Effect of postglacial weathering on phosphorus speciation in acid forest soils

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In many forest soils, phosphorus is in relatively short supply, and the mechanisms of P acquisition have been discussed. We investigated seven Swedish forest soil profiles developed in glacial till or wave-washed sand, all with a relatively short history of soil development (between 8,000 and 15,000 yrs), and with pH values ranging from 4 to 6. Six of them were Spodosols. All soil samples were investigated by XRD and P K-edge XANES, while two profiles were selected for μ-XRF and μ-XANES.

The results show a strong influence of weathering on P speciation. According to XANES-LCF, Ca phosphates (primarily apatite) accounted for between 20 and 80 % of the P in the C horizons, depending on the soil. In the upper 30 cm of the mineral soil, however, Ca phosphates were absent or low – instead P speciation was dominated by organic P in the O horizon and by PO_4 adsorbed to hydrous Fe(III) and Al(III) precipitates, mainly ferrihydrite and allophane, in the B horizon. In the latter, most of the P was found in coatings precipitated in the pores between individual particles, while in the C horizon a large part of the P was present in dispersed individual P-rich particles (e.g., apatite grains).

Despite the relatively young age of these soils, the results imply that primary mineral apatite is strongly depleted by weathering in the upper 30 cm, probably mediated by the acid pH conditions in combination with biotically driven processes. At greater depth, varying amounts of surface-reactive apatite and other P-containing minerals (such as Fe and Al phosphates) remain, constituting a possible source of P that can be accessed by deep mycorrhizal root systems. Still, however, the speciation results suggest that already after ~10,000 years the role of primary mineral apatite for plant uptake of P is limited, while mineralization of organic P and solubilization of adsorbed P species are probably more important.