CLIMATE CHANGE

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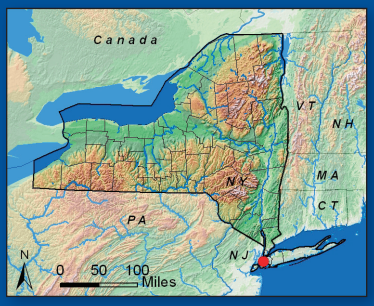
PROJECT LOCATION
New York City



Source: E&S Environmental Chemistry, Inc.

CONTACT INFORMATION
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PROJECT NUMBER 10114

KEYWORDS
- Carbon capture and storage (CCS)
- Carbon dioxide
- Carbon sequestration
- Climate change
- Mineralization
- Wollastonite

0908

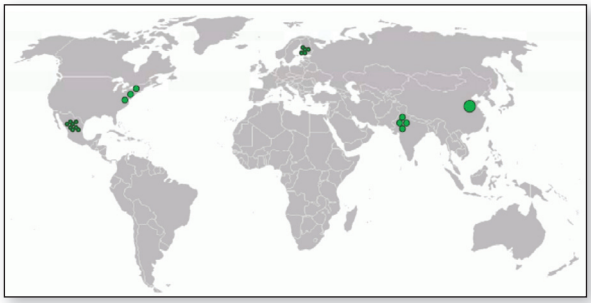
Disposing of Greenhouse Gases through Mineralization Using the Wollastonite Deposits of New York State

PROJECT FOCUS

This project explores the potential for mineral sequestration of carbon dioxide (CO_2) in a carbonation reactor using wollastonite, a calcium silicate mineral found in large quantities in New York State. The project team will attempt to determine the optimum conditions for CO_2 mineralization, including an assessment of the potential use of chemical additives. The results will be used to design multi-phase reactors to be employed for each stage of the process. The overall mass and energy balance of the process will be calculated, and mineral production and reserve data will be analyzed to estimate the carbon mineral sequestration capacity for New York State.

CONTEXT

Carbon dioxide, the primary greenhouse gas, is a byproduct of fossil fuel combustion in power generation plants. Efforts to capture and store the carbon emissions from these plants have focused on CO_2 sequesration in underground rock formations, such as depleted natural gas reservoirs and deep saline aquifers. Such systems require extensive site-characterization and long-term monitoring, however, to be sure that the CO_2 behaves as expected over time.



Worldwide distribution of wollastonite production in 2005. Source: Ah-Hyung (Alissa) Park (based on data from Hetherington, L. E. (2008), World Mineral Production 2002-06, British Geological Survey.)

Carbon dioxide may also be permanently stored in solid form via mineral carbonation. In this process, CO_2 is combined with the alkaline metal ions in silicate minerals to form thermodynamically stable carbonate minerals. Such carbonation reactions occur naturally on geological time scales, but the process can be greatly accelerated through the use of carbonation reactors.

Several mineral types have been identified as candidates for use in an industrial-scale mineral carbonation process. The process has already been successfully demonstrated with wollastonite, a highly reactive calcium silicate mineral. New York State is in the unique position of possessing the largest deposits of wollastonite in the United States. These deposits, in Essex and Lewis counties, are currently being mined, but it is estimated that seven to fourteen million tons (Mt) of wollastonite remain, an amount sufficient for the permanent sequestration of two to five Mt of CO_2.

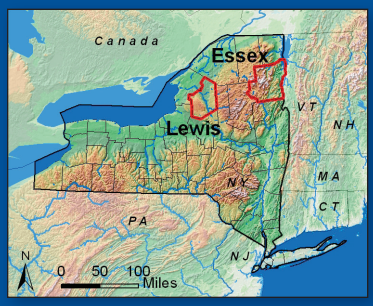
Due to its limited applications, new sources for wollastonite have not been sought. There is potential, therefore, to find additional deposits with further exploration. In the United States, deposits of wollastonite are known to exist in New York, Arizona, California, Idaho, Nevada, New Mexico, and Utah; however, few U.S. mines are in active production.

PROJECT IMPLICATIONS

Carbon dioxide capture and sequestration is increasingly viewed as a necessary step toward carbon-neutral fossil fuel-based energy generation, especially given coal as a primary energy source in the United States. Although carbon sequestration is possible in depleted gas reservoirs, unmineable coal seams, and deep saline aquifers, this process requires extensive site-characterization and long-term monitoring to ensure that the stored CO_2 will remain underground. Mineralization offers a leak-proof, permanent solution, whereby CO_2 is fixed into a solid matrix of silicate minerals to form thermodynamically stable carbonate minerals. This process has been demonstrated using the calcium silicate mineral wollastonite. This project seeks to optimize the CO_2 mineralization process using wollastonite and to estimate the total sequestration potential based on known deposits in New York State.

PROJECT STATUS
Ongoing

Photos of wollastonite samples illustrate coarse particles (top) and fine particles (bottom). Source: Columbia University.



Lewis and Essex Counties have the largest known wollastonite deposits in the U.S. Source: E&S Environmental Chemistry, Inc.

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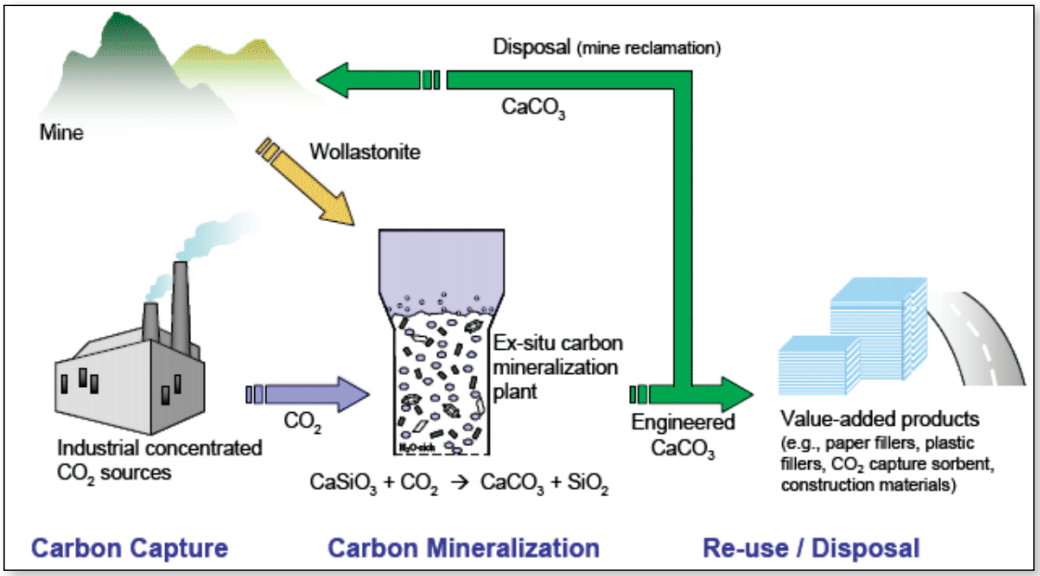
NYSERDA

Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State's energy efficiency, economic growth, and environmental protection. One of NYSERDA's key efforts, the Environmental Monitoring, Evaluation, and Protection (EMEP) Program, supports energy related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State's investor owned utilities. NYSERDA administers the SBC program under an agreement with the Public Service Commission.

METHODOLOGY

Thermodynamic studies of wollastonite dissolution and carbonate precipitation will be conducted to determine optimal reaction conditions for each step in the process. Comparison of dissolution characteristics of wollastonite at various CO_2 partial pressures will be used to indicate an improvement in the reaction process; pH and chemical additives will be key variables in this optimization, as will energy constraints that will be used to estimate the net quantity of CO_2 sequestered. Optimal conditions for carbonate precipitation will also be obtained through thermodynamic modeling.



Ex-situ carbon mineral sequestration using wollastonite. Source: Ah-Hyung Alissa Park, Columbia University.

Based on the thermodynamic calculations, experimental studies of the dissolution and carbonation of wollastonite will be carried out with varying amounts of chemical additives, such as, citric acid, EDTA, ammonium chloride, acetic acid and phosphoric acid. The effects of temperature and chemical concentrations on the reaction rates will be investigated. Once optimal reaction kinetics are obtained for both the dissolution and precipitation steps, multi-phase reactors will be designed for each stage of the process.

In addition, to estimate the sequestration capacity of New York State's wollastonite, and to understand the economic values of various wollastonite product streams, the project team will analyze production and reserve data obtained from mining companies and geological surveys.

FINDINGS

Wollastonite samples procured for this project were mostly mining tailings with a large particle size distribution. To obtain a uniform particle size for the kinetic studies, wollastonite samples were ground and separated by size. The average particle size for the fine wollastonite sample was 51.2 micrometers (μm). The particle density of the wollastonite sample was found to be 2.68 grams per mililiter (g/ml). Current project tasks include continuing the characterization and dissolution studies of the wollastonite samples and developing an efficient carbonation process.