To Integrate CO_2 Mineralization and Mining for the Recovery of Construction Materials and Energy-Relevant Elements from Waste

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Several studies have been conducted over the years on carbon dioxide (CO_2) mineralization helping to identify suitable source materials ranging from natural rocks and brines to industrial solid and liquid waste. However, the study of CO_2 mineralization combined with the recovery of energy relevant elements (EREs) is still at its initial stage. To overcome the commercialization barrier, feasible operating conditions must be selected, process design needs to be developed, and the scale-up of the system is required.

The goal of the proposed project is to identify optimal conditions to develop a new technology that integrates CO_2 mineralization with the mining of EREs and the synthesis of carbonate minerals to be reused in construction. The technology uses as source materials solid waste such as mine tailings. Mine tailings from the mining of ultramafic rocks containing silicates, namely wollastonite, olivine, and serpentine, are optimal candidates for an integrated CO_2 mineralization-mining process [1]. They are naturally rich in both CO_2-reactive elements (CO2REs, e.g., calcium (Ca) and magnesium (Mg)) and EREs (e.g., cobalt (Co), copper (Cu), manganese (Mn), lithium (Li), and titanium (Ti)) which will be extracted and separated to create eventually carbonates and metals reusable in the constructions of buildings, infrastructure, and renewable energy systems. The core of the proposed technology comprises: 1) enhanced mineral dissolution of wollastonite using organic acids; 2) nanofiltration for EREs recovery; 3) microbially-induced seeded precipitation for CO_2 mineralization and carbonate synthesis. While enhanced mineral dissolution and precipitation will be the focus of the research at the University of Padua, nanofiltration will be studied by the collaborators at Clarkson University (New York, U.S.A.).

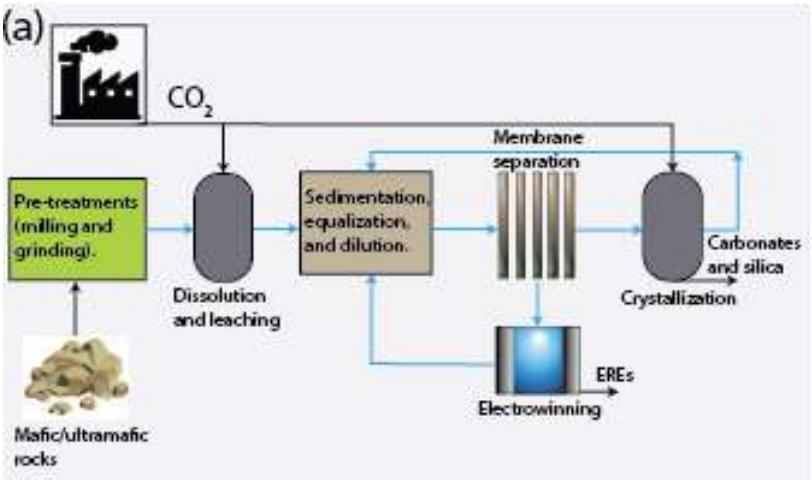

Figure 1. Conceptual scheme of CO_2 mineralization integrated with EREs recovery.

The project is funded by the Department of Energy (DOE, U.S.A.) through Columbia University (New York, U.S.A.). The mine tailing will be taken from a mine in New York State which has one of the largest deposits of wollastonite ($CaSiO_3$) in the United States and the largest production of the mineral [2]. Mine tailings from these deposits were recently investigated for CO_2 storage [3] however the potential of mining of EREs from them has not been explored, yet.

Laboratory experiments using a batch reactor will be carried out under well-controlled conditions to study mineral dissolution and carbonate precipitation processes and the measurements will help formulating and validate a process model. A recursive approach of modeling, experiments, and again modeling activities will be used.

Within the three years of the project, the Ph.D. student will gain an extraordinary background of experimental and modelling of particulate processes in geochemical aqueous systems. The student

will have several opportunities of networking within academia by attending national and international conferences and by spending up to 6 months in an academic institution within Europe or the United States as a visiting scholar.

References

[1] Nicholas LePan, “Visualizing the Size of Mine Tailings,” visualcapitalist, May 2021.
[2] New York State Department of Environmental Conservation Division of Mineral Resources, “2019 Fact Sheets Products of New York State Mines,” file:///C:/Users/valen/OneDrive/Documents/StevensTech/2022Valentina/Research/CO2Mineralization/Literature/Waste/minfactsht.pdf, 2019.
[3] P. A.-H. A. and Z. H. Lackner K S, “Disposing of Greenhouse Gases through Mineralization Using the Wollastonite Deposits of New York State,” 2012.

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