

**ANNUAL PROJECT REPORT
AS OF DECEMBER 2001**

1. PROJECT SPONSOR:

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2. PROJECT MANAGER:

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3. OCDO GRANT NO: OCRC3/01-C1.12

4. PROJECT UPDATE OR
FINAL REPORT ✓

5. PROJECT TITLE: Carbonation of Mg and Ca-bearing Minerals: Kinetic and Mechanistic Studies

6. PROJECT TERM: FROM: September 1, 2000

TO: August 31, 2001

7. BUDGET:

<u>CO-SPONSORS NAME</u>	<u>COST SHARE</u>
OCDO	\$ 79,643
Ohio State University	\$ 36,916
Total Project Cost:	\$ 116,559

I. ABSTRACT

8. OBJECTIVES:

An increase in carbon emissions and a rising concentration of CO₂ in the atmosphere have been predicted based on our continued reliance on fossil fuel energy. This situation is unlikely to change unless major changes are made in the way we use and produce energy, and in particular, how we manage carbon. Particularly, the state of Ohio ranks second only to the state of Texas in annual CO₂ emissions, while economy of the state is very much related to our ability to use coal. Therefore, there is a strong need for development of processes that can convert separated and captured CO₂ to environmentally friendly products appropriate for long-term unmonitored disposal. The overall long term objectives of this project involve the study of reaction kinetics and mechanism of CO₂ with Mg-rich minerals with the ultimate goal of establishing mineral carbonation as a viable option for long-term and safe disposal of CO₂.

9. WORK DONE AND CONCLUSIONS:

Olivine and *serpentine* were chosen as the reactants for CO₂ mineral sequestration, since they are widely available in great quantities and the concentrations of MgO within these minerals are high. The average measured concentrations of Mg and Si in these minerals were approximately 30 and 22 wt %, respectively. The properties, such as specific surface areas

and pore volumes, and crushing strengths of these minerals were found to be dissimilar. SEM and EDS analysis were performed for all the minerals to characterize the surface morphology, local chemical composition, and hardness of the mineral samples. The solubility of these minerals in water increased as HCl and NaHCO₃ concentrations increased, and an increase in temperature resulted in the most significant improvement in solubility. As expected from the slow kinetics, there was no direct gas-solid carbonation of minerals occurred at 350 °C and 25 atm. On the other hand, 10 % conversion was achieved at 100 °C and 15 atm through catalytic aqueous carbonation in the HPSR. This result was very promising. Therefore, the aqueous carbonation process was chosen for the further studies. From the SEM analysis on the products of the aqueous carbonation of Mg-bearing minerals, it was found that the limiting factor for the conversion was the rate of dissolution of Mg into the liquid medium. Next, a new water-soluble reactant, Mg(OH)₂ (i.e. *Brucite*), was used to carry out the carbonation in the HPSR and we achieved up to 90 % of conversion within 4 hours at 20 °C and 15 atm. It is important to note that the solubility of Mg(OH)₂ increases as temperature decreases. As a result, high degree of carbonation can be obtained at a low reactor temperature, which reduces the cost of the process. Currently, the experimental setup is being modified to accommodate a CO₂ booster pump. This will allow the reactor pressure to be closer to the pressure of the separated and captured CO₂ from the power plant. This increase in pressure will further reduce the reaction time for the carbonation reaction.

10. PLANS FOR THE COMING YEAR:

This is the final report for this project.

II. HIGHLIGHTS/ACCOMPLISHMENTS

Carbon management is still in its infancy and it is critical to explore various CO₂ disposal options. This project was carried out to develop a process that can convert separated and captured CO₂ to products appropriate for long-term, environmentally benign, and unmonitored storage. Throughout the last year, all the proposed objectives were successfully achieved. *Olivine*, *Serpentine* and *Brucite* were selected as feasible reactants and characterized. The aqueous carbonation gave promising results, whereas the kinetic of gas-solid carbonation was too slow. With a new and modified experimental setup, the optimum operating conditions for this process will be soon determined and the CO₂ mineral sequestration will be established as a feasible carbon dioxide disposal option in future.

III. ARTICLES/PRESENTATIONS

1. "Carbonation of Mg- and Ca-bearing Minerals: Kinetic and Mechanistic Studies," First Ohio CO₂ Reduction, Capture & Sequestration Forum, Ohio, March 23, 2001.
2. "CO₂ Mineral Sequestration through Carbonation of Mg-bearing Minerals," Park, A.-H., Jadhav, R. A., and Fan, L.-S., AIChE meeting, Reno, Nevada, November 4-9, 2001.
3. "CO₂ Mineral Sequestration through Carbonation of Mg-bearing Minerals," Park, A.-H., Jadhav, R. A., and Fan, L.-S., 2001 Annual Industry/University Consortium Meeting, Columbus, Ohio, December 10, 2001.