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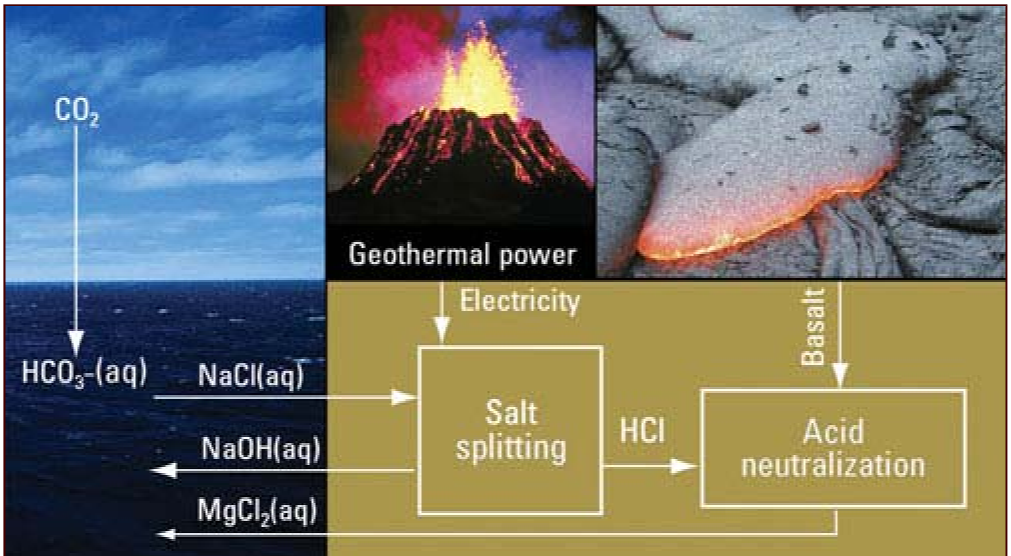
Science News –November 7, 2007

Speeding up earth's natural climate control

Could removing acid from seawater slow global warming?

As greenhouse gas levels rise faster, some scientists hope to drive the trend in the other direction by speeding up the planet's natural abilities to soak up CO_2. A new study published in *ES&T* (DOI: 10.1021/es072039a) proposes a novel way to accelerate the ocean chemistry that absorbs CO_2.



Kurt House/Rhonda Saunders

A new process would harness renewable energy such as geothermal power to bump up the ocean's alkalinity, which pulls CO_2 from the atmosphere.

Oceans have absorbed about one-third of the CO_2 that humans have produced so far, and if emissions ceased, the oceans would eventually take up all of it. But the process takes thousands of years, which is much too slow to keep up with the current CO_2 rise, says Kurt House, a Harvard doctoral student and lead author of the new study.

"The more acidic the ocean is, the less CO_2 it will hold," House explains. On the other hand, alkaline or basic solutions have a strong tendency to absorb CO_2. Thus, a more alkaline ocean would pull more of the gas from the air.

Other ideas for increasing ocean CO_2 uptake have focused on stimulating phytoplankton growth or increasing alkalinity directly. While House was jogging along the Charles River near Harvard one day, it struck him that he could instead remove acid to achieve the same effect. Eventually, he developed an approach called electrochemical weathering.

Weak acids in water normally dissolve rocks on land over time, forming an alkaline solution that runs into rivers and then the sea. Electrochemical weathering creates a stronger acid to drive much faster reactions. Still at a theoretical stage, the method involves passing an electric current through seawater to separate out chlorine and hydrogen gas, similar to the industrial chloralkali process used to make chlorine gas. The chlorine and hydrogen are then combined in fuel cells to form strong hydrochloric acid. The fuel cells would be housed in an industrial-scale plant that would collect and use the acid to dissolve silicate rocks, which are common worldwide. This would neutralize the acid and the resulting alkaline solution could then be returned to the sea. Overall, the process would help stabilize the oceans' pH, House says; oceans are currently becoming more acidic because of rising CO_2 levels.

For profit, plants could sell carbon reduction credits in a cap-and-trade scheme. House says the process could potentially absorb 1 gigaton of CO_2 annually. This would require building coastal processing plants equivalent in capacity to about 100 large sewage treatment plants, according to House and his coauthors, Michael Aziz and Daniel Schrag of Harvard University and House's brother Christopher House of Pennsylvania State University. That number of plants is "not a lot," says David Archer, an ocean chemist at the University of Chicago. Archer calls the approach "clever" and says that compared with planting more trees to take up CO_2, "with this method you have dealt with CO_2 in a more leakproof way."

The idea faces major hurdles. If put into practice today, it would cost at least $100 per ton of CO_2 removed; more efficient electrolysis and fuel cells could reduce the cost. Electrochemical weathering also uses a lot of electricity; if coal is burned to generate that power, the whole process saves less CO_2 than could have been reduced by replacing one coal-burning power plant with a plant run on carbon-free renewable energy. But in the best case, an electrochemical-weathering plant running on renewable energy could offset nearly twice as much CO_2 compared with the reduction from replacing a coal plant. The team suggests tapping into geothermal energy, which is underused because geothermal supplies are often located far from cities with high electricity demand.

Another problem is localized pollution. "Around the plant you would get a very basic solution," which could contain chlorinated byproducts, House says. These byproducts could harm sea life locally.

Researchers Greg Rau of the Lawrence Livermore National Laboratory and Ken Caldeira of Stanford University's Carnegie Institution proposed another weathering process. Called accelerated limestone weathering, their method would capture CO_2 from power plants to dissolve limestone, creating carbon-rich brine for ocean storage. Caldeira says the approach would use less energy than electrochemical weathering but would not capture airborne emissions. House's process "is on sound theoretical ground" but would likely be too expensive and inefficient to be practical unless it was run on cheap renewable energy, he says.

Nevertheless, Caldeira calls for research funding for a broad array of possible climate solutions in order "to get new ideas on the table." —ERIKA ENGELHAUPT