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Experimental geobiology links evolutionary intensification of rooting systems and weathering

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The evolution of mycorrhizal fungi in partnership with early land plants over 440 million years ago led to the greening of the continents by plants of increasing biomass, rooting depth, nutrient demand and capacity to alter soil minerals, culminating in modern forested ecosystems. The later co-evolution of trees and rooting systems with arbuscular mycorrhizal (AM) fungi, together driving the biogeochemical cycling of elements and weathering of minerals in soil to meet subsequent increased phosphorus demands is thought to constitute one the most important biotic feedbacks on the geochemical carbon cycle to emerge during the Phanerozoic, and fundamentally rests on the intensifying effect of trees and their root-associating mycorrhizal fungal partners on mineral weathering. Here I present experimental and field evidence linking these evolutionary events to a mechanistic framework whereby: (1) as plants evolved in stature, biomass, and rooting depth, their mycorrhizal fungal partnerships received increasing amounts of plant photosynthate; (2) this enabled intensification of plant-driven fungal weathering of rocks to release growth-limiting nutrients; (3) in turn, this increased land-to-ocean export of Ca and P and enhanced ocean carbonate precipitation impacting the global carbon cycle and biosphere-geosphere-ocean-atmosphere interactions over the past 410 Ma. Our findings support an over-arching hypothesis that evolution has selected plant and mycorrhizal partnerships that have intensified mineral weathering and altered global biogeochemical cycles.