Fungal Weathering of Micas in Spruce Forest Soils

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Chemical weathering of silicate minerals is well documented in soil profiles, and biotite and muscovite micas are primary potassium sources. Short-term weathering processes in root-zones can be represented by microbe-fungi-mineral interactions. Experimental studies demonstrated that fungi is an important player in nutrient uptake, especially under nutrient limiting conditions, and direct attachment to mineral surfaces allow fungi to exert both physical and chemical forces to take up the needed cations. The magnitude of alterations caused by fungi is difficult to quantify and its significance in larger scale weathering is still debated.

The main focus of this study was to determine the direct contribution of fungi weathering in three watersheds of the Slavkov Forest, the western Czech Republic with very distinct differences in available cation nutrients. A five-year mesh bag experiment was carried out in soils of spruce forests with felsic (Mg limited), mafic (no cation limitations), and ultramafic (K limited) parent materials. Five replicated mesh bags containing 20 grams of quartz sand and 3 wt% of biotite or muscovite were buried in the top mineral soil horizon at three slope positions in each forest. The mesh size allowed fungal hyphae and bacteria to colonize the bags but excluded direct plant root contact with the minerals. The study used various microscopic and spectroscopic techniques to estimate morphological and chemical changes of the micas and to show fungal-mineral interactions. Fungal concentration was calculated from ergosterol content of each mesh bag.

Microscopy images documented the highest (12-15%) amount of dissolution features under K limitations, while fungal attachment to mica surfaces was highly variable. However, based on ergosterol results fungal concentrations (0.30 – 0.60 ug/g of soil) were also the highest under K limitations, and the two other sites had no significant differences in fungal colonization of the bags. A decrease in major elements (Fe, K, and Mg) and silica ratios of the mica surfaces compared to the initial material were also observed under limiting conditions. No clear correlations were observed between fungal concentrations and elemental depletion ratios. The data suggest that the signature of the selective elemental uptake by fungi is overprinted by a soil solution mediated weathering over the length of the study.