EXPERIMENTAL EVOLUTION OF THERMAL WATER-RELATED PRECIPITATES

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1. MOTIVATIONS

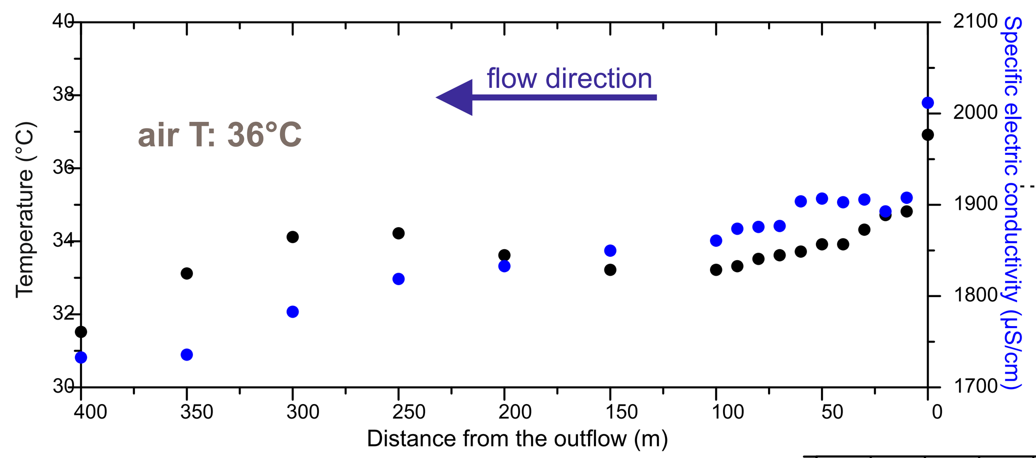
The active hypogenic karst area of Buda Thermal Karst (Hungary) is a good natural laboratory to study mineral precipitation processes. Around thermal springs carbonates and biogeochemical precipitates are the most abundant.

The goals of the research:
– study the evolution of thermal water-related precipitates with in situ experiment in time and with changing aquatic chemistry
– demonstrate the relationship between the evolved precipitates and the parent fluid flow component

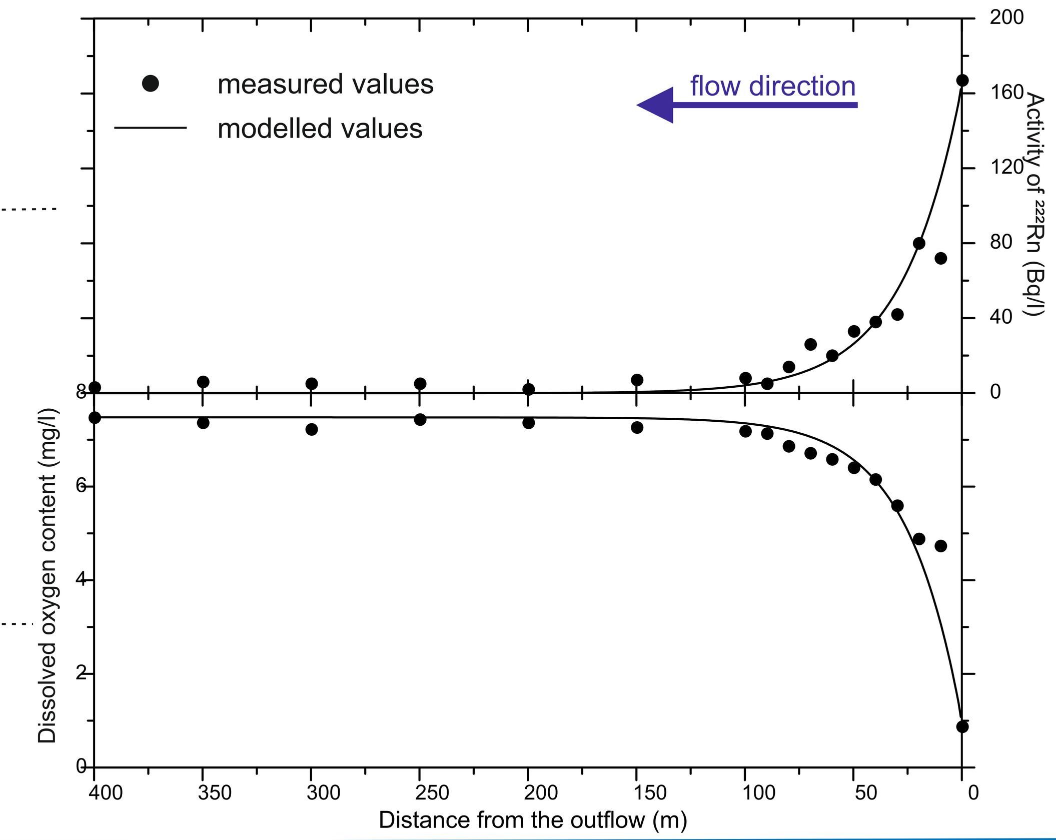
2. THE IN SITU EXPERIMENT AND METHODS

Two-phase in situ experiment in a controlled environment:
– 1st phase: 1-day-long experiment along a 400-m-long flow path
 aquatic chemistry: temperature, pH, specific electrical conductivity (EC), dissolved oxygen content (DO), concentration of Ca^{2+} and HCO^{3-}
 parallel reactive transport modelling (PHREEQC)
– 2nd phase: 3-months-long experiment along a 130-m-long flow path
 glass slides in different distances from the outflow, perpendicular to the flow direction
 aquatic chemistry: temperature, pH, specific electrical conductivity, dissolved oxygen content, concentration of major Ca^{2+} and HCO^{3-}
 precipitates: stereo and transmitted light microscopy (TLM), scanning electron microscopy (SEM), X-ray powder diffraction

3. 1ST PHASE – aquatic chemistry and reactive transport model

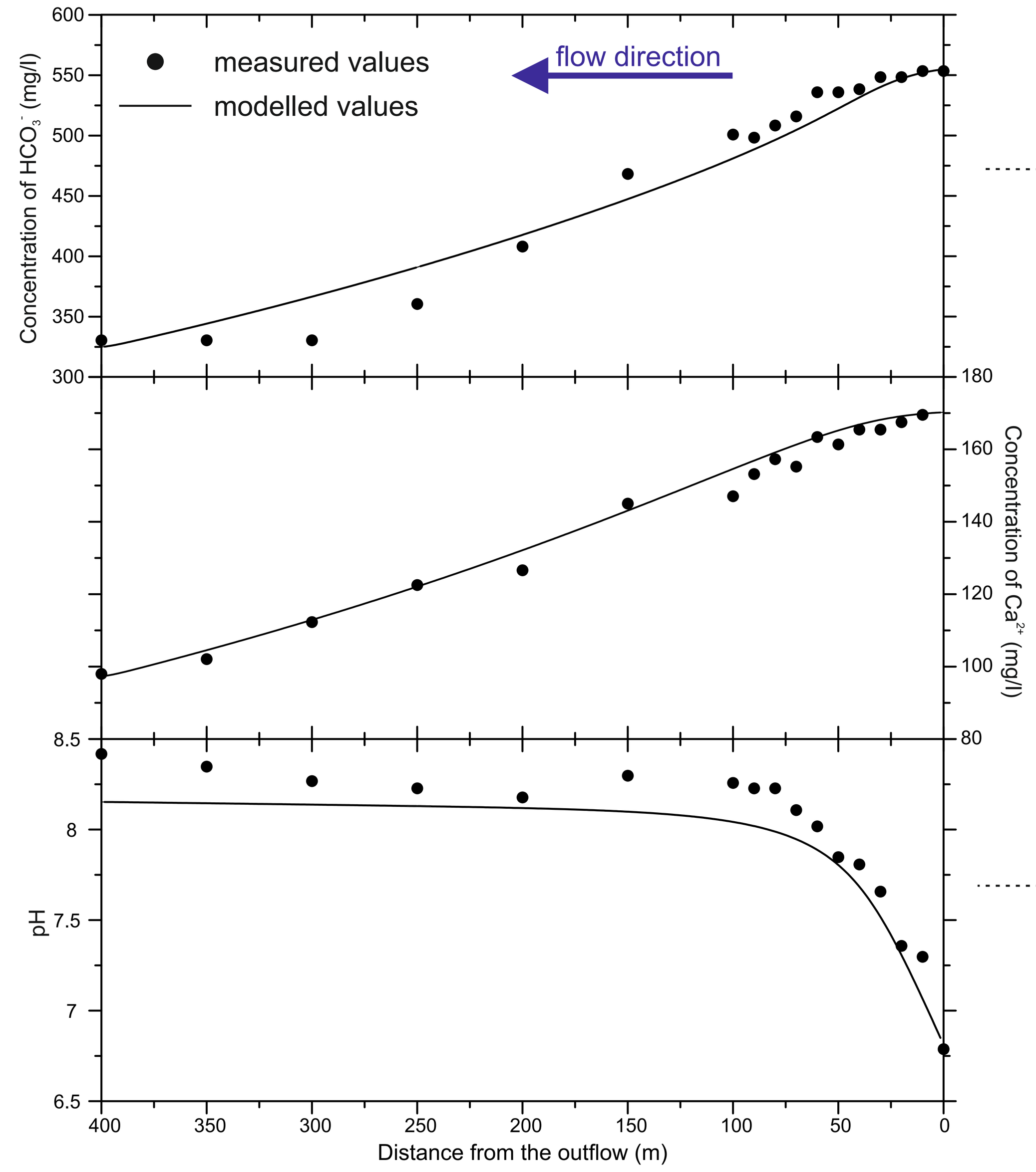


– continuously decreasing EC
– generally decreasing T, increasing between 150 and 250 m



– decreasing ^{222}Rn activity – degassing
– stable ^{222}Rn activity after 100 m
– good agreement between measured and modelled values

– increasing DO – change from reductive to oxidative environment
– stable DO after 100 m
– good agreement between measured and modelled values



– continuously decreasing HCO_3^- concentration
– immediate HCO_3^- drop in the model

– continuously decreasing Ca^{2+} concentration
– initially slow Ca^{2+} decrease in the model

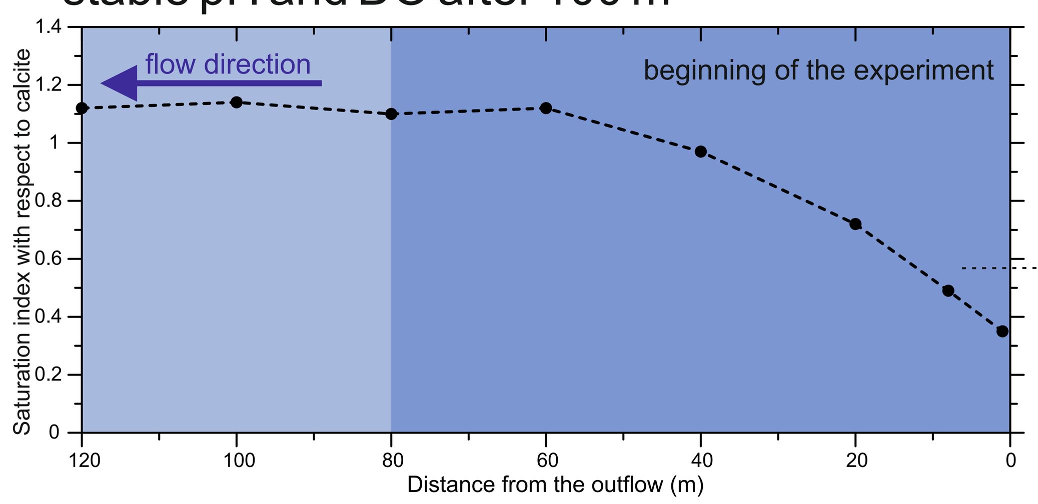
– increasing pH until 100 m, stable pH after 100 m
– the model underestimates pH

4. CONCLUSIONS OF THE 1ST PHASE:

– significant changes in the first 100 m
– continuous $CaCO_3$ precipitation is expected
– ingassing and degassing processes are controlled by pure chemical reactions
– in the variations in pH and in the concentrations of Ca^{2+} and HCO_3^- other processes also take part

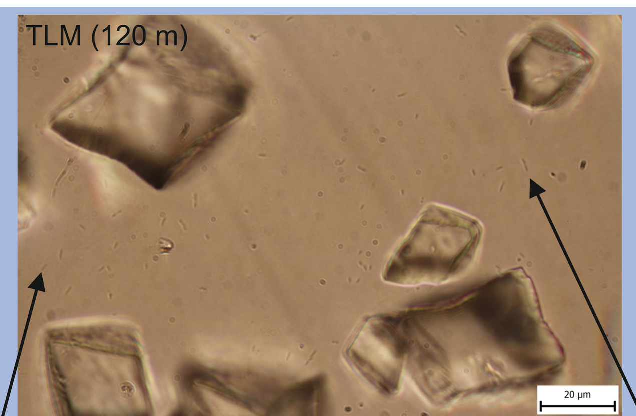
5. 2ND PHASE – aquatic chemistry and precipitates

– same variations as in the 1st phase
 continuously decreasing T, EC, Ca^{2+} and HCO_3^- concentrations
 increasing pH, DO
 stable pH and DO after 100 m



Beginning of the experiment

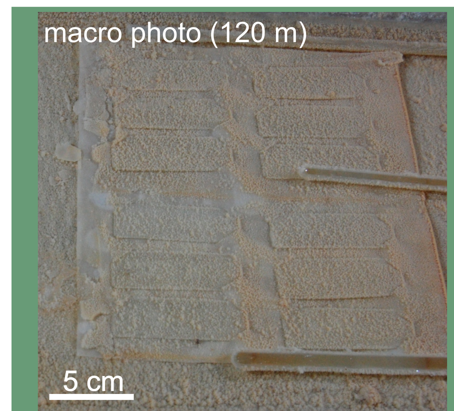
– supersaturation (>0) along the whole interval
– increasing saturation index with respect to calcite until 60–80m



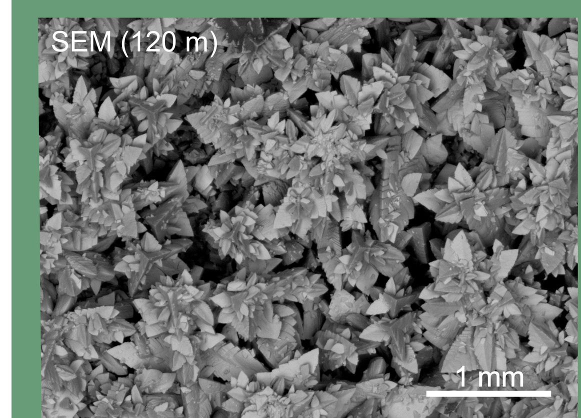
rod-shaped and filamentous bacteria, crystals of diameter 20–30 µm

after two days

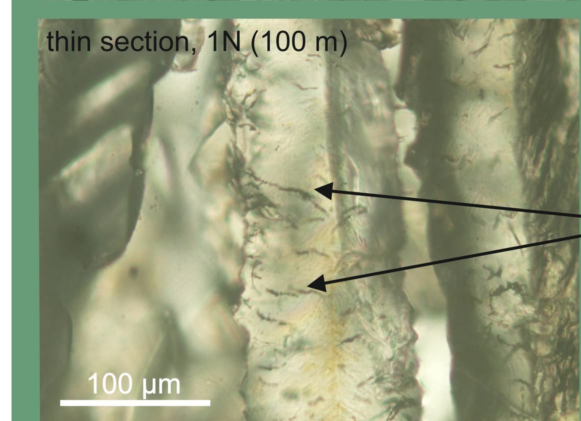
rod-shaped and filamentous bacteria attached to the glass slides



yellowish white calcite formed after 40 m

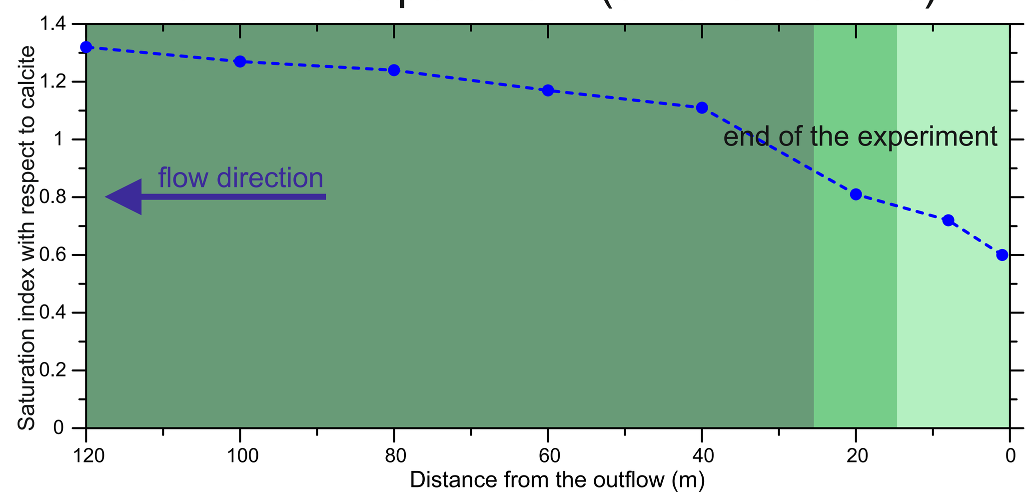


dendrite crystals with serrated edges, arranged into brunches

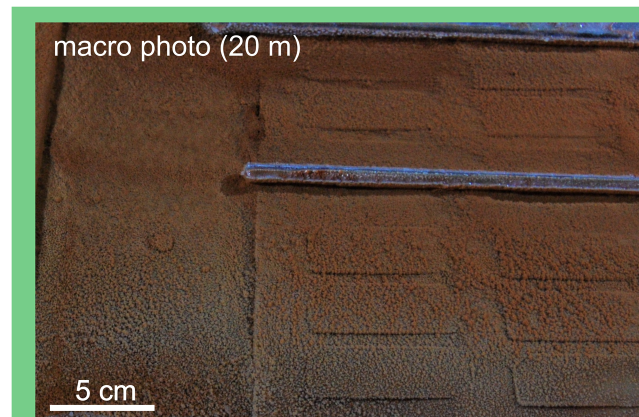


20–50 µm long red filaments inside the calcite crystals

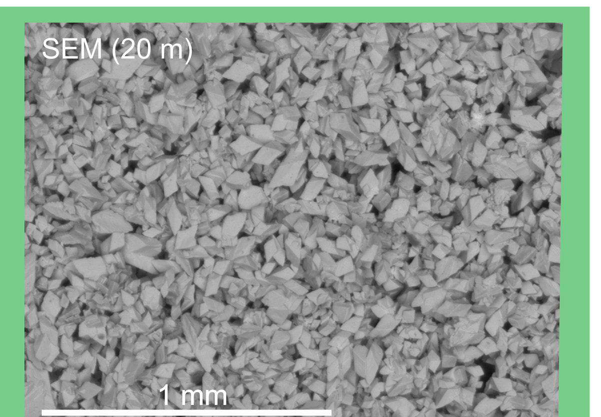
End of the experiment (after 3 months)



increasing calcite supersaturation along the whole section

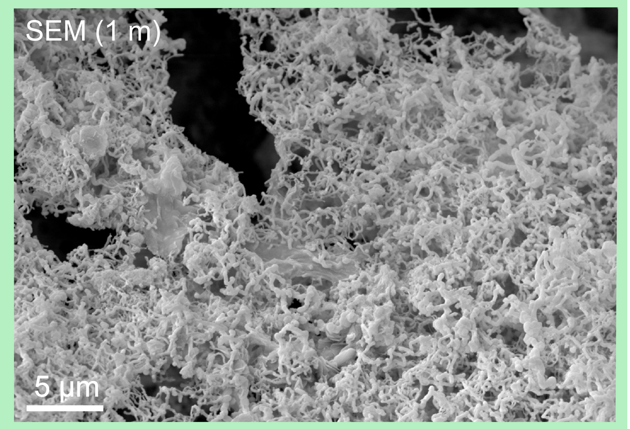


red calcite formed around 20 m



rhombohedral calcite crystals uniformly cover the surface

red amorphous, loosely attached FeOOH, identified as biofilm between outflow and 15 m



filamentous bacteria build up the biofilm

6. CONCLUSIONS OF THE 2ND PHASE:

– chemical and additional microbiological reactions take part in precipitation, the former dominates close to the outflow, while the latter futher away
– bacteria attached to the slides in the vicinity of the outflow
– $CaCO_3$ precipitates at SI>0.8
– rhombohedral calcite crystals grow at relatively low supersaturation
– dendrite calcite crystals grow at relatively higher supersaturation
– bacteria try to inhabit calcite surfaces too, but chemical precipitation suppresses biological one

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