

SUMMARY

Thorough understanding of processes within karst unsaturated zone (including soil, epikarst and deeper part of unsaturated zone) along with description of flow conditions between particular parts of the system are objects of intensive investigations at the present time. There are several reasons:

- 1- The research of paleoclimatology and paleohydrology of karst regions is based on observation of trace elements and isotopic composition in dripstone sinters developed from drip waters whose signal is formed/affected in unsaturated zone.
- 2- The flow geometry in unsaturated zone, the response of vadose reservoir on recharge events and mean residence time of water in unsaturated zone are important parameters in designing the right measures in karst aquifers and caves protection.

Unsaturated zone above Ochozská Cave (Moravian Karst, Czech Republic) was studied for 36 months (10/2006 - 5/2008). Unsaturated zone consists of very pure limestone (low Mg as well as other elements). It is between 20 and 80 m thick. Chemistry and isotopic composition of drip waters and soil water from lysimeters in depth 0, 15, 60 cm was studied on monthly basis. In the samples Ca^{2+} , Mg^{2+} , Sr^{2+} , K^+ , Na^+ , Fe^{2+} , Mn^{3+} , Cl^- , NO_3^- , SO_4^{2-} , alkalinity, COD (chemical oxygen demand) and $\delta^{13}\text{C}$ were analysed. Electrical conductivity (EC), pH, temperature (T), dissolved oxygen (DO) and discharge (Q) in drip waters were measured. Concerning soil water the volume of collected water in no tension lysimeters was measured beside other above mentioned parameters. Rain depth was measured on daily basis 600 m far from the cave.

Since January 2007 water dyetracing was realized via 72 m thick unsaturated zone above cave. Four inert tracers were used (Na-fluorescein, pyranin, sulforhodamin B and rylux NT). Six drip places were continuously sampled by 2 automatic samplers (ZKZ 1.0) in 30 hours step. Additional 50 places were sampled on monthly basis, or more frequently during recharge events. More than 2700 samples have been collected and analyzed since the start of the tracer test.

The discharge, temperature and EC of drip water were continuously measured on E site (in 20 min. step). Chemical parameters of water were measured in through-flow cell sealed from cave atmosphere ($\text{pH} \leq 7$, $\text{DO} \leq 80\%$). Water level was monitored by pressure transducer in collecting vessel of L15 no tension lysimeter in order to record recharge events from soil to topmost epikarst.

On the base of these continuous measurement (record from L15, Q, EC, and tracer concentration in the drip water at the E site) conceptual model of unsaturated zone was designed.

Evapotranspiration in various depths in soil and epikarst was calculated based on chloride and water balance approaches. Subsequently, the mass balance for individual ions were calculated and sources, sinks and fluxes were estimated. We have found pronounced influence of atmospheric deposition and vegetation uptake/release on Mg^{2+} and K^+ mass fluxes.

Depth intervals of intensive carbonate rock dissolution were established based on chemical analysis of cave drips from different depths 5 - 80 m (the Ochozská Cave and small shallow caves in its close surrounding).

Time series of individual ions and $\delta^{13}\text{C}$ in drip water have been compared with continuous signal of EC, Q and dye tracer concentration (tracer clearly marks water from epikarst) to test whether the variation in concentration can be explained by natural processes.

On two diverse drips 1) drip O - intensive degassing of CO_2 ; and 2) drip E2 (no degassing) the chemical and isotopic data have been compared. Degassing of water strongly affects chemical and

isotopic signal water from unsaturated zone. Use of molar ratios Mg/Ca or Sr/Ca, which are the common toll in paleohydrological studies, is complicated in this case thanks to:

- 1) Predominant source of Mg is not the carbonate rock/unsaturated zone as commonly supposed by researches but the precipitations at this locality
- 2) Degassing has predominant affect on chemical and namely isotopic (^{13}C) composition of drips.

To avoid the second effect the water should be measured and sampled directly from tubing attached to drip place and sealed from cave atmosphere.