Evolutionary advances in tree-fungal partnerships accelerate carbonate mineral weathering

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Over multi-million year timescales, Earth's climate is controlled by the regulation of global atmospheric CO_2 concentration by the long-term sink of Ca and Mg, released through continental silicate weathering, in marine carbonates. Forests are the main biotic drivers of continental mineral weathering through symbioses with root-associated soil fungi, known as mycorrhizal fungi, that actively dissolve minerals. Because the weathering of uplifted carbonates eventually delivers Ca and Mg back into the oceans, where they are reprecipitated into carbonates, this provides a millenial-term geochemical CO_2 cycle.

Today, rapid ocean acidification, driven by absorption of about 1/3rd of the anthopogenic CO_2 release, threatens the capacity of marine organisms to precipitate carbonates. Carbonate weathering provides a major source of alkalinity for the oceans and occurs at a much faster rate than that of silicates. Important silicate rocks such as basalt contain carbonates, the dissolution of which will increase weathering of its Ca-silicates, and the resulting long-term sink for CO_2.

Here we report the effect of evolutionary advancement of trees and their mycorrhizal partnerships over the past 150 million years, on the weathering of four major types of carbonate minerals: limestone, chalk, dolomite and marble compared with basalt. In a year-long field-experiment, we buried rock grains under mature trees at the UK National Pinetum, harvesting samples every 3 months. We found weathering intensity increases from gymnosperm to angiosperm hosts and from arbuscular mycorrhizal hosts to later, but independently-evolved, ectomycorrhizal fungal partnerships. Mass loss from carbonates was 7 times higher than for basalt under ectomycorrhizal angiosperms.

Our findings indicate that evolutionary advances in trees and mycorrhizal partnerships intensified biogeochemical calcium dissolution from a wide range of carbonates. This holds important implications for short-term carbon cycling, river alkalinity and even surface ocean pH through transfer of Ca^{2+} and HCO_3^- ions from rock dissolution.