AN ENVIRONMENTAL IMPACT OF ANTHROPOGENIC CO_2-FLUXES IN THE CÍSAŘSKÁ CAVE (MORAVIAN KARST, CZECH REPUBLIC)

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Abstract: Comparing the CO_2-peaks at staying of persons in cave with cave drip water chemistry suggests that cave CO_2 does not reach the concentrations, at which both the carbonate species in drip water and in cave air are at equilibrium. Under given conditions, the drip waters will continue (1) in further CO_2-degassing and (2) in increasing of the current supersaturation. The threshold values, at which water would became aggressive with respect to calcite, log $p_{CO2[soil]}$ about -2, were not reached. Generally, a reversion of speleothem growth into speleothem dissolution by human breath impact is highly improbable; it would need really extreme conditions.

Key words: atmosphere, carbon dioxide, cave, dissolution, dripwater, flux, growth, speleothem

INTRODUCTION

Carbon dioxide is a key component controlling carbonate karst processes as limestone dissolution and speleothem growth/dissolution. In general, the driving force of the later process is the difference between the CO_2 partial pressures in upper epikarst and in cave atmosphere. Whereas epikarst CO_2-levels are relative invariant, cave CO_2-levels are widely variable. The instantaneous CO_2-level in cave represents a steady state, at which the sum of CO_2-fluxes into cave equals to the sum of all CO_2-fluxes out away from cave. The total CO_2-flux into cave can consist of both natural and anthropogenic fluxes. The total CO_2-flux out away from cave is controlled by cave ventilation that depends on cave geometry and differences in the pressures/temperatures of the cave and outer atmospheres. The role of cave CO_2 was tested in the Císařská Cave (Moravian Karst, Czech Rebublic). The goal of the work is (1) to distinguish between natural and anthropogenic CO_2, (2) to quantify single CO_2-fluxes, and (3) to estimate a potential risk of the anthropogenic CO_2 for cave environment.

METHODS

The monitoring was carried out in winter 2005 at ventilated/unventilated cave, with/without human presence. CO_2 was monitored by CO_2-meter (IR-detector FT A600-CO2H linked with the ALMEMO 2290-4 V5 meter, Ahlborn, Germany). ^{222}Rn as conservative component was monitored by Rn-meter (α-detector, PRASSI-5S, SILENA, Italy). Temperature was monitored by GFTH 200 digital hydro-/thermometer (Greisinger electronic GmbH, Germany). Airflow rate was measured by anemometer EA-3000 (Europe Supplies Ltd.) at the door windows. Dimensions of the Nagel Dome was estimated under using of ultrasonic length meter TCM 220 050 (Tchibo GmbH, Germany). Speciation calculations were performed by using of computer code PHREEQC (Parkhurst and Appelo, 1999).

RESULTS

^{222}Rn as a "conservative component" (Rn-flux was presumed to be constant and unchangeable by a human activity) and CO_2 were monitored in cave atmosphere at standard and depressed ventilation rates and wit/without human presence. Rn-level evolved from 700 at standard ventilation to 1200 $Bq.m^{-3}$ at depressed ventilation. CO_2-levels increase from initial 600 – 800 vol. ppm to 1000 – 1500 vol. ppm, depending on the number of present people. At standard ventilation, these CO_2-levels returned to the initial values in 15 – 24 hours. At depressed ventilation, on the other hand, the decrease was very slow. A dynamic one-reservoir model was used to interpret monitored data. Two CO_2-fluxes into cave were distinguished: (1) natural flux of about $9x10^{-6}$ $m^3.s^{-1}$ relating to a flux density of $3x10^{-9}$ $m^3.m^{-2}$ s^{-1} and (2) anthropogenic flux of about $2x10^{-4}$ $m^3.s^{-1}$ relating to an average partial flux of $8x10^{-6}$ $m^3.s^{-1}$ $person^{-1}$. Comparing cave CO_2-concentrations with cave drip water chemistry suggests that the CO_2-peaks at staying of persons in cave, log p_{CO_2} ~ -2.8 on average, do not reach the concentrations, at which the carbonate species in drip water and in cave air are at equilibrium, log $p_{CO_2[d.w.]}$ about -2.75. Under these conditions, the drip waters will continue (1) in further CO_2-degassing and (2) in increasing of the current supersaturation, $SI_{(calcite)}$ about 0.8.

Maximal reachable CO_2-concentrations under given conditions are the *hypothetical steady states at continual staying of the person in cave,* log p_{CO_2} about -2.5 at enhanced ventilation and log p_{CO_2} about -2.1

at suppressed ventilation. These concentrations would exceed the $p_{CO_2[d.w.]}$ values, -2.75, and CO_2-degassing would be inverted into CO_2-dissolution. In this case, dripwater supersaturation would decrease.

The threshold values, at which would water became aggressive with respect to calcite, log $p_{CO_2[TV]}$ below -2, were not reached even so the hypothetical steady state at continual staying of persons in cave at suppressed ventilation, log p_{CO_2} ~ -2, approaches very closely this value.

SUMMARY

The presented study models fluxes and levels of cave CO_2 depending on different conditions. Comparison both actual and hypothetic CO_2-levels with dripwater chemistry question a hypothesis that speleothem growth could be reversed into dissolution by human breath impact. Such event could eventually became only at an long-term/continual staying of extremely high number of persons in unventilated cave, particularly at (1) elevated natural cave CO_2-levels and (2) reduced soil CO_2-concentrations, influencing negatively drip water chemistry (i.e., in dry seasons, in winter or in regions with a poor soil profile).

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REFERENCES

Parkhurst, D. L. – Appelo, C. A. J. 1999. User‘s guide to PHREEQC (Version 2) a computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations: U.S. Geol. Surv. Water-Res. Investig. Report 99-4259, 312 p.