles, naval propulsion systems, and advanced weaponry, requiring neodymium, dysprosium, and praseodymium processed to exacting specifications. China controls 92 percent of global processing capacity, with U.S. domestic production capacity minimal. Military specifications require proven supply chains with assured continuity, meaning alternative sourcing would require 3 to 5 year certification processes and manufacturing line redesigns, delays unacceptable during peer conflicts. Gallium, germanium, and indium essential for semiconductor substrates in radar systems, communications equipment, and advanced electronics face similar constraints, with China's December 2024 restrictions creating cascading vulnerabilities across defense electronics supply chains (Perera, 2025; Meredith, 2025; Liang & Marsh, 2023) [20, 24].

4. West African Resources and Governance Constraints

West Africa and the Gulf of Guinea possess the mineral endowments necessary to diversify global critical minerals supply chains away from China's dominance. Guinea possesses 7.4 billion metric tons of proven bauxite reserves representing 26.4 percent of global total reserves, generating 130,000 kilotons per year approximately 30 percent of global supply. Ghana ranks as the world's second largest bauxite producer. South Africa, Gabon, and Ghana collectively account for over 60 percent of global manganese production, with Gabon holding the world's second largest manganese deposits in the Moanda region with globally competitive ore grades. While the DRC adjacent to the Gulf dominates cobalt supply at 71 percent of global reserves and 67 to 70 percent of production, Guinea and other coastal states hold underdeveloped copper reserves, and Chinese companies have rapidly scaled DRC cobalt production demonstrating the feasibility of replicating this approach in alternative West African jurisdictions (Goosen, 2023; Tang et al., 2025) [18].

However, the translation of resource abundance into operational supply chains encounters persistent governance obstacles that constrain investment and institutional development. Collier documents how resource wealth generates institutional dysfunction through multiple mechanisms including reduced government incentive to develop tax systems or invest in human capital when resources generate windfall revenues, elevated political violence as resource control becomes a prize worth fighting for, and commodity price volatility creating budget instability undermining long term institutional investment. Nigeria exemplifies these dynamics, where oil wealth has funded infrastructure investment while concentrating governance in executive hands, reducing parliamentary oversight, and generating corruption enabling oil theft and smuggling. Angola demonstrates similar patterns with oil revenue driving political centralization despite recent reforms (Collier, 2008; Eigen, 2023).

Corruption permeates governance across Gulf states to degrees indicating systemic rather than isolated institutional challenges. Transparency International's Corruption Perceptions Index reveals that most Gulf of Guinea countries scored below 43 out of 100 in 2023, indicating significant corruption perception. This corruption manifests in permit allocation to politically connected operators rather than technically qualified firms, under collection of mining taxes and royalties through shell company structures and transfer pricing, environmental degradation unchecked by regulatory agencies, and labor exploitation and child labor in artisanal mining operations. Mining to market value chains require substantial infrastructure including roads, railways, ports, electricity, and water, yet West African infrastructure suffers from chronic underinvestment with many states spending 2 to 3 percent of GDP on infrastructure maintenance versus 5 to 7 percent required for sustained capacity (Brookings analysis cited in Ijjasz-Vasquez et al., 2025) [15].

The critical constraint is not ore availability but processing capacity absence. West African states currently perform minimal beneficiation or processing of extracted minerals. Guinea exports 95 percent or greater of bauxite as raw ore, generating minimal value-added revenue and constraining government revenues and industrial development. Ghana has initiated a Green Minerals Policy and announced a 500 million dollar lithium refining facility, though feasibility studies remain incomplete and capital mobilization is uncertain. Without indigenous processing capacity, West Africa remains locked in a resource extraction model where prices are set by global processors, overwhelmingly Chinese firms, profit margins are compressed, and technological development occurs elsewhere. The absence of processing capacity is the binding constraint on supply chain transformation, not the abundance of raw materials.

5. U.S. Policy Response and Implementation Gaps

The Biden administration has prioritized critical minerals security through executive orders, legislative provisions including the Inflation Reduction Act of 2022, and bilateral partnerships. Analysis reveals progress in supply chain visibility and partnership initiation, but substantial implementation gaps undermine policy effectiveness.

The December 2021 U.S. Zambia DRC Memorandum of Understanding represents the most comprehensive U.S.

attempt to develop an integrated African critical minerals value chain. The MOU articulates objectives to facilitate the development of an integrated value chain for the production of electric vehicle batteries in the DRC and Zambia, incorporating extraction, processing, manufacturing, and end of life recycling. Three years post signature, implementation lags substantially behind ambitions (Ijjasz-Vasquez et al., 2025.; Byamungu, 2023). The MOU commits U.S. support to promote awareness of the DRC and Zambia Electric Vehicle Battery initiative within the U.S. private and investment sector but does not constitute a binding capital commitment. Private capital mobilization has proven slower than anticipated as investors assess political risk, infrastructure adequacy, and return timelines. The DRC's cobalt sector has a documented history of child labor, corruption, and environmental degradation. U.S. firms face reputational and legal risks investing in operations failing to meet U.S. ESG standards, while the MOU includes governance provisions, but enforcement mechanisms remain underdeveloped (Byamungu, 2023; Allan & Goldman, 2025) [1].

Processing capacity requires reliable electricity, water, and logistics. The DRC's electricity sector is constrained, and Zambia faces power deficits exacerbated by climate driven drought. Processing lithium ore or refining cobalt requires megawatt scale power generation. Building dedicated power plants or expanding grid capacity requires parallel investments of 500 million to 1 billion dollars, deterring private investment. The Trump administration and Biden administration expanded bilateral critical minerals agreements with Argentina, Australia, DRC, India, Mongolia, Norway, Peru, Uzbekistan, Zambia, and others with variation in specificity and binding commitment. High specificity agreements outline sectoral value chains and governance frameworks but lack binding capital commitments and enforcement mechanisms. General framework agreements establish bilateral cooperation on supply chain coordination, processing technology transfer, and research partnerships with implementation remaining nascent (Ijjasz-Vasquez et al., 2025; Allan & Goldman, 2025) [1, 15].

The Inflation Reduction Act provides substantial incentives for domestic electric vehicle and battery manufacturing including tax credits for battery components manufactured in the U.S. However, IRA provisions include a critical minerals requirement stipulating that battery minerals must be sourced from U.S. or Free Trade Agreement partner countries, with China explicitly excluded. While this aims to incentivize supply chain reshoring and FTA partner sourcing away from Chinese inputs, it inadvertently disadvantages African mineral suppliers not party to U.S. FTAs. While Ghana, Côte d'Ivoire, Senegal, and others can negotiate FTA status, current negotiations remain nascent. African governments perceive IRA provisions as protectionist, potentially deterring African capital from U.S. sponsored supply chain initiatives. Additionally, IRA processing requirements mandate that batteries be assembled in North America for full tax credit eligibility, requiring processing and manufacturing to occur in the U.S. or Canada rather than in Africa (Ijjasz-Vasquez et al., 2025; Michalek et al., 2025) [15, 21].

6. Supply Chain Resilience and Strategic Alternatives

Current U.S. policy emphasizes raw material acquisition and domestic mining, remaining insufficient without parallel midstream processing development. China's strategic advantage derives not from ore possession but from processing dominance, suggesting U.S. strategy must invert this logic by investing in establishing processing capacity outside China, localized to raw material sources where economically and politically feasible. West African processing development offers multiple advantages including reduced transportation costs and environmental impact compared to intercontinental ore shipment, substantial labor cost advantages making processing competitive relative to U.S. operations, regional skill development that advances African industrial capacity, and supply chain resilience through distributed processing across multiple geographies that reduces concentration risk inherent in China dependent supply chains (Allan & Goldman, 2025; Tang et al., 2025) [1, 18].

Implementation requires addressing energy constraints where West African electricity grids often operate at capacity constraints. Processing expansion requires parallel investment in renewable energy infrastructure that could be financed through Green Climate Fund, multilateral development banks, and private investment leveraging feed in tariff mechanisms guaranteeing processing facility power purchase. Lithium refining facilities require 200 to 500 million dollar initial capital and cobalt processing require 100 to 300 million dollar investment, exceeding private investment appetites absent government risk sharing. The U.S. government could establish a dedicated critical minerals infrastructure fund capitalized at 10 to 20 billion dollars focused on processing facility development through DFC and multilateral vehicles. Processing requires proprietary technologies concentrated in China, Russia, and Australia, suggesting U.S. government could facilitate technology partnerships between U.S. processing firms and West African entities leveraging universities and national laboratories for process research (Allan & Goldman, 2025; Ijjasz-Vasquez et al., 2025) [1].

Successful private investment requires governance credibility demanding systemic reform in transparency, rule of law, and anti-corruption capacity. The Extractive Industries Transparency Initiative has published comprehensive audit reports documenting revenue flows in DRC, Ghana, Angola, and other nations. Implementation of EITI recommendations including establishing sovereign wealth funds, implementing beneficial ownership registries, and mandating competitive bidding for permits would enhance investor confidence and reduce corruption. Establishing harmonized environmental and labor standards across West African mining jurisdictions would enable competitive operations while protecting ecosystems and communities. Ghana's Green Minerals Policy and ongoing harmonization efforts through ECOWAS and ECCAS frameworks provide models. Disputes over mining contracts, environmental liability, and labor rights require independent judicial resolution, suggesting investment in judicial capacity through judge training and court infrastructure would enhance contractual enforceability and investor confidence.

Individual national approaches to mineral development cannot achieve economies of scale or regional competitiveness. Regional frameworks leveraging ECOWAS, ECCAS, and the African Continental Free Trade Area enable standardized permitting and environmental frameworks reducing investor uncertainty and regulatory arbitrage, cross border value chain integration combining extraction in one country with processing in another,

infrastructure corridor development coordinating rail, road, and port investments to create competitive logistics corridors, and skilled labor pooling supporting regional centers of excellence for mining engineering and environmental management. The African Union's Green Minerals Strategy adopted in December 2024 articulates these principles, though implementation remains nascent. U.S. government engagement with African regional institutions through technical assistance, capacity building support, and coordinated infrastructure financing would accelerate implementation (Allan & Goldman, 2025; Ijjasz-Vasquez et al., 2025) [1].

Reducing dependence on virgin mining through advanced recycling offers complementary supply chain resilience. U.S. battery recycling capacity remains underdeveloped, though companies have initiated commercial scale electric vehicle battery recycling. Government incentives including tax credits and procurement preferences could accelerate scaling. For West Africa, recycling presents distinct opportunities including electronics waste processing where the region receives substantial waste streams, establishing circular economy processing infrastructure to enable value recovery from current waste streams, mining waste valorization from historical mining operations that left substantial tailings, and advanced beneficiation techniques that could recover residual minerals. Positioning West African facilities as global recycling centers for electronics and batteries would create permanent employment and technological capacity (Allan & Goldman, 2025; Tang et al., 2025) [1, 18].

7. Conclusion

West Africa's mineral endowments are verified and commercially viable. Global demand for critical minerals for the energy transition and defense manufacturing accelerates inexorably. The technologies for extraction, processing, and manufacturing exist in demonstrated form in China and elsewhere. Yet the translation of these components into U.S. supply chain resilience faces a paradox: abundance is constrained by absence. Institutional capacity enabling transparent, rule of law compliant mineral development does not exist at scale in Gulf states. Raw material extraction remains decoupled from value adding processing with minerals shipped to China for intermediate processing. Logistics networks enabling cost competitive ore movement remain fragmented and underinvested. Private investment gravitates toward proven jurisdictions with frontier markets facing prohibitive risk premium. Processing expertise concentrated in China leaves West African firms lacking technical capacity for advanced processing.

U.S. policy has addressed these absences incrementally through bilateral partnerships and development finance. This incremental approach is insufficient for the strategic challenge. China's supply chain dominance was built over decades through state investment, long term strategic planning, and vertical integration. Comparable U.S. strategy requires shifting emphasis from raw material acquisition toward midstream processing development as the binding constraint on supply chain resilience. It demands establishing dedicated infrastructure finance mechanisms capitalized at 10 to 20 billion dollars focused on processing facility development and grid expansion in partnership with West African governments and private entities. It necessitates coordinating with allies and multilaterals to align U.S., European, Japanese, and other allied mineral security objectives enabling coordinated investment and standards development. It requires conditioning investment on governance reform by linking capital deployment to demonstrable anti-corruption, environmental, and labor standards compliance. Most critically, it demands integrating African agency and leadership by ensuring West African governments and private entities lead mineral strategy development with U.S. role facilitative rather than prescriptive.

The Gulf of Guinea's mineral abundance represents not destiny but potential. Realizing this potential requires sustained U.S. government commitment, coordinated multilateral action, and genuine partnership with African governments and private entities. Without this systematic approach addressing both national capacity and regional coordination, the Gulf's mineral wealth will continue functioning as a resource extraction periphery with value captured by external processors and strategic leverage concentrated in Beijing rather than distributed among consumers, producers, and allies.

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