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Weathering at the fungi-biotite interface: a FIB-TEM approach.

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Classical studies of biotic weathering have mainly focussed on solution phase interactions with minerals and on the ability of plants and microorganisms to influence soil solution composition. Recently, the relevance of contact interactions between fungi and minerals in weathering has gained recognition as examplified by the fungal components of lichen or the ectomycorrhizal fungi interactions with rocks.

In the latter, the distal feeding roots of trees are entangled in a mantle of fungal mycelium from which large hyphal networks extend and explore soil organic and mineral surfaces. These fungal extensions are supported by 20-30 % of the net photosynthate of the trees, and in return, they solubilize minerals and are directly involved in the mass transfer of a large array of elements (e.g., P, N, K, Zn, Fe, Cu etc) towards the tree roots. Exudation of protons, ligands and siderophores by hyphae tips have been suggested to be primarily responsible for the weathering of minerals. However, fungal hyphae are in close contact with the mineral surface and therefore may destabilize the lattice structure of the mineral surface. At the fungi-mineral interface, the weathering is thought to be maximal. However, this interaction has been largely overlooked in weathering studies and our contribution intends to fill that gap.

We investigated the weathering of biotite induced by *Paxillus involutus* hyphae grown in symbiosis with *Pinus sylvestris* on agar-perlite system. The system were maintained

under sterile conditons and fungal hyphae have colonized the biotite surface (around one cm^2) for a duration of three months before removal of the mineral for analysis. Focused Ion Beam (FIB) sections were sampled across mature and terminal hyphae. These sections were observed at the nanoscale using high resolution analytical TEM, selected area electron diffraction and Scanning Transmission Electron Microscopy (STEM). The results indicate that hyphae tips exert a strong mechanical constraint at the biotite-fungi interface, minor chemical alterations only occur in a later stage of the weathering process.