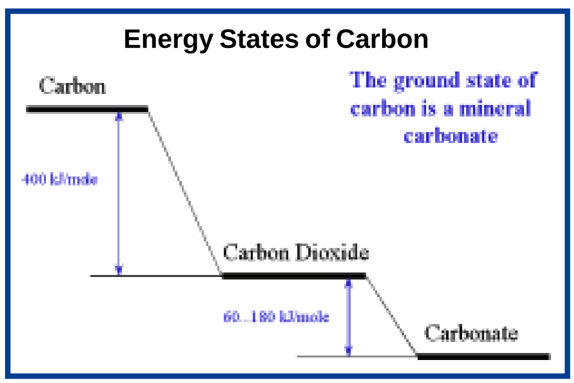
MINERAL CARBONATION STUDY PROGRAM

Description

The availability of clean, affordable energy is essential for the prosperity and security of the United States, as well as the rest of the world. About 85% of the energy used in the US is derived from fossil fuels, and continued dependence on these fuels is expected well into the 21st century. The continuing demand for energy and the associated rising CO_2 concentration in the atmosphere may have potentially large impacts on climate change. Comprehensive measures, including CO_2 sequestration, would be required to reduce CO_2 emissions while sustaining the demand for energy. Several methods have been suggested for sequestering CO_2, all of which have advantages and disadvantages. Among them, mineral carbonation is a relatively new and less-studied method with potential to sequester substantial amounts of CO_2.

Mineral carbonation, alternately referred to as Mineral Sequestration, is the reaction of CO_2 with non-carbonate minerals such as olivine and serpentine to form geologically stable mineral carbonates. Mineral carbonation could be realized in two ways. First, minerals could be mixed and reacted with CO_2 in a process plant. Second, CO_2 could be injected into selected underground mineral deposits for carbonation, similar to geological sequestration. Using mineral carbonation to reduce CO_2 emissions has many potential advantages such as:



Mineral Carbonization occurs naturally

Long Term Stability. Mineral carbonates, the product of this process, are known to be stable over geological time frames. This process ensures permanent fixation rather than temporary storage of CO_2, thereby guaranteeing no legacy issues for future generations. Mineral carbonation mimics the natural weathering of rock.

Vast Capacity. The raw materials for binding CO_2 exist in vast quantities across the globe. Readily accessible deposits exist in quantities that far exceed even the most optimistic estimates of coal reserves.

Potential to Become Economically Viable. The overall process is exothermic and, hence, has the potential to become economically viable. In addition, its potential to produce value-added by-products during the carbonation process, such as strategically important metals, may further reduce its costs.

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MINERAL SEQUESTRATION HOMEPAGE

http://www.fe.doe.gov/products/gcc/index.html

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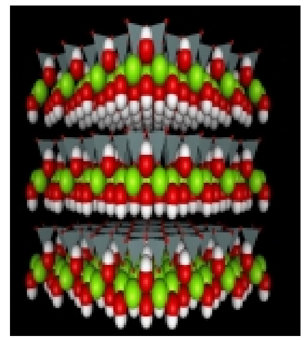
Despite these advantages, mineral carbonation processes will be practical only when two key issues are resolved. First, for sequestration purposes, a fast reaction route that optimizes energy management must be found. Second, issues with respect to the mining and processing activities required for mineral sequestration need to be quantified, especially concerns related to overall economics and environmental impact.

Goals

The primary goal of the mineral carbonation study is to generate a useful knowledge base that can lead to development of mineral CO_2 sequestration methods. To achieve this goal, the reaction mechanisms, heat requirements and environmental interactions must be understood well enough to permit engineering process development. A secondary goal is to acquire knowledge essential to understanding the reactions of CO_2 with underground minerals, in support of the U.S. Department of Energy's geological sequestration programs where CO_2 may be injected to deep saline aquifers or depleted oil or gas reservoirs. Knowledge of the reaction characteristics of CO_2 with various minerals at elevated pressures and temperatures such as those found deep underground will help scientists predict the long-term effects of such practices.

Elements



$Mg_3Si_2O_3(OH)$ - Atomic representation of serpentine structure (commonly called Lizardite)

The team of researchers comprising this working group are pooling their knowledge and experimental capabilities in order to effectively conduct the structured program outlined below.

***Study of Carbonation Reactions*.** Progress to date has been extremely encouraging. It has been found that finely ground serpentine $Mg_3Si_2O_5(OH)_4$, or olivine Mg_2SiO_4, will react with CO_2 in solutions of supercritical CO_2 and water to form magnesium carbonate $MgCO_3$. The reaction can be summarized as

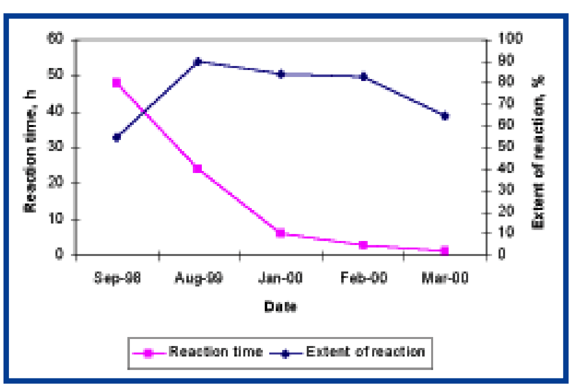
$$1/3\ Mg_3Si_2O_5(OH)_4 + CO_2 \text{ -----> } MgCO_3 + 2/3\ SiO_2 + 2/3\ H_2O$$

When the program first started, it required 24 hours to produce a 50% carbonation level using an olivine feedstock, reaction temperatures of 150-250°C and pressures of 85-100 bar. Through careful control of solution chemistry, the process has been accelerated so that 84% conversion of olivine can be achieved in just 6 hours. Furthermore, when heat pretreated serpentine is reacted using the same enhanced reaction process, approximately 80% conversion occurs in less than an hour. Carbonation studies are continuing utilizing highly instrumented reactors and atomic level simulations to optimize reaction conditions, and explore the use of catalysts and alternative feedstocks.

***System Feasibility*.** A life cycle assessment is under way to establish the feasibility of the baseline mineral sequestration concept with respect to system costs, development requirements and environmental attributes.

***Feedstock Characterization*.** Specific mineral deposits are being identified and characterized based upon potential co-location of mines and sequestration plants with fossil power plants. In addition, potential feedstock sources from industrial byproducts and waste streams are being examined.

These efforts are being conducted as part of Fossil Energy's Advanced Research and Technology Development efforts. The Mineral Carbonation Program is being managed through the National Energy Technology Laboratory's Environmental Product Division and is supported by the Coal Utilization Science, University Coal Research, and the Advanced Metallurgical Processes programs. The activities of the working group are being coordinated by the CUS program. Note that the group is seeking to interact with other interested researchers and industry stakeholders as a means to increase overall program scope and impact.



Mineral carbonation reaction time has been reduced from 48 hours to one hour over the period from Sept. 1998 to March 2000 at the Albany Research Center.