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Phosphorus pools in boreal forest podzols: quantitative and micro-spectroscopic analysis

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Phosphorus (P) is a critical macronutrient for the growth and functioning of all life on earth. In forest ecosystems, the cycling of soil P is tightly controlled by biological and geochemical processes, which are interlinked but stratified across the soil profile. Previous studies have focused on biogeochemical P cycling in the topsoils including the forest floor, and characterization of P speciation in temperate and boreal forests. However, no research has been conducted to quantify the storage of P pools in the soil profile.

We combined synchrotron X-ray atomic absorption (Bulk-, and μ-XANES) spectroscopy, multi-elemental mapping by X-ray fluorescence microscopy (μ-XRF), and X-ray diffraction (XRD) to investigate the storage and distribution of P pools in upper 80 cm of the seven podzolized soils of Sweden. The samples were collected to encompass different climate and geochemical conditions as influenced by the long-term weathering and podzolization. In addition, micro-spectroscopic and mineralogical analyses were complemented by chemical extractions to determine the major biological and geochemical P controls in these systems.

The total P pool in the upper 80 cm ranged from 69.1 to 379.0 g m^{-2} of which on average, 94 % was stored in the B and C horizons. In the O horizon, 87% of the P was stored as soil organic P (SOP). In the B horizon, the pools of Fe-, and Al-bound P dominated, especially PO_4 adsorbed to allophane. Ca-bound P was nearly absent in the O horizon but its abundance increased with soil depth; the Ca-bound P, mainly apatite, ranged from 25 to 63% in the C horizon.

The results showed that podzolization has strongly influenced the P dynamics, i.e. P has accumulated in the B horizons along with secondary Fe and Al. In conclusion, subsoil P, consisting of adsorbed P and apatite, dominates the P inventory and probably serves as a long-term buffer of P at these forest sites.