The role of forest trees and their mycorrhizal fungi in carbonate weathering and phosphorus biogeochemical cycling

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On timescales of decades-to-centuries, accelerated weathering of carbonate rocks may increase the land–ocean alkalinity flux, counteracting ocean acidification. Historical land use change and recent experimental evidence show that trees and their symbiotic root-associated mycorrhizal fungi, are key players in weathering biogeochemical cycles. Here we report the effect of the evolutionary advancement of trees and their mycorrhizal partnerships in intensifying carbonate mineral weathering within forests.

In a 2-year field-experiment at the UK's national pinetum, we buried rock grains from four carbonates (chalk, oolite, marble and dolomite) and an acid volcanic rock, under 65 mature trees from a range of species that form arbuscular (AM) or ectomycorrhizal (EM) fungal partnerships. Throughout the study, carbonate dissolution under EM trees was 12 times as fast as that of volcanic rocks.

During the first 3 months, chalk, oolite, and marble weathered significantly faster under EM angiosperm tree species than under AM trees, an effect linked to rhizosphere acidification by EM trees. Weathering peaked after 6 months for tree-mycorrhiza combinations especially within EM forest soils, confirming the important role of EM fungi in initial mineral dissolution and nutrient mobilisation.

Fungal hyphae preferentially colonised chalk and volcanic rock grains which were both relatively rich in the plant-growth limiting nutrient, phosphorus, compared to the other minerals. In the volcanic silicate, phosphorus was preferentially removed from the rock grains, especially in EM forests. Contrastingly, carbonates showed net phosphorus accumulation, most likely of biological origin.

Our analyses suggest that EM tree species substantially increase carbonate weathering, so that strategic planting of key taxa on carbonate-rich terrain could help slow rates of localized anthropogenic ocean acidification.