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Estimates suggest that olivine could be used to sequester a significant proportion of carbon emissions.

GEOCHEMISTRY

Rock's power to mop up carbon revisited

Experts push for more research into olivine weathering.

BY DANIEL CRESSEY

Last week, a group of geoengineers met in Hamburg to discuss what on the face of it sounds like a very attractive idea: to soak up anthropogenic carbon emissions using only rocks and water. In particular, they want to help to mitigate climate change by crushing rocks and dropping them into the sea or spreading them on land. The meeting was hailed a success, but the idea is still far from fruition.

The 'weathering', or breaking down, of rocks is a hugely important but very slow part of the carbon cycle. Natural weathering locks up atmospheric carbon dioxide by means of chemical reactions between common silicate minerals and air. For example, when magnesium-rich olivine, a rock of particular interest to geoengineers, is brought together with CO_2 and water under natural conditions, the resulting reaction forms magnesium carbonate and silicic acid, thereby removing and storing carbon.

But some scientists think that this natural process could be exploited to offset at least some of the carbon emitted by human activities. Rather than waiting for rocks to be slowly weathered away, olivine could be mined on an industrial scale, ground up, and spread over land or in the sea, speeding up these chemical reactions and sucking vast quantities of CO_2 out of the atmosphere. But this presents practical problems: according to one estimate, you would need to spread 5 gigatonnes of olivine on beaches annually to offset 30% of global CO_2 emissions (assuming 1990 levels of emissions; S. J. T. Hangx & C. J. Spiers *Int. J. Greenhouse Gas Contr.* **3,** 757–767; 2009).

At the informal meeting, about 20 enhanced-weathering experts discussed recent research in the area and tried to summarize and coordinate future work, for example by agreeing to standardize experiments. Until now, there has been no organized research agenda for the fledgling field, says meeting convener Jens Hartmann, who works on geological cycles and carbon sequestration at the University of Hamburg in Germany. "It was very positive; we know we are now a community," he says.

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Hartmann points out that humans have been exploiting rock weathering for decades — for example, by spreading minerals such as olivine, pyroxenes and serpentines as fertilizers. "The question is, can we optimize it and can we do it in areas we are not doing it?" he says.

As with its use as a fertilizer, olivine would have to be finely crushed to maximize its exposure to carbon. Olaf Schuiling, a geochemist at Utrecht University in the Netherlands and a passionate advocate of enhanced weathering, proposes spreading coarse olivine grains on beaches that experience heavy seas. "There the grains are tumbling around in the surf and the waves, they collide, they abrade each other, and produce very rapidly a lot of tiny olivine slivers that weather quickly," he says.

However, there is little evidence for the practical rates of weathering that could be expected if large amounts of olivine or other rocks were mined and spread on fields or dumped into the sea. This, in turn, means it is not clear how much would be needed to significantly mitigate carbon emissions, how long it would take to work or whether it would be cost and energy efficient.

In theory, one kilogram of olivine sequesters about one kilogram of CO_2, but the rate at which this happens can be slow. And the actual efficiency of sequestration will be much lower than 100%, because of the energy used — and emissions released — in grinding and transporting the rock. In some cases, this could emit more carbon than would be sequestered.

Francesc Montserrat, a marine benthic ecologist at the Royal Netherlands Institute for Sea Research in Yerseke, is trying to pin down the figures. He is using small tanks to measure the weathering of olivine in various conditions — including the impact of worms that live in and eat the sandy sediment. Montserrat's experiments will test the idea that when these worms eat tiny grains of olivine they also help to break down the crust that can form on olivine's surface, which slows down the weathering effect.

"You need to have some hard numbers to go to the authorities to say whether it will be safe enough to try it out," he says. "We have good and very promising results, but there are still a lot of unknowns."

Even advocates of this method of geoengineering admit that large-scale enhanced weathering is not without risk. Olivine can contain toxic heavy metals such as nickel that could accumulate in the environment. Grinding rocks would produce dust, which might harm human health. And putting olivine into the sea could change the pH of the water, helping to combat ocean acidification driven by climate change but also potentially harming marine organisms by altering their environment.

Phil Renforth studies carbon sequestration and minerals at the University of Oxford, UK, and attended the Hamburg meeting. He says that there is a pressing need to conduct more work on enhanced weathering given that carbon emissions are likely to continue to rise, and because of the current focus on dealing with emissions by capturing them from power stations and storing them underground.

"We're putting all our eggs in one basket if we're only looking at one method," he says. There's a real need to diversify the portfolio." ■