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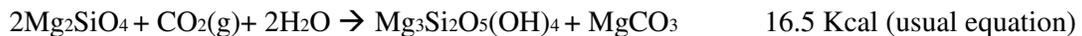
12.085 Seminar in Environmental Science
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12.085 Homework 6

This week, I researched how serpentine could be used to form magnetite (MgCO_3) for long-term carbon dioxide removal. The reaction simulates the process of creating serpentine in nature, where ultramafic rocks (ie forsterite Mg_2SiO_4) form serpentine when reacted with water. If there is carbon dioxide in the water, MgCO_3 is formed as an additional product. The goal for CO_2 removal is to maximize the amount of MgCO_3 that is formed.



The reaction also works if serpentine is used as the initial reactant instead of forsterite. To speed up the reaction, the minerals are ground up into micron-sized particles. Overall, serpentine requires more energy and is less efficient at storing CO_2 . However, serpentine makes more sense in terms of scale—there is more serpentine than olivine readily available.

Scale is the main issue with this reaction. There are large deposits of olivine available; for example, the Twin Sisters deposit in Washington state yields about 1.8 billion tons of olivine. According to Gerdemann et al. (2003), that provides enough olivine to sequester the carbon dioxide emissions from 8-10 1GW coal-powered plants for 15 years (Gerdemann et al., 2003; O'Connor et al., 2000). I did a simple, order of magnitude calculation for the amount of coal used by these plants in 15 years:

A typical bituminous coal provides 1.09 MJ of energy/kg of coal. 1 GW = 1GJ/s, and a 1 GW power plant provides 473,040,000 GJ of energy over 15 years, using 433,982 thousand tonnes of coal. 10 power plants would use 4,339,820 thousand tonnes of coal (World Coal Institute, 2007). The worldwide consumption of coal in 2005 was 5,850,319 thousand tonnes

(World Energy Council, 2005). My estimate is overly optimistic, since coal plants are neither 100% efficient (50% efficiency or less is closer to accurate) nor do they run 100% of the time (World Coal Institute, 2007). This will further decrease the amount of coal whose emissions can be offset through the formation of carbonates. In addition, there are energy and emissions costs associated with mining the olivine needed for the reactions. Overall, it will take enormous amounts of mined olivine to approximately offset the emissions from coal from 1 year; this process cannot be used as a long-term solution.

References:

Gerdemann, S.J. et al. (2003), Carbon dioxide sequestration by aqueous mineral carbonation of magnesium silicate minerals, Office of Fossil Energy, US DOE, <http://www.osti.gov/bridge/servlets/purl/898299-wXwUr6/898299.PDF>.

O'Connor, W.K. et al. (2000), Carbon dioxide sequestration by direct mineral carbonation with carbonic acid, Proceedings of the 25th International Technical Conf. on Coal Utilization & Fuel Systems, Coal Technology Assoc., Clear Water, FL, March 6-9, 2000.

World Coal Institute (2007), Coal Conversion Facts (December 2007), <http://www.worldcoal.org/pages/content/index.asp?PageID=190>.

World Energy Council (2005), Table 1.4 Coal: 2005 consumption, http://www.worldenergy.org/documents/coal_1_4.pdf.