MINERAL CARBON DIOXIDE SEQUESTRATION: STILL A VIABLE OPTION

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ABSTRACT

This paper provides background and summarizes evidence supporting the possibility of developing a low-cost mineral carbon dioxide sequestration technology.

INTRODUCTION

Mineral carbon dioxide sequestration refers to a technology whereby carbon dioxide is disposed of via the creation of magnesium or calcium carbonate solids, the thermodynamic ground state of carbon. Despite the potential for permanent storage and zero monitoring costs via this technology, research efforts to develop this technology are small relative to other sequestration technologies such as geologic storage. Despite current high costs estimates, increasing amounts of research both from geochemical studies and those directly devoted to developing cost-effective mineral sequestration pathways provide evidence that a low-cost process may be developed.

THE COST OF SEQUESTRATION

The most heavily developed economic assessments for sequestration technologies have been performed for the various types of geologic storage and for disposal in mineral form. It is estimated that the large capacity options of geologic storage in saline aquifers, depleted oil, and depleted gas reservoirs will incur a cost of \$1-5/ton CO_2

Cost estimates for the industrial-scale implementation of current mineral carbon sequestration processes range from \$60-100/ton CO_2 avoided for the direct carbonation of olivine to several hundred dollars per ton of CO_2 avoided for the direct carbonation of serpentine.

MINERAL SEQUESTRATION

Efforts to develop a mineral sequestration process have focused on using the magnesium silicate minerals olivine and serpentine, and to a lesser extent the calcium silicate wollastonite, as a source of magnesium or calcium ions for carbonation.

The largest cost of mineral sequestration technologies comes with the chemical processing of the mineral necessary for accelerating the carbonation reaction to a suitable rate. Using a direct carbonation approach on the mineral serpentine, an energy penalty is incurred in a pre-processing step in which the mineral is heated to a temperature above 630 C [*O'Connor et. al.* 2002].

This heat treatment may be avoided if the cations from the mineral are made available for carbonation by rapid dissolution into a solution. If a chemical treatment may be used in which the mineral is activated in a weakly acidic environment then the solution may be directly carbonated without the addition of a base. In this case, the recovery of the solvent will occur as a result of the carbonation reaction. Thus, no recovery of the solvent will be necessary and a process may be developed which has net zero energy costs or is a net energy producer. This translates into minimal costs for the technology.

DISSOLUTION AND WEAKLY ACIDIC SOLUTIONS

Understanding the dissolution mechanism of these minerals is essential to understanding the possibilities for accelerated dissolution in a weakly acidic solution. Chizmeshya et. al. have imaged and modeled the growth of a magnesium depleted “silica passivating layer” that develops on the surface of olivine particles as the mineral is reacted with carbonic acid [*Chizmeshya et. al* 2003]. This builds upon earlier studies performed by Pokrovsky and Schott [2000] and R.W. Luce et. al [1971]. Combined, these studies provide strong theory and experimental evidence that the diffusion of magnesium through this layer accounts for the slow kinetics of the reaction.

Several studies demonstrate that the addition of organic chelating agents to a solution significantly increases the rate of dissolution of olivine and serpentine in the weakly acidic pH regime [*Park et. al* 2003, *Wogelius and Walther* 1991]. It is not well understood by what mechanism these additives increase the rate of the dissolution reaction, but no doubt it is a result of some influence they have on the diffusion limiting effect of the silica passivating layer.

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