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Impact of uranium mining activity on cave deposit (stalagmite) and pine trees (S-Hungary)

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Speleothems are well known paleoclimate archives but their potential for monitoring environmental pollution has not been fully explored. This study deals with an actively growing stalagmite whose trace-element concentration suggests anthropogenic contamination, rather then natural forcing. Paralell, as a potential independent chemo-enviromental archive, living pine (Pinus sylvestis) trees were also involved into investigation.

U production in S-Hungary started in 1957 and was expanded closer to the cave site in 1965, covering a mining plot area of ca. 65 km2. The deep-level ore production ended in 1997 and remediation of the mine site has since been completed.

Our objective was to determine the possible effect of the four-decade-long uranium (U) ore mining activity on the environment, as recorded by a cave deposit and the pine trees. The Trio Cave is located in the Mecsek Mts (S-Hungary), ca. 1.5-3 km east from the nearest air-shaft and entrance of the uranium mine. A stalagmite located about 150 m away from the cave entrance was drilled and the core investigated for stable isotope and trace element compositions. Pine trees were sampled by increment borer. Continuous flow mass spectrometry was applied on carbonate samples and laser ablation ICP-MS was applied for trace element analysis of both stalagmite (Siklosy et al., 2009) and pine samples. The youngest 1 cm of the drill core was selected for this study that may represent the last cca. 100 years (based on MC-ICP-MS age dating of older parts of the core) that covers the uranium mining period. The pre-mining period is characterized by systematic co-variations of trace elements (U, P, Si, Al, Ba, Mg, etc.) that can be related to soil activity and precipitation amount. The youngest 1.3 mm, however, records a sudden change in U content uncorrelated with any other variables. Starting from a background value of 0.2-0.3 ppm, the concentration gradually increases to about 2 ppm (within about 1 mm), remains constant for about 0.5 mm, then declines to about 1.5 ppm at the surface.

The increase in U concentration coincided with a significant decrease in d234U initial values (Siklosy et al., 2008) suggesting contribution from a U source different from the natural weathering input. This is also supported by a change in the P/U ratio and much weaker correlation of the U concentrations with P in the U-enriched section of the stalagmite ("mining-period"). According to the average growth rate of the stalagmite, this period represents the last 30-50 years.

Dendrochemical data covered the 1914-2004 period. The trace element time series derived from tree rings are characterized by plateaux-like maxima during the late-1960s and the 1985-95 period. This elevated events closely coupled to opening of two different uranium mine pits.
Two prominent peaks emerged in the U-record coinciding the 1968 and 1991 tree rings. Dendrochemical data show abrupt increase in trace elemets (most pronounced in metals) from the tree ring dated to 1966 while the sudden decrease positioned to 1998 tree-ring. The perfect agreement between the dendrochronological dates of major changes in the chemistry of the wood and the onset–offset dates of mining history gives high probability that the mining activity is the main agent responsible for this environmental change.

The possible source of U is therefore the 40-year-old Mecsek uranium mine, which produced ca. 500 tons of U concentrate per year and has reworked millions of tons of solid material (Bánik et al., 2002).

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