ENHANCED MINERALIZATION

WHAT IS ENHANCED MINERALIZATION?

Enhanced mineralization, also known as enhanced weathering or accelerated weathering, accelerates the natural processes by which various minerals absorb carbon dioxide (CO_2) from the atmosphere. This natural process, called weathering, currently converts about one billion tons each year of atmospheric CO_2 into minerals, providing reliable, long-term storage. Enhancing or speeding up this weathering process would begin with the mining and processing of specific kinds of rock, such as olivine or basalt, or with waste materials from mining, steelmaking, or other industries. One prominent proposal for implementation would involve grinding basalt into powder and spreading the powder over soils, where it would react with CO_2 in the air to form stable carbonate minerals. Other proposals involve exposing the powdered rock to streams of pure CO_2 from power plants or direct air capture facilities or using it for a related oceans-based approach to carbon removal known as ocean alkalinization.

CO-BENEFITS AND CONCERNS

+ **Improved soil quality:** depending on the type of rock used, spreading powdered rock over soils could improve soil quality by adding nutrients.

− **Concerns associated with mining:** most enhanced mineralization requires extensive mining and processing of raw materials, which raises a range of local environmental and health concerns

− **Soil and groundwater contamination:** depending on the context and the type of rock used, heavy metals could leach from powdered rock into soils or groundwater

POTENTIAL SCALE AND COSTS

The long-term potential for enhanced mineralization is very large, both in terms of annual carbon removal and cumulative carbon sequestration. A recent expert assessment estimates that enhanced mineralization could be scaled up to capture **2–4 billion metric tons of CO_2 ($GtCO_2$) per year by 2050**, with rates of more than 20 $GtCO_2$ per year theoretically possible by 2100. Estimates of the **cumulative potential in this century range from 100 $GtCO_2$ to 367 $GtCO_2$**. Cost estimates vary widely, from **less than $50 per ton of CO_2 sequestered to more than $200 per ton.**

TECHNOLOGICAL READINESS

The basic chemistry of enhanced mineralization is well understood, and the technology to mine, grind, and disperse rock is widely available. Research on enhanced mineralization as a form of carbon removal, however, remains in comparatively early stages, with much more work to be done to evaluate its efficacy and social and environmental sustainability. The first major field trials, looking at on-site weathering of mining wastes, are under way in Canada.

ENHANCED MINERALIZATION

GOVERNANCE CONSIDERATIONS

- □ **Monitoring, verification, and reporting of sequestration:** processes, standards, and technologies need to be developed to reliably measure carbon sequestration
- □ **Encouraging adoption:** incentives would be needed to encourage widespread adoption in a range of different contexts
- □ **Ensuring environmental and social sustainability:** policies are needed to ensure the environmental and social sustainability of mining, processing, transport, and application of minerals across complex supply chains.
- □ For **cross-cutting considerations**, see the What Is Carbon Removal? fact sheet on our website.

FURTHER READING

Hartmann, J., et al. 2013. "Enhanced Chemical Weathering as a Geoengineering Strategy to Reduce Atmospheric Carbon Dioxide, Supply Nutrients, and Mitigate Ocean Acidification," *Reviews of Geophysics* 51: 113–49, doi 10.1002/rog.20004.

Kantola, I.B., et al. 2017. "Potential of Global Croplands and Bioenergy Crops for Climate Change Mitigation through Deployment for Enhanced Weathering," *Biology Letters* 13. doi 10.1098/rsbl.2016.0714

Strefler, J., et al. 2018. "Potential and Costs of Carbon Dioxide Removal by Enhanced Weathering of Rocks." *Environmental Research Letters* 13: 034010. doi 10.1088/1748-9326/aaa9c4.

For more fact sheets on carbon removal, visit https://carbonremoval.info/factsheets.

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