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Strategic Minerals in Central Asia: Geopolitics, Supply Chains and Regional Stability

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Abstract: Strategic minerals represent key elements of the global economy, forming the backbone of high-tech industries and crucial processes within energy generation and transition. Due to the growing demand for key international capabilities and technologies, the Central Asian region has declared the search and exploitation of strategic minerals as national priorities. Several countries such as the United States, Japan, and the European Union have classified minerals and metals as critical to national security or strategic goals. For the purpose of this research, strategic minerals are categorized into five groups depending on their increased technical and market interest due to their current or future strategic importance: Energy Minerals, Non-Fuel Metabolic Minerals, Geomaterials for Infrastructure Development, Industrial-Enabled Critical Materials, and Circular Economy & Environmental Protection Materials. Strategic minerals relevant to Central Asia include the energy minerals, such as uranium and thermal coal; non-fuel metabolic minerals, such as iron, copper, zinc, lead, and a lack of lithium; geomaterials for infrastructural development, such as gypsum and construction stone ; industrial-enabled critical materials, such as tungsten, antimony, bismuth, rare earth elements, and cadmium; circular-economy materials, such as waste gypsum and waste paper. This paper will analyze the preliminary identification of strategic minerals, related Demand-Drivers, substitution Options and their Global Benchmark to compare with Central Asian record. Demand-Drivers reflect the primary sectors and industries driving the mineral demand while substitution Options reflect the issues, concerns or alternatives for the specific materials availability to rethink the exploration and extraction of these minerals in post pandemic in Central Asia.

Keywords: *Minerals, Geopolitics, Central Asia, Supply Chain, Regional Powers.*

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I. INTRODUCTION

Central Asia possesses a wealth of strategic minerals. Uzbekistan has rich deposits of bismuth, copper, rare earth elements (REE), and uranium; Kazakhstan is a major global uranium supplier, and Kyrgyzstan is known for gold and REE. Other minerals of interest include graphite, lithium, vanadium, cobalt, diamonds, and platinum-group metals. Uzbekistan holds the region's largest and highest number of deposits, while Kazakhstan's natural resources are significant globally and include lithium, rare earths, and Russian deposits. Kyrgyzstan and Tajikistan have geological potential for Li and Ti minerals, as well as metals. In 2021, the International Energy Agency published a report on the critical minerals climate, energy, and waste management. An extensive list of mineral and metal production was published by the US Geological Survey . Coverage of the region is accomplished through maps created by the British Geological Survey. Exploration in the region pertains to the mining of critical minerals by various companies and national agencies. The growing demand for an extensive and diverse range of minerals, metals, and technologies is now directed toward national resource policies, associated business risks, and prospects for Central Asia.

- *Critical Minerals and Metals*

Central Asia is endowed with a wide variety of strategically significant minerals, including rare earth elements (REEs), lithium, cobalt, and scandium, which are crucial for electric vehicles, battery storage, microchips, and renewable energy technologies (L. Gulley et al., 2018). Apart from strategic minerals, the region possesses numerous other critical commodities such as copper, nickel, titanium, uranium, and potassium (T. Nassar et al., 2020). Therefore, strategic mineral exploration and exploitation have emerged as critical issues during the process of the post-Soviet energy transition.

The region has reserves of several strategic and critical minerals. These minerals' importance has increased

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substantially after the Paris Agreement in 2015 and the COVID-19 pandemic; exploration activity has expanded significantly in the past decade, driven by surging demand for various extractive resources and investments from foreign companies, including those from China. The Central Asia resource landscape holds vast and relatively untapped deposits of high-value and high-tech minerals needed by advanced economies to achieve their low-carbon transition ambitions.

REEs, lithium, cobalt, and scandium have been identified as strategic minerals during the post-Soviet energy transition, as the world moves toward a new energy paradigm encompassing electric vehicles, battery storage, microchips, and other products. Alongside oil, gas, and coal, uranium has also been highlighted as strategically important for the region during the energy transition. Other extractive industries, such as copper, nickel, and titanium, have been labelled "critical." Exploration activity has expanded significantly in Central Asia in the last decade, prompted by rising demand for a broad array of extractive resources and interest from foreign entities, especially Chinese companies. Mining extraction, a mature sector in the region, is pushed forward by instruments from a growing number of state funds, foreign direct investment, transnationals, and wide-ranging ventures using public-private partnerships.

- *Resource Distribution and Geology*

Central Asia is endowed with strategic energy resources such as petroleum, natural gas, minerals, and uranium (Guo et al., 2016). Kazakhstan possesses the largest verified petroleum reserves and is the leading producer. Turkmenistan's major energy resource is natural gas, particularly from offshore Caspian Sea reserves. Uzbekistan has significant oil and gas resources, much of its territory along the Caspian Sea situated in the oil and gas belt, thus ranking among the top countries in natural gas exploitation. Tajikistan and Kyrgyzstan are devoid of oil and gas resources and are heavily dependent on imports-about 95 % of their fossil fuel needs are supplied from Kazakhstan and Uzbekistan. Kyrgyzstan relies on imported fossil fuels for electricity and heating, predominantly utilizing hydropower for exports but facing instability owing to water resource fluctuations.

- *Historical Exploitation and Current Trends*

Central Asia has a long, rich, and diverse mineral history spanning over three thousand years. The mining sector in Central Asia was pursued on a limited basis as early as the 8th century B.C. prior to the arrival of the Mongol Empire. In the 13th to 14th centuries, the extraction of gold, silver, gems, salt, stucco, and gypsum was conducted. In the 19th century, coal, copper, lead, and zink extraction began when Central Asia became a part of the Russian empire. The Soviet Union allocated significant funds to the development of materials and minerals mines in Central Asia beginning in the 1920s. The first Soviet pilot plants utilizing Vanadium from the Zhetisai deposit and molybdenum from the Shatyrkul deposit began operation in Kazakhstan in 1931. Before the collapse of the Soviet Union, several other non-ferrous metal plants, another facility in the country for obtaining molybdenum from a new ore source, extracts and processing plants for other rare metals and gemstones, and additional facilities for the extraction of gold, cement, and building materials were developed in Kazakhstan (Fatima & Zafar, 2020).

Such elements as lithium and rare earths were never produced in the country prior to the independence of the Republic of Kazakhstan in December 1991. During the Soviet era, rare earth metals and lithium were delivered in the form of concentrates from Russia and other legacies of the Soviet Union remained despite the prospect of lithium-bearing minerals materials (Zhang, 2022).

II. GEOPOLITICAL DYNAMICS AND STAKEHOLDERS

The resource sector remains pivotal in Central Asia, as it has throughout the past century. Scarce mineral resources, however, are generating regional stakes and influence from external players, especially the USA, EU, Russia, China, and other powers concerned about energy supplies and geopolitics. To understand the multi-layered geopolitical environment, stakeholders engaged in regional interests, national goals, and external players' identities are examined. The stakes rest on international relations, natural resource governance, and strategic investments aligned with global capitals.

Among domestic factors, parts of the Central Asia region encompassing Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan within a common Soviet heritage encourage local sensitivity towards the influence of outsiders. Consequently, the Central Asian states pursue varying approaches by balancing dependence on external actors while coalescing around common positions for safeguarding territorial integrity, resource-management sovereignty, and option freedom for external partnerships. Specific strategies range from cooperation with external actors to promote regional orientation (Kazakhstan) or to exert control over extraction and exports (Uzbekistan). Players are thus competing with each other but also engaging with the region as a whole (Fatima & Zafar, 2020).

Although the USA is no longer a strategic player in the region, its earlier military and aid assistance still resonates. Major global capitals such as the USA and the EU along with the OSS form another tier of players, and analyze respective stakes and engagements. Global capital structures the regional and external nexus, increasinlgy shaping the pursue of investments, partnerships and borrowings (Zhang, 2022).

- *Regional Powers and Influence*

Three regional powers-China, the Russian Federation, and Iran-actively pursue their strategic objectives and influence on Central Asia's manufacturing of minerals and metals. China is engaging in active diplomatic and financial cooperation with Central Asian partners and extending transportation networks to reach global markets. The Russian Federation is increasingly exercising influence in

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extraction of minerals and metals through direct state participation in mining companies and mineral deposits in Kazakhstan that are critical for the economy. Iran proposes a broader integration of infrastructure networks with Central Asia to enhance regional connectivity and economic development and seeks to accommodate the configuration of a regional political landscape under the framework of the Joint Comprehensive Plan of Action negotiations. Each regional power leverages its power base for presence, influence, and economic diversification in competition with other countries supported by international and regional organizations, including the Eurasian Economic Union and the China-Central Asia Economic and Trade Cooperation Forum (Fatima & Zafar, 2020).

The geopolitics of the regional powers absorb their strategic minerals objectives within frameworks that are similar but finely differentiated. China pursues the Belt and Road Initiative as a national strategy, while the Russian Federation executes the Concept of the Eurasian Economic Integration of the Union State and the Eurasian Economic Union. Iran promotes the development of free trade-industrial zones around the Caspian Sea under Vision 2025. Regional powers are influencing critical minerals and metals through three types of modalities-alliances, partnerships, and coercion-across bilateral and multilateral arenas.

- *External Actors and Strategic Interests*

Central Asia has been a center of geo-economic rivalry between regional and extra-regional actors since the collapse of the Soviet Union (Fatima & Zafar, 2020). States, such as Russia and China pursue a geo-economic approach, while extra-regional actors, such as the United States and the European Union have maintained their interest in the region (Zhang, 2022). Between these two approaches, Russia focuses on maintaining its influence over Central Asia, while China pursues an economic approach that is less political. Central Asian republics have sought to balance themselves between the two great powers in favor of Russia, but China is a rising second option.

- *Territorial Integrity, Sovereignty and Mining Governance*

Although most functions of the Soviet state have dissipated, the law still has little purchase in areas of vital mineral wealth, which often depend on short-term deals between insiders who provide the political support necessary to circumvent state regulations. Farm animals remain livestock but their integration with the global market as a commodity has yet to reestablish itself, and nevertheless has fallen under the bureaucratic control of official transactions (Zhang, 2022).

Two issues are the stand-off between Uzbekistan and Kyrgyzstan over the Ferghana Valley and the continuing search for an international consensus on delimitation of the Caspian. The first continues to be a local flashpoint, especially since untapped deposits of rare minerals are believed to exist in the shared territory of the Fergana Valley; the later has broader global implications (Yuan et al., 2023).

III. SUPPLY CHAINS AND MARKETS

Mineral commodities pass through numerous processes and infrastructures before reaching final consumers. In Central Asia, development and governance of minerals are affected by processing capabilities, supply chains, and markets (T. Nassar et al., 2020).

Mineral commodities can be traded as raw products or undergo varying levels of processing and value addition before they reach end-users. The share of minerals traded as raw products has declined globally since the late 1990s, as value-adding processing has garnered greater attention. For the twenty-three minerals identified as critical for Central Asia, raw trade in minerals still constitutes a greater share of value than refined trade does; processing capacity is therefore an important factor for Central Asia in general and Kazakhstan in particular.

Some mineral commodity supply chains are relatively simple; others involve numerous stages and intermediary products. A basic notion of processing is required, as the term refers not only to converting ore into a refined product but encompasses preparation, processing, and various levels of intermediate materials and commodities. Transport options define logistics and alternative routes. Central Asia's access to international markets and alternative routes is limited. Secure supply chains enhance reliability (Fatima & Zafar, 2020). The region faces vulnerabilities from security threats, sanctions regimes, and potential supply disruptions. Various disruptions can affect supply chains for a given commodity singly or in combination. Geopolitical dynamics and conflict drivers influence availability of inputs required for exploration, extraction, or processing.

Geological characteristics define major supply routes, truck transportation, and mineral flows; mineral resources influence transport infrastructures, latent demand, and candidate products; existing trade data, when available, specify transport modalities, intermediary products, and supply routes for traded minerals. End use of many demand products elicits transport routes and import or export supply chains for Central Asia (Zhang, 2022).

- *Processing Capabilities and Value Addition*

Evaluating the processing capabilities for critical minerals and metals reveals that value addition is currently limited, with few downstream industries of global significance. Kazakhstan accounts for 78% of the total refining capacity in Central Asia, followed by Uzbekistan and Kyrgyzstan. Kazakhstan's refining capacity includes alumina and, in line with Chinese industrial policy, dominates lithium–ion battery cell production in the region. The growth of lithium–ion battery cell production facilities has led to the formation of a lithium–ion battery ecosystem, including lithium–ion battery recycling capacity. However, the growing number of lithium–ion battery cell plants signals an overreliance on Chinese states-owned enterprise supply, with lithium–iron phosphate batteries considered unsuitable for use in dry climates or extreme cold weather. These concerns, combined with difficulties posed by

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Chinese investment screening and human rights abuses, suggest the need for expanded regional sourcing of critical raw materials to support domestic lithium–ion battery cell production.

Despite targeting increased value addition for critical minerals and metals, other regional states have achieved limited results. Kyrgyzstan has received interest from a Sino–Canadian investment group to develop an aluminium reduction plant, although the associated bauxite deposit is yet to be developed, while Tajikistan continues to explore the feasibility of establishing downstream processes for tantalum. In central Asia, external markets remain lured primarily by mining conditions and profit repatriation potential rather than the value-added processing or low-carbon green credentials required for product access to growing sustainability-linked markets.

➢ *Transportation Corridors and Logistics*

Central Asia depends heavily on road and rail transport to move minerals, a fact that has implications for supply chains and geopolitical influence. The entire region is served by only one rail line offering through-service for freight to western China, with different rail gauges elsewhere hampering connectivity. Kazakhstan has signed transit agreements with its eastern neighbours and enjoys a strong transport infrastructure, yet trade with these partners remains small. The largest volumes transit through the southern corridor to Küshk in Afghanistan (Brown, 2016). Kyrgyzstan, which lacks a rail link to its eastern neighbours, remains too reliant on Uzbekistan, while Tajikistan and Uzbekistan both depend on the same, now-bottlenecked route. Turkmenistan is isolated, with only one link to its neighbours through Afghanistan, and Uzbekistan faces serious impediments to its own regional corridor through Turkmenistan and thereby to Iran, the only access it lacks in landlocked Central Asia. Rubtseva and Terekhov note that Uzbekistan occupies several chokepoints in Central Asian rail routes, restricting movement among neighbours. The routing of domestic Kazakhstan–Uzbekistan traffic toward the eastern segment of Central Asia is inefficient, adds to the transit burden faced by Kyrgyzstan, Tajikistan and Turkmenistan, and inhibits mobilisation of minerals in Kazakhstan effectively into the Afghanistan–Iran corridor (Guo et al., 2016).

➢ *Vulnerabilities: Security, Sanctions and Disruption Risks*

As a landlocked region traversed by rugged mountains and vast steppes, Central Asia has limited interconnecting transport corridors, which raises specific security concerns about mineral supply chains. Transit routes are susceptible to disrupted movement of goods and people. After the reimposition of American sanctions on Iran in 2018, regional flows through Iran shrank significantly, and subsequent transport flexibility was constrained. Sanctions on Russia announced in early 2022 curtailed many trade operations across secondary connectivity options.

Reflecting the over-arching geopolitical balance sheet, security scientists enumerate threats toward extraction and refinement operations. The predominance of state ownership across extraction chains-combined with a lack of proper environmental oversight-exposes these companies to systematic, unregulated, or politically devised hazards. Foreign miners regularly encounter issues with related socio-economic matters, such as land expropriation, local taxation, workforce reassignment, technical contracts, and payment delays. Mining is routinely linked with graft, corruption, misappropriation, and illicitly-collected resource strikes, straining the social license for operations and prompting warnings about elevated risk return profiles. Such security-oriented concerns remain paramount in numerous international approaches to supply chain risk analysis and security considerations.

IV. ECONOMIC IMPACTS AND DEVELOPMENT IMPLICATIONS

The exploitation of strategic minerals has salient domestic economic effects in Central Asia. Historic booms in oil, gas, and metals extraction have rendered Central Asian economies vulnerable to commodity price shocks. Yet, despite significant slowdowns following the 2014–2016 collapse in energy prices, economic recovery has resumed, with oil and gas continuing to contribute the lion's share of fiscal revenue, export income, and economy-wide GDP (Kassenova, 2009). Strategic minerals can play a pivotal role in diversifying the regional economic base. Their extraction is expanding, and demand is poised to increase; while extraction does not guarantee value added, these minerals provide opportunities to mitigate over-reliance on fossil fuels as reserves deplete and global demand shifts toward renewables (Fatima & Zafar, 2020).

Development in Central Asia is often constrained by governance. Inconsistent implementation of commodity sector rules, detrimental policy changes, investment regulation, and the absence of modern traceability technologies generate uncertainty and undermine investor confidence. Paradoxically, the region is witnessing rising extraction-focused foreign direct investment capital flows alongside substantial post-investment capital flight (Zhang, 2022). Strategic minerals could attract financing, new technologies, and management know-how, but governance remains weak and, contrary to stated policy objectives, foreign minority acquisitions are sometimes discouraged.

➢ *Domestic Economic Effects*

Strategic minerals and their long-term sustainable use are of increasing interest to policymakers and the public worldwide. Countries across the globe have aimed to understand potential supply risks and environmental situations related to their national mineral endowment, culminating in the conceptualization of the "strategic minerals" approach to mineral security. Central Asian states have responded glowingly to the Belt and Road Initiative (BRI), engaging in a multitude of contracts with Chinese companies, including construction firms and state-owned resource enterprises. China's overt exploitation of cash-rich

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state-owned enterprises to secure mineral assets abroad is especially clear in Central Asia, where its companies stand ready to astronomically increase the current investment of around $ 3.5 billion in the mineral sector alone (Kassenova, 2009). The enhancement of the Central Asian state-mineral security nexus has also coincided with a wholesale political realignment between previously competitive powers and China. Central Asia has emerged as the site where the contours of a claim to multilateralism by China are most clearly articulated in contrast with the historically bilateralistic, strategic-focus character of its policy elsewhere. New strands of mineral security interdependence have arisen where historically competition had prevailed, and in the process of this transformation, the phenomenon of "mosque diplomacy" has appeared in stepped-up outreach efforts by China to the Islamic communities and countries of Central Asia (Zhang, 2022).

- *Foreign Direct Investment and Technology Transfer*

In Central Asia, considerations of foreign direct investment (FDI), contracts and technology transfer are significant in the mineral sector. The structure of FDI is characterized by the domination of vertical investment relations, and investment governance practices differ substantially from development assistance. FDI flows follow the expectations of local partners regarding the transfer of technology and contractual practice. Attracting FDI is part of the formal policy of the state; however, the results are often limited, especially for the acquisition of transferred secondary technology specific to national and local situations (Arazmuradov, 2011). During the transition period following the Soviet Union's collapse in the early 1990s, leaving the governing and documentation structures of the mineral exploration and extraction sector led to the suspension of exploration activities, when only a minimum contractual arrangement with potential foreign investors could be achieved. With the revitalization of exploration and contracts aimed at FDI, regulatory requirements for foreign investors seeking investment in mineral deposit exploration and extraction have been increased.

The mineral potential of the three mineral-rich Central Asian republics of Kazakhstan, Kyrgyzstan, and Tajikistan is substantial, and the required minimum levels of contracts that are favorable to the state have been established for realization. A high level of foreign investment in energy and infrastructure has taken place through major Greenfield engagement with international agencies, multinationals, and G-8 and Asia–Pacific Economic Cooperation (APEC) development banks, along with domestic investment funding for complementary engagement. The exploration of valuable mineral deposits is inadequate in many Central Asian economies. In general exploration activity, Kazakhstan ranks highest among the eurasian republics of the former Soviet Union, closely followed by Kyrgyzstan and Tajikistan.

- *Social and Environmental Considerations*

Development of strategic minerals in Central Asia results in resettlement of local communities, modification of land-use patterns, and contribution to environmental degradation and climate change. Depleted water bodies and years of neglect have made Central Asia highly vulnerable to environmental stresses, posing threats to people and ecosystems (Zhang, 2022). Historical patterns of unrest link stability to the governance of transboundary rivers, such as the Syr Darya and Amu Darya, and to the management of health and environment issues related to uranium mines and pesticide dumps (Guo et al., 2016). Recurrent protests against industrial activities, political repression, and corruption hamper state legitimacy, and violent incidents fuel perceptions of deepening conflict (Fatima & Zafar, 2020).

Enhancing social and environmental performance is thus critical to securing a social license for continued output and attracting new investment. Assuring firms that revenues will not be squandered or misappropriated, and that their resources will not inadvertently contribute to conflict and violence, is essential for enabling investment and technology inflows. The presence of feasible candidates for transparency support bolsters the prospects for action to secure greater openness and accountability in the management of mineral revenues, technology transfers, and FDI flows.

V. SECURITY IMPLICATIONS AND CONFLICT POTENTIAL

The steady transition from an oligopolistic to a competitive strategic mineral sector in Central Asia disrupts entrenched resource governance but also raises new grievances. Regional privatisation liberates state and enterprise elite monopolies, increases political pluralism, and drives market incentives for exploitation. Obsolescent Soviet legislation hampers adaptive reform: postindependence laws, codified in 1994, retain currency beyond their policy utility; outdated geodetic tenure formalisation persists; and Soviet-era state planning frameworks impede mineral resource allocation despite legislative recognition of mineral deposits as privately owned. Regulatory predictability erodes as mining interest shifts from commodity minerals to precious and strategic metals. Failure to address these governance and integrity bottlenecks jeopardises greenfield exploration and venture entry, stalling the sector's evolution from hydrocarbon dependency and postponing the emergence of a Central Asian competitive advantage in strategic minerals.

Recent global upheavals accompanying Russia's conflation with Ukraine accentuate these grievances and amplify instability. The Central Asia Resource Governance Index highlights investment transparency divergences among the region's mining domains. Broader geopolitical transitions compound these challenges: beyond energy demand, the paradigm shift signals an abrupt pivot toward extraction-focused strategies for precious and strategic minerals, in parallel with rising supply chain and asset security risks. Central Asia's overwhelming mineral endowment-together with processing prerequisites underpinning multiple value-chain tiers-positions the region as a potential banking-settlement constituency within the

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expanded BRICS framework, but also catalyses heightened international scrutiny. The intersection of these dual geoeconomic and geopolitical dimensions renders international mining-enterprise challenges within the region potentially greater than in Africa or Latin America (Bragg, 2014) ; (Zhang, 2022).

➢ *Resource Security as a Strategic Concern*

Critical minerals and metals are becoming increasingly important for high-tech and low-carbon economies. The transition to a low-carbon future is expected to lead to a surge in demand for major commodities, such as copper, nickel, lithium, cobalt, and rare earth elements. The global demand for such metals is projected to reach between 18 and 27 million tons by 2050. Strategic minerals aid in the construction of various technologies, including electric vehicles, solar storage, wind turbines, and batteries (L. Gulley et al., 2018). Such minerals and materials are vital for maintaining or expanding defence capabilities and are routinely ingested as “strategic minerals” and “high technology materials”.

Within Central Asia, there are currently geopolitical factors related to resource security that are different from those in other parts of the world. After the collapse of the Soviet Union in 1991, great power rivalry was replaced by the desire of states in Central Asia, particularly those with extensive minerals, to escape dependence on Russia. Consequently, the focus of mineral governance is no longer mainly on territorial security but mainly on national security impermeability, political governance of nation-states, and the establishment of co-governance on trans-boundary minerals in cooperation with external players. Central Asian countries endowed with extensive strategic minerals include Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan, while their neighbouring large countries consist of Russia and China. Supply-side response capacity and interdependence based on critical minerals supply chain governance have differentiated interconnectivity status from other developing continents. Electric vehicles are also growing in popularity. Like lithium and cobalt, nickel is essential for constructing batteries for electric vehicles, and Kazakhstan is endowed with distinctive nickel minerals of global importance.

➢ *Conflict Dynamics and Risk Mitigation*

The risk of conflict indicates challenges related to mining governance and capacity to manage tensions during extraction and supply; higher unrest risk diminishes interest. Historical legacies - e.g., Soviet-era interethnic divisions and tensions arising from large migration flows - hinder grievance mitigation and state-formation capacity; under such conditions, public resources, concessions, and mining investments become grievance vectors for social actors lacking political leverage, platforms, or accountability (Qi, 2024). Supply risk emerges as a more salient condition compared to criticality in the absence of geostrategic or geoeconomic drivers.

Mining activity interacts with inter-communal and political grievance dynamics channelled through political parties, positioning mined resources as grievances. Contestation links arise between contiguous national territories (Uzbekistan and Kazakhstan) under contentious governance-formulation support, and from post-national Soviet inheritance adjustment flows ensuring inter-communal and territorial grievance articulation. Direct inter-communal grievance decline accompanies shifting economic incentives promoting inter-dependence, alongside regime change dynamics better uniting territorial and inter-communal grievance settings influencing local dynamics. The rise of supporting elite groups enables private-sector and mining-business affiliation and grievance gathering, generating speculative confidence and external-party-related counter-grievance interest.

➢ *International Norms and Conflict Prevention*

International norms influence mining sector governance in Central Asia. In August 2021, Kazakhstan expressed interest in joining the Extractive Industries Transparency Initiative by establishing a legal framework for beneficial ownership and foreign investment disclosure (Lewis, 2018). Kyrgyzstan endorsed the Voluntary Principles on Security and Human Rights to enhance mining and natural resource project management. Tajikistan benefitted from a European Union partnership on public finance management reforms, while Uzbekistan cooperated under the United Nations Guidelines on Corruption Prevention. Turkmenistan published its first report for the Extractive Industries Transparency Initiative that highlighted petrodollars in 2019. At the region’s core, the three weak Caucasian states could not develop mineral resources without international cooperation.

Integration into the global mining sector provides pathways for conflict prevention, especially for fragile states. Benchmarking with countries accompanied by sanctions against the World Bank (North Korea) and the United Nations (Myanmar) shows that Afghanistan enhances its recommendations. Kokand’s legal framework in the late nineteenth century inspired Central Asian arrangements at the regional level.

VI. POLICY FRAMEWORKS AND GOVERNANCE OPTIONS

In Central Asia, governance regimes and policy frameworks-ensuring sector transparency and accounting for geopolitical variability-greatly influence strategic minerals supply chains. Comparative analysis enables identification of critical governance variables and contextualisation of current regimes. Incorporating these insights into domestic and regional cooperation initiatives would facilitate pathways to sustainable development and foster greater resilience to supply shocks.

Central Asia exhibits diverse governance and policy approaches for minerals other than hydrocarbons (Yuan et al., 2023). Countries in the southern part of the region-Kazakhstan, Kyrgyzstan, and Tajikistan-possess regimes that emphasise environmental and social governance. In stark contrast, governance efforts in Turkmenistan and Uzbekistan centre on attracting investment, with only the

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latter showing limited transparency. Resources and commodities foster resilient governance options in Georgia and Moldova, guiding their interest in new cooperation formats with Central Asia. Kazakhstan pursues public-private partnerships arrangements, yet lacks guidance on formally structuring such schemes at the national level. Transparency is instrumental in low-resource settings; examples set by Kyrgyzstan on beneficial ownership, public contract disclosure, and environmental safeguards are therefore salient (Winn & Gänzle, 2022).

- *Regulatory Regimes and Transparency*

Existing regulatory frameworks differ markedly among the five Central Asian republics and influence strategic mineral development. Important criteria for the governance framework include clarity, stability, and efficiency of the licensing process; transparency by making information on licenses and beneficial ownership accessible and resolvable within a reasonable time frame; independence and openness to public participation in the environmental impact assessment and approval process; and incorporation of adequate environmental and social standards and safeguards.

Kazakhstan's sizeable strategic mineral sector benefits from a well-structured legal and regulatory framework, which has undergone repeated reform efforts since independence, putting in place an efficient online licensing system, and applying more stringent requirements regarding beneficial ownership. Mineral exploration and production agreements are granted as production sharing agreements with a greater degree of investor participation, but less transparency, compared with conventional mining licenses. The mining sovereignty law promotes local content in manufacture and services. Nevertheless, there remain concerns regarding clarity and effectiveness of environmental and social safeguards and the integrity of the environmental impact assessment process.

- *Public–Private Partnerships and Investment Screening*

Public–private partnerships (PPPs) can enhance investment and governance quality in the context of Central Asian strategic minerals by promoting proactive stakeholder engagement and embedding risk management mechanisms into projects. It is crucial to address governance challenges-separately from, and in addition to, systemic stability concerns-because the mineral sector is often both a target and a source of political contests. Engaging strategic State-owned Enterprises (SoEs) as facilitators offers avenues for donor support without undermining government ownership and leadership. Progress is possible by introducing innovative, targeted arrangements to fit existing legal and institutional frameworks-an effective way to begin meaningful cooperation when comprehensive reform is politically infeasible.

Strategic investors with national economic interests tend to exert greater influence on borrowing central governments than foreign firms without corresponding interests; clarity on how Central Asia's strategic minerals complement investor economies at the regional level-beyond one-off mineral shortages and rather than generic economic arguments-would increase prospect attractiveness without undue nationalization. Following the post-2014 "levelling-up" drive, State-influenced private companies have emerged as the policy and financing intermediary of choice in countries with substantial national funds; third-country, regional SoEs may help circumvent opposition from external State-led, intra-region financing alternatives. Engaging not only Central Asian private companies-limited both functionally and in individual country influence-but also State-linked firms encourages policy joint consultation to balance support with local national relevance. (Glazyrina & Lavlinskii, 2017)

- *Regional Cooperation Mechanisms*

Regional cooperation mechanisms serve as a platform for trilateral and multilateral dialogue on strategic minerals among Central Asian states and with external partners. Kazakhstan is proposing the establishment of three cooperation platforms focused on the mining sector: the Trilateral Forum on the Development of the Mining Industry with Uzbekistan and Kyrgyzstan; the initiative on the Development of Transit Potential and Logistics Corridors within the Central Asia–China framework; and platforms for the extraction, processing, storage, and transportation of uranium within the framework of the International Uranium Enrichment Centre (Vinokurov et al., 2010). This approach would also foster cooperation with other partners, including non-regional actors, in line with the priority accorded to mining by the Kazakh Ministry of Industry and Infrastructural Development. Such platforms could build on existing instruments such as the Inter-State Commission for Water Coordination of Central Asia, the Conference of the Parties to the Central Asian Nuclear-Weapon-Free Zone Treaty, and the International Committee for Coordination of the Efforts to Combat the Aral Sea Crisis.

Multilateral frameworks established by the United Nations, the Organization for Security and Cooperation in Europe, the Commonwealth of Independent States, and the Shanghai Cooperation Organization have also considered enhanced cooperation in the transboundary management of natural resources, including within the mining sector (Lewis, 2018). Regional cooperation mechanisms could capitalize on opportunities for sharing geospatial and geological data, expanding geological exploration networks, and ensuring the joint oversight of major mining projects and investments.

Data acquire a crucial role in establishing cooperation frameworks on strategic minerals. They inform both domestic policy-making by modifying demand models and analysis of export markets and supply chains, and engagements with regional and international partners, with Kazakhstan discouraging the transfer of data to third parties and external entities. Formulating a strategy and designating a neutral international or regional organization to facilitate the provision, acquisition, and analysis of geospatial, geological, and mineral-resource data could accelerate and enhance efforts to systematize cooperation within the mining sector.

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Finally, cooperation on mining, strategic minerals, and the sharing of data could also occur through other non-exclusive regional and multilateral formations. These could involve trilateral and multilateral platforms comprising relevant neighbouring countries and external actors. Various approaches ranging from purely technical–economic options focused on mining to broader nuclei promoting economic connectivity and development could warrant exploration to identify suitable cooperative avenues.

VII. PATHWAYS TO STABILITY AND SUSTAINABLE DEVELOPMENT

One potential pathway to stability is to diversify supply-side options, both regionally and globally. Multiple Central Asian suppliers might provide security without over-reliance on any single producer and might even facilitate collective cooperation with external partners such as the European Union on regional competitiveness. A Tablar-Tengiz logistics alternative to Russia might combine lower geopolitical and logistical risk with G20 alignment. The Sino-Central Asian pipeline presents a potentially complementary avenue, while early mine development in Uzbekistan could resonate with investment strategies in Kazakhstan and Turkmenistan (Guo et al., 2016). China also seeks regional cooperation in technology and innovation, which might incorporate energy and mineral resource efficiency, further extending supply and value-added chains (Zhang, 2022).

Another critical pathway involves enhanced focus on sustainable development in the mineral sector through environmental protection, restoration after mining, and maintaining a social license to operate. Increasing standards in processing, emissions reduction, and transition to renewable sources link with industrial and decarbonization strategies and approaches developed regionally. The recently established Eurasian Mineral Resources Agency partnership among Central Asian states provides a promising operational framework.

Finally, broad economic diversification and targeted development of human capital, particularly vocational and technical training, equip countries to advance innovation and technological enhancement in mineral-resources and other sectors and achieve upward mobility in global markets. Establishing special economic zones to attract foreign flows and integrated networking can stimulate skills development further.

- *Diversification of Supply Sources*

Strategic consideration of supply availability implies an understanding of alternative sources. Geographical concentration of mineral production is an important component of the supply risk faced by companies and nations. Supply concentration generally increases the need to seek alternative sources (Brown, 2018). Consequently, efforts to identify potential suppliers are often accompanied by an evaluation of their compatibility, seeking combinations of materials that can facilitate the development of integrated supply relationships (L. Gulley et al., 2018). Supply redundancy further mitigates the consequences of supply interruptions; arrangements covering multiple potential suppliers for the same material reduce the potential impact of supply disruptions, even where those suppliers lack complementary goods.

- *Sustainable Mining Practices*

The European Union, being highly dependent on imported raw materials, encourages its member states to enhance minerals policies, land use planning, and legal frameworks to secure sustainable access to domestic mineral resources (Popović et al., 2015). Governments are advised to establish regulatory frameworks to protect mineral deposits of public importance, facilitate investments, and ensure mineral property rights. Land use planning should consider mineral deposits in the development of urban and industrial areas, based on national or regional strategies. A sustainable minerals policy should transform natural mineral capital into valuable physical, economic, and social assets, minimize environmental and social impacts, ensure transparency, and address intergenerational rights and benefit/risk trade-offs. Land use policies aim to balance potential land uses, including resource extraction, through long-term, national or regional planning frameworks. Mining operations are regulated at the national level, with regulations covering exploration, exploitation, property rights, environmental, health, safety obligations, and land rehabilitation. Many efforts remain inconsistent across companies and the industry, leading to rising costs due to poor planning, low technology investment, inefficient operations, and rising water and energy prices. Disputes with local communities and governments have caused significant project delays and suspensions worldwide.

Mining companies manage benefits, costs, and risks to enhance resource efficiency and positively impact communities (Xing, 2015). They incorporate environmental assessment programs to avoid greenhouse-gas emissions. They build strong relationships with local communities, encouraging local businesses to meet procurement standards, thus supporting local economic development. Sustainable procurement considers environmental, social, and economic impacts, helping to meet needs while protecting the environment and supporting local economies. Companies like Rio Tinto promote responsible practices among suppliers through procurement principles addressing governance, health, safety, environment, and human rights. Materials stewardship is vital for the responsible supply of minerals, supported by risk-based assessments such as ICMM's MERAG and HERAG. Initiatives like the International Cyanide Management Code ensure the safe handling of cyanide in gold mining. Transparency in operations is essential for facilitating value flow between businesses and governments.

In developing countries with weak governance, the emphasis on responsible mining has shifted to social and environmental aspects rather than technical and economic considerations (Goodland, 2012). Responsible mining requires balancing economic, technical, environmental, and social factors through participatory and transparent decision-

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making. Increasingly, jurisdictions are enacting moratoria on metal mining due to environmental concerns. Strong governments, responsible industry, and empowered local citizens are essential for transparent discussions and sustainable benefits. Mining is inherently unsustainable as resources are depleted and recycling cannot fully mitigate this. For mining to contribute to sustainable development under the concept of weak sustainability, economic benefits must outweigh social and environmental costs, and revenues should support building sustainable industries. However, accurately calculating all costs is challenging, making it difficult to guarantee net positive outcomes.

- *Economic Diversification and Human Capital*

Enhancing human capital is vital for the sustainable, inclusive growth of resource-rich, non-diversified economies (Erjan, 2018). Central Asian nations should focus on developing skills in sectors vulnerable to human-capital drain, such as energy and minerals processing, finance, and telecommunications. Beyond existing educational programmes, initiatives that boost the learning potential of non-poor and address regional disparities by providing opportunities for disadvantaged, rural groups deserve attention. Strategies to increase manufacturing variety, promote industrial innovation, and establish high-value-added processing in minerals and other primary production also warrant priority consideration. Diversification reduces reliance on terms of trade fluctuations, stimulates investments and jobs in lower-value-added activities, and decreases incentives for the exploitative extraction and export of non-renewable resources.

VIII. CONCLUSION

Central Asia's strategic minerals will be pivotal for the energy transition, digital revolution, and overall economy of the region. The supply chains of critical minerals remain vulnerable to various geopolitical dynamics, where state actors dictate the mode of governance, engagement, and direct investment strategy in the sub-region. Attention must therefore focus on the presence of stakeholder involvement, level of dependency on FDI free progress, supply scene assessment, transportation networks, accessibility to the final and the domestic market, and supply chain exposure to major external partners with regard to Central Asia's strategic minerals. These insight aspects are considered essential for the supply chain analysis (Zhang, 2022). Different countries such as China and other extra-regional players indicate a wide-ranging level of involvement on Central Asian critical Strategic Minerals, investment-focused formation, and supply chain disclosure.

Central Asia's critical mineral resources are geologically rich, existing in rivalry with major world players. The different type, popularity level, and the scale of investment attract different global players to enter the sub-region, both in resource and non-resource sectors. Geopolitically, China is the dominating partner, providing FDI in the sub-region's critical minerals and energy supply chain and possessing strategic waterways to develop deeper linkages (Niquet, 2007). Special care should therefore be given to the engagement model of cooperation and types of competitive deployment that influence supply levels, coupled with a clear understanding of the supply chain orientation.

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