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# Potential of critical raw materials of Slovakia

## Introduction

The topic of critical minerals is topical and important not only from the perspective of Slovakia, but also of the wider European space and is of growing importance for contemporary society. In recent years, the need to ensure stable and accessible sources of raw materials, which are essential for the functioning of modern industry, technological development and the transition to sustainable forms of energy, has been increasingly emphasized. This issue is extremely topical, especially in the context of the European Union's efforts to reduce dependence on imports of raw materials from third countries, as well as in connection with the development of electromobility, digitalization and renewable energy sources.

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Critical minerals play a key role in the production of batteries, electronics and other technologies that are the basis of the modern economy. The importance of this topic will continue to grow in the future, as the demand for these raw materials is growing and their availability is limited. At the same time, it is an issue with significant economic, environmental, and geopolitical dimension. The topic points to the close connection between natural resources and everyday human life. We often do not realize how much raw material is needed to produce common technologies. At the same time, we consider it important to pay attention to issues of sustainability and efficient use of natural resources.

For this reason, the aim of the work is to evaluate the potential of selected critical raw materials in Slovakia and to assess the possibilities of their use in the context of the raw material security of the Slovak Republic and the strategies of the European Union. The work includes an analysis of the development of prices of selected critical raw materials in the period from 2015 to 2025 in order to assess their economic prospects and importance for the potential use of domestic resources. The study does not aim to cover all critical raw materials; instead, it focuses specifically on antimony, lithium, cobalt, and natural graphite because these commodities are relevant to the geological context and available datasets considered in this study. The work aims to contribute to a better understanding of the issue of critical raw materials and to provide data for a professional discussion on the possibilities of using Slovakia's mineral resources in the future.

## 1. Literature review

Critical raw materials (CRM) are essential for various industries; however, they are unevenly distributed (Hofmann et al. 2018). Moreover, the critical availability of some CRM is an urgent need, when Girtan et al. (2021) underline that the availability of CRM in EU sources leads to the suggestion that a wide-ranging approach is essential. According to the critical raw materials act (CRMA), the aim of EU countries is to reduce dependencies on third countries, and like-minded countries intend to strengthen international partnerships in the EU (Hool et al. 2024). Due to the growing import dependency and associated risk of supply disruptions of CRM from third countries, there is a need to encourage their domestic production (Lewicka et al. 2021) and to supply CRM from the EU primary sources. For strategic development and for identifying improvement options that reduce reliance on CRM, there is therefore a necessity to study CRM from the view of macroscale (EU) and microscale – individual countries (Mancini et al. 2015), as well as from the view of regions, states, and investors (Šimková et al. 2021). Such a study was made by Guzik et al. (2021) in Poland, Finland, Spain, and Norway, finding different problems and constraints in individual countries. Svermova et al. (2026) studied the situation in the Czech Republic, finding that Czechia combines a strong manufacturing base with limited reserves for many CRM, while possessing notable strategic potential, e.g., lithium.

According to Domaracká et al. (2025), based on the examination of import and export data, it is evident that imports are on the rise while exports are declining. This trend underscores the EU's continued reliance on raw materials sourced from other global regions; domestic production and consumption are not sufficient; on the other hand, the EU remains dependent on imports of critical raw materials. Potential risks and challenges associated with critical raw materials also include environmental and social impacts, dependence on these raw materials, and dependence on foreign countries. Understanding these factors is crucial for ensuring the continued success of critical metals in various industries (Petrova 2023). The risks are widening due to the widening of the CRM list, when modified in 2011, 2014, 2017, etc. (Blengini et al. 2017). According to the fifth EU list from 2023, the CRM list contains 34 raw materials (Kollová et al. 2025).

There are several studies of CRM in Slovakia from the technological and ecological point of view (Bačo et al. 2015; Šimková et al. 2021; Kollová et al. 2025); however, CRM potential also needs to be verified from the economic point of view. In this area, Domaracká et al. (2022) studied CRM in connection with resource productivity, import reliance, net additions to stock, domestic material consumption, etc. The ambition of the paper is to fill the gap in providing information from Slovakia on CRM price development, and to fill the next development, connected with previous researches, and in this way encourage domestic production and ensure the succes of CRM in Slovakia.

## 2. Present state of problem solving

The increasing dependence on critical raw materials such as lithium, cobalt, and rare earth elements represents a significant challenge for the sustainable development of the European energy system (Čulková et al. 2020). These materials play a crucial role in modern energy technologies and are essential for the functioning of low-carbon energy systems. As Europe advances its energy transition, the demand for these resources has grown substantially, raising concerns related to supply security, environmental impacts, and long-term resource management.

As shown in the Figure 1 below, between 2024 and 2030, global lithium demand is projected to grow by 146 percent, while graphite and cobalt needs are expected to increase by 50–75 percent, according to the IEA's baseline scenario, mainly driven by electric vehicles and energy storage. Furthermore, the demand for rare earths, essential for permanent magnets used in wind turbines and electric motors, is projected to increase by 45 percent (IEA 2026).

Lithium is a key component in energy storage technologies and is widely used in batteries that support energy systems and electrified transport. The rapid growth in demand for lithium has intensified pressure on global supply chains, which are geographically concentrated outside Europe. Lithium extraction often involves water-intensive processes that can strain local ecosystems and water resources, particularly in regions already facing

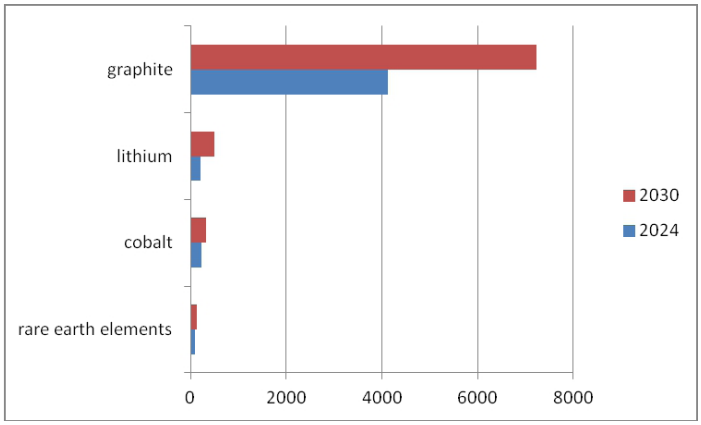


Fig. 1. The growing demand for critical minerals (IEA 2026)

Rys. 1. Rosnące zapotrzebowanie na minerały o znaczeniu krytycznym

environmental stress. From a resource management perspective, the increasing reliance on lithium highlights the need for careful assessment of environmental impacts and sustainable sourcing practices.

Cobalt is another critical material closely linked to the development of sustainable energy systems. It is primarily used to improve the performance and durability of energy storage systems and related technologies. However, cobalt supply chains are associated with significant economic and ethical challenges, including high supply concentration and social risks in extraction regions. These issues raise concerns about the sustainability and resilience of resource supply. For Europe, dependence on imported cobalt creates strategic vulnerabilities and complicates efforts to ensure secure and responsible access to essential materials.

Rare earth elements are a group of materials that are vital for various energy-related applications due to their unique physical and chemical properties. They are used in components that enhance efficiency and performance in energy systems. Despite their importance, rare earth elements are characterized by complex extraction and processing processes that can cause substantial environmental damage if not properly managed. Mining activities may lead to soil degradation, water pollution, and long-term ecological harm. Effective governance and environmental regulation are therefore essential to minimize negative impacts.

From a strategic perspective, dependence on lithium, cobalt, and rare earth elements poses challenges for European resource security. The limited domestic availability of these materials increases reliance on external suppliers and exposes the energy system to geopolitical risks and market volatility. Disruptions in supply chains can delay energy projects and increase costs, undermining the stability of the energy transition. This situation emphasizes the importance of diversification, strategic planning, and risk management in resource governance.

The growing demand for critical raw materials also underscores the need for more sustainable resource management approaches. Improving material efficiency, extending product lifecycles, and promoting recycling are key strategies for reducing dependence on primary resource extraction. By recovering valuable materials from end-of-life products, Europe can decrease pressure on global supply chains and limit environmental impacts associated with mining activities. These measures align with circular economy principles and support more sustainable use of natural resources.

Policy and management frameworks play a central role in addressing challenges related to critical raw materials. Coordinated strategies that integrate energy policy with resource management objectives are essential for ensuring long-term sustainability. This includes supporting research and innovation aimed at reducing material intensity and improving substitution options where feasible. Strengthening monitoring and governance mechanisms can also enhance transparency and responsibility across supply chains.

In conclusion, lithium, cobalt, and rare earth elements are indispensable for the development of sustainable energy systems in Europe, yet their increasing use introduces significant resource management challenges. Dependence on these materials raises concerns related to environmental impacts, supply security, and economic vulnerability. Addressing these issues requires a comprehensive approach that combines responsible sourcing, efficient use, recycling, and strategic governance. Managing critical raw materials effectively is essential for ensuring that the European energy transition remains sustainable, resilient, and environmentally responsible.

### 2.1. Environmental and geopolitical risks

For critical raw materials, environmental and geopolitical risks are amplified by the high geographical concentration of production and processing, dependence on a limited number of supplier countries, and their essential role in low-carbon technologies and digital industries, namely due to their high supply concentration, import dependence, limited substitution potential, and strategic importance for the energy transition and advanced technologies. As Europe transitions toward a low-carbon energy system, the demand for specific natural resources intensifies, creating new forms of vulnerability. These risks are not limited to energy systems alone but extend to broader environmental sustainability and geopolitical stability, making them a central concern in energy and resource management.

Environmental risks associated with the extraction and processing of critical raw materials are substantial. Mining activities often involve large-scale land disturbance, leading to soil degradation, deforestation, and loss of biodiversity. The extraction of certain materials can also generate significant amounts of waste and toxic by-products, which pose long-term threats to ecosystems if not properly managed. Water pollution and excessive water consumption are additional concerns, particularly in regions where water resources

are already under stress. These environmental impacts can undermine the sustainability objectives that the energy transition aims to achieve.

In addition to local environmental damage, the global nature of resource extraction amplifies environmental risks across borders. Environmental regulations and enforcement standards vary widely between regions, leading to uneven levels of protection. When resource extraction takes place in countries with weaker environmental governance, the risk of ecological degradation increases. From a European perspective, this raises ethical and sustainability concerns, as environmental impacts are often externalized to regions outside Europe while the benefits of energy transformation are realized domestically.

Geopolitical risks further complicate the reliance on critical raw materials. Many essential materials are concentrated in a limited number of countries, creating dependencies that expose Europe to external political and economic pressures. Supply chain concentration increases vulnerability to export restrictions, trade disputes, and political instability in supplier regions. Such disruptions can have direct consequences for energy system development, including delays in infrastructure projects and increased costs.

The geopolitical dimension of resource dependency also affects strategic autonomy. Heavy reliance on imports limits Europe's ability to independently manage its energy transition and respond to global crises. Fluctuations in international relations or changes in trade policies can significantly influence resource availability and pricing. These uncertainties pose challenges for long-term planning and investment, which are critical for sustainable energy development.

Environmental and geopolitical risks are closely interconnected. Environmental degradation in resource-rich regions can exacerbate social tensions and political instability, further increasing supply risks. Conversely, geopolitical competition over scarce resources may lead to intensified extraction efforts with limited regard for environmental protection. This interaction highlights the complexity of managing critical raw materials within a globalized energy system.

From a resource management perspective, addressing these risks requires a comprehensive and proactive approach. Environmental risks can be mitigated through stricter sustainability standards, improved monitoring, and the promotion of responsible sourcing practices. At the same time, geopolitical risks call for diversification of supply sources, enhanced international cooperation, and the development of strategic reserves. Integrating environmental considerations into trade and resource policies can help align energy objectives with broader sustainability goals.

The European policy framework plays a key role in managing environmental and geopolitical risks. Coordinated strategies that link energy policy, resource management, and foreign relations are essential for reducing vulnerabilities. Supporting research, innovation, and circular economy practices can further decrease dependence on primary resource extraction and limit exposure to external risks.

In conclusion, environmental and geopolitical risks represent major challenges associated with dependence on critical raw materials in Europe's sustainable energy

transition. Environmental degradation, supply chain concentration, and geopolitical instability can undermine the resilience and sustainability of energy systems if not properly addressed. Effective management of these risks requires integrated strategies that balance environmental protection, resource security, and geopolitical considerations. By adopting such approaches, Europe can strengthen the foundations of a sustainable and resilient energy future.

## 3. Methodology

The paper deals with the issue of critical minerals and their importance for the Slovak Republic in the context of the raw material security of the European Union. The main task of the paper is to evaluate the potential of selected critical minerals in the territory of the Slovak Republic from a geological, economic, and environmental perspective.

Attention is paid in particular to the raw materials cobalt, antimony, natural graphite, and lithium, which are among the strategically important raw materials for the industrial development and technological transformation of the European Union economy. The work includes an analysis of the development of prices of selected raw materials in the period 2023–2025 in order to assess their economic prospects and importance in terms of the possible use of domestic resources of the Slovak Republic.

The selection of these raw materials was intentional, as they represent different types of critical materials with different characteristics in terms of availability, use, and price development. Antimony was chosen mainly due to the existence of significant deposits in the territory of the Slovak Republic, which represents the potential for domestic use and reduced dependence on imports. Lithium, cobalt and natural graphite were selected as key raw materials for the production of lithium-ion batteries, which are essential for the development of electromobility, renewable energy sources and modern technologies. Their importance has been growing significantly in recent years, and the European Union considers them strategic in terms of future economic development. At the same time, these raw materials represent commodities for which Slovakia is largely dependent on imports, which also allows the issue of raw material security and the vulnerability of supply chains to be analyzed. The selection of the analyzed raw materials thus allows for a comprehensive assessment of the issue of critical mineral resources from the perspective of domestic potential, global markets and their importance for the economy of the Slovak Republic.

The methodological framework of the work is based on a quantitative analysis of secondary data, which allows for the systematic monitoring and evaluation of the development of prices of four selected critical minerals – antimony, lithium, cobalt and natural graphite – in the monitored period. The aim of this methodology is to create a comprehensive and analytically supported overview of price trends, their changes and connections with global economic and geopolitical factors. In the preparation of the work, professional literary sources, strategic documents of the European Union, data on mineral deposits in Slovakia, and available

information on the development of prices of the monitored commodities were used. The result of the work is an assessment of the prospects of selected critical minerals and an assessment of the possibilities of their use in the conditions of the Slovak Republic.

The research consists of three mutually connected analytical steps:

1. Data collection and processing.
   The starting point for the analysis is the collection of available data on the prices of individual commodities from international institutions and professional publications. The data comes mainly from commodity markets, professional institutes (e.g., USGS, LME, LBMA), as well as from analytical reports and statistical overviews. The data is then adjusted into a uniform form enabling comparisons across periods and commodities.
2. Descriptive analysis.
   Descriptive analysis is a basic step in data processing. It creates clear tables, summaries, and characteristics that describe the basic price development in the monitored period. This analysis allows you to identify:
   - main price levels,
   - periods of growth and decline,
   - fluctuations and anomalies.

   The goal of the descriptive approach is not to interpret causes, but to create a consistent overview as a basis for further analytical steps.
3. Comparative and trend analysis.
   The second part of the methodological procedure involves comparing price trajectories between individual commodities. The comparison includes:
   - intensity of price changes,
   - volatility,
   - stability of development.

Trend analysis then uses simple quantitative indicators, such as percentage changes between years, identification of local maxima and minima, or evaluation of the direction of long-term development. The result is the determination of dominant trends and their possible direction in the context of the monitored period.

The main research question of the research is: To what extent does the Slovak Republic have the potential to utilize selected critical mineral resources in terms of their availability, economic prospects and strategic importance for the European Union?

According to the findings, the next part is to evaluate the impacts of the trends on Slovakia, mainly from the view of:

- development of batteries and electrotechnical industry (lithium, cobalt, natural graphite),
- defense and chemical industry (antimony),
- potential of Slovakia from the view of connection to the supply chain of CRM in the EU,
- potential of domestic mining (Li, Co, Gr, Sb) and environmental limitations.

Obtained trends are connected with European political priorities, mainly with the Green Deal Europe, the European Act on CRM, and initiatives leading to strategic autonomy of the EU.

The goal of the research is at two levels:

- analytical, oriented to the description and interpretation of price development,
- application, oriented to the evaluation of whether the trends could be a perspective for the economy of Slovakia from the view of industrial orientation and investment possibilities.

The analysis is time-bound for the period 2015–2025, which represents a period of significant global changes, such as:

- increasing demand for critical raw materials used in the green transformation,
- export restrictions and geopolitical tensions (e.g., restrictions on exports of graphite and antimony from China),
- volatility in commodity markets influenced by macroeconomic and technological factors.

For each commodity, secondary data from relevant international sources were used:

- lithium: Jégourel (2025), USGS (2025),
- cobalt: USGS (2025), expert market reports,
- natural graphite: USGS (2025), international analytical reports,
- antimone: USGS (2024, 2025), RFC Ambrian (2025).

The data comes in the form of monthly or annual prices, graphical overviews, or market averages. The most common limitations are:

- incomplete time series,
- different methodologies and data formats between sources,
- the need to interpret graphical data,
- the absence of a single standard for all commodities.

## 4. Results

The results of the analysis present the development of prices of four monitored critical minerals – lithium, cobalt, natural graphite and antimony – in the period from 2015 to 2025. The overviews include numerical data available in professional sources, with emphasis also placed on their importance for the economy of the Slovak Republic.

### 4.1. Development of Cobalt prices (Co)

Balt prices registered in the analyzed period decreased after previous high values. The development is given in Table 1 and Figure 2.

Table 1. Development of cobalt price in 2015–2025

Tabela 1. Zmiany cen kobaltu w latach 2015–2025

| Period | Price of cobalt (USD/t) |
|---|---|
| 2015 | ~30,000 |
| 2016 | ~25,000 |
| 2017 | ~60,000 |
| 2018 | ~80,000 |
| 2019 | ~35,000 |
| 2020 | ~33,000 |
| 2021 | ~50,000 |
| 2022 | ~80,000 |
| 2023 | ~35,000 |
| 2024 | ~24,000 |
| 2025 | ~25,000 |

Source: own processing according to USGS (2025), expert market reports.

Figure 2 shows significant fluctuations in cobalt prices, with the highest values being reached in 2018 and 2022. Subsequently, prices decreased due to changes in battery technologies and growth in production. From the Slovak perspective, cobalt is important mainly as an imported raw material used in the battery and electrical engineering industries. Fluctuations in its prices pose a risk to the stability of supplies and costs in the industry.

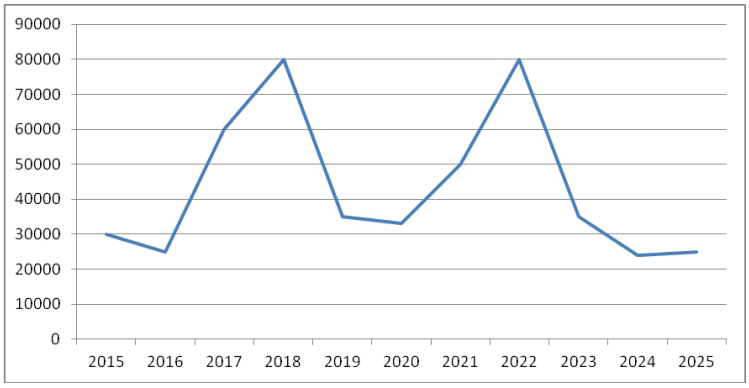


Fig. 2. Price of cobalt (USD/t) 2015–2025
Source: own processing according to USGS (2025), market reports

Rys. 2. Cena kobaltu (USD/t) w latach 2015–2025

### 4.2. Development of antimony prices (Sb)

Antimony is one of the most volatile critical raw materials in the period under review. Its price has experienced extremely dynamic growth, as documented by data from Nagambie Resources (2024) and RFC Ambrian (2025) (see Table 2 and Figure 3).

Table 2. Development of antimony prices in 2015–2025

Tabela 2. Zmiany cen antymonu w latach 2015–2025

| Year | Price (USD/t) |
|---|---|
| 2015 | ~7,000–8,000 |
| 2016 | ~7,500 |
| 2017 | ~8,500 |
| 2018 | ~8,000 |
| 2019 | ~6,500 |
| 2020 | ~6,000 |
| 2021 | ~12,000 |
| 2022 | ~10,000 |
| 2023 | ~11,000 |
| 2024 | ~13,000–23,000 |
| 2025 | ~35,000–43,000 |

Source: own processing according to USGS (2024, 2025), RFC Ambrian (2025).

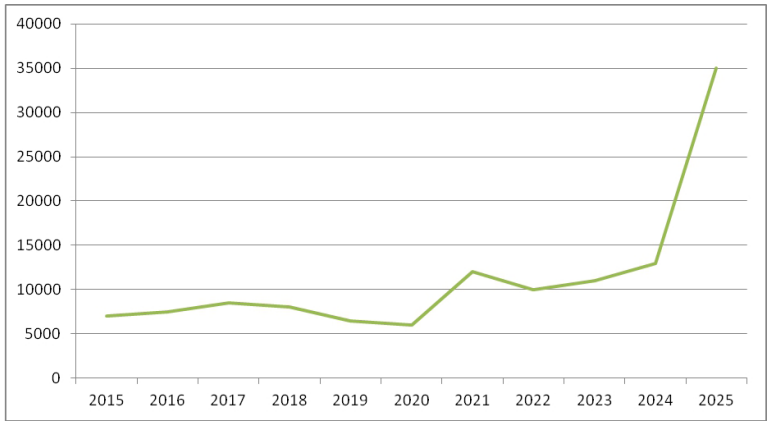


Fig. 3. Price of antimony (USD/t) 2015–2025
Source: own processing according to USGS (2024, 2025), RFC Ambrian (2025)

Rys. 3. Cena antymonu (USD/t) w latach 2015–2025

Figure 3 shows the development of the price of antimony in the period from 2015 to 2025. In the long term, a relatively stable price development can be observed until 2020, followed by significant growth. The most significant increase was recorded in the period from 2024 to 2025, when the price reached a level of approximately 43,000 USD/t. This development is mainly influenced by export restrictions from China and the shortage of raw materials on the global market. This is clear evidence of the high sensitivity of this commodity to geopolitical factors. From the point of view of the Slovak Republic, this trend is of fundamental importance, since Slovakia has significant antimony deposits. The growth in prices increases the economic attractiveness of its mining and represents a potential opportunity to reduce import dependence and strengthen the country's raw material security.

### 4.3. Development of natural graphite price (Gr)

Natural graphite shows a relatively more stable price development compared to lithium and antimony, but with slight fluctuations caused by global demand, as illustrated by Table 3 and Figure 4.

Figure 4 shows a relatively stable development of natural graphite prices with a slight increase in recent years. Unlike the other raw materials analyzed, it does not show

Table 3. Development of graphite prices 2015–2025

Tabela 3. Zmiany cen grafitu w latach 2015–2025

| Year | Price (USD/t) |
|---|---|
| 2015 | ~700 |
| 2016 | ~750 |
| 2017 | ~800 |
| 2018 | ~900 |
| 2019 | ~800 |
| 2020 | ~700 |
| 2021 | ~800 |
| 2022 | ~900 |
| 2023 | ~1,000 |
| 2024 | ~500–800 |
| 2025 | ~800–1,100 |

Source: own processing according to USGS (2025), international analytical reports.

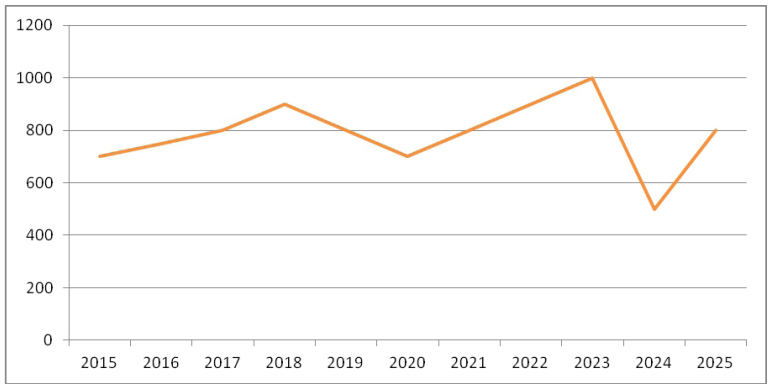


Fig. 4. Price of natural graphite (USD/t) 2015–2025
Source: own processing according to USGS (2025), international analytical reports

Rys. 4. Cena grafitu naturalnego (USD/t) w latach 2015–2025

significant price fluctuations. This development is mainly related to stable demand in the battery industry and the wider availability of this raw material on the market. For the Slovak Republic, graphite is important primarily as an imported raw material used in industry. Its relative price stability is an advantage, as it reduces the risk of sudden cost shocks.

### 4.4. Development of lithium price (Li)

Lithium price data is available in the USGS World Minerals Outlook (2025) and confirms sharp cyclical changes in the period 2023–2025. This is obvious from Table 4 and Figure 5.

Figure 5 shows a highly cyclical development of lithium prices. After a gradual increase until 2021, prices rose sharply in 2022–2023, followed by a significant decline and subsequent stabilization in 2025. This development is a consequence of the rapid growth in demand for batteries and electric vehicles, as well as the subsequent increase in supply on the market. From the perspective of the Slovak Republic, lithium is of strategic importance, especially for the automotive industry. Since Slovakia does not have significant deposits of this raw material, it is dependent on imports. Price fluctuations can thus directly affect production costs and the competitiveness of the industry.

Of the analyzed commodities, lithium, cobalt, and graphite are of greatest importance for the Slovak Republic in terms of industrial use, while antimony represents a potential for domestic mining. The price development of these raw materials points to the growing importance of critical materials for Slovakia's economic security and competitiveness within the European Union.

Table 4. Development of lithium price in 2015–2025

Tabela 4. Zmiany cen litu w latach 2015–2025

| Year | LCE price (USD/t) |
|---|---|
| 2015 | ~6,500 |
| 2016 | ~7,475 |
| 2017 | ~9,100 |
| 2018 | ~16,500 |
| 2019 | ~12,000 |
| 2020 | ~12,000 |
| 2021 | ~8,000 |
| 2022 | ~17,000 |
| 2023 | ~35,000–60,000 |
| 2024 | ~40,000–60,000 |
| 2025 | ~28,000–32,000 |

Source: own processing according to USGS (2025).

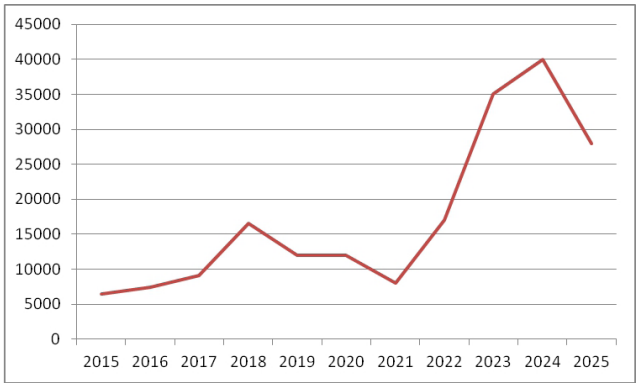


Fig. 5. LCE price (USD/t) 2015–2025
Source: own processing according to USGS (2025)

Rys. 5. Cena LCE (USD/t) w latach 2015–2025

### 4.5. Comparison of prices

The years 2018 and 2025 (considering average prices) were chosen as reference points for comparing the price developments of the analyzed critical minerals due to their different

economic and market contexts. The year 2018 represents a period of relative stability of the global economy before significant disruptions caused by the COVID-19 pandemic and subsequent geopolitical events. Commodity prices during this period reflected the standard functioning of markets without significant shocks. Therefore, they serve as a suitable starting point for comparison.

On the contrary, 2025 was characterized by significant global changes that had a major impact on commodity markets. These include the consequences of the pandemic, disruptions to supply chains, the energy crisis, and geopolitical tensions. These factors led to a sharp increase in the prices of several critical raw materials, making 2025 a suitable representative of a period of high volatility and market fluctuations.

Comparing these two years (see Table 5) thus allows us to better capture the change in the price level between a period of relative stability and a period of significant market turbulence, and thus to better assess the dynamics of price developments in the analyzed raw materials.

Table 5. Change of commodity prices (2018–2025)

Tabela 5. Zmiany cen surowców (2018–2025)

| Commodity | Price in 2018 | Price in 2025 | Absolute change | Percentual change |
|---|---|---|---|---|
| Natural graphite (Gr) | 900 USD/t | 950 USD/t | +50 USD | +5.56% |
| Antimony (Sb) | 8,000 USD/t | 18,000 USD/t | +10,000 USD | +125% |
| Cobalt (Co) | 80,000 USD/t | 25,000 USD/t | –55,000 USD | –31.25% |
| Lithium (Li – LCE) | 16,500 USD/t | 60,000 USD/t | +43,500 USD | +363.64% |

Source: own processing according to LBMA, LME and market reports.

Figure 6 shows a comparison of the price development of selected critical minerals – lithium (Li), antimony (Sb), cobalt (Co) and natural graphite (Gr) – in 2018 and 2025, including percentage changes between the monitored periods. The data shows that the analyzed commodities experienced different price developments between 2018 and 2025. The most significant increase was recorded for lithium, the price of which increased by approximately 363.64%, which was mainly related to the rapid development of electromobility and the growing demand for batteries. Significant growth was also recorded for antimony (+125%), while the price of cobalt decreased (–31.25%) due to overproduction and changes in the demand structure.

Between 2018 and 2025, the price development of individual commodities differed significantly. Antimony and lithium experienced a sharp price increase due to export restrictions and growing demand in strategic sectors. On the contrary, the price of cobalt fell by approximately 30% during this period, which indicates its high volatility and

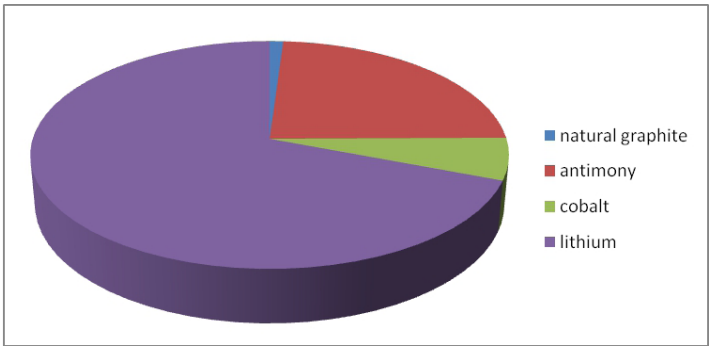


Fig. 6. Percentage change of commodities prices
Source: own processing according to LBMA, LME and market reports

Rys. 6. Zmiana cen towarów w ujęciu procentowym

sensitivity to market changes. Cobalt prices showed more stagnation or a slight decline, mainly influenced by the excess supply on the market. Natural graphite showed relatively stable development with slight fluctuations, which were mainly related to geopolitical factors and the concentration of production. This development points to the growing importance of critical minerals and their sensitivity to global economic, technological, and geopolitical factors.

From the perspective of the Slovak Republic, the development of prices of the analyzed critical minerals has significant economic and strategic implications. The growth of antimony prices increases the potential for the renewal or more intensive use of domestic deposits, which could contribute to strengthening the country's raw material self-sufficiency.

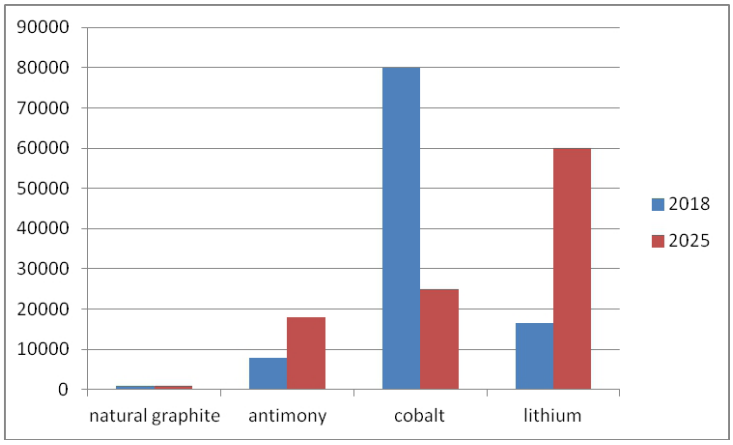


Fig. 7. Comparison of prices in 2018–2025
Source: own processing according to LBMA, LME and market reports

Rys. 7. Porównanie cen w latach 2018–2025

The development of the prices of lithium, cobalt and natural graphite has an indirect but significant impact on Slovak industry, especially the automotive sector, which is a key pillar of the economy. Fluctuations in the prices of these raw materials affect the costs of producing batteries and electric vehicles, which can affect the competitiveness of Slovak manufacturers within the European market.

At the same time, it can be stated that the increasing volatility of prices of critical raw materials (see Figure 7) increases the importance of diversifying supply chains and supporting domestic sources within the European Union. This represents an opportunity for Slovakia to join EU strategic initiatives aimed at ensuring stable supplies of critical materials and strengthening economic security.

### 4.6. Comparison of prices development of chosen CRM

In accord with the development of CRM prices, the EU acccepted in 2023 European Commission Critical Raw Materials Act (CRMA), since 2023 presented period of strategic planning for CRM due to the EU's dependence on China and Cobalt from the Congo (European Commission 2023). We compared the price levels in 2023–2025 (illustrated in Table 6).

A comparison of selected commodities – lithium, antimony, cobalt and natural graphite – allows us to assess the differences in price dynamics, volatility and stability of their development in the period 2023 to 2025 (Nagambie Resources 2024; RFC Ambrian 2025; Copper Council 2025; USGS 2025). Based on available data from expert sources, it is possible to identify significant contrasts between the markets for these critical raw materials. The following Table 6 provides an indicative comparison of prices in the monitored period. The minimum and maximum prices were intentionally reported to illustrate the price range and volatility of the selected critical raw materials over the study period.

Table 6. Comparison of prices level and the trend of development

Tabela 6. Porównanie poziomu cen i tendencji rozwoju

| Commodity | Lowest price (2023–2025) | Highest price (2023–2025) | Change |
|---|---|---|---|
| Cobalt (Co) | 24,000 USD/oz (2024) | 35,000 USD/oz (2023) | –30% |
| Antimony (Sb) | 13,298 USD/t (03/2024) | 43,000 USD/t (01/2025) | +223% |
| Natural graphite (Gr) | ~470 USD/t (01/2023) | ~1,100USD/t (07/2025) | –30% |
| Lithium (Li – LCE) | ~28,000 USD/t (2025) | ~60,000 USD/t (2023) | +~40% |

Source: own processing according to Nagambie Resources (2024), RFC Ambrian (2025), Copper Council (2025) and USGS (2025).

Antimony clearly dominates the price volatility scale. Between March 2024 (13,298 USD/t) and January 2025 (~43,000 USD/t), its price increased by more than 220%, the most significant increase among all critical raw materials analyzed. The main reasons for volatility are:

- export limitation from China (2024–2025),
- global shortage of concentrates,
- growing demand in the defense, chemical, and battery industry.

Natural graphite has shown a relatively more stable price development compared to the other raw materials analyzed. In the period from 2023 to 2025, its price fluctuated approximately in the range of 470–1,100 USD/t, with the growth being gradual and without extreme fluctuations. The stability of graphite prices is mainly connected to the following:

- broad geographical distribution of production, enhancing price stability by reducing supply concentration and increasing market resilience, whereas highly concentrated production increases vulnerability to geopolitical disruptions, supply shocks, and price volatility,
- gradually growing demand in the battery industry,
- lower measure of speculative influences in the market.

Cobalt shows a medium level of volatility, with its prices decreasing from around 35,000 USD/t (2023) to around 24,000 USD/t (2024–2025) in the monitored period. The price development of cobalt is mainly influenced by:

- high concentration of mining in Congo,
- changes in battery technologies (decrease in cobalt demand),
- development of global demand for electromobility.

Lithium is characterized by considerable price cyclicality:

- in 2023 historical maximum (~60,000 USD/t),
- in 2024 rapid decrease (~30,000 USD/t),
- in 2025 stabilization (~28,000–32,000 USD/t).

The trend reflects rapid mining expansion, temporary market saturation, and sensitivity to the development of batteries and electromobility demand.

## 5. Discussion

The results show significant differences in the price development of the analyzed critical minerals, which are mainly determined by the structure of the global market, the geographical concentration of mining, and the technological use of individual commodities. The most significant price dynamics was shown by antimony, whose price increased between 2018 and 2025. This extreme increase confirms the high sensitivity of the market to geopolitical factors, especially export restrictions from China and the limited availability of the raw material on world markets (Kaufmann et al. 2024). The results of the analysis thus point to a high level of risk, but also to the potential economic attractiveness of this raw material in the event of its mining (Bačo et al. 2015).

In contrast, lithium exhibits a highly cyclical nature. Record prices were followed by a sharp decline in 2024 and subsequent stabilization in 2025. This development indicates a high sensitivity of the market to the imbalance between supply and demand, with rapid expansion of mining and technological changes significantly affecting the price level (Leal-Arcas and Burstein 2023).

Cobalt was characterized by a moderate degree of volatility in the analyzed period, with its price tending to decline. This trend is mainly related to changes in battery technologies and the effort to reduce its share in batteries, as well as to the high concentration of production in geopolitically risky areas (Šuráne et al. 2024).

The most stable price development was recorded for natural graphite, which showed gradual growth without significant fluctuations. This trend is the result of stable demand in the battery industry and, at the same time, the wider availability of this raw material compared to other analyzed commodities (Opálek et al. 2021).

The greatest opportunity for the Slovak Republic is precisely antimony, especially given the existence of domestic deposits and its growing strategic importance within the European Union (Kollová et al. 2025). We believe that under appropriate economic and environmental conditions, its mining could contribute to reducing Slovakia's dependence on imports of critical raw materials.

On the other hand, we see Slovakia's high level of dependence on imports of lithium, cobalt and natural graphite as problematic, as price volatility of these raw materials can negatively affect the stability of industrial production (Fojtíková et al. 2025). It will therefore be crucial for Slovakia to actively participate in European initiatives aimed at securing supplies and diversifying sources. In the future, the importance of recycling and technological innovations will grow, which can alleviate the pressure on primary raw material sources and contribute to a more sustainable functioning of the economy.

The results of the analysis confirmed that the development of prices of critical raw materials directly affects their strategic importance and economic prospects. In the conditions of the Slovak Republic, the most promising raw material in terms of domestic use can be considered antimony, which has real deposit potential. On the contrary, lithium, cobalt, and natural graphite represent raw materials for which Slovakia is dependent on imports, which increases the importance of stable supply chains and strategic measures at the European Union level. Based on the analysis performed, it can be stated that the increasing volatility of prices of critical raw materials also increases their importance for economic security (Ashena et al. 2024). Their possible use in the territory of the Slovak Republic will depend primarily on the existence of deposits with sufficient reserves, as well as on the economic conditions of mining, technological progress, and environmental limits.

## Conclusion

In the presented paper, we focused on the analysis of the potential of critical minerals in Slovakia from an economic point of view. The aim of the work was to evaluate the prices development of selected critical minerals, assess the possibilities of their use, and analyze their importance in the context of raw material security of the Slovak Republic and the European Union.

Based on the theoretical foundations developed and the analysis performed, it can be stated that Slovakia has significant geological potential, especially in the case of antimony, which represents a promising raw material in terms of strategic importance for the economy and raw material security. On the contrary, lithium, cobalt, and natural graphite are important mainly from the point of view of their use in industry, while their availability is ensured mainly by imports.

The analysis of the development of prices of selected commodities in the period 2015–2025 confirmed their growing importance in connection with the energy transformation, the development of electromobility and the increased demand for raw materials for modern technologies. The results also pointed to different levels of volatility of prices of individual raw materials.

In terms of the usability of domestic resources, it can be stated that the greatest potential for reducing Slovakia's import dependence is represented by antimony, for which there are proven deposits and a historical mining tradition. On the contrary, for lithium, cobalt, and natural graphite, Slovakia is dependent on imports, which increases the importance of ensuring stable supply chains.

On the other hand, the implementation of the mining of critical minerals in Slovakia is conditioned by several factors, primarily environmental requirements, the economic complexity of projects, and legislative conditions. For this reason, it is necessary to approach their use in accordance with the principles of sustainable development (Tomala and Urbaniec 2024).

The presented study is limited to the economic point of view through the development of prices for the chosen CRM. Future research will cover the connection of economic, environmental, and geological points of view. The results are useful for the development of future EU and Slovakian raw material policy. Future research can be oriented to the estimation of price development of critical raw materials for several years ahead according to several possible development scenarios (optimistic, basic, and pessimistic).

In conclusion, it can be stated that Slovakia has promising resources of selected critical minerals, especially antimony, which may play a significant role in strengthening the country's raw material security in the future. However, the effective use of these resources will depend on technological progress, economic efficiency and environmental acceptability of mining, as well as on Slovakia's ability to respond to changing global market conditions.

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*The Authors have no conflict of interest to declare.*

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**POTENTIAL OF CRITICAL RAW MATERIALS OF SLOVAKIA**

Keywords

critical raw materials, raw material security, price trends,
raw material potential, European Union

Abstract

The paper deals with the analysis of the potential of selected critical minerals in the territory of the Slovak Republic from economic perspective. The aim of the work is to evaluate the possibilities of using selected minerals in the conditions of the Slovak Republic and to assess their importance in the context of raw material security of the European Union. The research analyses the development of prices of selected critical minerals, namely antimony, lithium, cobalt and natural graphite, in the period from 2015 to 2025 in order to assess their economic prospects in terms of the possible use of domestic resources. The results had been achieved through a quantitative analysis of secondary data and systematic monitoring and evaluation of CRM development, as well as an assessment of the prospects of selected CRM and possibilities of their use in concrete conditions. The results of the analysis show that the Slovak Republic has potential, especially in the case of antimony, which has confirmed deposits on its territory and at the same time an important strategic position within the European Union. On the contrary, lithium, cobalt and natural graphite are important for Slovakia primarily in terms of their use in industry, while their availability is ensured mainly by imports. The use of critical minerals in the territory of the Slovak Republic is conditioned by several factors, in particular the economic efficiency of mining, environmental requirements and legislative conditions.

**POTENCJAŁ SUROWCÓW KLUCZOWYCH W SŁOWACJI**

Słowa kluczowe

surowce o znaczeniu krytycznym, bezpieczeństwo dostaw surowców,
trendy cenowe, potencjał surowcowy, Unia Europejska

Streszczenie

Artykuł poświęcony jest analizie potencjału wybranych minerałów krytycznych na terytorium Republiki Słowackiej z perspektywy ekonomicznej. Celem pracy jest ocena możliwości wykorzystania wybranych minerałów w warunkach panujących w Republice Słowackiej oraz określenie ich znaczenia w kontekście bezpieczeństwa surowcowego Unii Europejskiej. W ramach badań przeanalizowano zmiany cen wybranych minerałów krytycznych, a mianowicie antymonu, litu, kobaltu i grafitu naturalnego, w latach 2015–2025 w celu oceny ich perspektyw ekonomicznych pod kątem ewentualnego wykorzystania zasobów krajowych. Wyniki uzyskano dzięki analizie ilościowej danych

wtórnych oraz systematycznemu monitorowaniu i ocenie rozwoju surowców krytycznych, a także dzięki ocenie perspektyw wybranych surowców krytycznych i możliwości ich wykorzystania w konkretnych warunkach. Wyniki analizy wskazują, że Republika Słowacka posiada potencjał, zwłaszcza w przypadku antymonu, którego złoża na jej terytorium zostały potwierdzone, a jednocześnie zajmuje ona ważną pozycję strategiczną w Unii Europejskiej. Z kolei lit, kobalt i grafit naturalny mają dla Słowacji znaczenie przede wszystkim ze względu na ich wykorzystanie w przemyśle, a ich dostępność zapewniana jest głównie poprzez import. Wykorzystanie minerałów o znaczeniu krytycznym na terytorium Republiki Słowackiej zależy od kilku czynników, w szczególności od opłacalności wydobycia, wymogów środowiskowych oraz uwarunkowań prawnych.