The alternative refractory magnesia sources in the context of decarbonization

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Introduction

Rudnick & Gao (2014) estimate that MgO represents 4.66 wt% of the continental crust composition. Most of the magnesia produced globally comes from minerals. Magnesite [MgCO3] is the most important source for magnesia production and its geogenic CO2 emissions are a big concern in the refractory magnesia aggregates production. Can we produce refractory MgO emitting less CO2 with other sources?

$$MgCO_{3(s)} \xrightarrow{\Delta} MgO_{(s)} + CO_{2(g)}$$

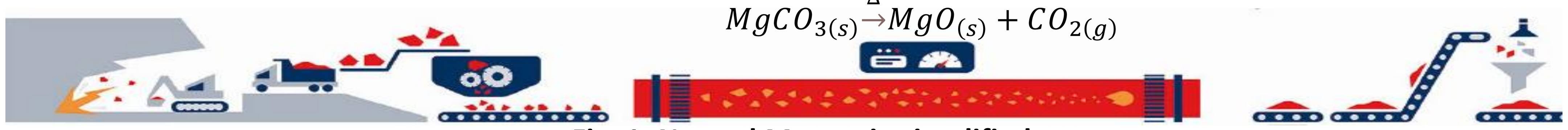

Fig. 1: Natural Magnesia simplified route

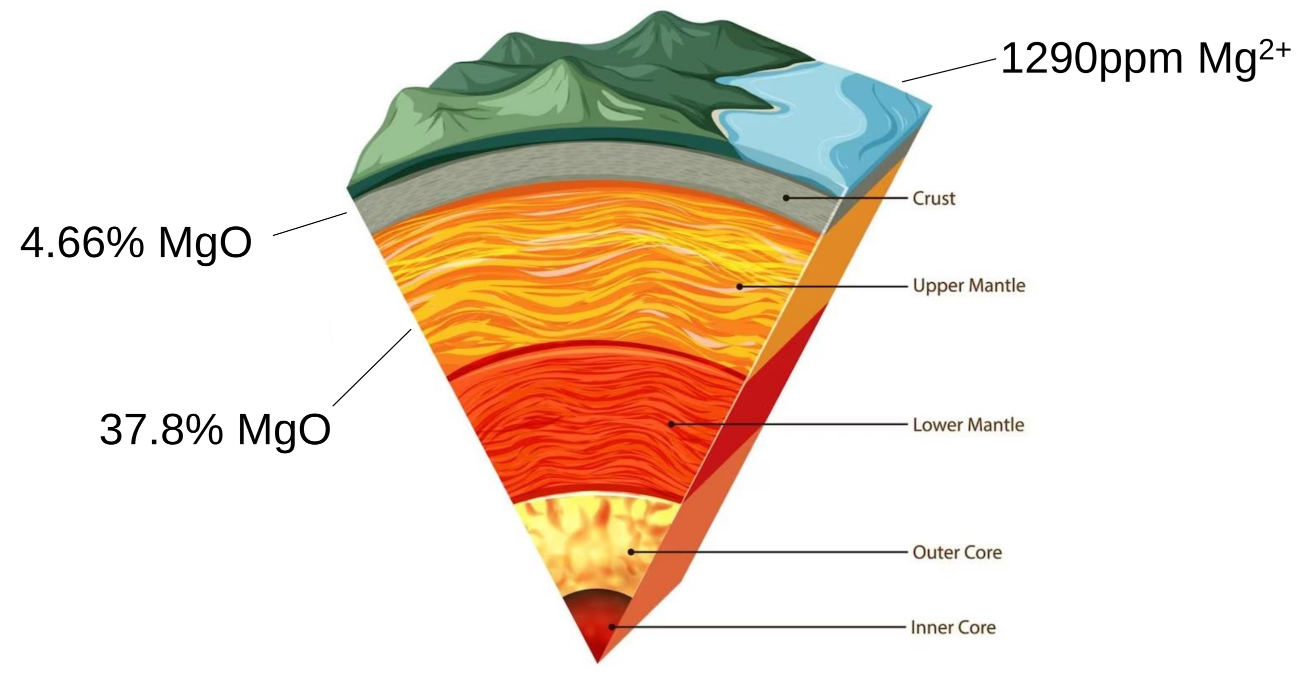

Fig. 2: Magnesium in our planet

Discussion:

Natural Magnesia

Natural magnesia is the name given to the MgO produced from magnesite. One factor that affects the quality of the refractory aggregate and its environmental performance is the quality of the magnesite ore. Fine-grained magnesite, associated with other gangue minerals, requires mineral processing before sintering to achieve the proper purity of the magnesia aggregate. This leads to a much more complex production route:

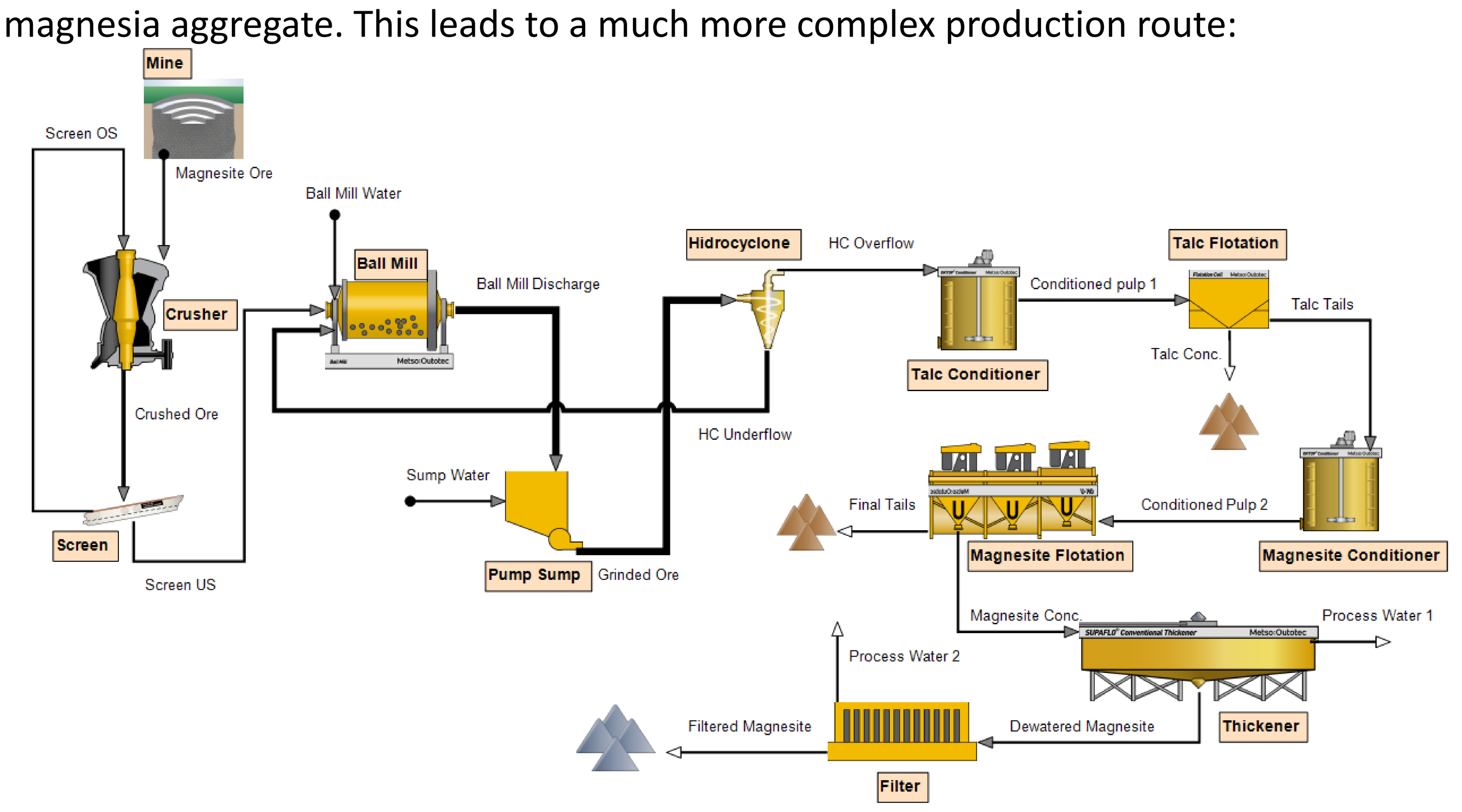

Fig. 3: Magnesite mineral processing

Synthetic Magnesia

Minerals are not the only source of magnesium on Earth. Seawater is the other huge, almost limitless, commercial source of high-purity magnesia. Magnesia production has also proven to be possible with Mg-bearing minerals. MgO produced from these alternative sources is called Synthetic Magnesia.

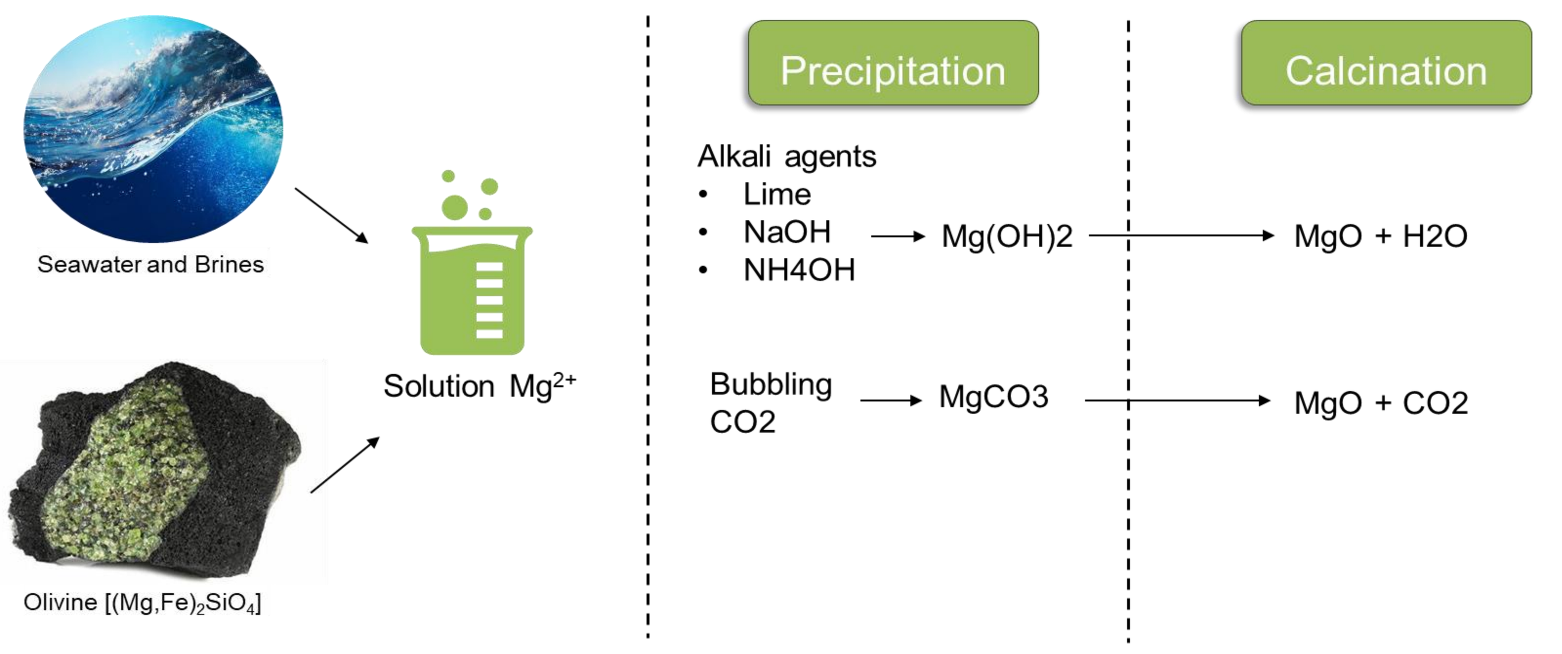

Fig. 4: Synthetic Magnesia routes

In addition to these techniques, synthetic magnesia can also be obtained by direct carbonation of Mg-bearing minerals or by CO2 bubbling into a Mg2+ concentrated solution. Another known process to produce magnesia from seawater and brines is the Aman process. It consists in feeding a thermal reactor (at 500 – 600 °C) with a concentrated magnesium chloride solution.

Despite having lower direct CO2 emissions compared to the natural route, the synthetic routes have a huge energy demand and considerable indirect emissions from chemicals. Additionally, synthetic routes are more expensive, and their production scale is smaller than that of natural routes.

Type	Source	Route	CO2 footprint	Energy	TRL	Product quality
Natural	Magnesite	Firing of magnesite concentrate (Drnek, 2002)	High[1]	Regular	9	Regular
Synthetic	Seawater	Brucite precipitation and firing (Fontana et al., 2022)	High[2]	High	7	High
		Aman process (Roskill, 2010)	Regular	Very High	8	Very High
		Carbonation and firing (Ferrini et al., 2009)	Regular	High	4	Regular
Mg-bearing minerals	Olivine, serpentine	Mineral decomposition (Teir et al., 2009)	Very High	Very High	4	Very High
		Direct carbonation and firing (Maroto-Valer et al., 2005)	Regular	Very High	3	Low

1 - CO_2 capture can reduce drastically.

2 - The use of NaOH or NH_3 (instead of lime) produced with green energy may reduce CO_2 emissions. Otherwise, it can be even higher than the natural one.

Fig. 5: Qualitative comparison of MgO production routes

Conclusions:

The urgency in tackling climate change turns the attention of the magnesia industry towards the reduction of CO2 emissions. In this context, synthetic magnesia could contribute to this goal in the future, but this would require a massive development of green energy production capacity. With the current conditions, the supplies required in the production of synthetic magnesia contribute to increasing the carbon footprint of the final product, leading to higher values than natural magnesia.

References:

Drnek, T. (2002). Die Sintermagnesia im Spannungsfeld von technologischen uns wirtschaftlichen Veränderungen. Montanuniversität Leoben.

Fontana, D., Forte, F., Pietrantonio, M., Pucciarmati, S., & Marcoaldi, C. (2022). Magnesium recovery from seawater desalination brines: A technical review. Environment, Development and Sustainability

Ferrini, V., De Vito, C., & Mignardi, S. (2009). Synthesis of nesquehonite by reaction of gaseous CO2 with Mg chloride solution: Its potential role in the sequestration of carbon dioxide. Journal of Hazardous Materials, 168(2–3), 832–837.

Maroto-Valer, M. M., Fauth, D. J., Kuchta, M. E., Zhang, Y., & Andrésen, J. M. (2005). Activation of magnesium rich minerals as carbonation feedstock materials for CO2 sequestration. Fuel Processing Technology, 86(14–15), 1627–1645.

Roskill Information Services (Ed.). (2010). Magnesium compounds and chemicals: Global industry markets and outlook (11. ed). Roskill Information Services.

Teir, S., Eloneva, S., Fogelholm, C.-J., & Zevenhoven, R. (2009). Fixation of carbon dioxide by producing hydromagnesite from serpentinite. Applied Energy, 86(2), 214–218. https://doi.org/10.1016/j.apenergy.2008.03.013

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