Mafic rocks – inadequate feedstock for CO_2 sequestration in Poland

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CO_2 sequestration by mineral carbonation

The capture and storage of CO_2 in geological formations is one of the most promising approaches to reduce the emission. A technology that could possibly contribute to reducing carbon dioxide emissions is the in-situ mineral sequestration or the ex-situ mineral sequestration. Natural minerals, such as olivine, serpentine, talc, or wastes as fly ashes, slag and waste concrete are used to bind CO_2. Magnesium minerals proved more attractive in mineral carbonation process, since there are large deposits of magnesium rich minerals. In addition the magnesium silicates are more reactive than calcium silicates.

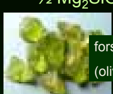
Mineral carbonation is based on the reaction of CO2 with metal oxide bearing materials to form insoluble carbonates, with calcium and magnesium being the most attractive metals. In the reaction some amount of heat is released [2]:

$$CaO + CO_2 \rightarrow CaCO_3 + 179\ \text{kJ/mol}$$

$$MgO + CO_2 \rightarrow MgCO_3 + 118\ \text{kJ/mol}$$

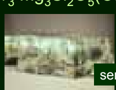
In nature however calcium and magnesium usually exist in natural silicates. The carbonation of silicates are also exothermic reaction, but the heat amount is less. Here the example reactions of forsterite (olivine) and serpentine are given:

$$\tfrac{1}{2} Mg_2SiO_4 + CO_2 \rightarrow MgCO_3 + \tfrac{1}{2}SiO2 + 95\ \text{kJ/mol}$$



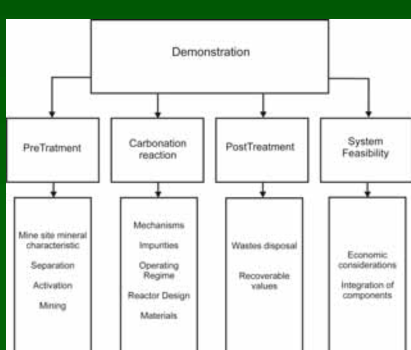
forsterite (olivine)

$$\tfrac{1}{3} Mg_3Si_2O_5(OH)_4 + CO_2 \rightarrow MgCO_3 + \tfrac{2}{3} SiO_2 + \tfrac{2}{3} H_2O + 64\ \text{kJ/mol}$$



serpentynite

The critical issues of mineral carbonation in practical process are among others: separation, activation of minerals, holding operating regime of the reaction, wastes disposal, integration of components and economy of the process. Developing an economical method to sequester CO_2 with minerals is still a challenging task, because the process is still relatively slow, and most reactions require high pressure and moderately elevated temperature.

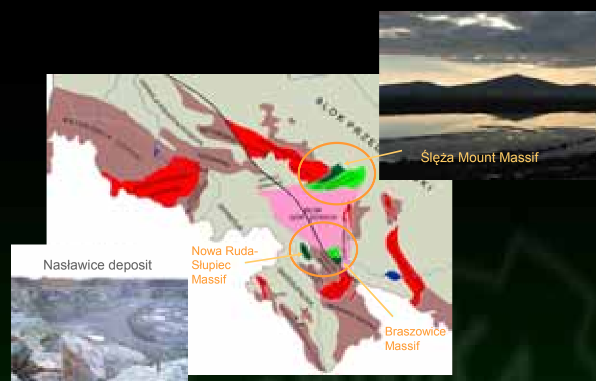


Critical issues of mineral carbonation in practical process (after Goldberg et al., [2])

Mafic rocks deposits in Poland

Among silicate rocks, mafic and ultramafic rocks are the ones that contain high amounts of magnesium, calcium, and iron and have a low content of sodium and potassium

The most promising as binding materials in carbonation reaction seems to mafic and ultramafic rocks of Lower Silesia. The most important deposits of serpentinite in Poland are located in the Sowie Mountains block surrounding. They origin as a result of metamorphism of peridotites and piroxenites. Available reserves of the deposits are over 64 mln Mg. The row material is yet quite poor, cracked and weathered.



To perform the mineral carbonation process we need a proper amount of silicate mineral. It could be calculated with use of Goff at al. [1] assumptions. For the Polish serpentinite conditions the following assumptions were set:

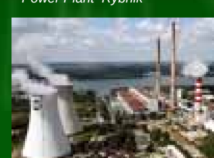
1. a mean magnesium oxide MgO content in the magnesium silicate ore mineral is of 30% weight percent,
2. 75% ore recovery, taking into account geological conditions,
3. 80% efficiency of the carbonation reaction,
4. stoichiometry of reaction:

$$(Mg, Ca)_xSi_yO_{x+2y+z}H_{2z} + xCO_2 \rightarrow x(Mg, Ca)CO_3 + ySiO_2 + zH_2O$$

Basing on the calculations [3], it was stated that about 5 Mg of serpentinite is required per 1 Mg of CO_2. It seems that the resources of serpentinite in Poland are not sufficient enough for industrial implementation in mineral carbonation process. Nevertheless the weathering processes which occurred in serpentinite in natural way are worth inquiring in order to examine carbonation reaction.

Taking into consideration one of the Polish power plants ("Rybnik"), which emission of CO_2 is 9 245 700 Mg per year it is possible to calculate that there will be a need of 46 mln Mg serpentinite to perform mineral carbonation. The requirements are enormous, knowing that total resources of serpentinite in Poland are 64 mln Mg,

Power Plant Rybnik



CO_2 emission
9 245 700 Mg /year

46 mln Mg/year
serpentinite

Conclusion

It seems that the resources of serpentinite in Poland are not sufficient enough for industrial implementation in mineral carbonation process. Nevertheless the weathering processes which occurred in serpentinite in natural way are worth inquiring in order to examine carbonation reaction.

References

•*1.* Goff, F., Guthrie, G., Counce, D., Kluk, E., Bergfeld, D., Snow, M., 1997, Preliminary Investigations on the Carbon Dioxide Sequestering Potential of Ultramafic Rocks, Los Alamos, Los Alamos National Laboratory; LA-13328-MS.

•2. *Goldberg* P.M., Zhong-Ying C., O'Connor W.K., Walters R.P., 2001, CO_2 *mineral sequestration* studies in US, Journal of Energy & Evironmental research, vol.1, no. 1, U.S. Department of Energy.

•3. Labus M., 2010, Próba oceny krajowych zasobów złóż serpentynitu dla celów sekwestracji CO2, Kwartalnik Górnictwo i Geologia, t. 5, z.2, 133-141.