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THE POTENTIAL SOURCES OF CRITICAL RAW MATERIALS IN SLOVAKIA

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ABSTRACT – Critical raw materials according to the fifth list of European Union from 2023, contain 34 raw materials [1]. This brief review will be focused on critical raw materials registered in Slovakia as reserved deposits or localities which show an economical potential. SGIDS has solved several projects aimed at verifying the potential of CRM in our territory. The solution resulted in the implementation of two technologically focused projects, to verify the source raw materials for the production of magnesium metal (dolomites, magnesites were tested) and silicon metal (vein quartz, quartzites were tested). The presence of a potential producer was one of the reasons for solving these projects. The suitability of the source raw materials was confirmed on several deposit objects of both types of source raw materials.

Keywords: Critical Raw Materials For EU Countries, Magnesium Metal, Potential Of Raw Materials.

INTRODUCTION

The situation regarding the availability of raw materials led to the development of the Regulation (EU) 2024/1252 of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials. The new regulation sets out a series of comprehensive measures to ensure the European Union's access to secure, diversified, affordable and sustainable supplies of critical raw materials. This is essential for Europe's competitiveness, including in green and digital industries, as well as defence and aerospace, according to a European Commission report. The EU should have the capacity to extract 10%, process 40% and recycle 25% of its annual consumption of strategic raw materials within the EU by 2030, according to the agreed benchmarks.

The objectives of the regulation should also be achieved through specific Strategic projects and National Exploration Programmes, which should be developed by individual EU countries. Slovakia is currently completing National Exploration Programme based on knowledge of the metallogenetic development of the territory, focusing on potentially significant sources of selected CRM. Information on the availability of the CRM, which are essential for industrial production in the Slovak Republic, but also in the EU countries in general, has recently been processed in several geological synthesis works [2,3,4]. This

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paper presents the summary results of geological research made by the State Geological Institute of Dionýz Štúr in the field of CRM in recent years.

THE POTENTIAL OF CRM IN SLOVAKIA

Mineral resources that have registered economic reserves have the potential for extraction and processing in Slovakia [5] – Table 1, Figure 1. Raw materials such as tungsten (molybdenum) ores (Ochtiná I deposit - calculation of new reserves in 2016), barite (mined till 2019) and feldspar (mined sporadically) have registered economic reserves. Our anthracite reserves are maintained as economic, but use these reserves for the production of coke is not possible.

Table 1 The deposits and occurrences of the CRM in Slovakia, status as of 1.1.2024, complied and supplemented according Bačo et al. [2]

Stages of CRM exploration in Slovakia				Inclusion in the CRM	metal/mineral/raw material	Mineralogical occurrence	Deposit occurrence	Deposit/reserves			Resources	
								small	medium	large	P2	P1
Study on KNS	Realized exploration of deposits (ED)	Resources	Reserves (according to BZVL SR)	2010	**Magnesium metal**							
				2014	**Silicon metal**							
				2010	**Antimony**							
				2020	**Tungsten**							
				2017	**Baryte**							
				2010	**Cobalt**							
				2010	**Natural graphite**							
				2014	**Borates***							
				2014	**Coking coal**							
				2010	**LREE****							
				2010	**HREE****							
				2020	**Bauxite**							
				2023	**Copper**							
				2023	**Feldspar**							
				2023	**Manganese**							
				2023	**Nickel**							
				2010	**Beryllium**							
	Realized ED			2010	**Niobium**							
				2010	**Tantalum**							
				2020	**Lithium**							
				2010	**Indium**							
				2010	**Gallium**							
				2010	**Germanium**							
				2017	**Bismuth**							
				2020	**Titanium**							
				2017	**Hafnium**							
				2014	**Phosphate rock**							
				2023	**Arsenic**							
				2017	**Phosphorus**							
				2010	**Fluorspar**							
				2017	**Vanadium**							
				2010	**Platinum group metals*****							
				2010	**Scandium**							
				2020	**Strontium**							

Legend:

Inclusion in the CRM list : **Antimony - 2010**; **Silicon metal - 2014**; **Baryte - 2017**; **Bauxite - 2020; Manganese - 2023**

exploration of deposits for the specific raw material (e.g. Sb, W, ..)

exploration of deposits for source raw material (e.g. Dolomite-Mg), or as a by-product source (e.g. base metal deposits - In, Ge, Ga)

metal obtained during bauxite processing in Al processing plant of Žiar nad Hronom

metal refined from secondary raw materials - recycling of Ge-containing products - Žarnovica

BZVL SR - Register of Reserves of Reserved Deposits of the SR

Resources P1 and P2 - prognostic resources according Slovak legislative

Note:

REE - light REE (LREE): Ce, La, Nd, Pr, Sm + Sc

- heavy REE (HREE): Dy, Er, Eu, Gd, Ho, Lu, Tb, Tm, Yb, Y

PGM - Ir, Pd, Pt, Rh, Ru

However, source raw materials for the production of magnesium metal (Mg) and silicon metal (Si) – (Table 1) have the greatest potential in Slovakia. The source raw materials for Mg (magnesite and dolomite) are mined in large volume for the production of other materials. Their reserves (mainly dolomite, but also magnesite) are large enough to be used for the production of Mg without limiting their current use in the economy.

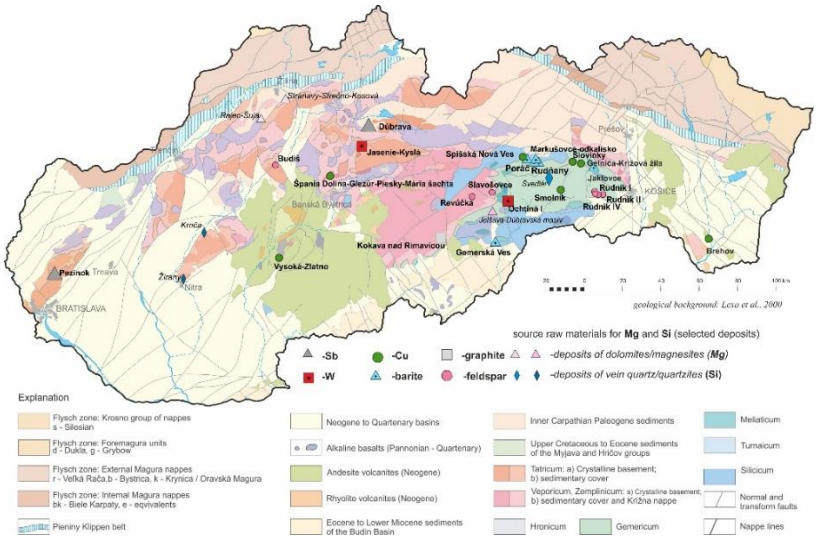

Figure 1 Deposits of CRM registered in Register of reserved deposits in Slovakia as of 1.1.2025.

Magnesium or silicon metal are from the CRM group, closest to real production in Slovakia. The reason is a real producer with a metallurgical operation for the production of ferroalloys (OFZ a.s., joint-stock company), which produced metallurgical silicon and had a real interest in participating in the production of magnesium. However, the real obstacle at the moment is the price of electricity, which is decisive in this case. We have sufficient reserves of source raw materials for the production of both Mg and Si.

Slovakia has relatively large reserves of antimony (Sb) and copper (Cu) ores. Antimony is a metal that was mined separately in several deposits in the past. The total remaining reserves in individual deposits are approximately 55,358 t Sb. Copper is another metal whose ores were mined in many deposits in the past and their mining and subsequent production of copper represented a significant part of its European production (18th and 19th centuries). In Slovakia, we record the remaining reserves of copper ores of approximately 316,429 t Cu. For now, they are registered as not economic, i.e., not economically exploitable. In the case of deposits of these ores, it would be appropriate to carry out economic feasibility studies (e.g., preliminary economic assessment). The potential miner himself will certainly prepare a feasibility study, which will be more time-consuming.

Until 2019, we covered the consumption of barite with our own mining. We register approximately 9 million tons of barite in deposits that are not mined yet. Manganese was

mined in the 19th and 20th centuries, the residual non-balance reserves in three deposits are 24,779 kt of ore with a low Mn content (9-17%). For Slovakia, polymetallic nodules from the ocean floor may become an unconventional source of Mn. Slovakia participates in the research activities of Interoceanmetal (IOM) in the Pacific Ocean - in the Clarion-Clipperton tectonic zone.

For other CRM for which we register (As, graphite) or we registered (Ni, Co, tourmaline, bauxite, or others - Table 1) reserves, the potential will become clear during additional deposit exploration work, which, however, means a longer period of time (certainly over 5 – 10 years, exceptionally less).

The assessment of CRM potential resulted in the selection of two projects, where we solved technological research of source raw materials for the production of Mg and Si. We briefly present the results of our research in case of magnesium metal.

SOURCES OF RAW MATERIALS FOR Mg IN THE SLOVAKIA

The main sources of raw materials for the production of magnesium metal in the world are dolomites and magnesite, other sources are oceans, seawater and terrestrial salt lakes, which contain some salts rich in magnesium. The Slovak Republic has significant reserves of both dolomite and magnesite raw materials. We have 25 registered dolomite deposits with total reserves of 879,808 kt of raw materials and 10 magnesite deposits with reserves of 1,127,856 kt of raw materials. The dolomite in Slovakia occurs in several Middle and Upper Triassic formations up to several 100 meters, or forming intercalaction, interbeds and lenses in beds irregulary alternating with the surrounding limestones. They are present in numerous geological units, their cover sequences and tectonic nappes. The most significant are the Middle- and Upper- Triassic dolomites of Hronicum unit, bearing the important dolomite deposits in the Choč nappe of the Strážovská hornatina Highlands [6].

TECHNOLOGICAL RESEARCH OF SOURCE RAW MATERIALS

The geological-technological characteristics of dolomite deposits in Slovakia with suitable technological types for use in the production of Mg include specific conditions for the utilization of reserves for this purpose and also verification of homogeneity-technological stability in the entire volume of raw material in the deposit. [7].

The technological investigation, aiming to prepare the calcined products, appropriate for the silicothermic production was done applying dolomite samples. The prepared calcined products of dolomite samples from the several deposits: Trebejov, Dolný Lopašov, Trstín, Mníchova Lehota, Malé Kršteňany, Hubina and Rajec Šuja meet the required criteria. Concerning the required parameters, the CO_2 content varied within the range of 0.18% to 0.29%, content of further oxides (except CaO and MgO) was 0.81 to 2.23% and the ratio CaO:MgO was within the range 1.37:1 to 1.43:1 and thus met the required parameters [8]. The estimate of the sources of input raw materials (calcinated product) for the production of magnesium by the silicothermic method was made on the basis of the results achieved in the treatment of dolomites from specific deposits. Based on the laboratory-verified suitability of the prepared calcinated product and on the basis

of experimental production of magnesium metal by the silicothermic method, an estimate of the sources of magnesium metal was made. With the estimated sources of dolomitic lime (164,023 kt) in the investigated deposits, according to the average recovery rate (77%) of the considered production method (Pidgeon method), approximately 31,270 kt of Mg metal can be potentially obtained [7]. From the final calcinated product of the sample from the Malé Kršteňany deposit, implemented into batch with ferrosilicon and calcium fluoride, the magnesium metal was produced with silicothermic method in laboratory condition. The detail study, applying the microprobe, has revealed the shrub shape of crystal intergrowths, the presence of lure magnesium metal in the central part and partly oxidic form of marginal, mainly apical parts (Fig. 2). The purity of the product was verified by microprobe up to 96% Mg.

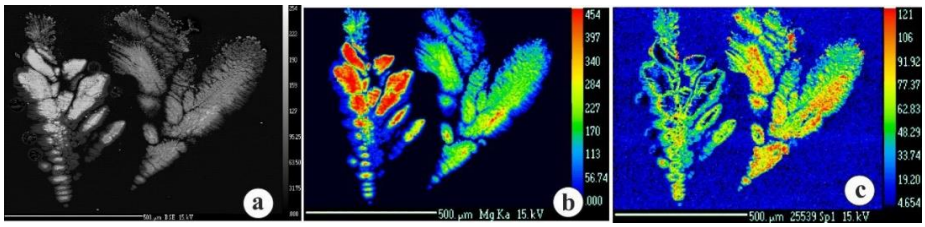

Figure 2 Habit of individual crystals of magnesium metal and their intergrowth (a - especially visible on BSE). Mg distribution map (b) and O distribution map (c). Photo: BSE images and distribution maps Konečný P.

This verified the suitability of the prepared intermediate product from a specific deposit in practice. Theoretically usable quantities of magnesium metal obtained from dolomite deposits indicate the possible multiple valorizations of this raw material [7]. The most significant potential source raw material for the production of Mg in Slovakia are dolomites. Currently known dolomite reserves in individual deposits are sufficient for this use. Dolomite is more suitable for the production of Mg, considering the possibilities of industrial applications of the source raw materials and the reserves and resources. The method of producing Mg from dolomite is more efficient with regard to economic (energy) and especially environmental aspects. The current price of 1 t of Mg is around 2,300 USD/t. According to some economic calculations, the profitable price should fluctuate around 2,500 to 3,000 USD per ton. The technological research of dolomite deposits in the vicinity of a potential producer of magnesium metal (OFZ a.s.) is underway. An important input in the Mg production process is ferrosilicon, which also represents the most financially and energetically demanding commodity. OFZ a.s. is direct producer of ferrosilicon, for the silicothermic process of Mg production it is necessary to provide calcinate, which does not represent high input financial costs.

CONCLUSION

The number of CRMs is constantly increasing, which means that their provision for the needs of the EU economy remains essential. An assessment of the potential of the Slovak Republic from the perspective of CRMs for the EU [1] pointed out the possibilities

of using domestic raw materials. The potential of ore minerals in terms of possible rapid/immediate use is currently not realistic at present. The reason is mainly that – with the exception of one (precious metals – Banská Hodruša) – all deposits are closed. However, the potential is already quite interesting considering the reserves in registered ore deposits. The issue of critical minerals puts the deposits of Sb, Cu, W and Co metals, into the foreground, where we record reserves in our territory. Among the important raw materials of Slovakia, we can consider source raw materials for metal production, dolomites, magnesite (Mg) and quartz raw materials (Si). Such use represents a possible high valuation of these raw materials. For future final production, it is crucial to know its potential producer and to ensure the most comprehensive verification of the currently existing source raw material deposit in the given immediate environment in sufficient time in advance.

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REFERENCES

1. European Commission (2023) Study on the critical raw materials for the EU 2023 – Final report, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Grohol, M., Veeh, C., Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2873/725585
2. Bačo, P., Kollová (Bačová), Z., Németh, Z. (2018) Critical Raw Materials for the EU countries - potential in the Slovak republic, SGIDS, Bratislava, 39 p.
3. Gonda, S., Dzurenda, Š., Fajtová, D., Gluch, G., Miháľ, I., Mikušová, J., Pijaková, R., Pramuka, S., Radvanec, M., Stašík, Ľ. (2018) Surovinový potenciál Slovenskej republiky - analýza a prognózne prehodnotenie kritických nerastných surovín, (Raw material potential of the Slovak Republic – analysis and prognostic reassessment of critical raw materials) Final report. Manuscript. Bratislava, Archive SGIDŠ, 275 p. (In Slovak).
4. Kollová, Z., Bačo, P., Danková, Z., Čechovská, K., Fedorová, E., Bekényiová, A., Németh, Z., Kollárová, V., Mikušová, J., Gonda, S., Stašík, Ľ., Pijaková, R. (2023) Domáce zdroje surovín pre odvetvia obnoviteľnej energie a elektromobility, (Domestic sources of raw materials for the renewable energy and electromobility sectors) Final report. Manuscript. Bratislava, Archive SGIDŠ, 275 p. (In Slovak).
5. Šoltés, S., Kúšik, D., Mižák, J., Kubač, A. (2024) Nerastné suroviny SR 2023, ŠGÚDŠ, (Slovak Mineral Yearbook), ŠGÚDŠ, Bratislava, 220 p.
6. Zuberec, J., Tréger, M., Lexa, J., Baláž, P., (2005) Nerastné suroviny Slovenska, ŠGÚDŠ Bratislava, (Mineral resources of Slovakia), 350 p.
7. Bačo, P., Tuček, Ľ., Németh, Z., Kollová (Bačová), Z., Repčiak, M., Čechovská, K., Kovaničová, Ľ., Košuth, M., Marčeková, M. 2016: Potenciálne zdroje surovín na výrobu kovového horčíka, (Potential sources of source raw materials for Magnesium metal production) Final report, ŠGÚDŠ, archív Geofond, Bratislava, 117 p. (In Slovak)
8. Tomášek, K., Rabatín, R., Špeťuch, V., Šeševička, O., Urban, Ľ. & Siták, R., 1997: Spôsob využitia magnezitových surovín na výrobu horčíka. Úrad priemyselného vlastníctva SR, zverejnené 09.07.1997, C 22B 26/22; 5 p.