Carbon180

Mineralization

When carbon dioxide reacts with materials such as mine waste or certain rocks, solid minerals are created and stored in formations at the earth's surface or underground. This process is called mineralization, and it's a powerful carbon removal solution.

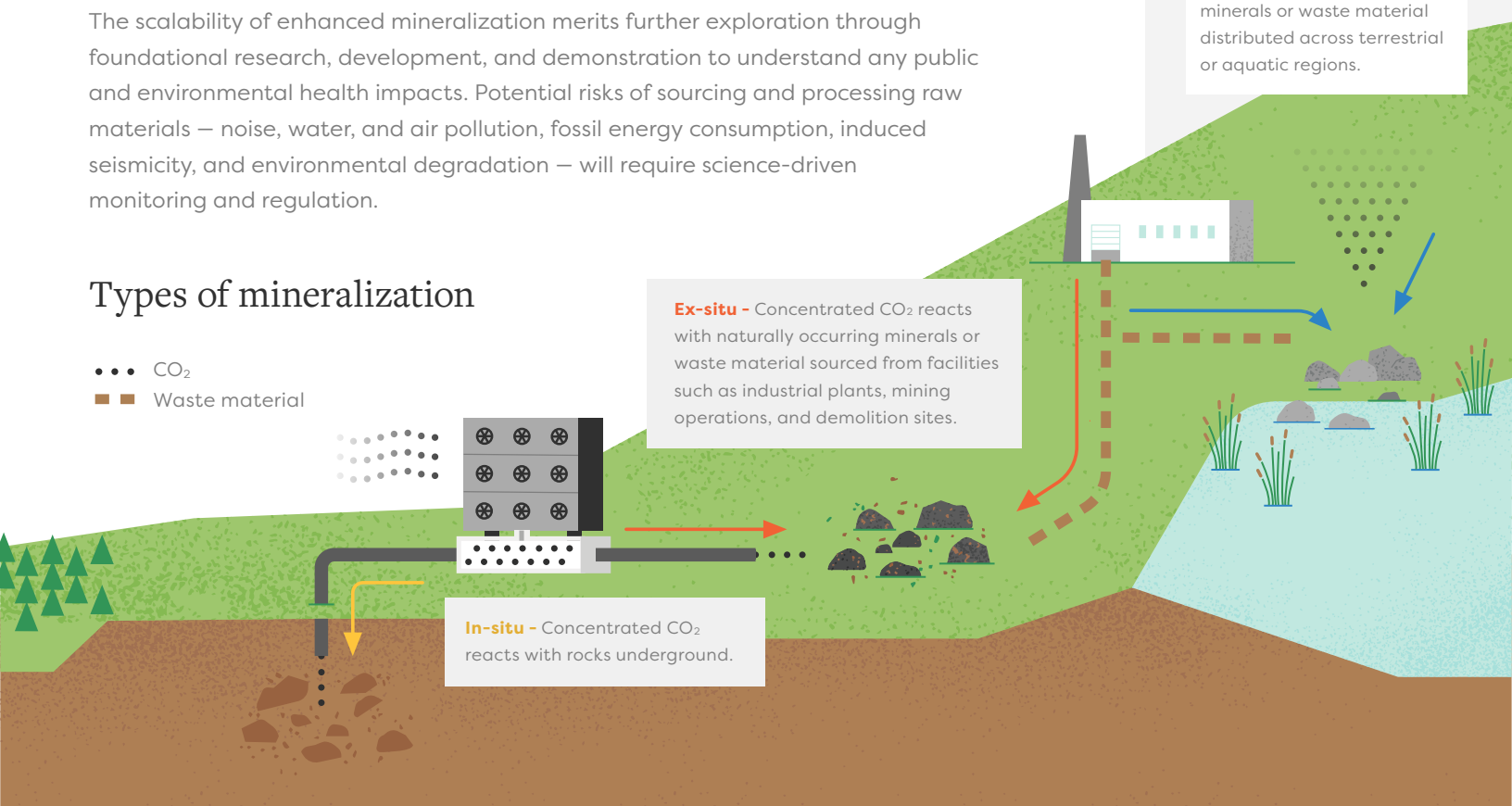
Each year, naturally occurring mineralization removes approximately one billion metric tons of carbon dioxide from the atmosphere. Enhanced mineralization — when this process is scaled by engineered methods — has the potential to sequester between five and ten billion metric tons of CO_2 annually. Mineralization is categorized three ways according to the type of material and carbon used: in-situ, ex-situ, and surficial.

Benefits and risks

Mineralization has several benefits in addition to carbon removal. Because water acidifies with the uptake of CO_2, ocean mineralization can help balance pH, restore ecosystems, and improve food security. Additionally, applying minerals to agricultural soils can increase crop yields, improve soil health, and expand carbon sequestration capacity. Mineralization can also support supply and demand for mineral products and help remediate hazardous waste.

The scalability of enhanced mineralization merits further exploration through foundational research, development, and demonstration to understand any public and environmental health impacts. Potential risks of sourcing and processing raw materials — noise, water, and air pollution, fossil energy consumption, induced seismicity, and environmental degradation — will require science-driven monitoring and regulation.

Types of mineralization



SECURING NET CARBON REMOVAL

Mineralization can help reduce CO_2 emissions or lead to permanent carbon removal. Emissions that result from the production of reactive materials (e.g., mine waste) must be taken into consideration, alongside whether CO_2 is captured at the source or pulled from the atmosphere.

CURRENT PROJECTS

Carbfix is an Iceland-based company that facilitates permanent carbon storage through in-situ methods. At the cost of $24.80 per metric ton of carbon dioxide, Carbfix turns carbon into stone underground in under two years. Carbfix established two new projects in 2021 — one intends to store one kiloton of carbon per year from a geothermal plant and the other intends to store four kilotons of carbon from Orca, a Climeworks direct air capture facility.

Pacific Northwest National Laboratory demonstrated carbon injection into basalts (in-situ mineralization) through their Wallula Basalt Pilot Project in Washington. The majority of the carbon was transformed into carbonate minerals within two years.

REFERENCES

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Current Policy Support

Less than 1% of federal carbon removal-related research and development (R&D) investments between 2002 and 2018 went towards enhanced mineralization, but a recent uptick in media coverage, academic research, and federal investment bodes well for future action.

The Department of Energy (DOE) includes enhanced mineralization as a pathway in their carbon utilization program, which focuses on early-stage R&D to develop novel ways of transforming waste carbon streams into valuable products. The R&D program includes partnerships among universities, national laboratories, and the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative, which houses DOE's Regional Carbon Sequestration Partnerships (RCSP) Initiative. RCSP characterizes regional potential for geologic storage and has carried out a small-scale in-situ mineralization field study to assess the feasibility of mineralization in oceanic basalts.

In 2018, the US Geological Survey (USGS) consulted with the Environmental Protection Agency (EPA) and DOE to survey the viability of enhanced mineralization. USGS reported on associated costs, benefits, and regional opportunities for mineralization, accounting for their proximity to carbon sources.

Despite this early progress, investment in mineralization drastically lags behind other carbon removal solutions. It will be important to increase federal R&D funding for enhanced mineralization with a focus on small-scale field experiments, feasibility studies, data collection, and feedstock inventory mapping to safely actualize its full carbon removal potential.