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PROPOSAL OF SUPPORT PLANNING SYSTEM FOR MAGNESITE MINING OPERATIONS BASED ON AN ASSORTMENT VOLUME SALE FORECASTING

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Abstract:
In the long term, the mining industry can be regarded as market volatile in terms of commodity price movements and sales. Although the general demand for raw materials is increasing, volatility in the different segments of the industry is visible. This paper presents a model for production planning system based on forecast for streamlining Magnesite assortment production in a prominent mining company in Slovakia. The forecast is based on several approaches i.e. quantitative approach – ARIMA method and regression and qualitative-probabilistic approach will be formed by the relevance tree method and discrete Markov chain under the final corrections of an expert (planner). The aim is to provide a medium-term production outlook over a 2-year time horizon for total magnesite production at active mining operation in Slovakia. The planning of magnesite production or extraction is thus based on the forecasted demand for particular processed product ranges in which magnesite is significantly or fully represented. Compared to the previous on-demand planning method, this innovative and implemented system has resulted in a more even production and a reduction of extracted magnesite stock by approximately 20%.

Key words: magnesite, mining operation, planning system, forecasting, sale

INTRODUCTION

The mining of magnesite ($MgCO_3$) in Slovakia has a long history of over 120 years [1] and it has a great importance, not only commercially, but also economically, because Slovakia is in the fourth place in the ranking of exporters of magnesite in the world now [2]. Magnesite reserves in Slovakia are still huge, it is estimated more than 1,012 billion tons [3, 4]. Current production, which has declined in Slovakia in recent years, is approximately 600 kt (kilotons) per year (see Fig. 1) [5].

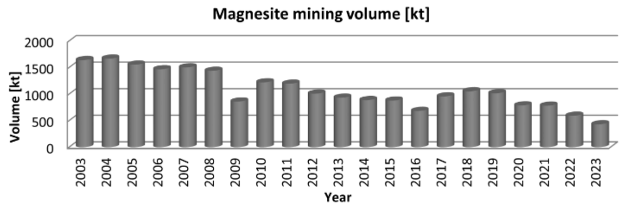

Fig. 1 The Magnesite mining volume in Slovakia within last 20 years
Source: [5].

Magnesite is the most important magnesium mineral. It occurs naturally in crystalline and cryptocrystalline (entire) forms. Magnesite deposits are associated with magnesium-rich rocks like dolomites and serpentinites. Crystalline magnesite is formed in hydrothermal conditions by the contribution of Mg to carbonate rocks, entire magnesite by the contribution of CO_2 to serpentinite. Entire magnesite may also have a sedimentary origin. Slovak crystalline magnesite deposits are among the largest and most important in Europe. Just to give an idea, the most important magnesite deposits, in terms of quantity and quality, can be seen in Fig. 2. The deposit nr. 1 – The Dúbrava Massif is one of the largest in Slovakia and as well as in the world [6]. From a qualitative point of view, the level of variability of MgO content in the central part of the deposit is very low, which means securing a permanent quality of MgO for metallurgy [7].

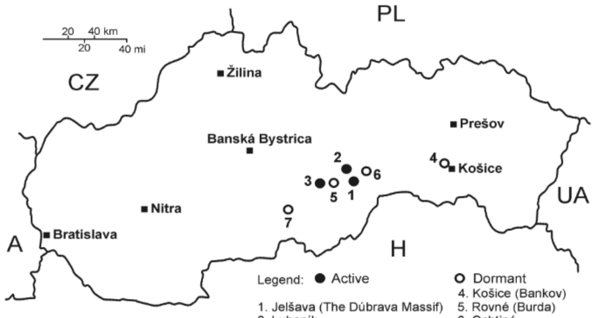

Fig. 2 The Slovak magnesite mines
Source: [8].

The importance of the mineral Magnesite lies in the fact that the magnesium content in association with dolomite ($CaMg(CO_3)_2$) results in its higher thermal stability and thus it can be used for the production of refractories. Therefore, magnesite is mainly used to produce refractory materials such as refractory and thermal insulation bricks and refractory linings for blast furnaces [3].
It was necessary to expand the product portfolio and thus respond to specific customer requirements for the long-term sustainability of the largest mining company in Slovakia. From a long-term offer of only two types of products (semi-finished products for brick and steel clinkers), the offer now has been expanded to the current 62 types, which can be in different modifications, depending on a customer's requirements. In addition to the alkaline monolithic materials, new types such as brick magnesite have been developed, the production of caustic magnesite has been launched and the sale of slag-forming mixtures has been expanded. Together, all these types have created a wide range of product portfolio that the company offers on the domestic and world market. The company's overall activity can be described as waste-free, despite the fact that enterprises carrying out similar activities are characterised by a negative impact on the environment. The waste that remains after the production and treatment activities is carried back into the mining areas as a backfill [9].
As the production is influenced by sales and sales tend to be on a downward trend overall, the importance of strategic planning and forecasting for individual products is increasing. The company currently offers a wide range of products on the market under the following main product programmes [9]:

– Brickmaking Magnesite (BM): its use is found in the production of building materials, the production of monolithic materials, the production of magnesite, magnesite – chromium, chromium – magnesite fittings. It is used in the chemical industry too.
– Steelmaking Magnesite (SM): it is used for the production of monolithic materials and in the steel industry as refractories.
– Alkaline Monolithic Refractory Materials (AMRM): a wide range of products designed for the preparation of new soils, cold and hot repairs and protection of linings of electric arc furnaces, converters, intermediate ladles, vacuum equipment and steel ladles.
– Slagging Mixtures (SMix): these products are designed to increase the basicity of slag and to protect the linings of steel aggregates.
– Caustic Magnesites (CM): these products are used as a mineral additive in livestock feed, to produce fertilisers in the chemical industry and in the environmental field to eliminate the effects of acid rain on the natural environment.
– Raw Magnesites (RM): they are used in the chemical industry for the production of magnesium-based chemicals and in the building industry, as well as for the production of Dead Burned Magnesia (DBM) and Caustic Calcined Magnesite (CCM).

LITERATURE REVIEW

Scherbakova and Shevelev from Russia are also aware of the importance of magnesite as a mineralogical base. With the development and increase in demand for metallurgical products, magnesite is becoming one of the main raw materials used for the production of refractories for metallurgy (large-block pressed products, unformed materials, powders, building materials or mixtures) [10]. Many works have been described in terms of production planning, (see review paper from Newman et al.) and on the production capacity of a mining operation [11]. There is an interesting study from Liu et al., who defined the relationship between working face length, annual advance rate and production capacity. In this way, they obtained a model of the relationship of the production capacity function with specific outputs applicable to the open-pit coal mine under study [12]. According to Dimitrakopoulos, the main drawback of estimation techniques and conventional planning approaches is that they are unable to account for the spatial variability of in-situ deposit series, and thus conventional methods assume perfect knowledge of the ore deposit under consideration [13]. Laptev and Gurin have developed a multi-factor algorithm for automated production planning in underground mines and it allows to take into account geological or geotechnical constraints and timing criteria for operation depending on resource availability, safety rules and characteristics of the mining system used [14]. Bak mentions two levels of planning in a coal mine, namely: planning of access and preparation works and planning of mining works. His view of the planning process is very complex and includes a number of factors that may be involved due to the specific nature of mine production. For example, the variety of conditions for carrying out the activity resulting from the changing geological and mineral conditions of the deposit, the low flexibility of the production process coupled with the impossibility of carrying out alternative production and the very long-term investment process. The planning of the course and scale of production in a mining enterprise must be carried out with the utmost care, taking into account a wide range of environmental, organisational, technical and safety conditions [15]. A more accurate reconciliation of short-term plans derived from long-term plans under conditions of uncertainty was elaborated in the research by Levison, Dimitrakopoulos and Huang et al. Optimized short and long term production plans leads through linking planning horizons with stochastic mathematical programming and reinforcement learning in real copper mine practice this yields significant improvements in the resulting production and financial forecasts [16, 17]. The risk of long-term planning associated with price volatility in global commodity markets [18] is highlighted by Rahmanpour and Osanloo. Their methodology is based on the search for effective long-term planning by calculating different price scenarios for the targeted commodity with minimum risk [19]. Similarly Asl and Sattarvand also look for a pseudo-optimal production plan using a metaheuristic method based on the imperialistic competitive algorithm (ICA) [20]. A modular approach combining several aspects of scheduling is incorporated in their work by Kuchta and Engberg [21]. McBrayer and Brickey have done a survey which points to an opportunity for software development and software companies to develop applications for more accurately modelling operational problems and reducing the time and labour requirements for creating production schedules [22]. Leite et al. presented an innovative Markov Decision Process (MDP) model to optimize the supply chain between a mine and a customer with uncertainties in operating parameters, prices, and demand. It is suitable for repeated planning horizons and allows arbitrary objective functions [23]. The need for an APS system in sales and operations planning (S&OP) processes is essential for streamlining processes. S&OP processes with ambitious aims, operating within a complex planning environment, are difficult if not impossible to implement without the support of APS systems [24, 25]. The necessity of linking forecasting tools with the planning system is also confirmed by the study, which points out that even if demand data are well managed and organisation readiness is high, improvements in the forecasting system and the control of forecast performance are needed [26, 27]. Today, artificial intelligence tools are also commonly incorporated into strategic planning. Its importance is highlighted and beneficial in an uncertain business environment [28]. It is also necessary to mention the environmental impacts of magnesite mining in Slovakia, which are common for the sites everywhere in the world. Magnesite mining is dangerous for the surrounding area from an environmental point of view. Štofejová et al. show in their study, that several times exceeded values of heavy metal content (such as: Cr, As, Mn and Mg) in soil and plants in the dumping grounds in surroundings of the mine [29]. Increased Mg content in air, soil, water, and subsequently, insignificantly, in biomass is a particular Slovak problem in the locations around the magnesite industry. More advanced technologies and realistic management of these valuable raw materials mean that the input of magnesium into the natural and municipal environment is expected to steadily decrease [1, 30]. Zero-waste technologies are planned for the industry, but this remains a long-term vision. Visible damage due to previous operational technologies will persist, but in general the situation will improve [1]. Despite the heavy metal contamination detected, the threshold values for drinking water were set by the Ministry of Health in decree Nr. 29/2002 Coll. are not significantly exceeded for the parameters tested. Future protection of the wells is possible due to the uninhabited and unused recharge area and the absence of agricultural or industrial production [31].

METHODS AND METHODOLOGY

In the elaboration of the above literature review, the authors did not mention how to develop a strategic plan based on the anticipated and expected long-term development of customer requirements in the future. Assume that a mining company plans its mining (production) based on the evolution of demand; this follows from sufficient underground reserves of magnesite. Therefore, the preparation of the strategic plan will be based on a combination of the results of the quantitative and qualitative forecast. The quantitative approach consists of the calculation of forecasts using the ARIMA method and trend coefficients (linear regression coefficients), which were calculated using the computer program Minitab® ver. 21.2, 64-bit) and the qualitative-probabilistic approach will consist of the relevance tree method and a discrete Markov chain (processing in MS Excel® ver. 365). The idea of creating and applying the qualitative-probabilistic approach was necessitated by the situation of selling products to individual contracted customers and it is scientifically unique. In principle, it involves the percentage distribution of the assortment to customers by defining the relevance tree (see Fig. 3).

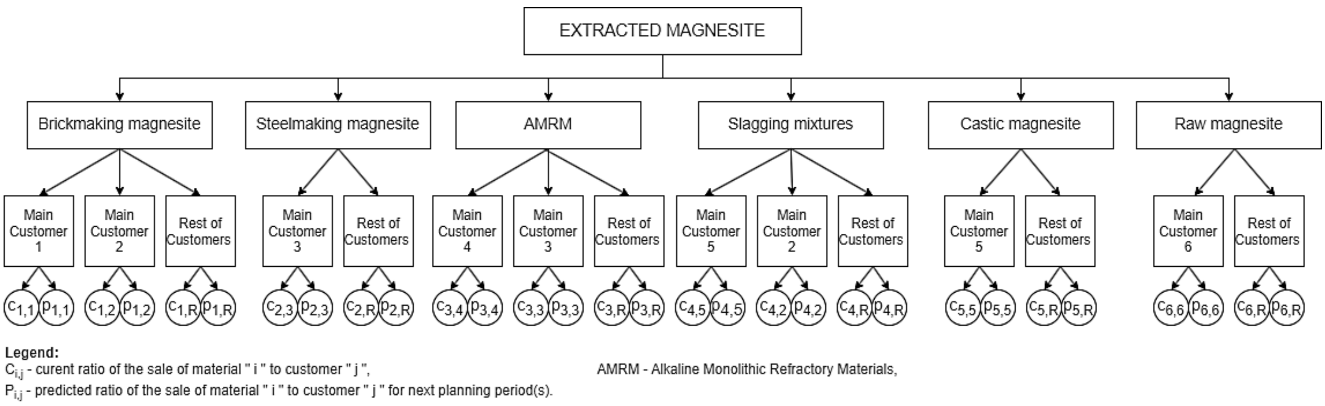

Fig. 3 The Relevance Tree of assortments and customers division

Assumed sales per assortment (*i*) (AS_i) is the sum of the percentages of customer sales within a given assortment (see Eq. 1). Customers report their expectations to the salesperson and the salesperson determines this value according to the Relevance Tree of assortments and customers division. The AS_i value is an expert given value entered by the retailer and is the result of a percentage increase or decrease from the customers' perspective.

$$AS_i = \sum_{j=1}^{m}(p_{i,j} - c_{i,j})\ [\%], \qquad (1)$$

where:
AS_i – total ratio of particular Assortment (*i*) Sale change;
$c_{i,j}$ – current ratio of the sale of *i-th* assortment to *j-th* customer;
$p_{i,j}$ – predicted ratio of the sale of *i-th* assortment to *j-th* customer for next planning period;
m – number of customers.

If AS_i = 0%, it means that the same sales volume is expected as in the last planning period. However, practice shows that while large trade customers usually keep their purchase volume as agreed with the sales department, smaller customers do not. This creates a gap between forecast and actual sales. On the basis of this experience, the sales forecast of a product range is not only determined by customer agreements, but also by the actual sales development of the product range, i.e. by the sales time series. This calculation averages the ARIMA and Linear Trend forecast values and this is corrected for the forecast increase or decrease in AS_i (Eq. 2).

$$FAS_i = \frac{F_{ARIMAi} + F_{LRi}}{2}(1 + AS_i), \qquad (2)$$

where:
FAS_i – Forecast of Assortment (*i*) Sale;
$FARIMA_i$ – ARIMA Forecast of assortment (*i*);
FLR_i – Lin. Regression Forecast of assortment (*i*).

Then, although the linear regression forecast is computed in the standard way using Gauss's Least Square Method (Eq. 3), it is augmented with a correction (*Corr*) (Eq. 4). The correction is the result of the absolute difference in the probability of the next value rising or falling in the time series (Eq. 4). These probabilities are the result of a Markov chain calculation (Eq. 7).

$$F_{LR} = s + b \times t \times Corr, \qquad (3)$$

where:
t – a time variable;
s – slope;
b – the *y*-intercept;
Corr – correction.

$$Corr = |p_{INC} - p_{DEC}|, \qquad (4)$$

where:
p_{INC} – probability of incrementation;
p_{INC} – probability of decline.

The last 10 known values of the sales time series (i.e. values from a period of 2.5 years) are taken to perform the calculation using Markov chains (see Eq. 5, Eq. 6 and Eg. 7). The initial state of the Markov chain ($STATE_0$) is characterized by a two-dimensional vector, where one value indicates the number of increasing values – Nr_{INC} (↑) in the selected interval of values and the other value indicates the number of decreasing values – Nr_{DEC} (↓). (See Table 1, column *INC/DEC*). Transition matrix (*TM*) indicates the probability of a given rising or falling state remaining, or a state of transitioning from rising to falling or vice versa, in the selected interval of values.

$$STATE_0 = (Nr_{INC} \quad Nr_{DEC}), \qquad (5)$$

$$TM = \begin{pmatrix} INCstayINC & INCchangeDEC \\ DECchangeINC & DECstayDEC \end{pmatrix}, \qquad (6)$$

$$(p_{INC} \quad p_{DEC}) = STATE_0 \times TM = (Nr_{INC} \quad Nr_{DEC}) \times \begin{pmatrix} INCstayINC & INCchangeDEC \\ DECchangeINC & DECstayDEC \end{pmatrix}. \qquad (7)$$

Finally, total magnesite production should be consistent with the Total sales Forecast (*TF*), which is made up of the sum of the sales forecasts (FAS_i) for the individual grades (Eq. 8):

$$TF = \sum_{i=1}^{n} FAS_i, \qquad (8)$$

where:
TF – Total Forecast;
n – number of assortments.

RESULTS

The forecasting solution based on the theory presented in the previous chapter was applied to the entire range of magnesite products offered by the mining company. Data selection involved an expert decision among the authors of the proposed system and the planner from the mining operation. While the planner preferred only data for the last four years, the authors of the proposed paper requested more data. Consensus eventually emerged by agreeing that the forecast should not be influenced by data that was too old and already far away from the present. This was actually data starting in 2017 through 2021, by the quarters when the testing period of the planning system was started. The data in 2022 and 2023 were collected sequentially and compared with the calculated forecasts for each type of assortment.

Forecast calculation for BM

The following case study shows the calculation of the forecast of one of the most important assortments in terms of sales volume. This is Brickmaking Magnesite (BM), which has annual sales of 50,000-60,000 kilotons (kt) and for this reason it is exemplary and, as well as, it is the best appropriated to describe the principle of the system's function. Its real sales and forecast are shown in Table 1.

Let the AS value be set by an expert at 11.00% for this assortment. This is the result of the difference of the expected increase compared to the current status. Calculation of the forecast using the ARIMA method indicated the best model was ARIMA (1,1,0). (See Table 1, FARIMA Column). The LR coefficients are: s = 13,010, b = 92.1.

Table 1
Brick Magnesite Sales with Sales Forecast for 2022-2023

t	Year	Quarters	Sale in kt	INC/DEC	Yearly sale in kt	F_{ARIMA}	F_{LR}	FAS
1	2017	I.	15802					
2		II.	13620					
3		III.	8971					
4		IV.	14895		53288			
5	2018	I.	10981					
6		II.	14874					
7		III.	13135					
8		IV.	13132		52122			
9	2019	I.	12791					
10		II.	12841					
11		III.	13582	↑				
12		IV.	14598	↑	53812			
13	2020	I.	15440	↑				
14		II.	19730	↑				
15		III.	14755	↓				
16		IV.	15595	↑	65520			
17	2021	I.	14500	↓				
18		II.	15645	↑				
19		III.	11330	↓				
20		IV.	13320	↑	54795			
21	2022	I.				11854	14132	14422
22		II.				12560	14185	14844
23		III.				11901	14238	14507
24		IV.				12100	14292	14648
25	2023	I.				11760	14345	14488
26		II.				11759	14398	14517
27		III.				11544	14452	14428
28		IV.				11464	14505	14413

The correction that was added to the linear model is the result of the following calculation using Markov chains. The initial state of the Markov chain is based on the fact that out of the last ten values, 7 are increasing (70%) and three are decreasing (30%), that is:

$$STATE_0 = (0.7 \quad 0.3).$$

The Transition matrix values are as follows: Increasing values changed to decreasing values in three cases out of ten ($INCchangeDEC$ = 0.3). None a single decreasing value out of ten remained decreasing, but changed to increasing ($DECstayDEC$= 0.0). Thus, TM will be:

$$TR = \begin{pmatrix} 0.7 & 0.3 \\ 1 & 0 \end{pmatrix},$$

then:

$$(p_{INC} \quad p_{DEC}) = STATE_0 \times TM = (0.7 \quad 0.3) \times \begin{pmatrix} 0.7 & 0.3 \\ 1 & 0 \end{pmatrix} = (0.79 \quad 0.21).$$

The correction for the linear trend will be:

$$Corr = |p_{INC} - p_{DEC}| = |0.79 - 0.21| = 0.58.$$

The equation of the trend line for forecasting using linear regression thus takes the following form:

$$F_{LR} = 13010 + 53.42t$$

(See Table 1, FLR Column). Finally the Forecast of Assortment (BM) Sale is calculated (See Table 1, FAS Column). The graphical diagram of FARIMA, FLR and FAS is shown in Figure 4.

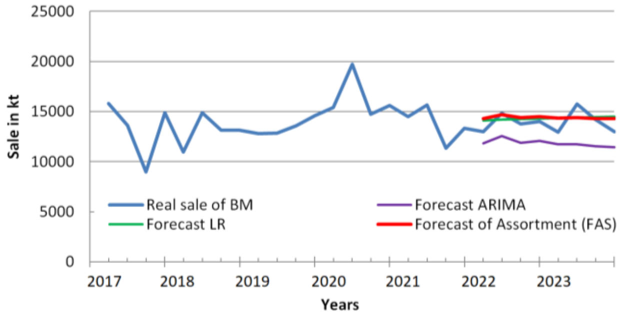

Fig. 4 Sale and Forecast of sale of Brickmaking Magnesite

Comparing actual sales data with forecast data is very important to evaluate the accuracy of forecasting models and improve future forecasts [32]. In order to evaluate the forecast, the data of the actual sales of brick magnesite were collected and then compared with the forecast values (Table 2). Forecast accuracy was evaluated by MAPE, RMSE, MAE and Theil (U) indicators [33].

Table 2
Real sale and forecast comparison

t	Year	Quartals	Sale in kt	FAS_{BM}
21	2022	I.	12985	14422
22		II.	14832	14844
23		III.	13758	14507
24		IV.	14012	14648
25	2023	I.	12941	14488
26		II.	15776	14517
27		III.	14224	14428
28		IV.	12998	14413

The calculated forecasts are then compared with the actual sales values during the two years 2022-2023, i.e. eight quarters. The evaluated forecasting errors are shown in Table 3.

Table 3
Forecast errors in sale of BM

MAPE	RMSE	MAE	Theil (U)
6.67%	1063.74	907.29	0.037

The calculated values of error indicators correspond to a very satisfactory forecast for the sale of BM during the two-year test operation. The following indicators of forecasting errors refer to the rest of the assortment (Table 4-8).

Table 4
Forecast errors in sale of SM

MAPE	RMSE	MAE	Theil (U)
8.53	940.63	785.14	0.052

Table 5
Forecast errors in sale of AMRM

MAPE	RMSE	MAE	Theil (U)
12.49%	2487.24	2153.42	0.065

Table 6
Forecast errors in sale of SMix

MAPE	RMSE	MAE	Theil (U)
18.08%	838.67	803.85	0.085

Table 7
Forecast errors in sale of CM

MAPE	RMSE	MAE	Theil (U)
12.91%	454.67	388.40	0.075

Table 8
Forecast errors in sale of RM

MAPE	RMSE	MAE	Theil (U)
11.81%	2645.00	2169.83	0.064

DISCUSSION

The calculation of the forecast was carried out on six products with the accuracies shown in Table 3-8. The forecast was compared with the actual values achieved per quarter in 2022-2023.

– The most accurate forecast for the mentioned period was for Brick Magnesite. This is due to the relatively stable sales during the period and, at the same time, the large sales volume (above 10,000 kt in a long term). According to expert expectations, this is one of the two product ranges on offer where sales are expected to increase in future periods (preliminarily in 2024 and 2025).
– In the case of Steel Magnesite, a reasonably accurate forecast can also be claimed. However, sales have been declining over the long term and are expected to fluctuate between 5,000-7,000 kt during the years 2024-2025.
– The third AMRM also has a large sale volumes compared to the rest, but the sales momentum is greater, which is reflected in the accuracy (MAPE exceeds 10%). Since the first quarter in 2017, sales have almost halved in the fourth quarter of 2021. The downward trend is expected to continue and is the largest among all assortments (up 12% year-on-year), as it is expected by experts. Despite these facts, the forecast is considered satisfactory.
– Sales volumes of the Slagging Mixtures are the most volatile of all the assortments. In the last quarter of 2021, sales volumes above 5,000 kt were not expected at all. This ultimately affected the forecast calculation and the accuracy is the lowest of all the assortments in this range. However, the accuracy values indicate that this is still an acceptable forecast. The year-on-year decrease is at 7%.
– The largest decline in sales over the five-year period is recorded for the Caustic Magnesite. Its sales fell from 12,000 kt to around 3,000 kt, a drop of approximately 75 %. Over the next two to three years, its sales are expected to oscillate around 3,000 kt. The expert expectation is for only a very slight decline (not more than 2%).
– The last mentioned type of assortment – Raw Magnesite can also be considered as a high-volume, it currently achieves the highest sales volumes compared to the rest assortment. Although sales are oscillating at 20,000 kt with an amplitude of several thousand kt, the accuracy of the forecast is surprisingly favourable. Even a year-on-year sales increase of 10% is expected.

If all the forecast results on a grade-by-grade basis are sum-up, the total forecast (TF) of magnesite sale is resulted. This should be reflected to the plan of magnesite production or extraction. The following table (Table 9, Fig. 5) shows the annual sales of magnesite assortments in the company described and the TF for 2022 and 2023 calculated according to Eg. 8.

Table 9
Annual overview of sales of major product assortment (in kt)

Year	BM	SM	AMRM	SMix	CM	RM	Total Sale	TF
2017	53288	85509	108910	27784	43421	80681	**399593**	N/A
2018	52122	55213	118708	22799	38087	88240	**375169**	N/A
2019	53812	62908	86064	22176	14747	84139	**323846**	N/A
2020	65520	61851	70870	13870	11924	77523	**301558**	N/A
2021	54795	37330	68335	15115	11565	74990	**262130**	N/A
2022	55587	38027	73810	18303	12815	77677	**276219**	**301385**
2023	55939	34728	70723	17906	12114	80106	**271516**	**282978**

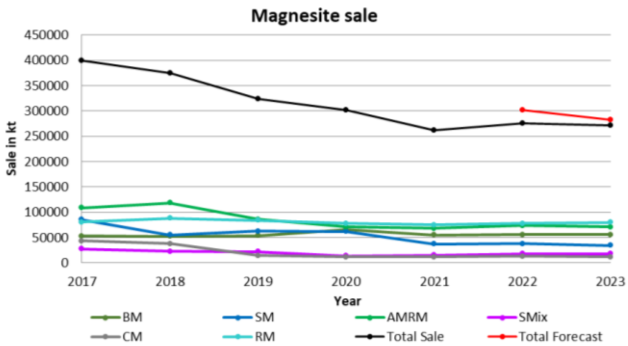

Fig. 5 Overview of the sales of each major product assortment and total sale (with forecast)

CONCLUSION

The mining and sale of magnesite in Slovakia has a long history and is the key to the local economy. Despite challenges related to environmental issues and market fluctuations, Slovakia remains a significant player in the global magnesite market. Innovations in technology and logistics, as well as sustainable practices in mining and processing, can help maintain competitiveness and reduce environmental impact. Magnesite is important for a variety of industrial applications, including the production of refractories, the chemical industry and agriculture. Most of the production is exported abroad, which is why magnesite exports are very important for Slovakia. This is also recognised by the company for which this data processing and forecasting elaboration was carried out.

As far as the proposed system is concerned, its use brings several advantages, but of course, like any forecasting system, it also has some limitations. The following advantages could be mentioned:

- More accurate planning in mining production – as the first visual results shows streamlining of the production process, thus minimizing storage costs and inefficient production capacities.
- Increased competitiveness – the ability to react faster to market changes which enables better customer satisfaction, especially in this segment of market.
- Reduced financial risks – more accurate forecasts and plans allow better management of cash flow and investment in production or distribution.
- The following could be summarised as limitations:
- Uncertainty and market volatility – predictions may be inaccurate due to unexpected economic fluctuations, geopolitical events or natural disasters. It is upon other discussion to set up forecasting period(s) for this proposal.
- Changes in customer behaviour – the magnesite market may be affected by new technologies, alternative materials or legislative regulations, which may reduce the accuracy of forecasts.

The future of magnesite consumption is closely linked to global trends in various industries, technological advances and environmental regulations. Forecasts suggest that demand for magnesite will grow globally, but the rate of growth will be influenced by a number of factors:

- Industrial Applications: Magnesite is the key ingredient in the production of refractory bricks and materials that are essential in the metallurgy, cement and glass industries. With the increasing production of steel and other metals, especially in Asia, the demand for refractories is expected to increase. Also, in the chemical industry, the consumption of magnesite is expected to increase because the use of magnesite in the chemical industry for the production of magnesium oxide and other chemicals is expected to grow with the development of the pharmaceutical and chemical industries.
- Environmental and regulatory factors are factors that, in turn, are pushing for production reductions due to stricter environmental regulations, efforts to reduce the environmental impact of industrial activities, and increased recycling of refractories. Therefore, innovative and environmentally friendly methods of mining and processing magnesite are required, which, although they increase costs, on the other hand, encourage the development of new technologies.
- Global economic trends: growth in the world economy, particularly in emerging countries, will support demand for industrial materials, including magnesite [34]. International trade agreements and tariffs may affect the flow of magnesite in global markets and hence its consumption. In the Europe and North America market segment, demand is expected to be stable, driven by industrial renewal and investment in sustainable technologies. In Asia, particularly China and India, which will continue to be the dominant consumers of magnesite, demand is expected to grow due to their large production capacity and developing industries. Other emerging economies in Africa and in South or Latin America may also experience increased demand for magnesite, albeit on a modest rate.

Slovakia can increase the added value from magnesite by focusing on the production of more sophisticated products and applications in new industries. With the development of new markets, especially in Asia and Africa, Slovakia can expand its export markets. International cooperation and partnerships can also bring new technologies and investments in magnesite mining and processing. However, all of the above is strongly dependent on political stability and the willingness of the government to promote favourable legislation and investment in the development of the mining industry in Slovakia.

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