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Harnessing organic molecules for controlling aluminosilicate material weathering and enhancing CO_2 mineralisation

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Weathering of natural solids, particularly basalt and other alkaline rocks, and dissolution of anthropogenic materials, such as demolition waste and mine tailings, have important economic and health implications in all levels of society, industry and the environment. The behaviour that we observe at the macroscopic scale is the result of many molecular scale processes. Geochemists have studied water-rock interactions for decades, including for volcanic and impact glasses, but much remains to be understood about the role of organic compounds in such processes. At best, empirical models describe reaction rates but results are unsatisfying because each new system requires its own set if empirical constants. Improved understanding about the molecular mechanisms controlling the role of organic compounds would contribute to a breakthrough in ability to predict solid-water reactions, which would have broad implications. One implication, that is a core focus of the work in our research group, is the ability of organic compounds to hasten silicate dissolution, to release divalent cations for trapping CO_2 as carbonate minerals, converting it to solid for geologic time. In nature, some organisms produce compounds that “eat” rocks and others produce compounds that enhance precipitation. Natural weathering, enhanced weathering and other approaches to mineralising CO2 generally rely on the release of divalent cations which then react with carbonate in aqueous solutions. Thermodynamics favours these reactions but in many cases, the rates are too slow for use in a factory chimney. The goal of our current research is to learn from nature and use its tricks i) to speed silicate dissolution, thus also speeding carbonate mineral formation, ii) to control the concentration of Si and Al, which would prevent formation of clays and zeolites, that steal divalent cations from CO_2 mineralisation and iii) to enhance precipitation of some secondary phases, such as amorphous silica colloids. Diatoms, single celled algae that trap Si from water at very low concentrations and make glass coverings, might provide a key for forming such silica colloids, thus depleting the system of Si needed for clay and zeolite formation and simultaneously providing a material that could be useful as a new building material.