ADVANCES IN THE CAVE AEROSOL RESEARCH: A CASE STUDY IN THE SELECTED CAVES OF THE MORAVIAN KARST (CZECH REPUBLIC)

Jiří Faimon[1] – Miroslav Komberec[1] – Jindřich Štelcl[1] – Pavel Slavík[2]
[1] Masaryk University, Institute of Geological Sciences, Kotlářská 2, 611 37 Brno, Czech Republic; faimon@sci.muni.cz
[2] Children Sanatorium with Speleotherapy, 679 14 Ostrov u Macochy, Czech Republic

Abstract: Aerosols were monitored in (1) atmospheres of the Císařská Cave and the Sloup-Šošůvka Caves and (2) outer atmosphere outside the caves. Both cave aerosol (CAS) and aerosol of outer atmosphere (ASOA) are polydispersive. They are composed of big particles (sharp-edged particles, 3 – 20μm in diameter) and super-fine matter (aggregates, 0.8 – 1.2 μm in diameter, composed of spherical particles, 30 – 100 nm in diameter). The composition of big particles (Si, Ca, Al, Fe as major elements) indicates an origin from minerals. The morphology of super-fine matter suggests a condensation as an origin mechanism. This is also confirmed by significant amounts of sulfur (Ca and S dominate in ASOA) and other elements (P, K, Cl) in the super-fine matter. The little differences between CAS and ASOA do not support a hypothesis that CAS could be an essential factor at speleotherapy.

Key words: aerosol, atmosphere, cave, composition, morphology

INTRODUCTION

Aerosol is defined as a system of solid or liquid particles of dimensions in the range from 1nm to 10 μm (1 x 10^{-9} to 1 x 10^{-5} m) dispersed in gas (atmosphere). Mechanisms of aerosol formation are (1) "disintegration" of big liquid or solid particles into smaller ones or (2) condensation of small particles from a homogeneous medium (e.g., from supersaturated vapor). Aerosol can be stable for certain time period because of (1) absence of sedimentation (due to low particle weight and thermal motion) and (2) existence of repulsive forces between particles (due to equal electric charge). Destruction of aerosol becomes by aggregation (binding of particles into bigger ones) followed by sedimentation.

Aerosols can be an important part of cave atmosphere. They are believed (1) to participate on a special speleothem growth and (2) to operate medicinally during speleotherapy.

The aim of the study is (1) to check cave aerosol composition and morphology, (2) to find differences between cave aerosol and outer aerosol, and (3) to verify influence of seasonal and local condition.

METHODS

Aerosol was monitored in (1) atmosphere of the Císařská Cave, (2) atmosphere of the Sloup-Šošůvka Caves, and (3) outer atmosphere outside the caves. The aerosol particles were retained on membrane filters. Atmosphere/speleo-atmosphere was filtered (about 10 m^3 per filter) by especial geochemical apparatus consisting of a steel probe with filter (Pragopor 11, pore diameter of 50±10 nm), two-chamber membrane pump (KNF, N 035.1.2 AN.18, 55 l/min) and standard gas-meter (G5 RF1, Qmax = 10 m^3/hour).

The filter with particles was covered with aurum in vacuum and imaged by method of electron microscopy (ISI SEI, 3,0 kV, X75 000). Alternatively, the filter was covered with carbon in vacuum and analyzed by method WDX (electron microprobe CAMECA, SX 100).

RESULTS AND DISCUSSION

Particle morphology. Both cave *aerosol* (CAS) and *aerosol of outer atmosphere* (ASOA) are polydispersive. They are composed of big particles and superfine matter. The big particles of 3 – 20μm in diameter are sharp-edged and probably represent mineral fragments dispersed in atmosphere (disintegrated big dust particles). The super-fine matters of both CAS and ASOA are composed of aggregates (0.8 – 1.2 μm in diameter) built by spherical particles of 30 – 100 nm in diameter (probably formed by condensation). The morphology of CAS and ASOA aggregates is very similar; ASOA aggregates seem to be somewhat less ordered.

Particle composition. Aerosol composition is largely variable – it changes locally and seasonally. The composition of big clastic particle (Si, Ca, Al, Fe as major elements) supports the hypothesis about their origin from minerals. The super-fine matters contain significant amounts of sulfur (Ca and S dominate in ASOA) and other elements (P, K, Cl).

SUMMARY

- Aerosol big particles are probably formed by mineral phase disintegration.
- Ultra-fine matter composed of aggregates of nanometer-sized particles was probably formed by condensation.
- The significant differences between cave aerosol (CAS) and aerosol of outer atmosphere (ASOA) are given by sulfur content. Less sulfur was found in CAS, whereas it often dominated in ASOA. The differences in the sulfur contents suggest that a part of CAS originates in cave independently on ASOA.
- The little differences between CAS and ASOA question a hypothesis that CAS could be an essential factor at speleotherapy.

This work was funded by the grant 205/03/1128 of the Grant Agency of Czech Republic and by the Children Sanatorium with Speleotherapy in the Ostrov u Macochy (Czech Republic).