Aluminum phosphate — sulfate minerals as indicator of Neoproterozoic Baltic paleosol paleoenvironment

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The aluminum phosphate-sulfate (APS) mineral solid-solutions are forming in different hydrothermal and sedimentary environments. We studied APS mineralization (< 4 wt.%) in paleosol profile developed on weathered monzogabbro-norites of Paleoproterozoic crystalline basement in northern Estonia.

APS minerals associate with kaolinite/clay matrix and are distributed in pore-space between kaolinite aggregates throughout paleosol profile. APS mineral crystallites are pseudo-rhombohedral/cubic shape with crystallite sizes <5 µm. Studied clay mineral composition change up by paleosol profile from illite, illite-smectitic to kaolinite 55 wt.% and Fe-oxyhydroxides (hematite and goethite) 25–30 wt.% rich horizon were primary mineral phases such as feldspars, biotite/mica, quartz, hematite, apatite (magmatic), anatase, zircon etc. remain strongly weathered grains. APS minerals have skeletal morphology in the upper part of paleosol (first ~1.5 m).

The APS minerals solid solutions are rich in LREE where chemical composition vary and are weathering grade dependent, for unnweathered APS crystallites from lowest part of paleosol horizon estimated chemical structural formula is ($Sr_{0.48}$, $Ca_{0.15}$, $Ba_{0.06}$, $Ce_{0.16}$, $La_{0.07}$, $Nd_{0.06}$, $Pr_{0.02}$)Al_3 $(PO4)_{1.82}(SO_4)_{0.18}$ $(OH)_6$.

The APS minerals precipitation, morphology and chemistry are closely related with weathering intensity and acidic and oxidizing meteoric waters/soil interaction down by profile. APS and an authigenic secondary apatite allows reconstruction of pH gradients in paleosol profile passing from acidic (pH 5) in the uppermost few meters thick section characterized by Sr-rich APS mineral solid solutions to progressively increasing pH with increasing depth down profile where secondary apatite prevails.