Acta Montanistica Slovaca
ISSN 1335-1788
actamont.tuke.sk

Dolomite market potential from the view of export and import in the chosen countries

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Funding information:
This research was funded by VEGA 1/0430/22, KEGA 013TUKE-4/2023, ITMS 3131011T564

How to cite this article:
Domaracká, L., Taušová, M., Čulková, K., Seňová, A., Koval, B., Šaffová, D. and Wiecek, D. (2025). Dolomite market potential from the view of export and import in the chosen countries, *Acta Montanistica Slovaca*, Volume 30 (1), 272-284

DOI:
https://doi.org/10.46544/AMS.v30i1.20

Abstract
Dolomite presents the most promising lightweight metal in the twenty-first century. The worldwide dolomite market is expected to increase. However, some countries registered a decrease in the export and import of dolomite. The goal of the presented paper is to evaluate the potential of the dolomite market from the perspective of export and import trends in V4, Austria, and Ukraine, to identify opportunities for market improvement. The research methods employed are basic statistical techniques, with subsequent processing in JMP software. The results show that there is an annual increase in exports and imports. However, EU countries are still dependent on imports of raw materials. The results are useful for decision-making, policymaking, and strategic planning in different sectors and at different levels.

Keywords
raw materials, market size, magnesite and dolomite, Slovakia, V4, Austria, Ukraine

Introduction

Due to its excellent properties, dolomite presents "the most promising lightweight metal in the twenty-first century." The Global Dolomite Market Size was valued at USD 1.92 billion in 2022. The Market is growing at a CAGR of 7.34% from 2022 to 2032. The Worldwide Dolomite Market could reach USD 3.90 billion by 2032. North America is expected to experience the fastest growth during the forecast period (Global Dolomite Market Size, 2032).

This is manifested, for instance, by Agrawal et al. (2021) in the field of the automotive industry. In response to increasingly stringent requirements in nearly all countries regarding exhaust gas emissions, fuel consumption, and noise, car manufacturers are attempting to replace conventional components made of steel and lead alloys with those made of magnesium alloys. As magnesium alloys are 77% lighter than steel and 36% lighter than lead alloys, the use of magnesium alloys can significantly reduce vehicle weight, thereby reducing fuel consumption and exhaust emissions.

Nowadays, electronic products have become a necessity in daily life, and electronic products are developing towards a small size and low cost. Compared to traditional engineering plastics that are widely used in electronic products, magnesium alloys have unique advantages in the miniaturization of electronic products due to a number of advantages, including ease of manufacturing high-performance thin walls, high strength, and strong impact resistance (Espiritu et al., 2019). Magnesium alloys are used in the manufacture of housings and components for electronic products, and the market for them is continually growing.

Due to their lightweight nature, magnesium alloys were utilized in the aircraft industry during World War I to reduce the weight of aircraft. Currently, magnesium alloys are still used in the manufacture of some parts of military and civil aircraft, such as the supporting structure, which helps to improve the dynamic characteristics of aircraft and reduce their weight (Warrington, K., 2018). The scope of application of magnesium alloys in the field of aviation will expand, because the properties of magnesium alloys are gradually improving.

Magnesium alloys have excellent mechanical properties and good formability, and magnesium is one of the basic metallic elements of the human body. Therefore, magnesium alloys can be used as a material for medical implants. Since magnesium is lightweight and pleasant to the touch, it is also suitable for the production of bicycles, wheelchairs, and other everyday-use devices (Dowling et al., 2015).

Since there is little of literature research, regarding evaluation of marketing potential from the view of economic indicators and they are more specific orientated (Hlavnova et al., 2014; Ban et al., 2022; Santhakumar, 2015), the ambition of the presented paper is to examine potential of dolomite market in chosen countries through the aspects of export and import.

Literature review

Mineral extraction in Europe has become more challenging since most member states have implemented measures to adhere to the principles of sustainable development. The industrial minerals sector provides important mineral commodities for the industries. The results of Čulková et al. (2020) show that despite the fact that there is an obvious certain boom and annual growth in mining volumes in the V4 countries, this growth does not mean the mining industry is following sustainable development. There is a vast space for the industry to improve. Mineral resources are among the most important natural resources of countries, and they are widely used both on the domestic market as a fuel and as raw materials for construction, the production of construction materials, agriculture, and metallurgy; they are also exported. Jekabson et al. (2013) presented an analysis of the development of external trade in non-metallic mineral products across various product groups. The major export markets (regions and countries), as well as the major product groups and sources of imports, have been identified through the analysis.

There has been a rapid demand for dolomite in parallel with the steel production. Tripathy et al. (2013) evaluated the global dolomite market across various industries. The main driver of magnesite markets over many decades has been the refractories industry where magnesite is used to produce magnesia (MgO) as the principal component of basic refractory formulations used to line furnaces in the steel industry, and for heat containment in some areas of cement, non-ferrous metal and glass manufacture (Keeling et al., 2019). The dissolved components of calcium-bearing gangue minerals that are adsorbed on the surface of magnesite can make it difficult to effectively separate magnesite from dolomite (Sun et al., 2020). Dolomitization also creates new crystals, with new rhomb growth following the dissolution of less stable precursors. The dolomitization model and formation depend on the source dolomitization site, and ultimately, favorable conditions must exist for a chemical reaction to occur. One particular type of dolomite, which may serve as a cement or a replacement, is baroque dolomite, also known as 'saddle' or 'white sparry' dolomite and recognized by mineral collectors as pearl spar. It is characterized by a warped crystal lattice (Mehmood et al., 2018).

Fillers derived from natural minerals, such as dolomite, are among the best reinforcement materials for polymeric materials because they are abundant and low-cost, have high rigidity and hardness, and can even have

tailorable surface chemistry. The use of dolomite as a filler in a polymer composite system has gained increasing attention in recent years after researchers successfully proved that it is capable of improving the mechanical, physical, and thermal properties of various polymeric materials (Fauzi et al., 2022).

The development of the dolomite market depends on prices and currency exchange rates. Over the last 20 years, China's exports benefited from favourable currency exchange rates and positive relations with the USA and European countries (Simandl et al., 2007; Dvořáček et al., 2018). As magnesium production costs in China are rising and environmental restrictions are being enforced, the potential for developing magnesium resources outside of China, especially in North America, is increasing.

Much information is available in the general literature concerning this mineral. The observation of trends in mineral demand is of fundamental importance in the long-term assessment of prospects for economic development (Galos et al., 2021); however, this is often linked to technological evaluation. For example, in Slovakia, there are large resources of magnesium-bearing substitutes such as dolomite, brucite, and olivine. Furthermore, magnesium compounds can be recovered economically (Csikosova et al., 2013). Domaracka et al. (2018) is dealing with the issue of limestone in V4 countries, in the countries, Slovakia, the Czech Republic, Poland and Hungary through data collected about export and import of the limestone led to the acquisition of business analyses and the creation of maps for better visualisation of acquired knowledge, showing the business has a local character. The biggest producer is Poland, followed by the Czech Republic, Slovakia, and Hungary. Poland is the largest exporter of limestone, while the Czech Republic is the largest importer. Business involving dolomite and mineral resources has a considerable connection with the price of minerals and non-metallic materials, which significantly contribute to the gross domestic product and represent their export share. Some non-metallic materials used in the Slovak Republic maintain their stable position not only on the Slovak market but also on the European market (Muchová et al., 2016). Mykhailov et al. (2023) analyzed the state of the mineral resource base of Ukraine for a number of elements that are essential for the development of 'green power energy' in Europe, found that their exploitation is doubtful and perspectives for commercial output are not clear (see also Bazaluk et al., 2021).

In connection with the aforementioned, the goal of this contribution is to provide further analysis, building on our previous research, such as Csikosova et al. (2013), Muchova et al. (2016), and Domaracka et al. (2018).

Materials and Methods

The contribution aims to examine the potential of the dolomite market in chosen countries. A key aspect of the research is a detailed analysis of exports and imports. By the way, using statistical methods, we determined the possibilities of trend development for dolomite in Central Europe.

The sources of the research present information from the European Commission, as well as various expert studies. We carried out the statistical analysis according to available data from the Eurostat database, which serves as the statistical office of the European Union. We also evaluated the data obtained regarding the raw material policy using the Excel program to create illustrations. The data for the chosen countries' analysis are from the available statistical software, mainly:

- Czech Statistical Office. Statistical Yearbook of the Czech Republic
- European Commission. 2017. MINLEX – Hungary Country Report.
- World Mining Data (www.world-mining-data).

Research is carried out through the JMP software tool for statistical analysis and data visualization developed by SAS Institute. The name JMP originally means "Jump". This tool provides a wide range of statistical and analytical functions that allow users to explore, analyze, and visualize data. The software mainly includes:

1. Statistical analysis (JMP provides various statistical methods and techniques, including statistical tests, analysis of variance (ANOVA), regression analyses, clustering analysis
2. Data visualization (Visualization is one of the key features of JMP. Users can create various types of graphs and visualizations for better understanding of data and identification of patterns)
3. Tools for statistical modeling (JMP includes tools for creating statistical models, such as linear and non-linear regression models, models for generalized linear models (GLM)
4. Analytical tools for data quality (JMP offers tools for data quality control and identification of outliers)
5. Integration with other programs (JMP allows integration with other software tools, which facilitates the transfer of data and analysis results between different programs).

The research requires the use of comparative analysis as a means to compare two or more countries. The aim is to identify the common characteristics and the characteristics of market development that differ, to identify possibilities for improving the dolomite market. Together with comparison, trend analysis also describes the development over time. Cartographer, bubble graphs, and box plots supported the illustrations of the analysis results.

The subjects of the study were the Visegrad 4 countries, Austria, and Ukraine. The countries' selections resulted from economic cooperation that can ensure the growth of competitiveness and provide valuable information for policymakers. Currently, geopolitical factors have also significantly influenced the choice of countries, perceptions of political stability, and the possibility of economic integration, particularly for Ukraine in the context of its efforts for European integration. In this way, the comparison of the V4 countries, Austria and Ukraine, can contribute to a better understanding and improvement of the political, economic, social, and environmental conditions in these countries (Pysarenko, 2014).

Results

This part presents the results of the trend analysis of dolomite from the perspective of export and import development over time, followed by an analysis of exports and imports in selected countries (Visegrad group, Austria, Ukraine) in 2022, along with the determination of the trend in development. Finally, the export and import of dolomite have been studied from the perspective of the chosen country, Slovakia, along with an evaluation of the countries from which dolomite is exported and to which it is imported. Figure 1 presents the trend of dolomite export during 20 years of development.

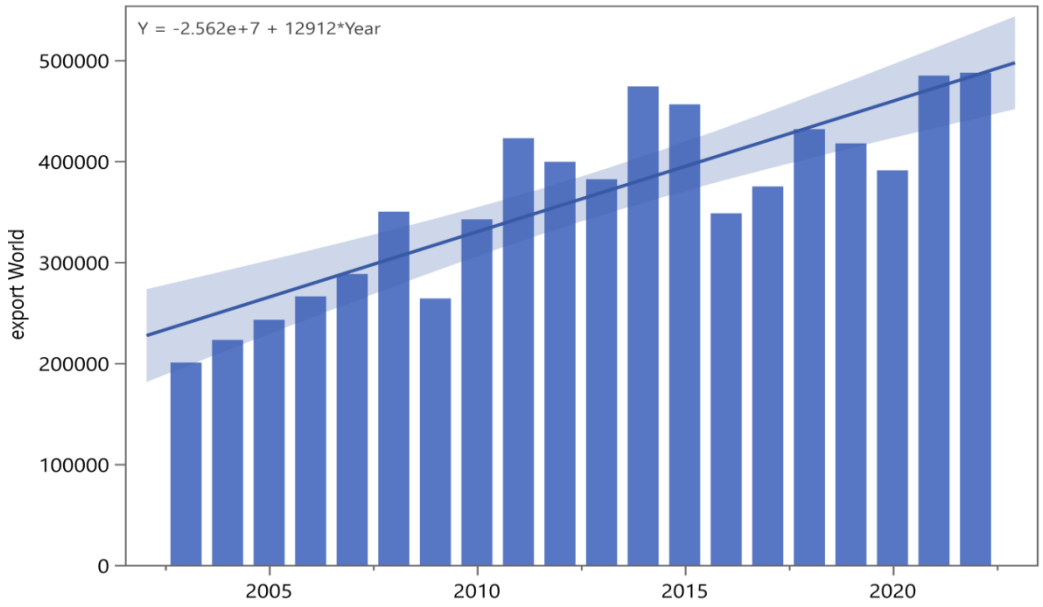

Fig. 1. Dolomite export development

From Figure 1, it is obvious that the trend of export development registered an annual increase of 12,912 million USD. The increase in export of dolomite can be attributed to several reasons related to its diverse use in various industries, e.g. in the field of industrial use as a flux in the production of steel and iron, as an additive in the production of warehouses, in agriculture as lime and fertilizer, in building materials, etc. Together, these factors lead to an increasing trend in dolomite exports worldwide. Therefore, due to its widespread use in various industries, it is logical that the demand for dolomite remains consistently high. The import of dolomite is developing, as shown in Figure 2.

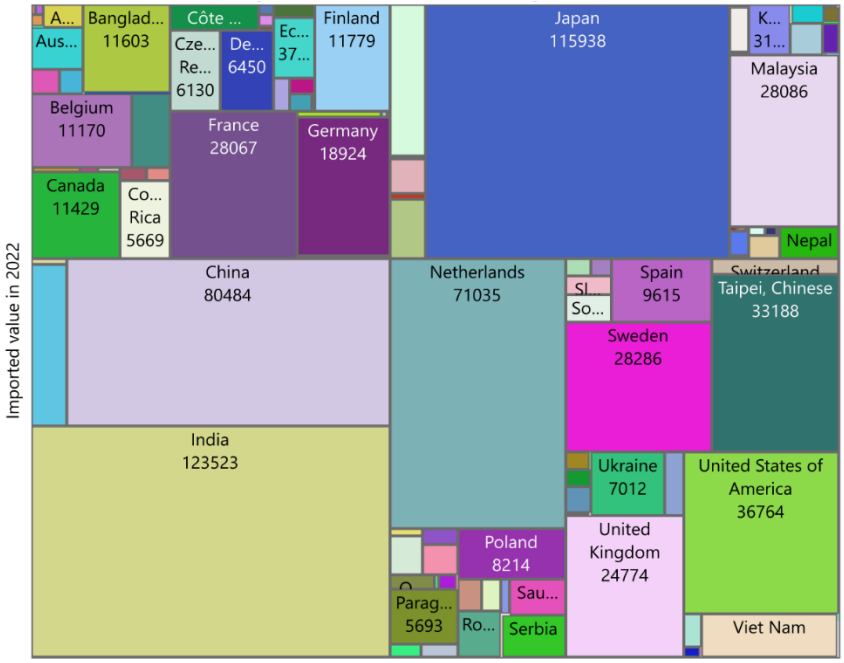

Fig. 2. Dolomite import worldwide in 2022 (thousand USD)

The import of dolomite worldwide develops dynamically and is influenced by several factors. As with export, import is also a main factor related to its wide use in various industries. For example, high steel-producing countries that do not have sufficient domestic dolomite resources import dolomite to meet their production needs. Some countries import dolomite to ensure quality raw materials for the glass and ceramics industry. Countries with intensive agriculture and limited domestic resources import dolomite to improve soil fertility and increase agricultural production. Furthermore, the import of dolomite is significant in countries with a developed construction sector that do not have sufficient domestic resources. The import of dolomite is also increasing due to the growing demand for mineral supplements and cosmetic products, for which dolomite is a key raw material. Some countries lack sufficient quality dolomite and are therefore forced to import it from countries where it is available in sufficient quantity and quality. These factors contribute to an overall increase in dolomite imports globally. The trend of importing dolomite is often linked to economic growth, industrialization, and urbanization of individual countries, which increases the demand for this important raw material.

Due to the potential economic integration and sustainable development of the dolomite market, we compared V4, Austria, and Ukraine, also from the perspective of export and import in 2022. The exported value is shown in Figure 3, and the imported value is shown in Figure 4.

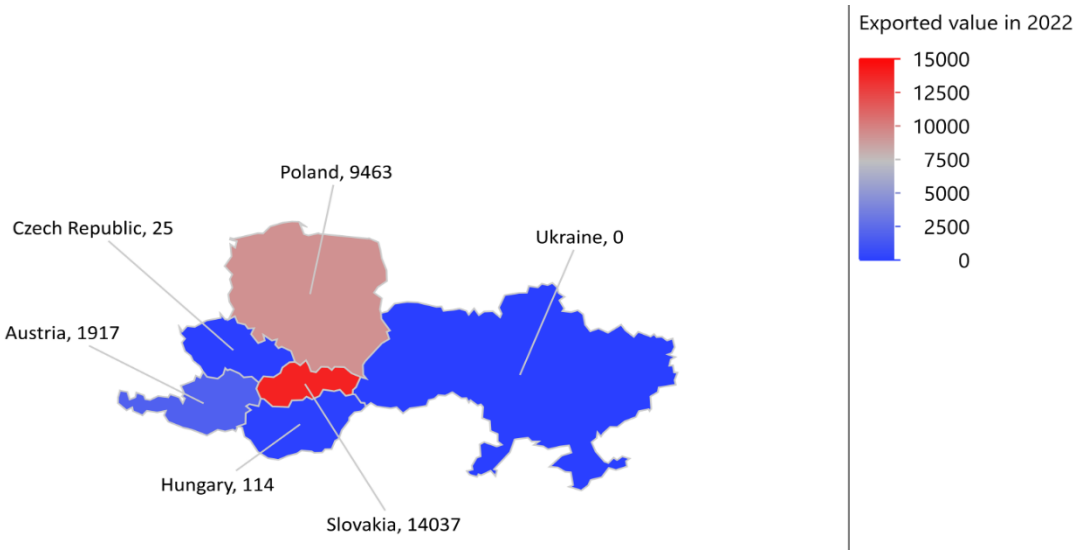

Fig. 3. Export analysis in V4, Austria, and Ukraine

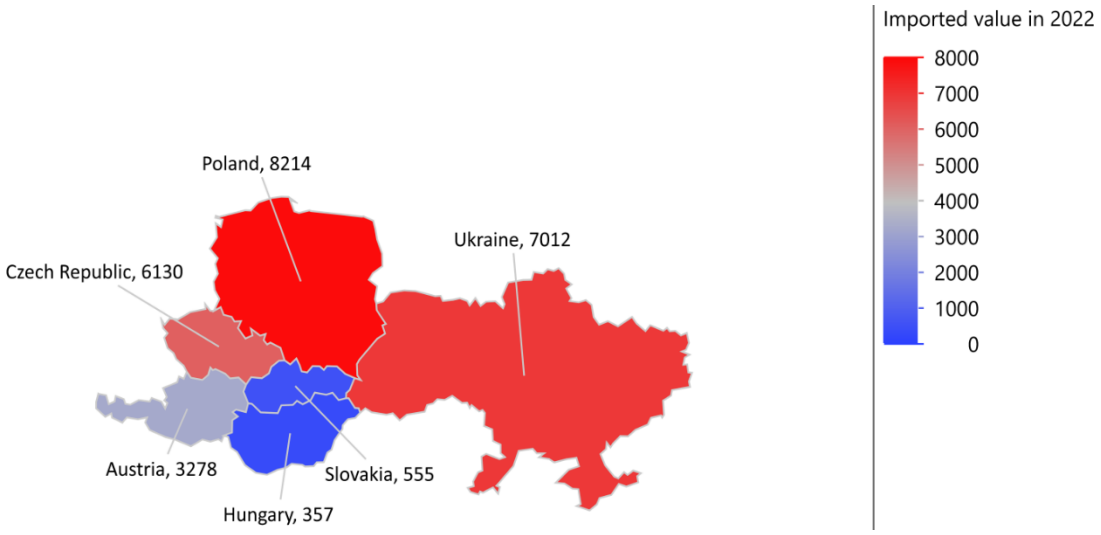

Fig. 4. Import analysis in V4, Austria, and Ukraine

The maps above give the following information: export is the highest in Slovakia, followed by Poland. Ukraine registered the lowest export value of 0, which could be attributed to the geopolitical situation. Import value was highest in Poland, followed by Ukraine and the Czech Republic. Slovakia and Hungary had the lowest import value in 2022.

Consequently, the research continued in line with the trend of export and import development, which is important due to the provision of precious information about global trends in the dolomite market. It could help organizations and investors during investment decisions and the expansion of production. Figures 5 and 6 illustrate the trend of export and import development in the analyzed countries.

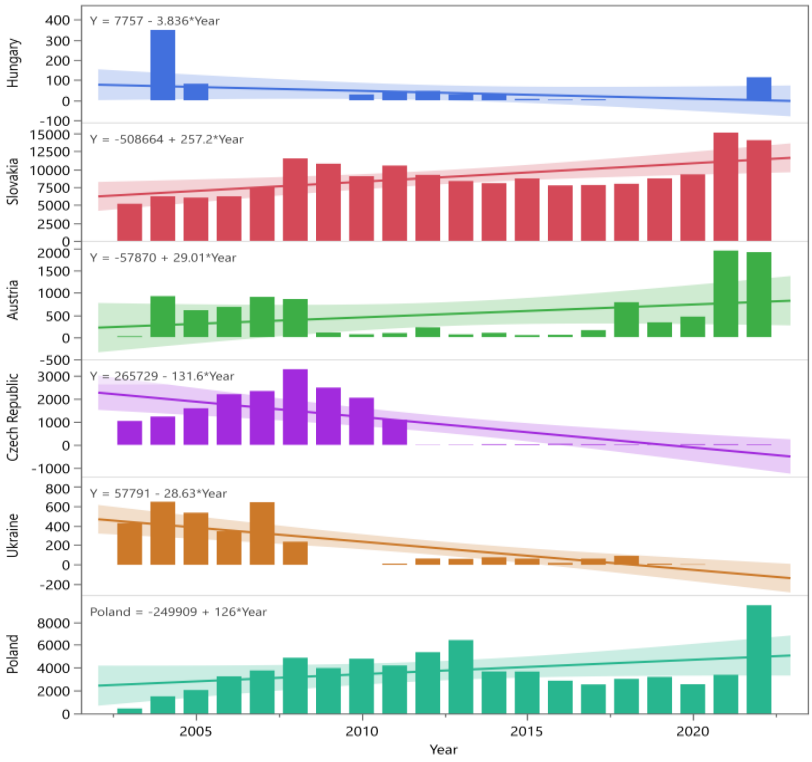

Fig. 5. Export analysis and trend of development in V4, Austria, and Ukraine

Development of export in Hungary registered in the analyzed period decreased from around 300 to 150 thousand USD, Slovakia recorded a fluctuating trend, from a minimal value of 5,000 in 2005 to a maximal value of 15,000 in 2021. Austria also had a fluctuating trend, with an increase in the last year to 2000. The Czech Republic recorded a decrease, whereas last year, it had almost no exports. The highest value was in 2008, around 3000. Ukraine recorded an export decrease to a value close to zero. The best export period was from 2003 to 2008,

with the highest value in 2007, at around 700. Poland had an increase in dolomite export, with the highest value in 2022 of over 8000.

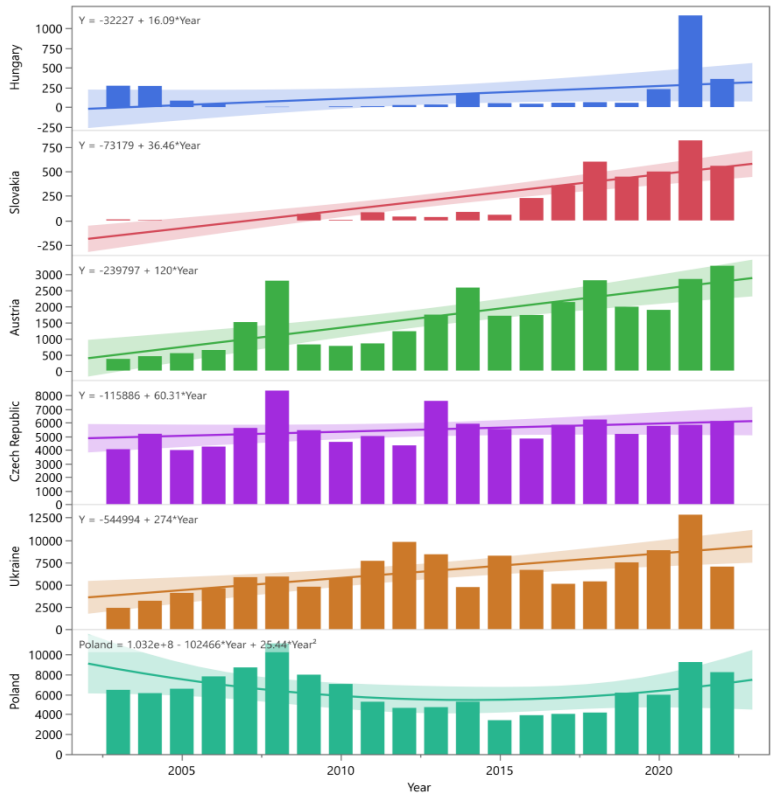

Fig. 6. Import analysis and trend of development in V4, Austria, and Ukraine

Import development shows the following: Hungary had low import values of around 50 - 250, with a significant increase in 2021 to 1,000. Slovakia recorded an increase from 2016 to 2022, with the highest value in 2021, around 750. Austria had a fluctuating trend, with significant growth in 2008, 2014, and 2022 (with the last registered value in 2022 around 3000). The Czech Republic registered steady development around 5000, with a smooth increase in 2008 and 2013. Ukraine recorded gradual growth in imports, reaching its highest value in 2021 at over 12,000. Poland's imports show fluctuating development, with the best years being 2008 and 2021. However, in 2021, the values were not achieved, as in 2008. On the other hand, 2022 was a year with repeated decreases.

Next, we analyze the export and import of dolomite in Slovakia. A special analysis of the dolomite market in Slovakia is important for economic, industrial, environmental, geopolitical, and social reasons. Dolomite is a crucial raw material for various industries in Slovakia, including steel production, glass manufacturing, ceramics, and construction. Slovakia may be dependent on importing dolomite from other countries. Market analysis can thus help identify the risks associated with this dependence and look for ways to increase domestic production or diversify resources. In addition, Slovakia is a member of the V4, which means that it can have common interests with the Czech Republic, Hungary, and Poland. The analysis in Slovakia, from the perspective of a 20-year development, with the definition of the development trend, is presented in Figure 7, from which we see an annual increase of 257.2 thousand USD.

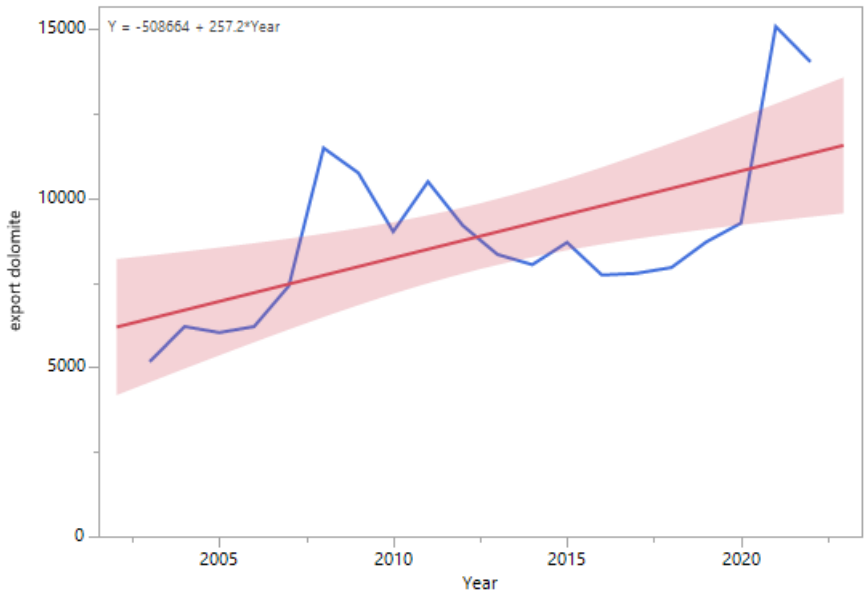

Fig. 7. Trend of dolomite export analysis in Slovakia

Slovakia exported dolomite, along with all other products, to the following countries (Fig. 8). The highest volume is represented by the export of products to the Czech Republic and Poland, as shown in the figure. Poland has doubled the consumption of this raw material in recent years. Figure 9 provides information about exports by individual product.

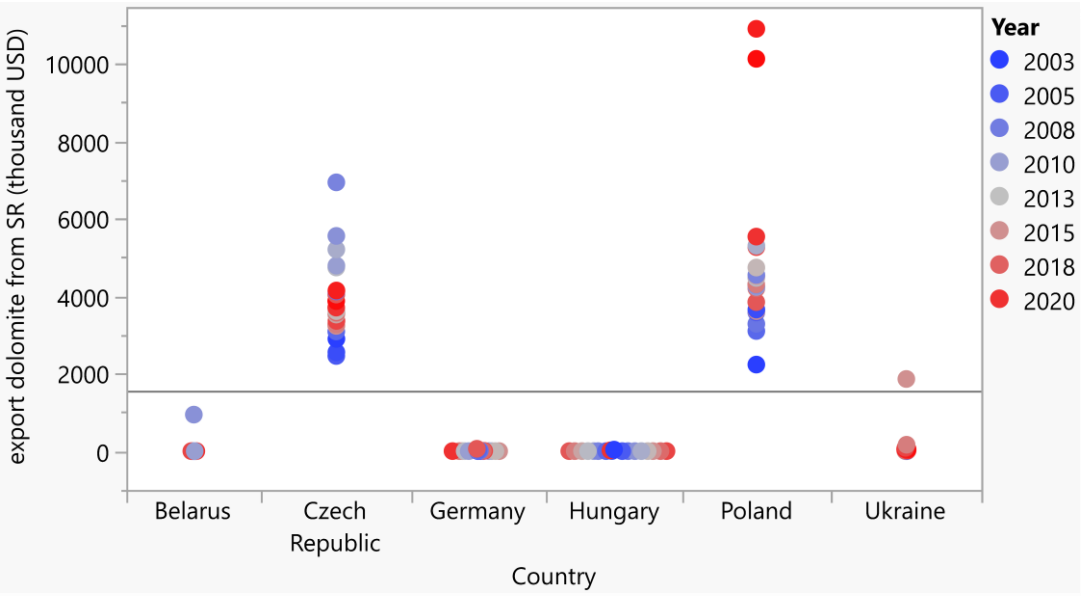

Fig. 8. Comparison of countries from the view of dolomite export from Slovakia

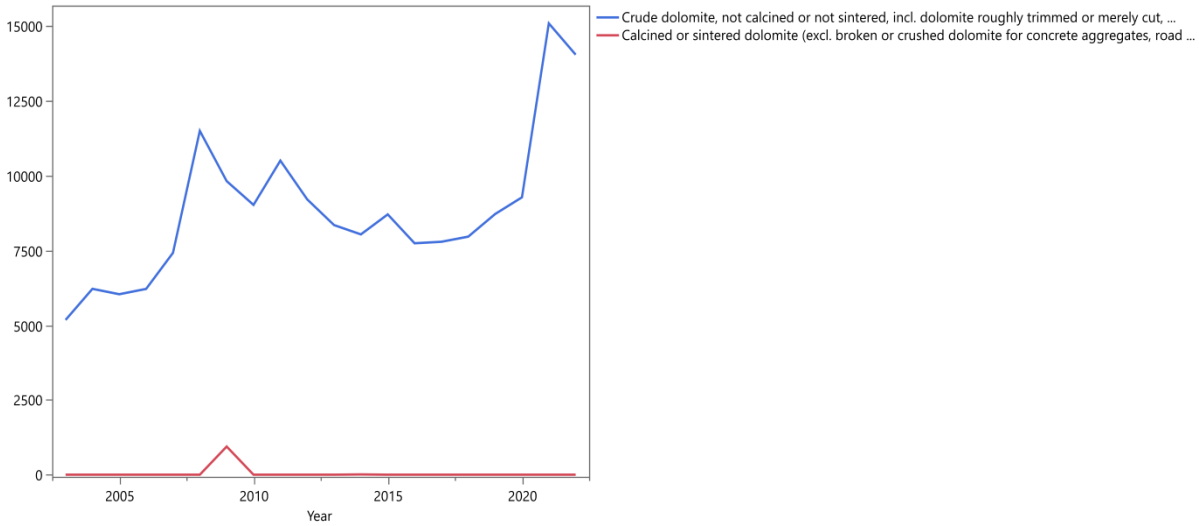

Fig. 9. Dolomite export from Slovakia according to products

Crude dolomite, not calcined or not sintered, including dolomite roughly trimmed or merely cut, registered the highest export. These products recorded an increase during the analyzed period, with the highest value in 2021; year 2022 recorded a decrease. Calcined or sintered dolomite, excluding broken or crushed dolomite for concrete aggregates, registered low values compared to crude dolomite, with a smooth increase in 2009 to around 500.

We conducted a similar analysis from the perspective of dolomite imports to Slovakia. Figures 10 and 11 illustrate the development over a 20-year period, according to the products (Figure 10) and according to the imported countries (Figure 11, for all products).

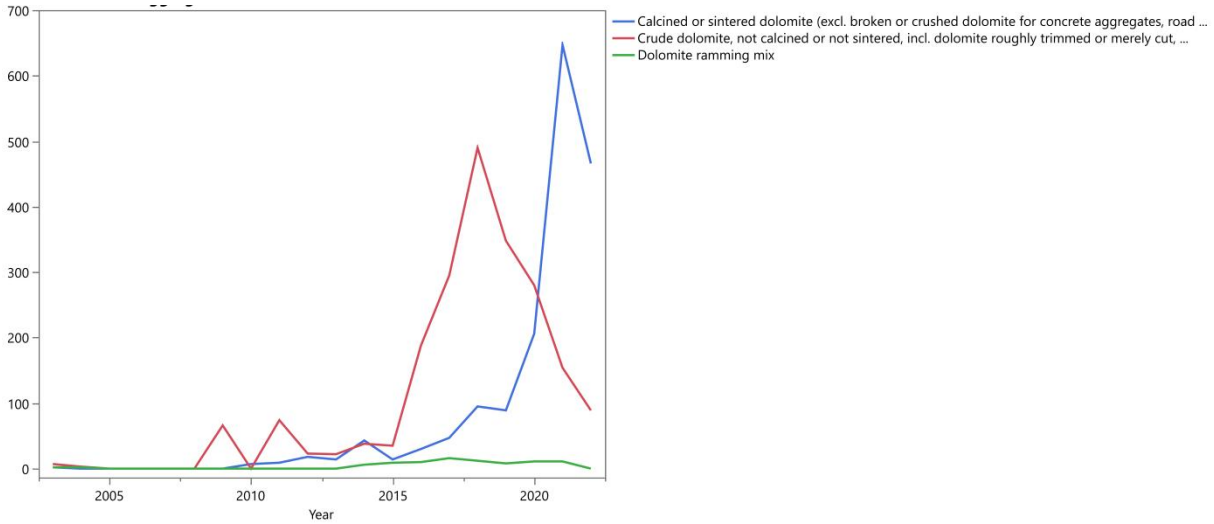

Fig. 10. Dolomite imports to Slovakia according to products (thousand USD)

Characteristics of dolomite imports to Slovakia present three levels:

- Calcined or sintered dolomite, excluding broken or crushed dolomite for concrete aggregates and road, registered an increase with rapid growth from 2019 to 2021. However, 2022 recorded a significant decrease.
- Crude dolomite, not calcined or not sintered, including dolomite roughly trimmed or merely cut, recorded an increase. A rapid increase was registered from 2015 to 2018, reaching a value of around 500, after which a period of rapid decrease was registered. The pandemic situation could cause such a situation.
- The dolomite ramming mix had stable development during the analyzed period, around 10.

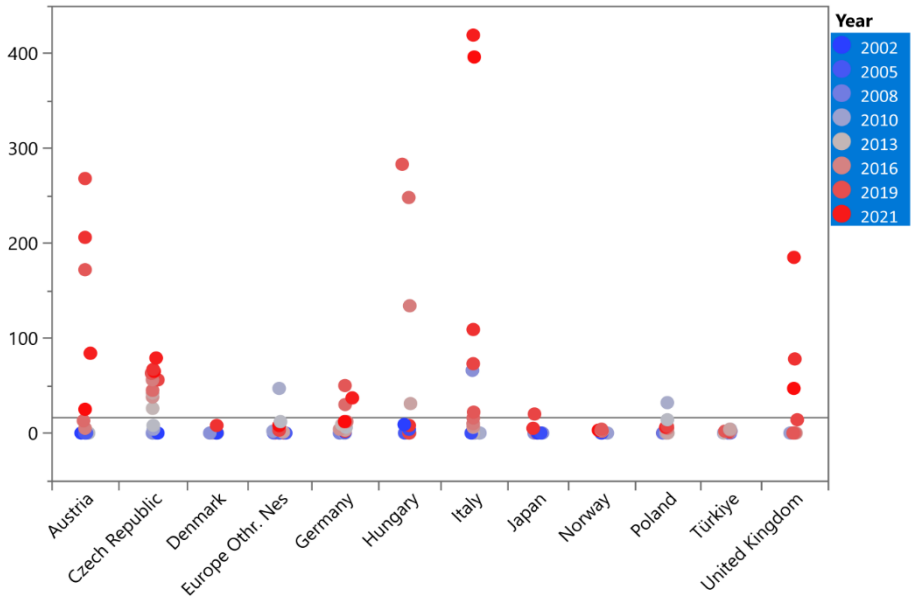

Fig. 11. Dolomite imports to Slovakia according to the supply countries

The import of dolomite is provided by the following countries (Fig. 11), with the most significant volumes in 2020 and 2021 being supplied by Italy, Austria, Hungary, and the United Kingdom, with an import volume exceeding 200 thousand dollars. In addition, other suppliers are the Czech Republic, Germany, Japan, Norway, and Poland.

Discussion and conclusions

The research shows that at the global level, there is an annual increase in exports and imports. This trend continues with the previous trends, as found, for example, by Tiess et al. (2011). In 2022, Slovakia had the highest exports; Ukraine registered the lowest. The import value was highest in Poland, and Slovakia and Hungary had the lowest imports. Results of Hastorun (2019) supported the situation in Hungary. The fluctuating trend from Austria is comparable to Holnsteiner et al. (2023). However, despite this, Slovakia, as well as most EU countries, is dependent on imports of other raw materials. The new deposits and new technologies for deposit use represent new potential (Šimková et al., 2021). Slovakia recorded the highest export of crude dolomite. On the other hand, the highest import in Slovakia was recorded for calcined, or sintered dolomite.

Despite positive developments, the prosperity of Slovak dolomite exploitation and the market has unfavorable impacts on the basic components of the environment, i.e., soil, water, and the surrounding air and biota (Csikosova et al., 2013). There is a space to find out ways mainly for decreasing the stored dumps of dolomite and to find out possible ways for decreasing the volume of dumps by use of new technologies, which could increase the sale of the dumped dolomite (Santos and Hanak, 2024). This will be the orientation of the future research. Moreover, the research is limited to the chosen countries in Central Europe. Similar research will be done for the comparison of broader regions. Comparing the countries could help identify areas for cooperation and provide a rich source of data for researchers.

Monitoring the development of export and import of dolomite is important for a better understanding of economic, industrial, environmental, geopolitical, and agricultural trends (Budaj et al., 2018). This information is crucial for informed decision-making, policymaking, and strategic planning in various sectors and at different levels (Vasilková, Kmecová, et al., 2017). Effective business practices in dolomite mining require an economic analysis of efficiency, focusing on key indicators such as costs, revenues, and profits (Teplická et al., 2021; Ali et al., 2017), which can enhance the competitiveness of mining companies in the pursuit of sustainable development and economic growth.

The results of the current study in V4 countries highlight significant parallels with other post-communist nations like Latvia, where mineral resources, particularly dolomite, play a pivotal role in shaping sustainable development strategies (Lazdins, 2014). In Latvia, the integration of mineral resources into the economy is not merely a matter of extraction; it extends toward conscious efforts to harmonize industrial needs with environmental sustainability. The challenges associated with dolomite use in Lithuania, for instance, have been innovatively addressed by Bučas and Kučinskienė (2011). Their approach emphasizes the transformation of dolomite quarries into recreational landscape parks, achieving both environmental restoration and community revitalization.

Montenegro presents another interesting case where dolomite's industrial potential is also being explored, particularly in sectors such as steel manufacturing and agriculture (Božovič et al., 2024). The geochemical composition of dolomite positions it as a valuable resource in these industries, pointing to potential economic benefits that could be harnessed with strategic policies and investments.

However, it is essential to acknowledge the limitations of the current research, notably its reliance on market data constrained by the availability and variety of the chosen indices. This recognition opens a pathway for future studies, particularly those investigating the non-traditional uses of dolomite. There is promising potential for dolomite in various industries, including pharmaceuticals, chemicals, and agriculture, where it could serve as a high-quality filler and fertilizer. Such applications could not only diversify the uses of dolomite but also stimulate economic growth in the region.

Moreover, the post-pandemic landscape presents both challenges and opportunities for the raw materials market. For instance, in Poland, the anticipation of a resurgence in the raw materials sector following the pandemic showcases the need for adaptive strategies geared toward revitalizing these industries (Sukiennik et al., 2021). Understanding this context is crucial for gauging the future of dolomite and other mineral resources in the region.

The findings of the current research have wide-ranging implications. They serve as a foundation for the development of the dolomite market, addressing pressing issues related to raw material availability and economic viability in affected states. For business leaders, the insights provided can guide strategic decision-making in identifying new opportunities and locations for investment and operation.

Further, policymakers can leverage these findings to craft informed raw material policies that align with strategic development goals in the extraction industry. By recognizing potential market gaps for dolomite, they can implement initiatives that not only enhance resource management but also encourage sustainable economic growth.

In summary, the journey of dolomite—from quarry to diverse industrial applications—embodies a broader narrative of resource utilization in post-communist countries. Future research focused on innovative applications and sustainable practices could significantly contribute to economic resilience and environmental stewardship in the region, paving the way for a more integrated approach to resource management that benefits both communities and industries.

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