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Sustainable weathering of silicate minerals driven by fungi

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Silicate weathering modulates the mass redistribution and carbon cycle, which stabilize Earth's climate and habitability. Yet the formed altered layers on silicates during weathering severely limits the sustainability of the dissolution under abiotic conditions [1]. While bacteria can actively hydrolyze the altered layers, they contribute little to the dissolution of the weathered silicates [2]. In comparison to bacteria, fungi possess additional biomechanical forces that can directly destroy the crystalline structure [3]. Fungi are capable of continuously boosting the dissolution of silicate minerals in the field. However, the effects of fungi on the dissolution of weathered silicate minerals and the underlying mechanism have yet to be determined. In the present study, we investigated the interfacial interactions of the saprotrophic fungus *Talaromyces flavus* with the preweathered olivine [nesosilicate, $(Mg,Fe)_2SiO_4$] and lizardite [phyllosilicate, $Mg_3Si_2O_5(OH)_4$] at the nanoscale using a variety of cutting-edge analytical techniques (high-resolution transmission electron microscopy-electron energy-loss spectroscopy and energy dispersive X-ray spectroscopy, high-resolution scanning electron microscopy). We found *T. flavus* hyphae produced dissolution channels on the olivine and lizardite with altered layers (thicknesses of ~65 nm for olivine and of ~3.0 µm for lizardite), eliminated the enriched Fe and Si on olivine as well as oxidized Fe(II) and disrupted crystalline structure in olivine. Furthermore, *T. flavus* hyphae significantly promoted the release of elements from the altered layers and the pristine olivine/lizardite, and the promotion became more pronounced as the contact time between hyphae and minerals increased. These results demonstrate that fungi can persistently promote silicate dissolution through the dynamic interplay of biomechanical and biochemical forces that degrade the altered layers and subsequently facilitate the transport of electrons, as well as the diffusion of metabolites and dissolved elements across the altered layers. These are novel findings with important implications for the coevolution of mycorrhizal associations and atmospheric CO_2 concentrations over geological timescales, as well as CO_2 removal via enhanced silicate weathering.

References

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