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Energy Espionage 5.0: Corporate Intelligence, Critical Metals, and Artificial Intelligence

Tuğba Çakıroğlu[1,*]

Abstract

The strategic significance of critical minerals in the global energy transition has intensified, transforming competition among states and corporations into a geopolitical security challenge. This study examines intelligence practices and industrial espionage strategies targeting critical mineral resources. It analyses how lithium, cobalt, nickel, and rare earth elements influence national security agendas and supply-chain protection policies, focusing on cyber-espionage, insider information leakage, and covert data acquisition methods. The paper evaluates the use of satellites, high-resolution drones, AI-driven mineral exploration systems, and remote-sensing technologies for resource detection and production monitoring. It further explores the capacity of multinational mining firms to shape energy diplomacy and public policy, positioning them as strategic non-state actors. Additionally, the research investigates open-source intelligence systems, AI-based commercial data platforms, and competitive intelligence tools as mechanisms for gaining informational advantage in the energy sector. Findings indicate that the convergence of digital surveillance technologies and geoeconomic rivalry has created a new security architecture, where artificial intelligence emerges as a decisive force in mineral geopolitics.

Keywords: Energy espionage, critical minerals, artificial intelligence, satellite surveillance, drone systems, corporate intelligence, OSINT.

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[1] Turkish Energy, Nuclear and Mineral Research Agency, Ankara, Türkiye
* Corresponding author.
✉ safrantugba78@gmail.com

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1. Introduction

The global energy transition has accelerated the shift toward sustainable and carbon-neutral energy systems, significantly increasing the strategic demand for critical minerals. Minerals such as lithium, cobalt, nickel, and Rare Earth Elements (REEs) have become essential components in the production of advanced battery technologies, defence systems, electric vehicles, and artificial intelligence-based hardware (IEA, 2021). This trend has not only intensified economic competition but also exacerbated geopolitical power struggles, driving both states and multinational corporations to design comprehensive overt strategies and covert mechanisms aimed at securing critical mineral supply chains. As the security of these supply networks becomes central to national economic and strategic policies, there has been a notable increase in state-led interventions, regulatory measures, and competitive actions aimed at diversifying and protecting access to critical mineral resources (Nakano, 2021).

To contextualize the concept of Energy Espionage 5.0, it is useful to briefly outline the historical evolution of energy-related intelligence practices. Energy espionage initially emerged in the twentieth century as a state-centred activity focused on securing access to oil reserves, pipeline routes, and strategic chokepoints, often relying on human intelligence and diplomatic reporting. In subsequent phases, particularly during the late Cold War and post-Cold War periods, energy intelligence expanded to include industrial espionage, corporate infiltration, and the protection of proprietary extraction technologies. With the digitalization of energy systems and the globalization of supply chains in the early twenty-first century, cyber espionage and open-source intelligence became integral to monitoring energy markets and infrastructure. The current phase conceptualized in this study as Energy Espionage 5.0 represents a qualitative shift characterized by the convergence of artificial intelligence, commercial satellite data, corporate intelligence, and large-scale data analytics, thereby redefining both the actors and the instruments of energy-related intelligence.

The intelligence dimension of competition in the energy and resource sectors encompasses a broad range of techniques, from classical espionage practices to advanced digital surveillance and analytical tools. Modern remote sensing technologies—including satellite imagery, Unmanned Aerial Vehicles (UAVs), and other airborne platforms—combined with artificial intelligence–based data processing and pattern recognition software, play an increasingly critical role in detecting resource deposits, monitoring production activities, and generating high-resolution geospatial intelligence that enhances situational awareness for both corporate and state actors. These developments reflect the growing integration of geospatial analytics and machine learning in strategic resource governance and decision-making processes (Yang et al., 2024). In this context, energy espionage has emerged as a new strategic domain with implications for both national security and economic sustainability. This study examines the intelligence and technological aspects of the competition over critical minerals and analyses the interplay between corporate, geopolitical, and digital instruments.

This research employs descriptive analysis and document review methods within the scope of a qualitative research design. Academic articles, reports published by international organizations, defence strategy documents, and the corporate intelligence literature were first surveyed. Sources were selected through Google Scholar, Scopus, and Web of Science indexes. During the review process, key concepts were identified within the thematic framework of energy security, the geopolitics of critical minerals, cyber espionage, OSINT, and artificial intelligence–supported monitoring technologies.

The selected sources were classified through content analysis, and three main research questions were formulated:

1. How does competition over critical minerals shape international security dynamics?
2. How are power relations between mining corporations and state actors evolving?
3. How do artificial intelligence and surveillance technologies transform energy intelligence practices?

A systematic literature approach was employed in compiling the data, with a particular emphasis on studies published in the last decade to evaluate recent technological and strategic developments. Several analyses were supported by up-to-date industry reports and policy documents. The results suggest that competition over critical minerals has increasingly become a central issue in global geopolitics and economic security debates. The concentration of rare earth element production and processing capacity in a limited number of countries particularly China has prompted the United States and the European Union to treat mineral supply chains as a strategic priority and to develop policies aimed at diversifying and securing access to these resources (IEA, 2021).Consequently, alternative supply routes have been developed, strategic stockpiling programs have been strengthened, and mining investments have increasingly been utilized as geopolitical instruments.

Multinational mining corporations are emerging not merely as economic entities but increasingly as significant geopolitical actors with the capacity to shape international relations and strategic policy outcomes. Through their involvement in critical mineral extraction and processing, these firms influence diplomatic engagements, contribute to infrastructure financing, and intersect with national energy security strategies. Their strategic investments and operations are embedded within broader geopolitical frameworks, where access to resources such as lithium, cobalt, and rare earths has implications for technological competition, supply-chain resilience, and state foreign policy priorities (Müller, 2023). As a result, corporate diplomacy and the influence of non-state actors in security and policy-making processes are expanding.

From a technological standpoint, strategic competition in energy and minerals has been increasingly shaped by digitization, as satellite remote sensing, drone-based field surveys, and artificial intelligence–enhanced analytical tools transform how reserves are estimated and production performance is monitored. These advanced technologies enable more transparent mapping of geological features and real-time data acquisition, while machine learning models accelerate the processing and interpretation of large geospatial datasets, thereby increasing both the efficiency and competitive intensity of exploration and monitoring activities in the mining sector (Yang, et al., 2024).OSINT platforms and commercial data analytics firms enable the acquisition of strategic insights through market movements, logistics networks, and corporate datasets. This dynamic deepens debates surrounding data privacy, energy security, and national sovereignty.

The findings of this research indicate that artificial intelligence–based intelligence methods will assume an increasingly decisive role in the geopolitics of energy and minerals in the coming period. The interplay between digital surveillance and strategic data analytics will redefine geopolitical competition and bring new security risks to the forefront.

This study adopts a qualitative and analytical research design grounded in geopolitics, security studies, and political economy. Rather than relying on empirical field data, the analysis is based on secondary data sources in order to conceptualize and examine the emerging phenomenon of Energy Espionage 5.0. The methodological approach aims to synthesize fragmented discussions across energy security, critical mineral geopolitics, corporate intelligence, and artificial intelligence into an integrated analytical framework.

The data utilized in this study consist of peer-reviewed academic literature, policy documents, official government publications, reports by international organizations, and publicly available cybersecurity and intelligence assessments. Sources were selected based on their relevance to critical minerals, energy security, industrial espionage, satellite surveillance, and artificial intelligence–driven intelligence practices. Particular emphasis was placed on materials published by institutions such as the International Energy Agency, national security agencies, and leading cybersecurity firms to ensure analytical validity and contemporary relevance.

The analysis was conducted through qualitative content analysis and thematic synthesis. Selected sources were systematically examined to identify recurring patterns related to resource competition, surveillance technologies, corporate intelligence practices, and data sovereignty. These themes were subsequently interpreted through a geopolitical and security-oriented analytical lens to demonstrate how artificial intelligence and digital surveillance technologies reshape traditional forms of energy-related industrial espionage. This structured analytical process enables the transformation of descriptive material into a coherent theoretical interpretation.

1.1. Mineral Geopolitics and Industrial Espionage

The global economy has historically been shaped by access to resources. From antiquity to the present, power dynamics have revolved around gold, silver, spices, oil, and, in today's context, strategic metals and rare earth elements (Rare Earth Elements, REE). In the twenty-first century, developments such as the transformation of energy systems, the expansion of the knowledge-based economy, and the rapid advancement of artificial intelligence technologies have carried traditional energy competition into a new strategic dimension. Competition is no longer limited to oil and natural gas resources; critical minerals including lithium, cobalt, nickel, graphite, titanium, palladium, platinum, and neodymium have increasingly emerged as essential components of global power projection (Gielen, 2021).

In this regard, mineral geopolitics has become an integral component of national security doctrines and economic strategies, while industrial espionage activities aimed at controlling the supply chains of critical minerals have intensified. The concept of "Energy Espionage 5.0" represents a new paradigm of competition shaped by artificial intelligence–supported data analytics, digital surveillance, corporate penetration techniques, and hybrid operations targeting global supply chains.

The geopolitical positioning of critical minerals carries strategic significance due to their use in high value–added sectors such as energy storage, the defence industry, telecommunications, semiconductor manufacturing, artificial intelligence hardware, and space technologies. The International Energy Agency (IEA) projects that the demand for lithium, cobalt, and nickel will increase by a factor of 40, 20, and 25, respectively, by 2040, driven by the expansion of electric vehicles and battery storage systems (Kim, et al, 2021).

A review of global production structures reveals that the geographical distribution of critical minerals is highly asymmetric. For example (U.S. Geological Survey, 2024):

- 56% of the world's lithium reserves are located in Chile,
- 70% of global cobalt production takes place in the Democratic Republic of Congo,
- More than 60% of rare earth elements are processed in China.

This asymmetric distribution brings supply chain dependencies and geoeconomic vulnerabilities to the forefront. States simultaneously employ diplomatic, financial, and intelligence instruments to secure access to strategic minerals. This approach reflects a shift from Joseph Nye's concepts of "soft power" and "hard power" toward a "smart power" model (Nye, 2011).

Competition over strategic minerals involves not only access to physical resources but also processing technologies, advanced metallurgy, R&D infrastructure, and data-driven exploration capabilities. Accordingly, the geopolitics of minerals is situated at the intersection of natural resource diplomacy and technology geopolitics.

The development of industrial espionage and competition over strategic resources encompasses actions taken by state and private actors to acquire competitors' critical information and technologies for the purpose of gaining commercial or strategic advantage (Holmström, 2020). Throughout the 20th century, espionage in the energy sector primarily targeted oil reserves, pipeline infrastructures, and refinery technologies. Today, however, the focus has shifted toward a digitalized information ecosystem involving mineral exploration data, material science innovations, and battery technologies.

Table 1 summarizes the principal espionage methods currently employed in strategic resource competition.

Table 1. Contemporary industrial espionage tactics in strategic resource competition.

Espionage Method	Description
Digital penetration and cyber intelligence	The monitoring of unauthorized access attempts targeting corporate networks and industrial control systems is conducted to gather information and enhance adversarial influence; in this context, cyber intelligence focuses on identifying threat vectors and vulnerabilities.
Corporate infiltration and insider agents	The covert acquisition of strategic information through individuals positioned or placed within a company to gain competitive advantage targets organizational security vulnerabilities; corporate infiltration operates on exploiting these internal weaknesses.
Supply chain manipulation	It refers to the disruption of supply security by manipulating material flows, supplier relations, or logistics processes through informational or physical interventions, thereby placing competitors at a disadvantage.
Information leakage through academic partnerships	It refers to the transfer of scientific data obtained through university–industry collaborations and research projects to third parties outside ethical and legal frameworks, or its indirect use for profit-driven purposes.
Intelligence operations disguised as legal investments	It refers to the intertwining of legitimate economic activities—such as direct investment, joint ventures, or acquisitions—with intelligence operations aimed at obtaining strategic information and securing competitive advantage.
The theft of geological modelling data	The seizure of databases containing reserve estimates, sample analyses, and model configurations weakens companies' exploration investments and market positioning.

Source: Nasheri (2005), Hannas et al. (2013), Noonan and Archuleta (2008), Hou and Wang (2020).

A publicly documented example that illustrates the evolution of industrial espionage in the energy domain is the cyber operation widely known as *Stuxnet*. Although originally targeting Iran's nuclear infrastructure, this operation demonstrated how cyber capabilities could be used to infiltrate industrial control systems, manipulate operational data, and disrupt strategic energy-related assets without direct physical intervention (Langner, 2011). The Stuxnet incident is widely regarded as a turning point in revealing the feasibility of digitally driven sabotage and intelligence operations against critical energy infrastructures.

More recent publicly reported cases indicate that similar cyber-espionage patterns have targeted mining companies involved in critical minerals such as lithium, rare earth elements, and battery technologies. Reports by cybersecurity firms and governmental institutions document attempts to access geological survey data, mineral processing technologies, and supply chain intelligence, underscoring the relevance of Energy Espionage 5.0 as a data-driven and hybrid form of strategic competition (U.S. Department of Justice, 2023).

The competition between China and the United States over technology and critical raw materials is extensively examined in the academic literature as a key arena where strategic rivalry and industrial espionage have intensified. Scholars note that China's dominant position in the mining, processing, and supply of rare earth elements and other strategic minerals which are essential inputs for advanced technologies and defence systems has prompted concern in Washington about risks to intellectual property, supply chain vulnerabilities, and the potential use of covert methods to secure technological advantage. As a result, economic security debates increasingly frame resource and technology competition as intertwined domains of the broader Sino-American strategic rivalry (Stango, 2024). Economies such as the European Union and Japan are also developing intelligence-driven policies to ensure the security of critical mineral supplies.

Artificial intelligence–driven analytical systems are increasingly transforming mineral exploration and extraction processes. The integration of satellite imagery, extensive geophysical datasets, machine-learning-based geological modelling, and automated or remotely operated mining technologies is progressively transforming the sector into a data-driven and digitally governed industry. Although such technological advancements improve efficiency and support more informed decision-making in resource exploration and production processes, the increasing reliance on digital infrastructures simultaneously heightens the exposure of mining systems to cyber espionage and data-related security vulnerabilities (Marshall et al., 2015). Table 2 presents the key domains in which artificial intelligence intersects with intelligence activities in the mining sector.

Table 2. Artificial intelligence applications and intelligence purposes in the context of energy espionage in the mining sector.

Domain	Purpose
Digital geological data mining	New reserve estimation and the theft of competitors' exploration data
Machine learning	Supply chain risk analysis and speculation
Cyber intelligence	Infiltration into industrial control systems
Autonomous operations	The risk of remote sabotage or manipulation
Deepfake technologies	Social engineering attacks in executive communications

Source: Gaber et al. (2021), Frankovits and Mirsky (2023), and Pedersen et al. (2025).

This situation demonstrates that information security in the mining industry is not confined to the physical domain; rather, it requires a broad security ecosystem ranging from data centres to academic collaborations.

State–corporate cooperation and the new geoeconomic competition over access to critical minerals have shifted from classical state-cantered policies toward hybrid models supported by corporations. State-backed mining initiatives conduct global competition through financial instruments, geostrategic partnerships, and international legal mechanisms (Bridg, 2008). For example:

- The United States provides federal support for battery metals under the Defence Production Act.
- China controls the entire rare earth elements supply chain under its “Made in China 2025” program.
- The European Union has developed strategic reserve policies through the Critical Raw Materials Act.

These policies demonstrate the rise of state capitalism in the energy sector and the incorporation of corporate intelligence units into national security strategies. From ethical, legal, and security perspectives, the growing competition over energy resources increasingly brings debates in international law to the forefront. Cyberattacks, corporate infiltration, and data manipulation create risks that have the potential to undermine both the stability of the international trade system and the functioning of democratic oversight mechanisms (Clarke & Knake, 2021). Ethical questions are particularly concentrated along the following axes:

1. How does the use of artificial intelligence in resource competition transform state sovereignty?
2. How will human rights be protected in regions where critical minerals are extracted?
3. Where is the boundary between industrial espionage and the protection of strategic information?

These questions make it necessary to evaluate mineral geopolitics not only as an economic and strategic domain but also within the context of human security, sustainability, and ethics. The era of Energy Espionage 5.0 represents a period in which competition over natural resources has become digitalized, mineral geopolitics has converged with technology geopolitics, and artificial intelligence has emerged as both a source of power and vulnerability. As demonstrated in this section, critical minerals carry not only economic value but also lie at the centre of national security strategies, global political balances, and corporate power relations.

As competition is expected to intensify in the coming years, the development of ethical, legal, and international cooperation mechanisms will be critical for achieving sustainable and equitable resource governance.

1.2. Satellites, Drones, and Resource Monitoring Technologies

Across the history of energy geopolitics and competition over mineral resources, states have consistently relied on advanced surveillance and reconnaissance capabilities to secure valuable extraction sites and protect strategic frontiers. From early aerial reconnaissance missions in the mid-20th century such as the U.S. CORONA satellite program, which pioneered space-based photographic intelligence to the widespread use of satellites, unmanned aerial vehicles (UAVs/drones), and data-driven monitoring systems in the twenty-first century, surveillance technologies have been integral to shaping strategic economic and military dynamics.

Contemporary remote sensing and aerial surveillance platforms now serve as essential tools for gathering real-time intelligence, enhancing situational awareness, and safeguarding critical resource infrastructure (Raghuvanshi et al., 2025).

Within the framework of contemporary strategic resource competition, the integration of satellite observation systems, geospatial analytics, unmanned platforms, and artificial intelligence–enhanced data fusion has transformed how critical mineral deposits are detected, monitored, and protected. For strategic resources such as lithium, cobalt, nickel, graphite, and rare earth elements, space-borne remote sensing and AI-assisted processing provide real-time, high-resolution geological insights that reduce dependence on traditional field campaigns and offer continuous, verifiable data independent of conventional diplomatic or ground intelligence methods. As such, these advanced monitoring technologies have emerged as pivotal instruments in securing resource supply chains and reinforcing geopolitical influence in the twenty-first century (Garcia-del-Real & Alcaráz, 2024).

Although satellite technologies were initially developed for military purposes during the 1960s, they are now widely utilized in areas such as natural resource management, environmental monitoring, mine planning, and national security (Prost, 2025). High-resolution optical satellites, hyperspectral imaging systems, synthetic aperture radar (SAR), and thermal sensors provide powerful tools for detecting subsurface resources and observing operational activities.

Hyperspectral satellites, in particular, provide critical data for analysing rock composition, mineral geochemistry, and detecting land-use changes (Yan, et al., 2022). This allows mineral exploration processes to be conducted much faster, more cost-effectively, and more comprehensively than classical geological field studies.

Table 3 outlines the principal applications of satellite and remote sensing data in mineral exploration and resource management.

Table 3. Applications of satellite and remote sensing data in mineral exploration and management.

Application Area	Operational Description
Identification of metallogenetic zones	The analysis of geological, geochemical, and remote sensing data to determine mineral formation processes, ore-forming zones, and potential reserve areas through scientific modelling.
Expansion analysis of open-pit mines	It refers to the assessment of the growth rate of open-pit areas, production expansion trends, and land-use changes using satellite imagery, drone data, and time-series analyses.
Detection of illegal mining activities	It refers to the early detection of unauthorized excavation sites, concealed mining equipment, and illicit production lines through satellite, radar, and thermal imaging technologies.
Monitoring of environmental impacts	It refers to the continuous assessment of the impacts of mining operations on ecosystems—such as vegetation loss, water resource degradation, soil alteration, and carbon emissions—using remote sensing and environmental sensors.

Table 3. (Continued)

Identification of geological fault lines and alteration zones	It refers to the identification of subsurface fault lines, hydrothermal alteration zones, and structurally significant features with high ore-forming potential using spectral analysis, geophysical data, and geographic information systems.
Analysis of infrastructure development	It refers to the monitoring of roads, power lines, storage facilities, processing plants, and other operational infrastructure in mining regions through remote sensing methods to evaluate capacity expansions and indicators of strategic preparedness.

Source: Bedini (2017), Peyghambari and Zhang (2021), and Balaniuk et al. (2020).

Hyperspectral imaging systems are capable of resolving and differentiating mineralogical components across hundreds of narrow spectral bands, enabling the detailed identification of surface composition, alteration zones, and mineral distributions. This advanced remote sensing technique is particularly valuable in the exploration of minerals such as lithium and copper, whose surface signatures can be detected and mapped with high spectral fidelity, thereby enhancing the accuracy and efficiency of targeting prospective ore bodies (Van der Meer et al., 2021).

In satellite intelligence and energy espionage, satellite systems provide not only reconnaissance but also strategic advantages in espionage activities. In the context of geopolitical competition, satellite data can:

Within the context of geopolitical competition, satellite data has become an important tool for monitoring strategic activities related to natural resources and industrial production. Remote sensing technologies enable the observation of mining investments carried out by rival states, the tracking of supply chain infrastructures such as railways and pipelines, and the surveillance of port and logistics operations that facilitate the global movement of critical materials. In addition, satellite imagery allows the early identification of newly planned mining sites and provides indirect indicators of industrial production levels through the analysis of infrastructure expansion, transportation intensity, and energy-related facilities. Such capabilities make satellite data a valuable component of contemporary geoeconomic intelligence and resource governance (Finer, Jenkins, Pimm, Keane & Ross, 2018).

For instance, China and the United States utilize space-based observation systems to monitor critical mineral regions in Africa and South America in order to detect potential investment opportunities at an early stage. Such practices point to the emergence of a new geoeconomic framework in which cooperation between states and corporations increasingly overlaps with intelligence activities. In parallel, drones have quickly become indispensable operational instruments within the mining sector. Supported by cloud-based data processing, lidar sensors, and high-resolution imaging systems, these platforms have significantly transformed both exploration processes and security operations (Shahmoradi et al., 2020). Table 4 summarizes the principal operational applications of drone technology in the mining sector.

Table 4. Operational applications of drone technology in the mining sector.

Drone Application Area	Operational Description
Topographic mapping	It refers to the three-dimensional modelling of elevation data, land morphology, and surface changes using satellite-, lidar-, and drone-based measurement techniques, and their use in mining planning.
Open-pit volume calculations	It refers to calculating the volumetric changes of excavated areas through photogrammetry, lidar scanning, and geotechnical analyses, thereby optimizing production efficiency and reserve utilization.
Blast planning	It refers to the analysis of geological structure, explosive types, rock resistance coefficients, and site safety data in order to design safe, controlled, and efficient blasts in ore-breaking operations.
Environmental monitoring	It refers to the monitoring of water, air, soil, and noise parameters through sensor networks, remote sensing, and field measurements to evaluate the environmental impacts of mining activities.
Environmental risk control (erosion, dust, water pollution)	It refers to the implementation and monitoring of environmental protection strategies such as erosion barriers, dust suppression practices, water filtration systems, and biotechnical measures.
Security patrols	It refers to the regular surveillance and threat detection activities conducted by physical security personnel and unmanned patrol systems around critical equipment, boundary lines, and operational areas.

Source: Shahmoradi et al. (2020) and Said et al. (2020).

In such environments, Table 5 illustrates how drones function as real-time surveillance instruments across various operational dimensions.

Table 5. Drone-Based surveillance applications in mining security and operations.

Surveillance Application	Operational Description
Strengthening border and site security	It refers to the reduction of unauthorized entry and sabotage risks along mining sites and boundary lines through the integration of physical barriers, access control systems, patrol arrangements, and electronic surveillance.
Detecting unauthorized intrusions	It refers to the early detection of unauthorized intrusions around site boundaries and perimeters using motion sensors, thermal cameras, radar systems, and data analysis algorithms, triggering appropriate response mechanisms.
Detecting infrastructure damage	It refers to the early detection of damage and deterioration in critical infrastructure components—such as pipelines, bridges, and storage facilities—through structural health monitoring (SHM), IoT sensors, satellite imagery, and regular inspections.

Table 5. (Continued)

Monitoring extraction equipment	It refers to ensuring production continuity by monitoring the operational status, maintenance needs, and potential failures of machines through equipment telemetry data, operational performance indicators, and remote monitoring.

Source: Ajayi & Ikemefuna, 2025

Artificial intelligence algorithms integrated into drone systems enhance autonomous security capacity by performing anomaly detection and threat classification. However, alongside their security benefits, drones also carry a significant potential for use in espionage. Table 6 illustrates how drones and artificial intelligence can be leveraged for strategic intelligence and espionage purposes in the mining sector.

Table 6. Drone and ai applications in strategic intelligence and mining espionage.

Espionage Application	Operational Description
Monitoring extraction rates	It refers to analytical activities aimed at gaining strategic competitive advantage by monitoring production volumes, ore extraction rates, and reserve depletion dynamics in real time through satellite, sensor, and data analysis tools.
Documenting facility designs	It refers to the examination and archiving of engineering layouts, production lines, and technical infrastructure related to mining facilities through imaging, infiltration, or open-source data tracking.
Analysing production infrastructure	It refers to the assessment of the operational capacity and vulnerabilities of critical components—such as power lines, processing equipment, transportation networks, and storage systems—using technical, logistical, and digital tools.
Monitoring personnel movements	It refers to the analysis of operational priorities and security vulnerabilities by tracking workforce distribution in the field, the activity intensity of specialist teams, and the movement patterns of critical personnel.
Collecting geological data	It refers to the collection of samples, sensor outputs, radar measurements, artificial intelligence–derived data, and geophysical information from the field to evaluate reserve quality, ore body structure, and geological formation characteristics for scientific and strategic purposes.

Source: Shahmoradi et al. (2020), Sihag et al. (2023), and Alsadie (2025).

Artificial intelligence algorithms embedded in unmanned aerial systems enhance autonomous security capacities by enabling advanced anomaly detection, behavioural classification, and predictive threat analysis. Despite these operational benefits, drones also pose significant risks for misuse in covert intelligence gathering. Both competing firms and state-linked actors can exploit such platforms to carry out a range of surveillance and strategic data collection tasks, including real-time monitoring of extraction and production metrics; documentation of plant layouts and critical infrastructure; assessment of operational vulnerabilities in processing and logistics networks; analysis of personnel movement patterns for security profiling; and collection of geological information to infer reserve characteristics (Ocelik, et al., 2024). This situation has made drone countermeasures a necessity in corporate security strategies. Advanced sensing technologies such as radar-based detection, radio-frequency monitoring, and laser-based scanning systems are increasingly applied at critical mineral sites to enhance situational awareness and security. The vast volume of data generated by satellite and unmanned aerial systems necessitates sophisticated computational frameworks for effective processing, classification, and interpretation. By integrating machine learning, deep learning, and Geographic Information Systems (GIS), contemporary mineral exploration and monitoring workflows have become significantly more automated and data-driven, improving both target identification and operational efficiency (Yang et al., 2024). Data fusion encompasses the following components:

1. Hyperspectral analysis + topographic mapping
2. SAR radar + optical imagery analysis
3. Satellite data + drone imagery + seismic data integration
4. AI-based reserve estimation

These systems shorten mineral exploration timelines and minimize investment risks. The same technologies can also be used for espionage-oriented data collection. For instance, the production volume, stockpile areas, and logistical traffic of a mining company can be analysed to conduct an economic assessment. This blurs the boundaries between energy security and intelligence activities.

Although satellite observations are often categorized as a form of Open-Source Intelligence (OSINT), the unauthorized use of such imagery to reveal proprietary or trade-secret information raises significant ethical and legal concerns. The expanding availability of high-resolution commercial satellite data has outpaced existing legal frameworks governing privacy, intellectual property, and competitive information rights, prompting debate over how OSINT practices should be regulated to balance transparency with the protection of confidential data (Pedram, Chandler & Georgiades, 2025). Space law generally regulates data collection activities at the state level; however, the rise of commercial satellite companies has created grey areas.

Regulatory frameworks governing drone operations remain insufficient in numerous jurisdictions, particularly within many developing nations where critical mineral sites are concentrated. In these contexts, weak or poorly enforced aviation laws create legal gaps that can be exploited for unauthorized drone flights, including the illicit collection of aerial data and surveillance over sensitive areas. The absence of comprehensive legal structures and enforcement mechanisms underscores the challenges that developing countries face in regulating unmanned aerial systems, which in turn facilitates operational vulnerabilities and unauthorized uses (Ayamga, Tekinerdogan & Kassahun, 2021).

The governance and ownership of data generated through resource monitoring systems has become a matter of strategic importance for states. Control over geological and mineral resource data—particularly when managed by foreign companies or external technological infrastructures—can create vulnerabilities in terms of national security and economic sovereignty. For this reason, many countries increasingly treat critical geological information as a strategic asset and seek to ensure that its collection, storage, and analysis remain under national oversight (Bradshaw, 2010). Satellites and drones are invisible yet decisive actors in energy and mineral competition. While these technologies offer revolutionary opportunities for mineral exploration and security, they also introduce new dimensions to industrial espionage and intelligence operations.

The increasing reliance on commercial satellite imagery in critical mineral exploration and energy security has intensified debates surrounding data sovereignty. Unlike traditional state-operated reconnaissance systems, commercial satellite platforms operate across jurisdictions, enabling foreign actors to collect, process, and monetize geospatial data related to strategic resources without the explicit consent of the territorial state. This raises fundamental legal questions regarding ownership, control, and jurisdiction over resource-related data generated beyond national airspace but directly affecting national economic security (Jakhu, Pelton, & Nyampong, 2017).

From an ethical perspective, the cross-border use of commercial satellite data challenges existing principles of state sovereignty and informed consent, particularly in developing countries where critical mineral sites are located. The asymmetry between technologically advanced data-collecting states and data-subject states may result in extractive data practices that mirror historical patterns of resource exploitation, albeit in digital form. Consequently, data sovereignty has emerged as a core concept linking satellite governance, energy security, and ethical resource management in the era of Energy Espionage 5.0 (Fischer, 2023).

In the context of Energy Espionage 5.0, the satellite–drone–artificial intelligence triad shifts strategic resource oversight toward a cyber-physical security axis. In the future, these technologies are expected to become more autonomous, more intelligent, and more covert. This process makes the urgent development of ethical, legal, and diplomatic regulations essential; otherwise, the deepening of global vulnerabilities becomes inevitable.

1.3. The Geostrategic Role of Mining Companies

One of the fundamental pillars of the global order lies in the capacity of states to project economic and military power through control and utilization of natural resources. Since the onset of the industrial era, minerals have functioned as concrete indicators of national power: coal and iron enabled the expansion of the locomotive industry, hydrocarbons shaped the structure of modern geopolitics, and in the contemporary period, strategic metals and rare earth elements have gained critical importance for artificial intelligence, defence systems, and advanced technological production (Haglund, 2025).

In this context, mining corporations have transcended their traditional roles as mere economic actors to become influential participants in shaping national security policies, geoeconomic competition strategies, and the global balance of power. Their extensive financial resources, international investment networks, control over strategically vital mineral assets, and integration into geopolitical supply chains grant these firms a geostrategic significance traditionally associated with states. Consequently, major mining companies are increasingly embedded within national and transnational security frameworks, reflecting their role in securing supply chains critical to defence, energy transition, and high-technology sectors (Critical Minerals and Great Power Competition, SIPRI, 2024).

Although the geopolitical significance of minerals has transformed over time, their strategic importance has remained constant. During the nineteenth century, coal strengthened the United Kingdom's global dominance by supporting steam-powered industry and steel production, while in the early twentieth century petroleum resources played a decisive role in the rise of the United States as a major global power (Dannreuther, 2013). In the 21st century, lithium, cobalt, nickel, and rare earth elements have become essential inputs for the digital economy, electric vehicles, defence industries, and artificial intelligence infrastructures.

Multinational mining corporations have increasingly taken on roles that extend beyond traditional economic functions to encompass strategic political and security influence in the regions where they operate. Large extractive firms such as Anglo American, Rio Tinto, BHP, Vale, and Glencore are deeply embedded in global value chains and geopolitical competition, often shaping public policy, local governance, and state–corporate relations through their investment decisions and interactions with host governments. In some contexts, these firms assume quasi-governmental functions by influencing policy outcomes, negotiating regulatory frameworks, and embedding themselves in political-economic structures in resource-rich territories (Bechtum, 2024).

Since the latter half of the twentieth century, resource nationalism has gained prominence, leading numerous states in Latin America, Africa, and Asia to assert greater control over their mineral sectors through nationalization and restrictive ownership policies. Nonetheless, the forces of globalization and the liberalization of capital markets have subsequently facilitated the reintegration of foreign and transnational mining firms into these economies, enabling them to regain influence and operational strength within global extractive networks. This interplay between nationalist policies and global capital flows highlights the evolving nature of state-firm relations in the extractive industries (Radetzki, 2024).

Today, geopolitical competition has transformed into a multi-layered struggle involving states, transnational corporations, and financial consortia. For this reason, the functions of mining companies are not limited to the economic sphere:

- Geographical exploration capabilities = geopolitical projection
- Supply chain control = strategic dependency
- Technology and R&D investments = competitive advantage
- Intelligence activities = an element of information warfare
- Diplomatic networks = economic influence

In the current global arena, competition for critical mineral supply chains has evolved into a complex geopolitical contest that engages not only states but also powerful non-state and corporate actors. Control over these resources has shifted from mere economic competition to a broader strategic framework where multinational companies and financial consortia function as integral parts of international supply networks. Their capacities in exploration, supply-chain governance, technological investment, intelligence provision, and diplomatic engagement embed them in the geopolitical strategies of states, effectively positioning dominant mining firms as actors with influence comparable to traditional sovereignty mechanisms in international relations (Vivoda et al., 2024). The strategic competition over critical minerals is increasingly reflected in national and multilateral strategy documents, where key actors such as the United States, the European Union, China, Japan, and South Korea have elevated rare earth elements and battery metals to matters of national security and economic resilience. These governments have introduced dedicated policies, strategic partnerships, and cooperative frameworks to diversify supply chains, strengthen domestic processing capacities, and pursue joint mining and investment projects with allied partners. Such initiatives form part of broader efforts to reduce dependence on dominant suppliers and embed critical mineral industries within national security priorities (European Parliamentary Research Service, 2023; U.S.–Japan Framework for Securing Critical Minerals, 2025). Table 7 provides an overview of selected national strategies and state-supported mining instruments adopted by major economies to secure critical mineral supply chains.

Table 7. National strategies and state-supported mining instruments for critical minerals.

Country	Strategy	Mining Instrument
United States (USA)	Defence Production Act	State-backed credit for mining investments
European Union (EU)	Critical Raw Materials Act	Joint strategic fund and diplomatic support
China	Made in China 2025	State-owned enterprises + global acquisitions
Australia	Critical Minerals Strategy	Supply diplomacy independent of China
Canada	Critical Minerals Infrastructure Fund	Northern mineral corridor investments

Source: European Commission (2024), IEA (2023)

In this context, states deploy a variety of instruments such as financial diplomacy, infrastructure development support, international legal agreements, military security assurances, and intelligence cooperation to secure access to critical mineral resources that are vital for economic and strategic objectives. This multifaceted approach is reflected in initiatives like the Minerals Security Partnership and bilateral frameworks aimed at strengthening resilient and trusted supply chains, alongside diplomatic and regulatory efforts that align geopolitical interests with sustainable resource access (Minerals Security Partnership, 2022).

These units do not merely collect economic information; they gather and process a wide range of data, including analyses of regional instability, changes in government policy, investment security, social movements, and environmental risks. For this reason, mining companies have become the corporate component of energy espionage. China's Belt and Road Initiative is not only an infrastructure investment program but also a systematic strategy for controlling global mineral supply chains (Zhao & Zhao, 2025). Investments in cobalt in Africa, lithium in Latin America, and rare earth sites in Asia are projects carried out by Chinese state-owned enterprises with diplomatic and military support.

The United States and the European Union have increasingly aligned their strategies to secure critical mineral supply chains through cooperative frameworks that emphasize trusted partnerships, diversification of sources, and supply-chain resilience. As part of this effort, transatlantic coordination under initiatives such as the Minerals Security Partnership and bilateral memoranda of understanding aims to strengthen joint mining and processing projects with democratic partners while reducing strategic dependencies on dominant suppliers. These "secure supply chain" and allied sourcing approaches reflect broader economic security priorities and friend-shoring principles in critical minerals policy (U.S. Department of Commerce & European Commission Joint Statement, 2024). This competitive strategic landscape has fostered a broad framework in which coercive diplomacy, financial sanctions, technology transfer agreements, and intelligence activities are employed to influence modern mining operations. Contemporary mining practices increasingly rely on advanced technological tools such as satellite remote sensing for geological and operational surveillance, unmanned aerial reconnaissance systems for detailed site monitoring, machine learning–based geological modelling for data-driven exploration, IoT-enabled field systems for real-time equipment and infrastructure monitoring, and .blockchain enhanced supply chain solutions to ensure traceability and transparency throughout mineral value chains (Onifade, Adebisi & Zvarivadza, 2023). Table 8 presents the principal technological tools and their strategic functions in modern mining operations.

Table 8. Technological tools and strategic functions in modern mining operations.

Technology / Tool	Operational and Strategic Purpose
Satellite imagery	It refers to the detection of mineral reserves, the monitoring of land-use changes, and the analysis of illegal mining activities through non-destructive and large-scale remote sensing techniques.
Drone reconnaissance systems	These are autonomous or semi-autonomous aerial platforms that collect high-resolution imagery and sensor data in hard-to-access areas, enabling geological analysis, site security, and operational monitoring.
Machine learning–based geological modelling	This involves the use of artificial intelligence algorithms to analyse geological datasets for mineral reserve estimation, ore quality classification, and the reduction of exploration risks.

Table 8. (Continued)

IoT-based field systems	These are connected device networks that enable real-time monitoring of equipment, sensors, and infrastructure in mining sites, collecting data to enhance operational security and efficiency.
Blockchain-based supply chain security	These are distributed ledger technology mechanisms that provide traceability, transparency, and anti-counterfeiting capabilities from the extraction of critical minerals to the final product stage.

Source: Onifade et al. (2023), Zvarivadza et al. (2024), and Onifade, Adebisi and Zvarivadza (2024).

Data has increasingly become a strategic resource that generates both economic value and geopolitical leverage. As a result, companies operating in resource-intensive sectors such as mining are becoming active actors within the broader competition over data and digital capabilities. Artificial intelligence technologies are applied across multiple areas, including large-scale data analytics, OSINT processing, automated monitoring systems such as drones, and production optimization in industrial operations. These developments demonstrate how digital infrastructures and data analytics are reshaping strategic decision-making in resource industries (Bughin et al., 2018). At the same time, it opens the door to hybrid threats such as data manipulation and competitor sabotage.

Mining companies carry the responsibility of securing not only economic legitimacy but also social and environmental legitimacy in the communities where they operate. Engagement with local populations, investment in sustainability initiatives, effective management of environmental impacts, and adherence to human rights and corporate social responsibility protocols significantly influence the operational environment and long-term viability of mining firms. The literature emphasizes that constructive relations with surrounding communities and responsive environmental practices are necessary for acquiring a “social license to operate,” shaping both corporate reputation and regulatory legitimacy in the extractive sector (Rodrigues, et al, 2022).

However, in some regions, the discourse of social investment often masks broader geostrategic influence-building strategies. Corporations may deploy corporate social responsibility initiatives, cultivate relationships with local elites, and leverage communication networks to shape local political dynamics and secure operational legitimacy in resource-rich areas (Csevár, 2021). As competition over critical minerals intensifies, risks are also increasing. Table 9 categorizes the principal geostrategic risks and operational threats confronting critical mineral operations.

Table 9. Geostrategic risks and operational threats in critical mineral operations.

Risk / Threat	Description / Operational Impact
Cyberattacks	This refers to the targeting of critical mineral databases, production systems, and supply chain infrastructures to steal information, disrupt operations, or conduct strategic manipulation.
Logistics sabotage	This involves disrupting supply security through physical or digital interventions targeting mining and energy transport lines, ports, railways, and storage facilities.
Drone espionage	This refers to the use of unmanned aerial vehicles to monitor mining sites, access confidential reserve information, or record field operations.
Local militia influence	This describes the activities of non-state armed groups operating in mining regions to exert control over security, access, or economic gains, thereby placing pressure on companies.
Disinformation campaigns	This refers to the deliberate spread of false information through social media and media channels to discredit companies, destabilize the investment environment, or manipulate public perception.
Political intervention	This involves the strategic direction of mining policies and corporate activities by governments or international actors through laws, permits, taxation, or diplomatic processes.

Source: IRENA (2023)

This trend has intensified not only economic competition but also geopolitical power struggles, compelling both states and multinational corporations to formulate an array of explicit strategic policies and covert operational methods to secure critical mineral supply chains. As the security and resilience of these supply networks have become central elements of national strategic agendas, governments are increasingly integrating political intervention into mining policies, regulatory frameworks, and foreign investment rules. Such dynamics have, in turn, driven corporate actors to adopt more robust security postures sometimes resembling quasi-military protection arrangements to defend their assets, operations, and geopolitical interests in contested resource environments (Yeh & Ni, 2025). Today, mining corporations have moved beyond their traditional identity as economic actors and have become geopolitical players, components of intelligence architectures, and agents of security strategy. In the era of Energy Espionage 5.0, mining corporations assume multifaceted strategic roles that extend well beyond conventional commercial operations. Table 10 delineates these evolving corporate functions within the framework of energy espionage.

Table 10. Strategic roles of mining corporations in energy espionage 5.0.

Corporate Role	Operational and Strategic Description
An instrument of nation-state power projection	This refers to the use of commercial intelligence by states to gain strategic influence in the international arena and to expand their economic and geopolitical spheres of effect.
A data-driven economic intelligence actor	This denotes the capacity to generate strategic data by monitoring economic trends through artificial intelligence, big data, and financial analytics in order to gain competitive advantage.
A stakeholder in technological competition	This describes the strategic role played in advancing global technological leadership through R&D processes, critical minerals, and advanced production technologies.
An implementer of hybrid security systems	This involves conducting multi-layered security and intelligence operations by integrating cybersecurity, corporate security, satellite surveillance, and human intelligence.
A diplomatic negotiation actor	This refers to the role played in economic agreements, resource access arrangements, supply chain accords, and strategic partnerships in line with national interests.

Source: IRENA (2023), Holmström (2020), and Vivoda et al. (2025).

As illustrated in Table 10, mining corporations have risen to the status of systemic power actors. As global competition over critical minerals intensifies, the strategic significance of these corporate roles will continue to expand, making robust legal frameworks, ethical governance structures, and integrated geopolitical risk management increasingly decisive for both corporate sustainability and national security.

1.4. Commercial Data Collection Intelligence

With the digitalization of the global economy, commercial information has become one of the most critical power factors of the modern era. Commanding data plays a decisive role not only in economic decision-making processes but also in achieving geopolitical, industrial, and technological superiority. For this reason, international corporations, state institutions, and strategic sectors are increasingly investing in commercial data collection intelligence, employing big data analytics, artificial intelligence, satellite systems, Human Intelligence (HUMINT), and cyber-monitoring systems in an integrated manner.

The foundation of commercial intelligence lies in the systematic collection, classification, and transformation of diverse data sources into strategic insight. In this context, the data ecosystem is multidimensional and includes the following primary categories:

1. Digital monitoring systems: Competitive analyses are generated through corporate networks, digital platforms, and online user behaviour. Large-scale data mining is used to understand companies' production, distribution, and investment strategies.
2. Supply chain networks: Logistics flows, port activities, supplier linkages, and global trade data are examined. The directional movement of critical raw materials identifies competitive threats and opportunity areas.

3. Corporate communication infrastructures: Press releases, investor reports, industry meetings, and executive discourse are analysed to assess strategic orientations.
4. Market behaviours: Consumer trends, pricing strategies, and demand fluctuations are monitored to interpret competitive dynamics.
5. Artificial intelligence monitoring systems: AI-based algorithms detect patterns within data sets and generate predictive models.
6. Satellite and drone data: Mining sites, energy infrastructures, logistics corridors, and production facilities are observed remotely.
7. Financial transaction networks: Foreign direct investment flows, commercial bank transfers, and capital market movements are analysed.
8. Cybersecurity sensors: Data leaks, spyware activity, and indicators of corporate network penetration are identified.

The coordinated use of these data types enables companies not only to observe the current state of competition but also to shape their future strategic orientations. As Clarke and Knake (2019) emphasize, modern competition is no longer physical; it is structured around cognitive and digital dominance. Commercial data collection intelligence differs fundamentally from traditional market research. Table 11 provides a comparative analysis that highlights the fundamental distinctions between conventional market research and commercial intelligence in terms of purpose, scope, methodology, and risk.

Table 11. Comparative analysis of market research and commercial intelligence.

Criterion	Market Research	Commercial Intelligence
Primary purpose	Analysing customer behaviour	Ensuring competitive and strategic security
Data type	Sales, advertising, customer surveys	Digital networks, supply chain data, financial signals
Scope	Consumer-focused	Includes national security and industrial sovereignty
Method	Legal open sources	Authentic open sources + grey data channels
Focus	Micro-market analysis	Macro geo-economic analysis
risk factor	Low	High (cyber, diplomatic, industrial)

Source: Clarke and Knake (2019), Nasheri (2005), and Holmström (2020).

According to Alnoukari and Hanano (2017), commercial intelligence occupies a strategic space at the intersection of contemporary economic espionage and legitimate data analysis. Consequently, while states and corporations strive to maintain legal boundaries in their information-gathering activities, they must simultaneously navigate the reality that competing actors are constantly testing and extending those limits. In the current era marked by energy transition, the rising significance of critical minerals, and rapid technological transformation, the strategic value of information continues to grow. The critical mineral strategies of China, the United States, and the European Union demonstrate that state power and corporate intelligence are becoming deeply intertwined (Stango, 2024). In this context, the core motivations of commercial intelligence are as follows:

- Strategic resource security: Information dominance is achieved to secure the supply of critical minerals such as rare earth elements, lithium, cobalt, and graphite.
- Technological competition: Battery technologies, artificial intelligence models, refining solutions, and production innovations are monitored.
- Financial superiority: Market manipulation risks and capital flow directions are anticipated.
- Geopolitical positioning: State policies in energy and mineral regions are closely tracked.
- Defence and national security: Threats targeting industrial infrastructure are identified in advance.

Within this framework, commercial data collection is not merely an economic activity; it is also an instrument of strategic power projection. OSINT constitutes the cornerstone of the commercial information ecosystem. The primary open-source tools used include:

- Official reports: Government and international organization reports that contain strategic projections (Kim, et al, 2022).
- Commercial registries: Corporate ownership structures, capital distribution, and managerial history are analysed.
- Academic studies: R&D orientations and scientific capacity are monitored.
- Satellite maps: Production and logistics facilities are examined remotely.
- Patent databases: Emerging technological trends are identified.
- Industrial forums: Professional knowledge-sharing platforms serve as sources of strategic signals.
- Port and logistics data: Supply chain flows are interpreted through vessel and container movements.
- Financial reports: Investment strategies and profitability projections are assessed.
- Blockchain analytics: Digital financial movements and ledger chains are tracked.

The data obtained from these sources is transformed into strategic foresight at both corporate and state levels. The following methods, while legally and ethically contentious, are widely used in global competition:

- Fake buyer profiles: Used as identity-masking methods to obtain pricing and production details from rival companies.
- Supply chain infiltration: Gaining access to competitor supplier networks to acquire information on materials and cost structures.
- Industrial espionage: Attempts to access technologies, production formulas, and strategic plans.

- Financial monitoring: Analysing financial movements to identify capital flow directions.

Such methods are particularly widespread in the critical minerals sector, where competition over resources has increasingly assumed a strategic dimension (Maus et al., 2021). Increasing remote sensing capabilities in geo-economic domains have revolutionized corporate analysis:

- Reserve monitoring: Mineral capacity and extraction rates are estimated through satellite data.
- Site activity control: Production rhythm is measured by tracking personnel and machinery activity.
- Logistics monitoring: Ports, road networks, and storage facilities are observed.
- Infrastructure development: new mining wells, energy facilities, and transportation projects are monitored.

Recent studies indicate that digital technologies and artificial intelligence have significantly improved the capacity to collect and analyse geological and operational data in the mining sector. Nevertheless, intelligence gathering in strategic industries still relies heavily on human-centred channels in addition to technological monitoring systems (Davenport & Ronanki, 2018). Key human-based information channels include:

1. Talent mobility and expert recruitment: Firms may gain strategic knowledge through the hiring of specialists who previously worked for competitor companies.
2. Professional conferences and industry events: Informal exchanges and presentations often reveal technological trends and operational strategies.
3. Supplier and subcontractor networks: Secondary actors in the supply chain can provide insights into production processes, procurement strategies, and logistical operations.
4. On-site observers and field representatives: Direct observation of facilities, project sites, and infrastructure developments may generate valuable operational information.

With the expansion of data processing capacity, AI has become the primary component of intelligence:

- Demand forecasting systems: The future direction of market demand is predicted.
- Mineral price modelling: Commodity price fluctuations are analysed.
- Risk analytics: Geopolitical and logistical risks are modelled through scenario analysis.
- Cyber threat detection: Anomalies within corporate networks are identified.
- Deepfake and manipulative media analysis: Protection is provided against external information threats.

AI-driven intelligence provides states with rapid decision-making superiority and enhanced early-warning capabilities. At the same time, critical minerals constitute the primary raw material base of the emerging energy economy (Gielen, 2021 For this reason, data collection domains in the mining and energy sectors have expanded considerably. Table 12 outlines the strategic value of key data types in mining and energy intelligence.

Table 12. Strategic value of data types in mining and energy intelligence.

Data Type	Strategic Value
Reserve information	Provides power projection for states and corporations
Supply chain routes	Logistic disruptions can evolve into national security risks
R&D data	Emerging technologies form the basis of competitive advantage
Price movements	Enable financial manipulation and market dominance
Diplomatic data	Resource agreements generate geopolitical consequences

Source: (2021), IRENA (2023), and Holmström (2020).

IEA 2022 reports indicate that competition over critical minerals will stand at the centre of security doctrines after 2030 (Kim el al, 2021). The most sensitive aspect of commercial intelligence is the preservation of legal boundaries. The fundamental framework includes:

1. Competition law: Protection against unfair competition and corporate trade secrets.
2. Personal data protection: Limits of data processing under GDPR and national data regulations.
3. Intellectual property law: Protection of patents, know-how, and trade secrets.
4. Cyber law: Penalization of digital breaches and data theft.
5. Ethical governance: Transparency and human-rights principles in data processing.

Commercial intelligence requires a delicate balance between power dynamics and ethical norms.

Commercial data collection intelligence is a strategic domain of knowledge that bridges the global economy and national security. Critical minerals, energy security, artificial intelligence, and supply chain dynamics are shaping the competitive landscape of the future. Data superiority signifies not only economic growth but also geopolitical sovereignty. For this reason, states and corporations will continue to enhance their data-collection capacities and maintain their competitive advantage while upholding legal and ethical frameworks.

2. Discussion

The strategic competition of the 21st century is being reshaped within the framework of safeguarding energy supply and securing technological superiority. The global climate and sustainability goals driving the transition from fossil fuels to renewable energy systems have created a new economic and geopolitical paradigm. This transformation surpasses traditional energy security doctrines and places critical mineral security, data-driven competition, corporate intelligence strategies, and AI-supported surveillance systems at the centre. In this context, a new strategic environment—one that can be described as the Energy Espionage 5.0 paradigm—is emerging. This environment represents a multidimensional power domain in which not only states, but also multinational corporations, financial institutions, private military security companies, and technology giants have become influential actors.

Within the scope of this study, the four principal components—mineral geopolitics and industrial espionage; satellites, drones, and resource-monitoring technologies; the geostrategic role of mining companies; and commercial data-collection intelligence—were systematically analysed to understand the nature and future trends of contemporary energy competition. The findings demonstrate that the global energy order is not merely an economic or technical matter but is deeply intertwined with political, military, intelligence, and technological processes.

Lithium, cobalt, nickel, graphite, and rare earth elements have become the most critical inputs of the green energy transition. Used in electric vehicle batteries, wind turbine magnets, precision sensors, defence technologies, and artificial intelligence chips, these minerals form the strategic arteries of the global economic system. While this situation evokes the oil geopolitics of the Cold War era, it has produced a far more complex and technology-centred form of competition.

Operations carried out by multinational corporations, states, and private intelligence networks targeting critical mineral markets extend across a broad spectrum, ranging from the theft of trade secrets and cyber intrusions to geological data espionage and the manipulation of logistics systems. The acquisition of mining-related information is no longer based solely on field research conducted by geologists; instead, it increasingly relies on satellite imagery, electromagnetic scanning technologies, AI-assisted modelling, and large-scale data mining. Consequently, the convergence of geopolitical interests and advanced information technologies forms a central component of contemporary energy strategy (Binnemans et al., 2021; Gielen, 2021).

Satellite systems, unmanned aerial vehicles, and intelligent sensor networks have set the new standard for surveillance in the energy and mining sectors. Today, states and corporations can monitor their competitors' reserve areas, extraction capacities, infrastructural activity, shipment patterns, and environmental impacts in real time.

Not only physical operations but also logistical routes, financial flows, port movements, and even employee behaviour leave digital traces. These traces hold strategic value in energy espionage (Yang et al., 2024). At this point, the rise of drone operations specific to the energy sector occupies a critical position at the intersection of military and commercial applications. China's dominance in drone technologies, U.S. export restrictions, and debates over aerial data security stand as visible examples of this growing competition.

Alongside these technological and strategic developments, a growing body of literature highlights the normative tension between data privacy, commercial confidentiality, and national security imperatives. Scholars argue that the increasing reliance on commercial satellite data, open-source intelligence, and AI-driven surveillance blurs traditional boundaries between civilian and military intelligence domains, raising critical concerns regarding data governance and individual as well as corporate privacy (Deibert, 2019; Lyon, 2022). From a national security perspective, unrestricted access to high-resolution commercial data may expose critical infrastructure and strategic assets, while from a privacy-oriented viewpoint, expansive surveillance practices risk enabling forms of digital overreach and extraterritorial monitoring (Kello, 2017; Zuboff, 2024). This debate underscores that contemporary energy espionage is not solely a technical or geopolitical issue, but also a legal and ethical challenge situated at the intersection of security governance, corporate intelligence, and data sovereignty.

Traditional security literature has positioned states as the primary actors in the international system. However, in the transformational era of energy, mining corporations, technology giants, and financial institutions have emerged as strategic power centres capable of influencing national interests. Energy and mining giants such as Chevron, Glencore, Rio Tinto, and BHP are not merely economic actors; they are geostrategic players involved in diplomatic, military, and informational operations (Müller, 2023).

Power relations in the energy sector are no longer shaped solely by intergovernmental agreements but increasingly through corporate mergers, investment strategies, patent ownership, data dominance, and supply chain control. While this does not eliminate the role of states, it indicates the emergence of a non-hierarchical, multi-layered power architecture in the international system.

One of the most competitive areas in the energy sector is the pursuit of informational superiority. Open-source intelligence (OSINT), commercial data analytics platforms, AI-based market prediction algorithms, and information leaks constitute the invisible infrastructure of energy espionage.

In particular, big data analytics, blockchain-based supply chain monitoring systems, and deep learning models shape the decision-making processes of both state intelligence agencies and corporations. This creates a new geoeconomic order in which the actor who possesses information gains power (Zhao et al., 2022). However, this competition also increases the risks of data manipulation, disinformation operations, and economic sabotage.

This analysis demonstrates that energy security is no longer simply about ensuring the continuity of energy supply. In the new era, energy security is:

• Securing critical minerals
• Strategic technological investments
• Information superiority and cybersecurity
• Supply chain resilience
• Geopolitical alliance engineering
• Artificial intelligence and data dominance
• Corporate diplomacy and green regulation warfare

are the core components that define this new paradigm.

Taken together, these policy directions provide a practical framework through which developing economies can better protect strategic mineral assets in the era of Energy Espionage 5.0.

3. Conclusion

Accordingly, *Energy Espionage 5.0* represents not merely the modernization of espionage activities but the integration of economic, technological, diplomatic, and military strategies into a unified framework. The contribution of this study lies in redefining energy security not as a simple supply–demand equilibrium, but as a multi-actor, multi-layered geo-intelligence ecosystem.

Ultimately, strategic success for nations and corporations will no longer be measured solely by possessing resources, but by their capacity to collect, process, protect, and operationalize information about those resources. The future extends far beyond competition over physical minerals: whoever controls the data mines will also control the energy system. For this reason, the literature on energy espionage—located at the intersection of international politics, technology strategies, and industrial security—must deepen both theoretically and practically. This study makes an original contribution to the field of energy geopolitics by placing the informational dimension at the centre and integrating corporate intelligence with energy security. Future research should expand to include the legal, ethical, and security dimensions of AI-supported intelligence systems.

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Supplementary Materials
Not applicable.

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