U phase evolution in the bedrock around Forsmark, eastern Sweden

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Elevated gamma emisisons from some pegmatites, cataclasites, and vein fillings were found in drillcores from Forsmark, Sweden. A proposed host for nuclear waste repositories, these findings prompted interest in the geochemistry of U in the local bedrock. Coupled with existing knowledge of the site, characterization of solid-phase U has implications for the deposition, evolution, and behavior of U in this environment. A model of the low- to moderate-temperature evolution of the area was established during preceding fracture mineral studies. Four generations of fracture minerals record the relative timings and types of fluid migration and have been traced to regional events, such as orogeny and glaciation, by means of stable isotope, fluid inclusion, radiometric dating, and fracture orientation analysis [1]. This model has contributed to a working hypothesis on the stages of U alteration: 1) Palaeoproterozoic, U was introduced, likely as uraninite, by pegmatitic intrusion, 2) formation of cataclasite, U was mobilized and uraninite was altered to pitchblende then partially coffinitized, 3) Palaeozoic, U was remobilized and U-phospate precipitated on fracture surfaces and 4) Palaeozoic or later, amorphous U-silicate formed in fractures.

Thin sections from zones of elevated gamma radiation have been analyzed using SEM-EDS. A primary (U,Pb)-oxide mineral (250 μm) confined by a rim of (Fe, Mn)-chlorite has been found in a small pegmatite. Most U phases found in pegmatites are low-Pb, probably secondary U-silicates (10-30 μm) of mutually different habit and composition (e.g. Ca, Fe, Ti, Mn, Al, and/or Ba) and are associated with minerals like chlorite, hematite, quartz, K-feldspar, and calcite. In the cataclasite, both primary (Th, U, REE)-silicates (150 μm) within pegmatite clasts and secondary U(Ca, A1)-silicates were along calcite and quartz grain boundaries. In vein fillings, disseminated grains of secondary U-silicate were found associated with laumontite, a marker within the fracture mineral generation of 1.10 – 1.03 Ga. Additionally, U-phosphates were found with pyrite, mixed layer clays, and Palaeozoic asphaltite. These findings complement the hypothesisized stages of evolution and offer new U phases for integration.

[1] Sandström *et al.* (2009) *Tectonophysics* **478**, 158-174.

Drainage water chemistry reflects monolithologic Critical Zones

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Three small (27-55 ha) catchments covered by spruce, each underlain by geochemically contrasting rocks (LYS: granite, NAZ: amphibolite, PLB: serpentinite) were studied in the Slavkov Forest, Czech Rep [1]. Hydrochemical patterns were ascertained by concurrent stream water sampling (2001-2013) and soil water sampling by lysimeters placed at five depths in 2012-2013 (Fig. 1). Three boreholes drilled to 26-30 m probed deep critical zones. Strongly acidified LYS exhibited incomplete neutralization of acidic deposition and had chronically low drainage water pH and elevated levels of toxic Al [2]. PLB exhibited the most efficient neutralization by chemical weathering. LYS was Mg deficient with respect of spruce and ectomycorrhizal fungi, PLB was P and K deficient and NAZ was not deficient in any nutrients [1,3].

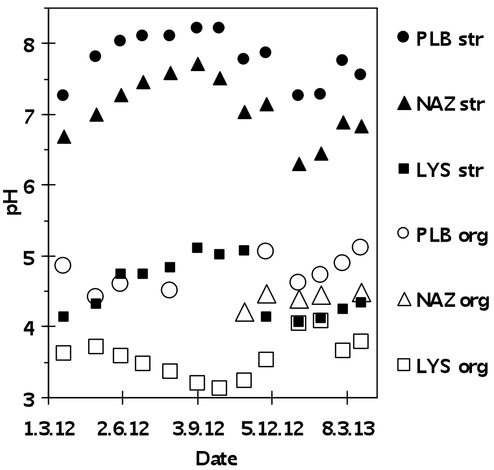

Figure 1: Temporal patterns of stream water (str) and organic horizon soil water (org) at Lysina (LYS), Na Zeleném (NAZ) and Pluhův Bor (PLB) in March 2012 - March 2013.

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[1] Krám *et al.* (2012) *Appl. Geoch.* **27**, 1854-1863. [2] Banwart *et al.* (2012) *Compt. Rend. Geosci.* **344**, 758-772. [3] Berner (2013) Doct. Thes., Lund Univ., Sweden.

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