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Magnesite resources and prospects for the development of new applications of magnesite raw materials in the light of energy transition and strategic needs of the EU raw materials economy

Introduction

Magnesite – a mineral of natural origin with a chemical composition of $MgCO_3$, occurs in deposits in two forms: crystalline or/and/or cryptocrystalline. Crystalline magnesite is mainly used to produce magnesite (magnesia) dead-burned (at 1,450–2,000°C) or fused (melting at a temperature close to 3,000°C). Both crystalline and crypto-crystalline varieties

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of natural magnesite are used for the production of calcined magnesite (magnesia) (calcination at a temperature of 800–1,000°C), used mainly in construction, the glass industry, and ceramics. Other magnesium compounds are also produced from magnesite calcined, used, among others, in the pharmacy, paper, chemical, plastics, etc. Magnesite raw materials (magnesia), dead-burned and fused, have so far been practically entirely intended for the production of alkaline refractory products used in iron and steel metallurgy, non-ferrous metals, the refractory materials industry, and others. Magnesite and magnesium oxides are also used for water and gas purification, in feed additives and fertilizers, in the production of building materials, fire-resistant boards, and in many other products. The second source of obtaining magnesites (magnesia) calcined, dead-burned, and fused, is seawaters and various types of surface and underground magnesium brines. For example, in the USA, most magnesite raw materials (magnesium oxides: magnesites and magnesia calcined, dead-burned and fused, magnesium hydroxides, magnesium chlorides and sulfates) are produced from seawater and natural brines. About 75% of magnesium compounds are used in industries (in order of decreasing application size): environmental protection, chemical industry, agriculture, construction, paper, pharmaceutical, food, and other industries (Galos 2014; Sroga 2020; Magnesium-compounds 2024; Szuflicki et al. 2025).

1. The global economy of magnesite raw materials and their resources

1.1. The production of crude magnesite

The world's reserves of crude (natural) magnesite, the main raw material for the production of magnesite raw materials, are estimated at 8–9 billion tons (Mineral commodity 2025), although their exact amount is difficult to determine. The lack of access to verified data from countries such as China, Russia, and North Korea causes divergent assessments of the size of the world's resources. Some sources even give resources of 13–15 billion tons (Kay 2018; Szuflicki et al. 2025). Regardless of the assessments, the sufficiency of the world's magnesite reserves seems to be unlimited, all the more so as the extraction of magnesite raw materials from seawater and brines is becoming increasingly important. Most of the world's deposits are formed by crystalline magnesites, formed as a result of hydrothermal-metasomatic processes in dolomite and limestone formations, as well as sedimentation processes in lagoons and shallow seas. Deposits of crypto-crystalline magnesites, formed in serpentinites as a result of hydrothermal transformations, weathering, and infiltration of serpentinite massifs, are of lesser importance. The main resources of magnesite deposits are concentrated in Russia (approx. 30%), Slovakia, China, Australia and Greece, as well as in Brazil (Mineral commodity 2011, 2020, 2025) The most important mining producers of magnesite are China (approx. 60% of world production) and Türkiye, Brazil, Russia, Australia, Austria, Spain, Slovakia, and Greece. Global magnesite extraction in recent years has fluctuated between 25–26 million tons per year (Table 1) (Mineral commodity 2011, 2020, 2025; Kay 2018) and is largely dependent on the economic situation in iron and steel metallurgy (Galos 2014). Magnesite mining takes place mainly in open-pit mines (Kicki and Kozioł 2000).

Table 1. Main producers of magnesite and their reserves (mln tons) (Mineral commodity 2011, 2020, 2025; Kay 2018; 10 Top 2024; USGS 2025)

Tabela 1. Główni producenci magnezytu i ich zasoby (mln ton)

Lp.	Country	Mining production per year			Resources
		2010	2020	2024	
1.	China	14.0	18.0	13.0	680.0
2.	Russia	2.2	1.5	2.5	2,300.0
3.	Brazil	1.5	1.5	1.8	200.0
4.	Türkiye	2.3	1.1	1.3	110.0
5.	Austria	0.76	0.76	0.76	49.0
6.	Spain	0.50	0.60	0.67	35.0
7.	Australia	0.27	0.31	0.49	280.0
8.	Greece	0.40	0.50	0.39	280.0
9.	Slovakia	0.80	0.46	0.38	1,200.0
10.	Iran	0.13	NA	0.21	10.0
11.	India	0.345	0.21	0.16	66.0
12.	World	24.9	22.0	22.0	7,700.0

In the EU, large reserves of natural magnesite are located in Slovakia in the Dubrava massif in the Košice region. Some sources give their resources at about 3.4 billion Mg (Csikósová et al. 2013), although other data specify resources at 1.2 billion Mg (Table 1) (Mineral commodity 2011, 2020, 2025). The exploitation of magnesite and the production of magnesite products are carried out by the Magnesite Plant in Jelśava (Jelśava 2025). These plants are one of the leading manufacturers of magnesite products in Europe, including mainly magnesia, refractory products, and natural magnesite. These products are delivered to many countries, and the largest recipients are: Ukraine, Germany, the Czech Republic, Poland, and Austria. Magnesite is exploited in an underground mine using pillar-chamber systems (Jelśava 2025). One of the most important countries in Europe in terms of extraction and production of high-quality magnesites is Greece (Table 1, Table 2).

Table 2. Quality specification of selected producers of calcined and dead-burned magnesites (Csikósová et al. 2013, supplemented by the authors)

Tabela 2. Specyfikacja jakościowa wybranych producentów magnezytów kalcynowanych i prażonych

Country	MgO (%)	SiO_2 (%)	CaO (%)	Fe_2O_3 (%)	Al_2O_3 (%)	Density (g/cm^3)
Calcined magnesites						
Canada	96.3	0.4	2.7	0.5	0.1	3.35[1)]
Slovakia	85.0	1.0	2.5	7.0	0.0	NA
Spain	85.0	3.6	7.0	2.5	0.4	NA
USA (brines)	97.0	0.5	1.0	0.3	0.2	NA
USA (seawater)	97.2	0.4	0.9	0.24	0.28	NA
Poland[1)]	7485	5–6	3.2–3.6	up to 1.0	0.5–1.0	3.0–3.2
Dead-burned magnesites						
Australia	97.0	0.5	2.3	0.1	NA	3.42
Brazil	94.9–98.4	0.25–1.29	0.43–0.77	0.41–2.11	0.05–0.35	3.07–3.34
China (DBM 95)	95.4	2.2	1.6	1.0	1.0	3.2
Greece	85–96	1.1–9.0	1.5–3.5	0.15–0.7	0.1 – 0.4	3.15–3.4
Italy	97.3	0.5	2.1	0.1	0.15	3.46
Japan	98.1	0.36	1.3	0.05	0.06	3.48
Netherlands	98.5	0.12	0.74	0.44	0.07	3.4
Serbia and Montenegro	85–96	1.0–5.0	2.0–5.5	0.6–3.5	0.3–1.3	3.51–3.55
Slovakia	87–90	0.7–3.5	2.0–2.5	4.7–7.5	0.3–0.8	3.2–3.35
Türkiye	89–97	0.6–6.0	1.7–3.0	0.4–1.2	0.1–0.2	3.3–3.45
USA	97.9–98.4	0.25–0.85	0.85–1.05	0.14–0.2	0.12–0.19	3.15–3.38

NA – not applicable.
[1)] supplemented by the authors.

The main subject of international trade is roasted magnesite, and the main suppliers are China, Türkiye, and Brazil, and, to a lesser extent, Austria, Australia, Spain, Slovakia, and Greece. Processed magnesites are also internationally traded, especially by China, Australia, and Canada. Trade in calcined magnesites is important mainly in regional exchange, while crude magnesites are exchanged on a very small scale (including imports by Poland).

1.2. Potassium-magnesium salts

For calcined, dead-burned, and fused magnesia, produced from natural magnesites, the competition is suitable species of synthetic magnesia (MgO) of better quality, and obtained mainly from brines and seawater. Potassium salts and potassium-magnesium salts (chloride and sulfate, rarer but more valued) are the main source of potassium and its compounds, to a lesser extent, magnesium (magnesium chloride $MgCl_2$). They are obtained in about 88% from deposits of natural chloride and sulphate salts, and in 12% from deposits of potassium nitrate, KNO_3, and brines of salt lakes and mineralized waters (Kamyk 2014; Durkowski and Wojciechowski 2024). These salts are mainly used in the form of mixed fertilizers, almost exclusively in agriculture (95%). Magnesium chloride (magnesium salt) in North America is mainly produced from brine from the Great North Lake. In a similar process, magnesium chloride is extracted from the sea in the Jordan Valley. As a natural bischophyte mineral, magnesium salt is also mined in Western Europe from ancient seabeds. Part of magnesium chloride is produced from the evaporation of seawater by the sun. Magnesium metal is produced on a large scale from anhydrous magnesium chloride. However, the production process is highly energy-intensive.

Global reserves of potassium-magnesium salts are estimated at about 3.7 billion Mg K_2O, and their extraction in 2015 amounted to 38.8 million tons K_2O. The largest resources are documented in Canada, Belarus, and Russia. Potassium chloride and magnesium salts (sylvin, carnalite) constitute the vast majority of the world's resources and are the main export commodity at prices about twice lower than potassium and magnesium sulfate salts (polyhalite, kiserite), as the occurrence and exploitation of sulfate-magnesium potassium-magnesium salts (SOPs) is rare, they are mined, among others, in the USA and the United Kingdom (Durkowski and Wojciechowski 2024). In the global production of magnesite raw materials, roasted magnesite raw materials are dominant, and the share of magnesite calcined raw materials is slightly over 10%, and the share of smelted raw materials is about 5% (Galos and Szlugaj 2000).

2. Resources, production and use of magnesite raw materials in Poland

2.1. The production of crude magnesite

In Poland, magnesite deposits are associated with the Precambrian serpentinite massifs: Szklary, Grochowa-Braszowice, and the Gogolów-Jordanów massif (Nieć 2000). So far, six magnesite deposits have been documented in the Dolnośląskie Voivodeship. These are deposits of vein-type magnesite, with a vein thickness of up to 3 meters, with a complex geological structure and variable quality. According to the Balance of Mineral Resources in Poland (Szuflicki et al. 2025), the geological resources of magnesite in 6 documented deposits were 16.44 million tons, including 14.25 million tons of anticipated economic resources and 2.18 million tons of uneconomic resources. A significant part of anticipated economic resources (4.1 million tons) is in the abandoned Wiry deposit near Sobótka, and almost half of the resources (5.92 million tons are in the initially identified Grochów, Wiry-Gogołów, Wiry-Tąpadła, and Szklary deposits. The resources in the exploited Braszowice deposit amount to – 4.2 million tons, of which approximately. 3.2 million tons are economic resources (Szuflicki et al. 2025). Prospective resources concentrated in the three serpentinite massifs of Gogołów-Jordanów, Szklary, and Grochów-Braszowice were estimated at 3.25 million tons (Sroga 2020). However, Poland is not a country rich in high-quality magnesite deposits. The best quality and relatively thick veins of magnesites in individual deposit massifs, including the Wiry deposit, have already been exploited in underground mines (Sroga 2020). Since 1997, the only exploited magnesite deposit in Poland is the Braszowice deposit in Grochów (Szewczyk 2013; Galos 2014; Stefanicka 2016; Szuflicki et al. 2025). Relatively low-quality magnesite-serpentinite ore is mined by the open-pit method. Between 2011 and 2019, the mine selectively extracted 75 to 102 thousand tons/year of crude magnesite. In the next 3 years, the production decreased to approximately. 66.0 thousand tons/year, most recently in 2023, only 28.6 thousand tons were extracted, and in 2024 production slightly increased to 44.7 thousand tons of magnesite. After processing, a concentrate with an MgO content of 43–45% is obtained from the extracted magnesite, produced in the form of ground (R-40) or crushed crude magnesite. The mine also uses exploited magnesite-serpentinite rocks, which are used to produce lower-quality types of ground magnesite (R-35 and R-30). The total production of R-40, R-35, and R-30 grades has been about 100 thousand tons/year in recent years. Occasionally, on a small scale for individual orders, the production of calcined magnesite with a content of 74–85% MgO is undertaken. Crushed (10–40, 10–80 mm) and ground (0–1, 0–2 mm) products of the mine are mainly used for artificial and natural compound fertilizers, for the production of various magnesium compounds, including magnesium sulfates $MgSO_4$, nitrates $MgNO_3$ and magnesium chlorides $MgCl_2$, as well as in water treatment processes, wastewater neutralization and as an additive to feed (Galos and Lewicka 2022). The variable, veined structure of the deposit, along with the growing requirements of the industry and the competitiveness of imported raw materials, caused the abandonment of the production of components for the metallurgical industry. A comparison of the quality of calcined and roasted magnesites from different countries is presented in Table 2 (Csikósová et al. 2013; Mineral commodity 2025). It shows that domestic calcined magnesite is characterized by a relatively low content of MgO (74–85%) and a high content of SiO_2 (5–6%) and CaO (3.2–3.6%). Currently, the entire domestic needs for dead-burned and fused magnesites (approx. 100 thousand tons/yr) and calcined magnesites (approx. 10 thousand tons/yr) are covered by imports mainly from China, Slovakia, Brazil, Greece, and Austria (Galos and Lewicka 2022; World Integrated 2025). Imports of crude magnesite in Poland, mainly from Slovakia and Serbia, have recently been at the level of 20–25 thousand tons. The estimated structure of magnesite and magnesium compound consumption in Poland is as follows (Galos and Lewicka 2022):

- crude magnesite: production of magnesium chemical compounds – over 50%, production of N-P-K-Mg compound fertilizers – over 40%, production of ceramic tiles, construction chemicals, etc. – less than 10%,
- magnesites and magnesia calcined, roasted and melted: production of alkaline refractories – over 90% (roasted, and melted varieties), production of magnesium chemical compounds – up to 10% (calcined varieties).

A large producer of magnesite products in Poland is the Ropczyce Magnesite Plant (Mokrzycki and Rżany 2000; Ropczyce 2025). They produce high-quality refractory materials – alkaline and aluminosilicate – on imported raw materials, for the domestic market and to a large extent for export, which are an indispensable element of the linings of furnaces and heating equipment operating at high temperatures. These products are mainly applicable to the steel industry, non-ferrous metals, cement-lime industry, glass metallurgy, foundry, coke industry, and other industries that use high-temperature processes.

2.2. Resource of potassium-magnesium and magnesium sulfate salts in Poland

In Polish, potassium-magnesium salts occur only within the Cechsztyn salt-bearing formation. Together with rock salt, they form two separate lithostratigraphic units – older and younger potassium salt, occurring in the area of the Polish Lowland. The predicted (prospective and prognostic) resources of Permian potassium-magnesium salts in Poland, estimated to a depth of 2 km in on-board outcrops, amount to nearly 3.64 billion tons (Sroga 2020, Szuflicki et al. 2025). The anticipated economic resources (without protective pillars) of the documented 5 deposits amount to over 686 million tons, and the sub-economic resources – nearly 19 million Mg, of which the majority (4) are deposits of sulphate-type salts (polyhalite), occurring in the area of the Bay of Puck (Szuflicki et al. 2025). Polyhalite occurs there as an early diagenetic mineral within anhydrites. The depth of occurrence of irregular nests and polyhalite overgrowths is 740–900 m, and the K_2O content ranges from 7.7% to 13.7%. These deposits, located on the edge of the Puck Bay rock salt deposit of the Puck Bay region, were initially documented in the years 1964–1971 in category C2 (anticipated economic resources of approx. 597 million tons) under the assumption of an even (on-board) distribution of polyhalite mineralization. Later studies showed that the process of polyhalite mineralization was more complex than previously thought, which should result in the need to re-estimate the mineral resources and the efficiency of mine construction and extraction (Szuflicki et al. 2025). Recently, there has been an increase in the interest of domestic and foreign companies in the possibility of developing domestic deposits and deposits of potassium-magnesium salts, especially polyhalite deposits in the Bay of Puck. Since 2015, KGHM Polska Miedź SA has been conducting geological exploration in the vicinity of this deposit. The studies made available so far show that the largest accumulation of polyhalite occurs within sulfate platforms, i.e., a predominance of sulfate-magnesium salts should be expected (Mizerska 2018). Such sulphate salts are not a direct substitute for magnesite in MgO production; however, they can be valorized as a feedstock for $MgSO_4$-rich brines used in chloride-free magnesium oxysulfate (MOS) binders and boards, increasingly adopted as noncombustible and moisture-tolerant alternatives to gypsum plasterboard in selected applications (Qi 2025; Zhou et al. 2025). Small amounts of potassium-magnesium salts (above 89 million Mg) have been identified in the Kłodawa salt done along its eastern boundary (within the Kłodawa 1 deposit documented in the central part), there are chloride-type salts (carnalite with a slight admixture of sylvite) and magnesium (kieserite) salts, accompanied by a significant amount of impurities (clayey substance, rock salt). The average content of K_2O is 8,5%, and MgO is 8,1%. The variable thickness of the seam (a few to 50 m) and the difficulties with mineral enrichment are the reasons for low economic interest. Small mining (as an accompanying mineral) was carried out periodically in the central part of the deposit – in 2000, 1.4 thousand tons were extracted – later, the extraction of potassium salts from this part of the deposit was discontinued. The extracted salt was used as an agricultural fertilizer and medicinal salt for balneological treatments. Mining conditions of mineral deposits and low quality limit the possibilities of their profitable use on a larger scale. Currently, there is no exploitation of potassium-magnesium salts in Poland. In the 80s of the last century, attempts were made to desalinate mine water from the former Dębieńsko coal mine with the possibility of recovering salt and iodine, bromine, and carnalite compounds (potassium and magnesium chlorides); unfortunately, this technology was abandoned in favor of Swedish-American membrane-thermal technology (Bobil and Labus 2014; Dubiński 2022). In waste anhydrite from mine water desalination in the former Dębieńsko mine, the content of MgO in the oxide composition is approximately. 2.5%, and SO_3 is over 30% (Kozioł et al. 2019). Magnesium and sulphur oxides are also contained in coal and ore waste stored in heaps.

3. New directions of application of magnesite raw materials

Among the new technologies for the use of magnesite and its raw materials, the storage of hydrogen in the form of magnesium hydride and the production of metallic magnesium should be particularly highlighted.

3.1. Storage of hydrogen in the form of MgH_2

Solid-phase hydrogen storage using metal hydrides is one of the most promising technologies for increasing the safety and efficiency of this energy carrier storage (Baran and Polański 2020; Xu et al. 2024; Gao 2025). Magnesium hydride (MgH_2) is distinguished by its high hydrogen weight capacity (7.6% H_2) and a favorable energy balance in the charge-discharge cycle MgH_2 remains stable under atmospheric conditions, and the release of hydrogen occurs only after the dehydrogenation temperature is reached, which increases the safety of operation (Baran and Polański 2020; Gao 2025). As a result, it is used in hydrogen power systems for special vehicles, agricultural machinery, drones, and compact emergency generators (Fasihi et al 2023). In Poland, taking into account magnesite and large dolomite resources, as well as serpentinite deposits, it is possible to develop a technological chain enabling the production of magnesium hydride in low-carbon processes, e.g., through aluminothermic reduction of MgO and subsequent synthesis of MgH_2 (Gao et al. 2025). Table 3 lists the main ways of storing hydrogen and their advantages and disadvantages. Among these technologies, magnesium hydride (MgH_2) is particularly noteworthy.

Table 3. Characteristics of hydrogen storage methods (Gao et al. 2025)

Tabela 3. Charakterystyka metod magazynowania wodoru

Method	Weight capacity (% H_2)	Operating temperature (°C)	Advantages	Disadvantages
Compressed hydrogen (350-700 bar)	4.5	–40 to 85	Technology availability, fast refuelling	High pressure, need for composite tanks
Liquefied hydrogen (LH_2)	7.1	–253	High energy density per volume	Low temperatures, high evaporation losses
Metal hydrides (MgH_2)	7.6	300–400	Safety, regeneration	High desorption temperature
Storage in porous materials (MOF)	5.0	–196 to 25	Lightweight, high-porosity structure	Costly synthesis and thermal stability
Chemical compounds (ammonia, methanol)	6.0	–20 to 100	Easy to transport and process	Complexity of chemical reactions, secondary emissions

3.1.1. Properties and safety of MgH_2 storage

MgH_2 is a solid material with a high mass density and low reactivity at ambient temperature, which significantly reduces the risk of explosion or rapid leakage compared to compressed or liquefied hydrogen. Thanks to its solid physical form, hydrogen is chemically bonded in it, which means that there is no need for heavy pressure vessels and complex cryogenic systems. Under normal weather conditions, MgH_2 is stable, and hydrogen is released only after the dehydrogenation temperature is reached, which further increases the level of operational safety. Compared to other hydride materials, MgH_2 exhibits some of the highest hydrogen storage parameters per unit mass, and its cyclic durability (reversibility of the process) can be significantly improved by catalytic additives and nanostructuring (Baran and Polański 2020).

3.1.2. Applications of MgH_2 in hydrogen-powered vehicles and machinery

Due to its beneficial physicochemical properties, MgH_2 is used in the construction of safe, lightweight, and compact hydrogen power systems, which is particularly important for (Gao et al. 2025):

- special vehicles (e.g., mining vehicles, warehouse vehicles, AGVs),
- agricultural and forestry machinery operating in off-road conditions, where the risk of impact or overheating is eliminated by the use of compressed gas,
- bicycles, motorcycles, and hydrogen scooters – as an alternative to lithium-ion batteries,
- drones and mobile robots – where both energy density and power reliability are important,
- compact emergency generators and power supply sets for distributed facilities (e.g., telecommunication masts, metering systems).

3.1.3. Process fundamentals and technology paths

To justify the above-described applications of MgH_2 in the process reality, the basics of manufacturing and technological limitations are given below. We start with a synthesis reaction from metallic magnesium and then show the $MgO \rightarrow Mg \rightarrow MgH_2$ pathway, other applications, and key process bottlenecks.

a) MgH_2 synthesis reaction from magnesium metallic (Gao et al. 2025).
   The synthesis of MgH_2 is most often carried out in a direct reaction between metallic magnesium and molecular hydrogen under high-pressure and temperature conditions:

$$Mg\ (s) + H_2\ (g) \rightarrow MgH_2\ (s)\ \Delta H = -75\ kJ/mol \quad (1)$$

   This process requires a temperature of 300–400°C and a pressure of 2–5 MPa to achieve a significant reaction rate. MgH_2 exhibits a tetragonal structure and forms a gray, crystalline mass that can be stable in weather conditions.

b) Possibility of using MgO as a raw material for the synthesis of MgH_2
   Since Poland has magnesite ($MgCO_3$) resources, it is possible to obtain magnesium hydride in a two-step process. Thermal decomposition of magnesite:

$$MgCO_3 \rightarrow MgO + CO_2\uparrow \quad (2)$$

Reduction of MgO to Mg – e.g. by aluminothermic method:

$$3MgO + 2Al \rightarrow 3Mg + Al_2O_3 \quad (3)$$

MgH_2 synthesis as above: However, this requires the development of an efficient process chain that will enable the production of magnesium metal in a low-carbon and economically viable manner.

c) MgH_2 applications

MgH_2 can be used in:
- stationary energy buffers in RES micro-installations,
- hybrid heating systems (simultaneous recovery of H_2 and heat of reaction),
- thermal insulation structures containing PCM-MgH_2 phase storage.

It is also possible to create hydride composites with additives (e.g., nanocatalysts Ti, Zr, graphene) to lower the desorption temperature and improve the reaction kinetics.

d) Limitations and prospects for development

The main barriers include:
- high dehydrogenation temperature (above 300°C),
- the need to protect the material from oxidation,
- difficulty in regeneration with a large number of cycles.

However, thanks to intensive research, including days in Germany, Japan, the USA, and China, and the first pilot implementations (e.g., mobile H_2 generators), MgH_2 is gaining importance as a safe alternative to compressed or liquid hydrogen, especially in custom and distributed applications (Gao 2025).

3.2. Production of magnesium metal

Metallic magnesium (Mg) is an element of increasing technological importance, used, among other, in lightweight engineering alloys for the automotive and aerospace industries (e.g. Mg-Al, Mg-Li), in energy storage systems (Mg-ion batteries), in the chemical industry as a reducer and as a pyrotechnic and alloying component. This metal is most often obtained by electrolysis of a mixture of magnesium chloride and other chlorides, or by reducing roasted dolomite or magnesium with ferrosilicon by the silicothermal method (Lewicka 2014; Magnesium Metal 2025). It is also increasingly obtained from carnalite-potassium-magnesium salts and pure seawater with high salinity. The world's resources of minerals (raw materials) for the production of metallic magnesium are practically unlimited. Secondary sources are used on a large scale in the production of metallic magnesium, primarily scrap alloys with Mg. Despite the prevalence and abundance of magnesium sources, its production, due to its high energy intensity, is developed mainly in countries with cheap energy sources. Currently, China is the global leader in the production of magnesium metal, accounting for more than 85% of the world's supply. In Europe, most countries have given up their own production in favor of imports, which is a significant structural weakness in the context of the raw materials crisis and the EU's policy of strategic autonomy. The size of the global trade market for metallic magnesium in 2021 reached about $4.4 billion (World Integrated Trade 2025). There are currently no installations for the production of metallic magnesium in Poland. A potential source for magnesium production in Poland is the common and easily accessible deposits of dolomites and serpentinites. Magnesium imports have recently been in the range of 7 to 10 thousand tons, and over 80% of them are mainly from China. It is used for aluminum alloys and for the production of die-cast plastic. Magnesium is manufactured by two methods: electrolytic reduction of magnesium chloride or thermic reduction of dolomite. Two thermal processes currently are in use to recover magnesium metal from dolomite – the Pidgeon process and the Magnetherm process (Grjotheim1962; Avedesian and Baker 1999; Hu 2016; Armaghan 2023; Jingzhng 2023; Telgerafchi et al. 2023; Xu et al. 2023).

These processes require the preparation of reagents (among others, high-purity crushed MgO), high-temperature ceramic reactors, and a vapor-phase magnesium condensation and separation system (Li 2025).

Research in this direction is carried out by the Łukasiewicz Research Network – Warsaw Institute of Technology, which develops theoretical technological assumptions and reaction models enabling local production of Mg in low-voltage installations (up to 100 kg/day) with the possibility of scaling. An additional goal is to integrate this technology with renewable sources of thermal energy (focused solar energy, thermal plasma), which would significantly reduce the emissivity of the process compared to classic electrolysis from brines or chlorides.

In the current market and legislative situation, the development of local Mg production technology from domestic raw materials is becoming a real option for rebuilding industrial competence in the EU and increasing independence from Asian suppliers.

3.3. Possible directions of application of domestic magnesite raw materials

Due to the relatively low quality of Polish magnesite, which is not suitable for processing into a top-class refractory material (Galos and Lewicka 2022), it is necessary to focus development on other forms of application that are consistent with quality parameters. The following may be of particular importance (Svajlenka 2021):

a) Agricultural and environmental applications
   - Calcined magnesite can be used as a soil deacidifier, especially on organic farms.
   - As a buffering and stabilizing additive in the industrial and municipal wastewater circuit, it acts as a pH neutralizer and heavy metal sorbent.
   - In powder form, it can be used in reclamation seals and mineral barriers in landfills.

b) Applications in building materials not exposed to extreme temperatures
   - Compact MgO blocks with an open porosity structure, used as structural and insulating underlays in low-carbon construction.

- Sound-absorbing panels and acoustic plasters in which the presence of MgO improves sound absorption and structural stability.
- Sorel magnesium cements with the addition of organic admixtures for the production of prefabricated elements with high resistance to de-icing salts (e.g., road slabs, bands around engineering structures).

c) Applications in power engineering and heat storage technology
- MgO as a component of solid heat carriers in solar installations and industrial energy buffers – thermal stability, high specific heat.
- MgO-based composite materials for the encapsulation of phase change substances (PCMs) used in accumulation walls and thermal partitions.

d) Functional carriers and substrates for chemical syntheses
- Thanks to its porous structure, calcined magnesite can act as a catalyst carrier or filtration component, among others in flue gas treatment systems or bioreactors for wastewater treatment.
- It can be used as a precursor for the production of light mineral foams (MgO-H_2O), which are chemically stable and can be used in insulation and explosion protection.

4. Applications of magnesite raw materials in construction

The use of magnesite-based products, in particular MgO boards, and magnesium cements, is gaining importance in modern construction. They are distinguished by their fire resistance, moisture resistance and biodegradation, which makes them the preferred materials for structural solutions that require durability and safety. This section outlines the most important areas of their use and the technical benefits associated with them (Svajlenka 2021; Critical Raw 2023; Qi 2025; Zhou et al. 2025).

Magnesite and its derivatives are used in:
- building boards (MgO) used in passive construction (Table 4),
- magnesium cements for quick assembly and prefabricated elements,
- fire and moisture insulation,
- materials for specialized structures exposed to temperatures and corrosion.

A wide range of applications of magnesium boards in construction and their advantages are presented in Table 4. These applications are particularly relevant due to the rapid development of the production of electric vehicles and the potential risks of their fires in garages and underground car parks.

Articles (Qi 2025; Zhou et al. 2025) provide a comprehensive overview of research on magnesiumsulphate (MOS) and magnesium chloride (MOC) cements, focusing on their properties, application opportunities, and challenges in the context of sustainable construction. This work indicates that magnesium cements represent a very promising group of binders with great potential for applications in construction and geoengineering.

Table 4. Applications of MgO Boards in Construction (Svajlenka 2021; Qi 2025; Zhou et al. 2025)

Tabela 4. Zastosowanie płyt MgO w budownictwie

Use	Technical benefits
Partition walls and fire partitions	Fire resistance, non-toxicity
Floor and ceiling tiles	Rigidity and bending strength
Underlays for plasters and facades	Adhesion to plasters and adhesive mortars
Prefabricated elements	Can be reinforced, easy to process
Drywall systems (alternative to G–K)	No deformation, higher mechanical resistance
Insulation in damp rooms	Resistant to fungi, mould, and moisture
Passive fire protection	Compliant with EI 60–EI 120 requirements
Structural layers in SIP panels	Reduction of thermal bridges, lightweight
Road and rail tunnels	RWS curve compliance
Hospitals and bunkers	High aseptic, moisture stabilization

Conclusions

Despite the growing importance of magnesite as a strategic raw material, its wider use in Poland faces significant technological, economic, and organizational barriers. At the same time, the development of modern energy storage technologies, the use of new building materials, and the recovery of raw materials creates a number of opportunities for the magnesium industry. This paper briefly presents the raw material base and the state of the economy of magnesite and its raw materials, as well as the main limitations and potential directions of action to overcome them. Taking into account the directions of energy transition implemented in the EU, as well as in Poland, and the strategic needs of the raw materials economy, the following challenges and opportunities arise for the country in terms of developing the production and applications of magnesite and magnesite raw materials (Svajlenka 2021; Strategic 2022; Critical Raw 2023; Regulation 2024):

a) Challenges:
- lack of installations for the production of magnesite raw materials in the country,
- poorly developed network of processing technologies,
- strong foreign competition.

b) Capabilities:
- re-assessment of magnesite resources and revitalization of selected sites,
- launch of pilot lines for the production of Mg and MgH_2,
- integration with European policy on critical raw materials and hydrogen energy,
- development of specialized construction applications using MgO.

Poland has documented and prognostic resources of magnesite and magnesium salts, the strategic use of which can no longer remain only in the sphere of potential. The inclusion of this raw material in national value chains – from refractory materials, through advanced construction technologies, to the hydrogen economy – should become an element of a conscious industrial policy. Research institutes such as the Łukasiewicz Research Network and the Polish Academy of Sciences have a key role to play in the process of initiating and implementing such changes (Gao et al. 2025) Thanks to their expert facilities, access to infrastructure and the ability to carry out R+D work, they are able to transform natural resources into industrial technologies with high added value. It is therefore necessary to build support mechanisms that will allow these institutions to act as active catalysts for new branches of industry based on their own raw materials, both on a national and European scale.

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MAGNESITE RESOURCES AND PROSPECTS FOR THE DEVELOPMENT OF NEW APPLICATIONS OF MAGNESITE RAW MATERIALS IN THE LIGHT OF ENERGY TRANSITION AND STRATEGIC NEEDS OF THE EU RAW MATERIALS ECONOMY

Keywords

magnesite resources, production and application, new technologies of magnesite applications

Abstract

The article presents the current state of domestic and global resources of magnesite deposits, potassium-magnesium salts, and magnesium sulfate salts. The volumes of extraction and production of magnesite raw materials, as well as the directions and tendencies of their consumption, are also presented. Compared to the size and quality of the world's magnesite and magnesium sulfate salts resources, Poland has relatively limited production capacities for magnesite raw materials, especially of high quality. New, promising prospects are the deposits of sulfate salt-type (polyhalite), which occur in the area of the Bay of Puck. They are currently being more thoroughly identified and documented. This type of salt is increasingly used in the production of, among other things, magnesium building materials (Qi 2025; Zhou et al. 2025). The use of building materials produced with the use of magnesite raw materials, in particular magnesium slabs, blocks, and cements, is gaining importance in modern construction. These products are distinguished by their high fire resistance, moisture resistance, and biodegradability, which makes them the materials of choice for construction considerations requiring durability and safety. The EU's energy transition program and the need to reduce dependence on external sources of natural resources create new directions for the use of magnesite raw materials, such as hydrogen storage or new technologies for the production of metallic magnesium. The inclusion of magnesite raw materials in national value chains – from refractories, through advanced construction technologies, to the hydrogen economy – should become an element of a conscious industrial policy.

ZASOBY MAGNEZYTÓW I PERSPEKTYWY ROZWOJU NOWYCH ZASTOSOWAŃ SUROWCÓW MAGNEZYTOWYCH W ŚWIETLE TRANSFORMACJI ENERGETYCZNEJ ORAZ STRATEGICZNYCH POTRZEB GOSPODARKI SUROWCOWEJ UE

Słowa kluczowe

zasoby magnezytu, produkcja i zastosowanie, nowe technologie zastosowań magnezytów

Streszczenie

Artykuł przedstawia aktualny stan krajowych i światowych zasobów złóż magnezytu i soli potasowo-magnezowych oraz siarczanowo-magnezowych. Przedstawiono także wielkości wydobycia i produkcji surowców magnezytowych oraz kierunki i tendencje ich zużycia. Polska w porównaniu do wielkości i jakości światowych zasobów magnezytu i soli magnezowych posiada stosunkowo ograniczone możliwości produkcji surowców magnezytowych, szczególnie wysokiej jakości. Nowe, obiecujące perspektywy stanowią złoża soli typu siarczanowego (polihalit) występujące w rejonie Zatoki Puckiej. Są one obecnie w trakcie dokładniejszego rozpoznania i dokumentowania. Tego typu sole mają coraz większe zastosowanie do produkcji magnezjowych materiałów budowlanych. Zastosowanie materiałów budowlanych produkowanych z zastosowaniem surowców magnezytowych, w szczególności płyt, bloczków i cementów magnezjowych, zyskuje na znaczeniu w nowoczesnym budownictwie. Płyty i inne produkty $MgO/MgSO_4$ charakteryzujące się wysoką impedancją ogniową są w wielu krajach i regionach (Chiny, Ameryka Północna, Bliski Wschód) szeroko stosowane i stanowią nowy standard budownictwie i infrastrukturze. Produkty te wyróżniają się wysoką odpornością ogniową oraz odpornością na wilgoć i biodegradacje, co czyni je materiałami preferowanymi w rozważaniach konstrukcyjnych wymagających trwałości i bezpieczeństwa. Realizowany w UE program transformacji energetycznej oraz potrzeba mniejszego uzależnienia się od zewnętrznych źródeł surowców naturalnych stwarzają nowe kierunki wykorzystania surowców magnezytowych takie jak magazynowanie wodoru, czy nowe technologie produkcji magnezu metalicznego. Włączenie surowców magnezytowych w krajowe łańcuchy wartości – od materiałów ogniotrwałych, przez zaawansowane technologie budowlane, aż po gospodarkę wodorową – powinno stać się elementem świadomej polityki przemysłowej.