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Ivanova M. I., Pomogaev S. O.

TOP 10 RISKS FOR MINING COMPANIES EXTRACTING CRITICAL MATERIALS IN A NAVI ENVIRONMENT

Dnipro University of Technology, Dnipro, Ukraine

This article presents a comprehensive study of the geo-economic and geopolitical risks associated with the production of critical minerals in Ukraine amid a full-scale war, the transformation of global supply chains, intensifying competition for strategic raw materials, and the growing role of mineral resources in facilitating the energy transition and technological modernization. The main focus is on identifying the factors that determine the functioning of Ukrainian mining enterprises involved in the extraction of critical mineral raw materials. The methodological basis of the study consists of a systematic approach, the synthesis of scientific sources, and a case study of the activities of Ukrainian mining enterprises and mineral resource projects. It is argued that the defining constraint on the sector's development is not only the presence of significant resource potential, but above all, the difficulty of transforming it into a production, financially and institutionally prepared asset capable of integrating into European and global value chains. It has been established that the functioning of enterprises is most affected by operational disruptions, rising costs, capital shortages, incomplete verification of reserves in accordance with international standards, imperfect permitting mechanisms, personnel shortages, and security threats. It has been demonstrated that, in the Ukrainian context, the criticality of mineral resources is determined not only by the geological presence of resources but also by the level of infrastructure accessibility, the stability of energy supply, the logistical suitability of assets, and the ability of enterprises to transition from a raw material model to deeper processing. It is demonstrated that geopolitical risks directly affect access to deposits, the pace of investment project implementation, and Ukraine's prospects for joining the European Union's strategic resource supply system. It is emphasized that enhancing the resilience of the critical minerals sector requires harmonizing subsoil policy, modernizing the reserve assessment system, developing processing capacities, strengthening enterprises' technological capabilities, and implementing the principles of sustainable development.

Keywords: enterprise risks, risk management, supply chains, strategic raw materials, strategic development, sustainable development, investments, innovations.

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Introduction and formulation of the problem

In the 21st century, critical minerals have become a key driver of technological development, structural economic modernization, and the energy transition. Lithium, titanium, nickel, cobalt, graphite, rare-earth elements, and other strategic mineral resources form the material basis for the production of batteries, electric vehicles, semiconductors, defense equipment, digital infrastructure, and renewable energy equipment. According to, stable access to such resources increasingly determines not only the pace of industrial growth but also the level of economic security of nations.

The growing global demand for critical minerals is accompanied by increasing competition for control over their extraction, processing, and logistics. Since the production of these raw materials is highly geographically concentrated, and certain countries hold dominant positions in key segments of the value chain, the global market has become particularly sensitive to trade restrictions, political pressure, investment imbalances, and military-political instability. As a result, critical minerals are increasingly shifting from the realm of mere resource supply to the sphere of geo-economic competition and geopolitical influence.

This is precisely why risk analysis in this area is impossible without considering the national dimension of critical mineral production. In today's environment, countries with mineral and raw material potential that can integrate into global supply chains and partially reduce the global market's dependence on a narrow circle of suppliers are of particular importance. In this context, Ukraine occupies an important position thanks to its deposits of strategic minerals, industrial experience in their extraction, and a geographical location that combines a resource base with opportunities for integration into European production and logistics systems.

At the same time, the production of critical minerals in Ukraine is developing amid a complex interplay of internal and external factors. On the one hand, natural resource conditions are conducive to increased extraction and processing of strategic raw materials, which could strengthen the country's position in the international division of labor and lay the groundwork for attracting investment into high-tech sectors of the economy. On the other hand, the realization of this potential is hampered by infrastructure constraints, technological gaps, institutional challenges, insufficient processing depth, and a high level of security threats that directly impact the stability of production processes and the long-term predictability of resource policy.

Under these conditions, the geo-economic risks of critical mineral production in Ukraine are closely intertwined with geopolitical ones. The integration of Ukraine's mineral resource base into the international strategic resource supply system heightens external actors' interest in controlling access to deposits, investment mechanisms, transportation routes, and future models of raw material processing. At the same time, military actions, the transformation of the regional security architecture, changes in the configuration of foreign economic ties, and the reorientation of global supply chains are shaping a new environment in which the production of critical minerals becomes not only an economic resource but also an element of Ukraine's strategic positioning.

In this regard, an analysis of the geo-economic and geopolitical risks associated with the production of critical minerals in Ukraine not only sheds light on the specific features of Ukraine's mineral resources sector but also provides a deeper understanding of its role in the current global economic transformation. This approach allows us to consider the Ukrainian case not in isolation, but as part of broader changes in global competition for strategic resources, where issues of extraction, processing, and control over critical minerals are directly linked to the state's economic resilience, political agency, and security prospects.

Analysis and research of publications

Analysis and research indicate that studies of critical minerals in recent years have developed primarily in three interrelated areas: methodological and technical, institutional and legal, and resource-based and applied. The first area includes the works of S. Lytvynyuk and S. Payuk [1, p. 29], devoted to the application of the criteria of the UN Framework Classification of Resources in the system of assessment, accounting, and management of Ukraine's mineral resources, as well as the article by N. Baryatska [2, p. 30] on methodological approaches to determining and assessing the resource potential of Ukraine's critical mineral raw materials. The scientific value of this section lies in shifting the Ukrainian discussion from general declarations to comparable criteria, international verification of reserves, and unification of the categorical framework. It is these works that form the methodological basis for the transition from old, internally closed schemes of subsoil assessment to standards suitable for international investment communication. At the same time, the methodological classification section has clear limitations. Its main strength – the systematization of criticality criteria, the harmonization of approaches to resource assessment, and the emphasis on reserve verification – also turns out to be its main limitation, since criticality in these works is largely interpreted as a category of state accounting and strategic planning, rather than as an operational characteristic of a specific mining project or enterprise. As a result, crucial issues for Ukrainian producers remain out of focus: how incomplete reserve verification translates into higher capital costs; how discrepancies between classification systems affect the timing of deposit development; and how geological potential correlates with an asset's transport, energy, or security suitability. Thus, these works provide methodological support but do not offer a comprehensive analytical framework for studying the risks of critical mineral production at the enterprise level.

The institutional and legal direction is represented by works that examine critical minerals through the prism of state policy, legal regulation, and European integration. Here, first and foremost, it is worth highlighting the article by S. Lytvynyuk, O. Lagoda, O. Netskyi, and M. Burlutskyi [3, p. 29] on the legal regulation of the mineral resource management system of the State Subsurface Fund of Ukraine, as well as the work by S. Vyzhva, O. Bilyavska, D. Babchuk, and Y. Babchuk [4, p. 132], in which critical materials are analyzed in the context of the Ukraine Facility program and Ukraine's European integration. These studies are significant in that they expand the purely geological discourse and demonstrate that critical minerals can no longer be considered in isolation from the subsoil use regime, state priorities, European support programs, and the new architecture of industrial policy. Their strength lies in identifying the institutional conditions without which even significant resource potential cannot be transformed into an operational production asset. However, a certain methodological bias is evident here as well: the legal and political-integration framework is analyzed in much greater depth than the economics of specific projects, while the link between the regulatory environment and the actual risks faced by mining enterprises – such as delays in development, rising costs, labor shortages, and a lack of processing capacity – is outlined only indirectly.

The resource-applied field comprises applied geological and production studies in which critical raw materials are examined at the site level. The most illustrative examples here are the work by T. Okholina, G. Kuzmanenko, and M. Merezhko [5, p. 24] on identifying priority areas for development within the Selyshchansky placer deposit using ArcGIS, as well as the article by M. Burlutsky and S. Lytvynyuk [6, p. 91] on germanium as a critical raw material and the lignite deposits of Transcarpathia as a potential source for its extraction. The strength of these works lies in the shift from a nationwide framing of the problem to a substantive analysis of specific deposits, spatial parameters, geoinformation tools, and opportunities for utilizing non-traditional sources of mineral raw materials. It is these studies that demonstrate that Ukraine's critical mineral base is not limited to "obvious" resources such as titanium, lithium, or graphite, but can also be formed through more complex, technologically mediated resources. At the same time, these studies mostly stop at the stage of geological or preliminary economic feasibility, without proceeding to a full-fledged analysis of the "deposit–investment–production–market" chain. As a result, issues such as commercial viability, CAPEX/OPEX, logistical accessibility, sensitivity to energy risks, and environmental constraints remain insufficiently addressed.

To summarize, the authors' publications have already established an important scientific foundation for the study of critical minerals, but research on the impact of geo-economic and geopolitical risks on the development of Ukraine's mining enterprises engaged in the extraction of critical materials remains quite fragmented. It is precisely this gap that determines the scientific relevance of further research.

Purpose of the article

The purpose of the article is to identify and critically analyze the geo-economic and geopolitical risks of critical mineral production in Ukraine in the context of domestic mining enterprises' operations.

Presentation of the main material

Ukraine possesses a wealth of critical raw materials (CRMs) vital to the European Union's ambitious green and digital transitions and to the defense sector. According to estimates, the country holds 5% of the world's total mineral resources [7] and has significant deposits of 25 of the 34 materials classified by the EU as critical [8]. It is worth noting that Ukraine has the largest titanium reserves in Europe, some of the largest lithium reserves on the continent (estimated at approximately 500,000 tons), and about 20% of the world's graphite [8]. Lithium and graphite are indispensable components of modern electric vehicle battery technologies [9]. Other significant mineral resources found in Ukraine include beryllium, manganese, gallium, uranium, zirconium, apatite, fluorite, cobalt, and nickel, which play a key role in sectors ranging from renewable energy production and electric mobility to semiconductors and advanced defense systems [8]. Thus, Ukraine can contribute to the EU's green transition as a supplier of critical raw materials (Table).

Therefore, mining companies seek to capitalize on growing demand while ensuring the resilience of their approaches in a nonlinear, accelerated, volatile, and interconnected (NAVI) environment. In the NAVI environment, risks (Fig. 1) can materialize overnight, triggering cascading consequences and unexpected outcomes.

For Ukrainian mining enterprises working with critical minerals, the primary concern is not the risk of raw material depletion, but rather the risk of operational activities, which, in wartime conditions, almost immediately translates into rising costs and falling productivity. This is particularly evident in the case of OGHK, whose records show that sales of ilmenite concentrate fell from 327,100 tons in 2021 to 68,500 tons in 2022, and recovered only to

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91,500 tons in 2023. Sales of rutile concentrate over the same period fell from 39,800 tons to 18,900 tons and further to 10,600 tons [11]. This means that even a company with operating branches in Vilnohirsk and Irshansk is losing market stability not because of a lack of mineral resources, but because disruptions in the production cycle increase the cost of each ton of product and worsen financial performance. A similar pattern is observed in the graphite segment; specifically, the USGS noted that in 2023, graphite production in Ukraine – represented primarily by Zavalievsky Graphite – resumed after the winter hiatus only in May and subsequently operated amid power outages. As a result, the country produced only about 2,000 tons of graphite, compared to approximately 10,000 tons per year before the war [11]. Thus, in the Ukrainian context, operational risk cannot be separated from cost risk; every shutdown due to electricity, logistics, or security automatically undermines productivity and renders even competitive deposits economically vulnerable (Fig. 2).

Table

Key critical raw material reserves in Ukraine and their strategic value for the EU

Critical raw materials	Estimated reserves / figures in Ukraine	Global / European rating of Ukraine (if available)	Key applications in the EU
Lithium	Approximately 500,000 tons; one of Europe's largest reserves	Europe: #1 (reserves)	Batteries, electric vehicles, energy storage
Titanium	Europe's largest reserves	Global: #9 (pre-war production 7%)	Aerospace, defense, industrial applications
Graphite	20% of global reserves	Global: significant	Batteries for electric vehicles, lubricants, refractory materials
Beryllium	Significant deposits	-	Defense, telecommunications, aerospace industry
Manganese	Significant deposits; Reserves: 140,000,000 tons	Global: #4 (reserves)	Steel production, batteries
Gallium	Significant deposits; Ukraine ranks 2nd in gallium	Europe: significant	Semiconductors, LEDs, electronics
Uranium	Significant deposits; Proven reserves	Europe: #1 (reserves)	Nuclear energy
Rare earth elements	Europe's largest recoverable (unused) reserves	Europe: #1 (renewable reserves)	Electronics, magnets, renewable energy sources, defense
Cobalt	Significant deposits	-	Batteries, superalloys
Nickel	Significant deposits	-	Batteries, stainless steel

Source: authors' development based on data [9]

Thus, the matrix of reasons for rejection presented in Fig. 2 allows not only to assess the degree of compatibility between grantors and grantees, but also to identify areas for optimizing the grant strategy to increase the effectiveness of participation in competitive selections. Based on this, an integrated map of donors is created, reflecting each potential grantor's financial capabilities, priorities, and risks of cooperation. Such a map becomes a strategic planning tool, allowing you to prioritize resources, select the most relevant funding sources, and predict the likelihood of success for submitted grant applications.

That is why the next most significant risk in terms of its impact on mining companies is capital risk, which in Ukraine is almost always intertwined with reserve risk. The market does not finance "Ukrainian deposits in general"; it finances only those assets for which the resource base has been proven, an internationally recognized geological model has been prepared, and the path to commercial production has been calculated. As is well known, Ukraine sold OGHK for 3.94 billion UAH, but simultaneously included in the privatization terms mandatory investments of at least 400 million UAH in technical re-equipment and energy modernization, and the new owner launched a JORC resource assessment through Micon International as early as 2025 [12]. This is an important signal, as even for an operational titanium business, access to capital hinges on an internationally recognized assessment of reserves; without it, the company remains undervalued and more expensive to finance.

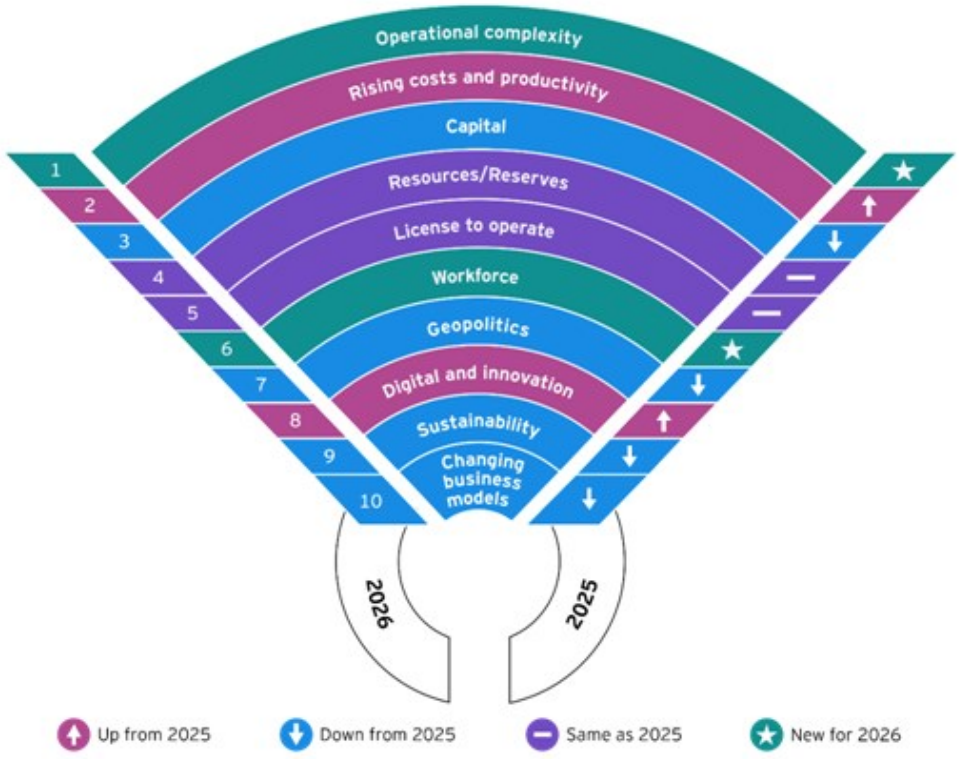

Fig. 1. Top 10 risks for mining companies extracting critical minerals in 2025–2026

Source: authors' development based on data [10]

In the lithium sector, this problem is even more acute. The Ukrainian Geological Service explicitly states that lithium is not yet being mined in Ukraine, and ULM's Polokhivske deposit is still only at the pre-feasibility stage, with an estimated CAPEX requirement of $330 million. ULM itself reported in 2024 only the completion of the PFS and the transition to the DFS [12].

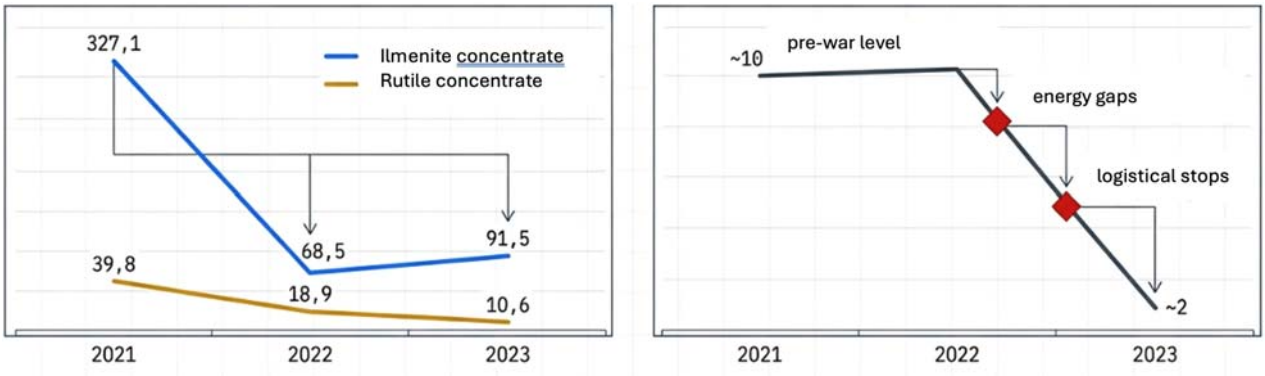

Fig. 2. Impact of operational risk on the activities of mining companies

Source: authors' development

The situation is similar for graphite mining. Specifically, according to the Geological Service, BGV's Balakhivske deposit contains 44 million tons of ore with a 5.4% C and requires $87 million for the first stage and another $316 million for the spheroidized graphite stage. In comparison, the modernization of Zavalivske/Volt to 60,000 tons of concentrate and 50,000 tons of CSPG also requires

over $200 million Thus, Ukraine's main problem is not the lack of critical minerals, but the fact that a long and costly path of reserve verification, project design, and capital raising lies between geological presence and a bankable asset [12], as illustrated in Fig. 3.

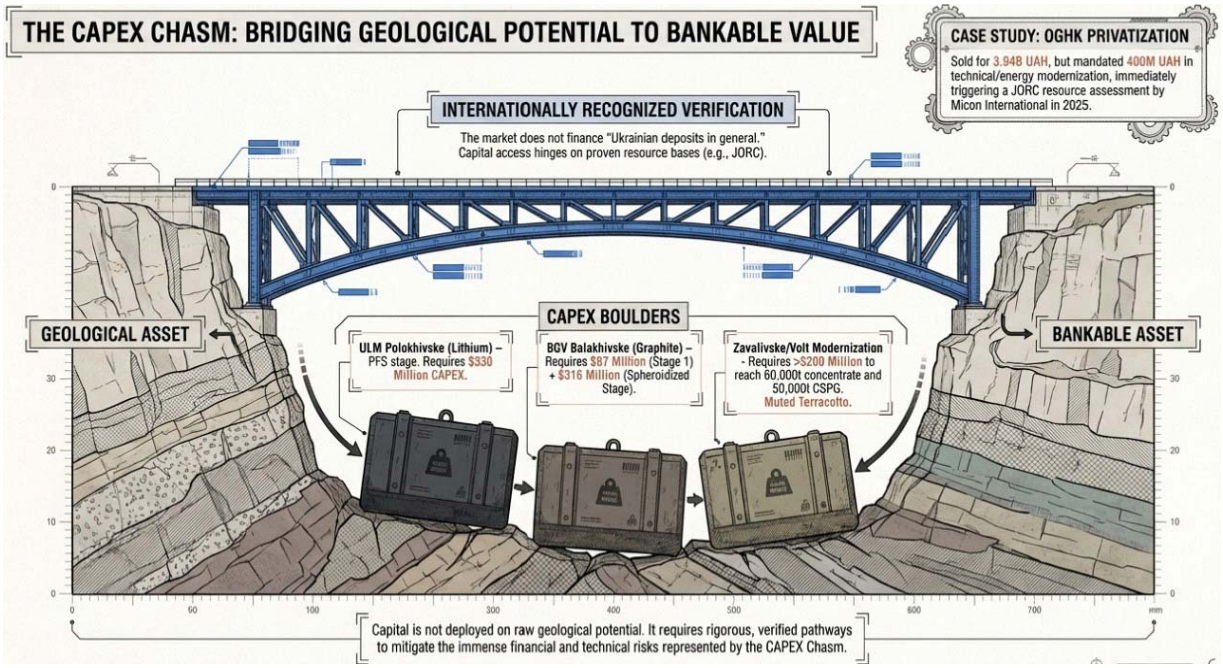

Fig. 3. The impact of capital risk on the operations of mining companies

Source: authors' development

This gap between the presence of mineral resources and the readiness for extraction brings the risk of the operating license to the forefront, which, in the Ukrainian context, is not limited to obtaining a special permit. BGV Graphite obtained a license for the southern section of the Balakhivske deposit back in 2019. However, as of 2025, the company has only completed the PFS and pilot process tests and has moved on to basic engineering with Metso. At ULM, the licensed Polokhivske asset, acquired in 2017, was only brought to the PFS stage in 2024 and is simultaneously undergoing EIA/ESIA. This means that the Ukrainian "operating license" is multi-layered, as it is not enough to have the right to use subsoil resources; one must also demonstrate the project's institutional, environmental, technical, and social viability. It is no coincidence that in 2025, the government began reviewing approximately 3,000 licenses, of which about 10% are officially suspected of being «dormant.» In other words, for the Ukrainian critical minerals market, the main regulatory risk is that a special permit alone does not enable production without going through a long chain of project, environmental, and financial decisions; it merely preserves the asset rather than launching it.

All of this is further complicated by a labor shortage, which in Ukraine is no longer merely a background social factor but directly impacts production stability, as well as by geopolitical risks that are reshaping the very map of industrially viable deposits. In 2024, Reuters reported that the country had lost more than a quarter of its workforce, and nearly 60% of businesses cited a shortage of skilled workers as their main problem. This is critical for the extractive sector, as operations cannot be scaled up solely with capital without a stable core workforce. This risk has become particularly acute with the escalation of the geopolitical situation due to Russia's full-scale invasion of Ukraine, which simultaneously narrowed the workforce base through external and internal population migration and the mobilization of men of working age into the Armed Forces of Ukraine. For mining companies, this is particularly critical, as it is the technical, maintenance, and production units that are most dependent on a stable core workforce, the training of which requires a long time; therefore, a personnel shortage directly increases the risks of downtime, reduced productivity, and disruptions to operational continuity.

However, the geopolitical situation has not only affected staffing at mining enterprises, but also at other sectors. However, it has also significantly increased the overall risk to mining operations due to the redistribution of resource value across territories. According to the Ukrainian Geological Service, the Polokhivske lithium deposit in the Kirovohrad region remains licensed and suitable for further development. In contrast, the Shevchenkivske deposit and the Kruta Balka site are located in temporarily occupied territories or zones where project implementation is effectively blocked. Reuters also noted in 2025 that the war had altered the geography of accessible mineral assets: a significant portion of Ukraine's territory – and with it, a substantial share of the country's resource potential – found itself under occupation or within the zone of direct military impact. Under these conditions, the geopolitical risk for Ukrainian mining enterprises has a dual effect: on the one hand, it removes part of the reserves from economic circulation, and on the other hand, it sharply increases the strategic and investment importance of the deposits that remain in controlled regions [12].

It is precisely this change in the spatial configuration of the resource base that logically leads to the issue of digitalization, since in the context of losing control over part of the deposits, high uncertainty regarding the status of licenses, and the fragmentation of geological archives, digital solutions become not only a tool for modernization but also a means of mitigating risks. This primarily involves digitizing geological data, creating open interactive databases of deposits, providing digital support for licensing procedures, and using geographic information systems to rapidly update data on available assets. At the same time, this is where a specific risk arises: if digitization is incomplete, uneven, or not synchronized with international standards for reserve assessment, it does not reduce uncertainty but merely transforms it into another form – information-based uncertainty. Therefore, for Ukraine's critical minerals sector, digitalization is both a necessary condition for enhancing investment attractiveness and a distinct risk area upon which the speed of decision-making, transparency of access to mineral resources, and the ability of enterprises to integrate into European supply chains depend [12].

A logical extension of geopolitical risk is the risk of sustainable development, since in the context of the loss of part of the resource base and the growing strategic value of controlled deposits, what becomes decisive for the investor is no longer merely the fact of the existence of reserves, but the enterprise's ability to demonstrate the environmental, social, and managerial acceptability of their development. This is particularly important given that EU Regulation 2024/1252 considers the secure supply of critical raw materials to be both sustainable and circular, and for strategic projects, it explicitly sets out requirements for risk monitoring, reducing environmental impact, waste management, and assessing the potential for recovering critical materials from mining sites and tailings. Under these conditions, a project's environmental parameters cease to be a secondary consideration to extraction and become a factor in accessing financing, partnerships, and European markets.

In this context, the risk to sustainable development has a very practical dimension for Ukrainian mining companies. For example, as part of the privatization of OGHK JSC, the new owner has been explicitly required to reclaim disturbed land, comply with discharge limits, waste management, developing a conservation and reclamation project for the tailings pond in the Morgunka ravine, as well as reconstructing the wastewater treatment facilities of the Vilnohirsk Mining and Metallurgical Complex in 2025–2027, which demonstrates the direct integration of environmental requirements into the framework for maintaining the enterprise's production capacity. A similar logic is demonstrated by the BGV Graphite project, where the development strategy has been linked from the outset not only to the extraction of graphite concentrate but also to the production of spheroidized graphite for the battery chain, basic engineering of the processing complex, environmental assessment, reclamation, waste minimization, and alignment with international ESG standards. Thus, the sustainability risk for Ukrainian producers of critical minerals lies not only in potential environmental losses but also in the fact that, without a proven ability to integrate mining with modern environmental management and resource-efficient processing, even a promising deposit will remain an underperforming asset for investors. Ultimately, all these risks converge into the risk of a business model shift, and this is the defining factor for Ukraine.

As long as a company relies on selling concentrate, it remains vulnerable to operational disruptions, high capital costs, low productivity, licensing delays, labor shortages, and geopolitical shocks. Therefore, the most viable cases among Ukrainian mining companies are already shifting toward a different approach. In particular, Velta is transitioning from ilmenite to titanium powder and end products. Meanwhile, Zavalievsky/Volt was already producing and shipping 99.5% high-purity micronized graphite to a client in Europe in 2024 and had declared the downstream

sector a priority. In contrast, BGV plans to produce not only concentrate but also 19,000 tons of SPG for lithium-ion battery anodes. Thus, for Ukraine's mining companies, all 10 risks presented in Fig. 1 converge into a single strategic choice: either Ukrainian mining companies remain suppliers of concentrates with high vulnerability and low added value, or they will leverage European demand for de-risked supply chains and their own projects in titanium, graphite, and lithium to transition to deeper processing, where threats begin to function as a mechanism for structural restructuring rather than as a fate of raw material peripherality [13].

Under such conditions, the issue of risk minimization goes beyond purely analytical concerns and shifts toward the formation of a comprehensive model of corporate response – that is, from piecemeal regulation to a regime of managed deployment of strategic projects. The most appropriate approach is to align the national model with the EU Critical Raw Materials Act's logic, which combines accelerated permitting procedures, a single point of coordination for investors, support for access to financing, and clear guidelines for value chain development. For strategic projects in the EU, shortened approval periods are provided – up to 27 months for extraction facilities and up to 15 months for processing and recycling facilities; At the same time, the regulation itself sets policy targets: 10% of domestic consumption to be met through extraction, 40% through processing, 25% through recycling, and no more than 65% dependence on a single third country [14]. For Ukraine, this means not only simplifying permitting procedures but also establishing a separate legal framework for critical mineral projects, defining in advance timelines, responsible authorities, and prioritization criteria (Fig. 4).

Fig. 4. Adherence to sustainable development principles and international ESG standards for expanding operations in EU markets

Source: authors' development

It follows that the primary risk mitigation tool should be the creation of an open digital geological data room, synchronized with international reserve assessment standards, as well as an audit of "dormant" special permits, followed by the return of unused plots to competitive circulation. Government incentives should be directed primarily toward projects that have already undergone at least preliminary internationally comparable reserve verification and have prepared PFS/DFS reports, since it is at this stage that a geological asset transforms into a financial and banking asset. Without such a filter, support risks preserving not production, but rent-seeking control over licenses.

The next avenue for risk minimization is no longer tied to subsoil rights but to a company's ability to operate physically within a wartime economy. That is why strategic mining projects must have a mandatory business continuity plan that includes backup power, alternative shipment routes for products, critical stocks of reagents and components, redundant communication links, and insurance against major logistical risks. In practical terms, this means that the resilience of a mining project must be assessed not only based on its resource base or expected profitability, but also on its readiness to operate during power outages, transport infrastructure damage, supply delays, and disruptions

to production chains. In the absence of such tools, even a promising deposit loses its investment appeal, as the risk of downtime, failure to meet contractual obligations, and rising production costs increases significantly. This is precisely why a business continuity plan should not be a secondary element of internal management but a mandatory component of the project architecture, determining the enterprise's actual ability to maintain stable production and product supply under a wartime economy. At the same time, internal operational redundancy must be combined with external risk mitigation mechanisms, as only such a combination enables reducing production vulnerability to force majeure events and increasing confidence among investors, creditors, and strategic partners.

However, even with improved regulation and insurance coverage, the sector will remain vulnerable if Ukraine continues to rely primarily on a raw materials-based model of participation in supply chains. The CRMA itself emphasizes not only extraction but also processing, recycling, geological resource exploration, recovery of critical components from mining waste, and stricter sustainability requirements for projects. Therefore, Ukraine's risk-mitigation policy should encourage not just the launch of mines or quarries, but the localization of at least part of the downstream sector: beneficiation, chemical processing, production of intermediate materials, and extraction of critical components from industrial waste dumps. It is precisely in this case that dependence on price fluctuations for concentrate decreases, the project's investment attractiveness increases, and a foundation is created for integration into European strategic supply chains, especially since the European Commission has already officially approved the first lists of strategic projects within and outside the EU. For Ukraine, this means that the most effective way to mitigate risks is to combine accelerated licensing, verification of reserves, insurance against military threats, personnel and technological modernization, and the promotion of deeper processing, since only such a combination moves critical minerals from the category of potential to that of a truly sustainable industrial asset (Fig. 5).

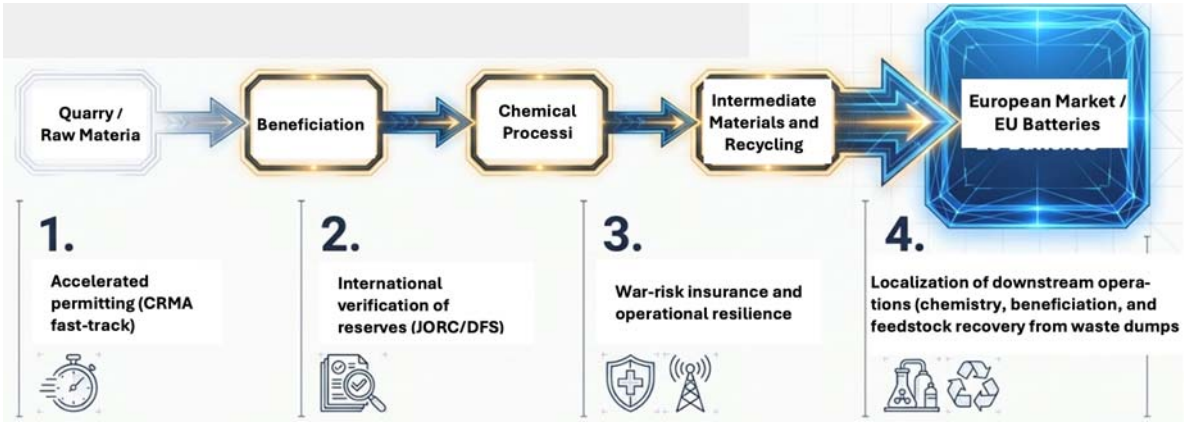

Fig. 5. The role of Ukraine and critical mineral raw material producers in EU value chains
Source: authors' development

Conclusions

The study provides grounds for asserting that the production of critical minerals in Ukraine is shaped by the intersection of geo-economic and geopolitical factors, which simultaneously expand the state's strategic capabilities while exacerbating systemic constraints on the development of mining enterprises. It has been established that the presence of deposits of titanium, graphite, lithium, and other types of critical raw materials does not in itself provide competitive advantages, since what is decisive is not so much the resource potential as the ability to transform it into an asset that is prepared in terms of production, technology, finance, and institutions.

The analysis revealed that the risks associated with the production of critical minerals in Ukraine are interrelated. Operational instability, rising costs, capital shortages, incomplete verification of reserves, delays in permitting procedures, labor shortages, technological dependence, environmental constraints, and security threats do not operate in isolation but form a single system of constraints. This is precisely why the criticality of mineral resources in the Ukrainian context is determined not only by their geological presence but also by access to infrastructure, the stability of energy supply, the investment attractiveness of projects, the level of local processing, and the ability of enterprises to operate under

conditions of military and market instability.

It has been demonstrated that the primary structural problem remains the persistence of a predominantly raw-material-based model for developing the mineral resource base. Under such a model, Ukrainian enterprises remain most vulnerable to external market conditions, logistical gaps, price fluctuations, and technological dependence on external processing centers. In contrast, a transition to a model of deeper processing, the development of intermediate and final products, expanded participation in European value chains, and the adoption of international standards for reserve assessment can mitigate the impact of most of the identified risks.

It has been argued that minimizing the negative consequences of geo-economic and geopolitical risks requires a coordinated combination of several areas of government and corporate policy: accelerating and increasing the transparency of permitting procedures, digitizing geological information, conducting international verification of reserves, expanding access to long-term capital, insuring against military and political risks, developing human capital, modernizing enterprises technologically, and implementing sustainable development standards. Only under such conditions can the critical minerals sector become not a peripheral raw-materials appendage, but a key element of Ukraine's economic security, industrial modernization, and post-war recovery.

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ТОП-10 РИЗИКІВ ГІРНИЧОВИДОБУВНИХ ПІДПРИЄМСТВ З ВИДОБУТКУ КРИТИЧНИХ МАТЕРІАЛІВ В УМОВАХ NAVI-СЕРЕДОВИЩА

Іванова М. І., Помогаєв С. О.

У статті здійснено комплексне дослідження геоекономічних та геополітичних ризиків виробництва критичних мінералів в Україні в умовах повномасштабної війни, трансформації глобальних ланцюгів постачання, посилення конкуренції за стратегічну сировину та зростання ролі мінеральних ресурсів у забезпеченні енергетичного переходу і технологічної модернізації. Основну увагу зосереджено на виявленні чинників, що визначають функціонування українських гірничих підприємств, пов'язаних із видобутком критичної мінеральної сировини. Методологічну основу дослідження становлять системний підхід, метод узагальнення наукових джерел, а також кейс-аналіз діяльності українських гірничих підприємств і мінерально-сировинних проєктів. Обґрунтовано, що визначальним обмеженням розвитку сектору є не лише наявність значного ресурсного потенціалу, а насамперед складність його трансформації у виробничо, фінансово та інституційно підготовлений актив, здатний інтегруватися у європейські та світові ланцюги створення вартості. Встановлено, що на функціонування підприємств найбільше впливають операційні перебої, зростання витрат, дефіцит капіталу, неповна верифікація запасів за міжнародними стандартами, недосконаліть дозвільних механізмів, кадровий дефіцит та безпекові загрози. Доведено, що в українських умовах критичність мінеральної сировини визначається не лише геологічною наявністю ресурсів, а й рівнем доступності інфраструктури, стабільністю енергопостачання, логістичною придатністю активів та здатністю підприємств переходити від сировинної моделі до глибшої переробки. Показано, що геополітичні ризики безпосередньо впливають на доступ до родовищ, темпи реалізації інвестиційних проєктів і перспективи входження України до системи стратегічного ресурсозабезпечення Європейського Союзу. Наголошено, що підвищення стійкості сектору критичних мінералів потребує узгодження надрової політики, модернізації системи оцінки запасів, розвитку переробних потужностей, посилення технологічної спроможності підприємств і впровадження принципів сталого розвитку.

Ключові слова: ризики діяльності підприємств, ризик-менеджмент, ланцюги постачання, стратегічна сировина, стратегічний розвиток, сталий розвиток, інвестиції, інновації.

TOP 10 RISKS FOR MINING COMPANIES EXTRACTING CRITICAL MATERIALS IN A NAVI ENVIRONMENT

Ivanova M. I.*, Pomogaev S. O.
Dnipro University of Technology, Dnipro, Ukraine
***e-mail: ma_riva@ukr.net**
Ivanova M. I. ORCID**: https://orcid.org/0000-0002-1130-0186**
Pomohaiev S. O. ORCID**: https://orcid.org/0009-0008-0010-7517**

This article presents a comprehensive study of the geo-economic and geopolitical risks associated with the production of critical minerals in Ukraine amid a full-scale war, the transformation of global supply chains, intensifying competition for strategic raw materials, and the growing role of mineral resources in facilitating the energy transition and technological modernization. The main focus is on identifying the factors that determine the functioning of Ukrainian mining enterprises involved in the extraction of critical mineral raw materials. The methodological basis of the study consists of a systematic approach, the synthesis of scientific sources, and a case study of the activities of Ukrainian mining enterprises and mineral resource projects. It is argued that the defining constraint on the sector's development is not only the presence of significant resource potential, but above all, the difficulty of transforming it into a production, financially and institutionally prepared asset capable of integrating into European and global value chains. It has been established that the functioning of enterprises is most affected by operational disruptions, rising costs, capital shortages, incomplete verification of reserves in accordance with international standards, imperfect permitting mechanisms, personnel shortages, and security threats. It has been demonstrated that, in the Ukrainian context, the criticality of mineral resources is determined not only by the geological presence of resources but also by the level of infrastructure accessibility, the stability of energy supply, the logistical suitability of assets, and the ability of enterprises to transition from a raw material model to deeper processing. It is demonstrated that geopolitical risks directly affect access to deposits, the pace of investment project implementation, and Ukraine's prospects for joining the European Union's strategic resource supply system. It is emphasized that enhancing the resilience of the critical minerals sector requires harmonizing subsoil policy, modernizing the reserve assessment system, developing processing capacities, strengthening enterprises' technological capabilities, and implementing the principles of sustainable development.

Keywords: enterprise risks, risk management, supply chains, strategic raw materials, strategic development, sustainable development, investments, innovations.

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