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MineATES

Microbial Response to Thermal Energy Storage and Extraction at the MTES Site Reiche Zeche

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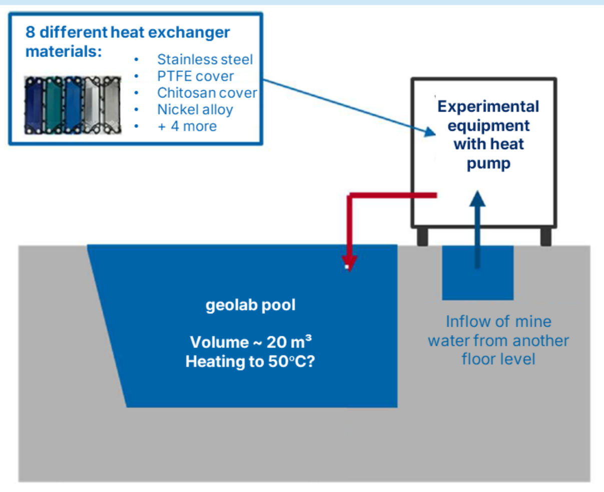
Study Site and Experimental Setup

Real laboratory Reiche Zeche

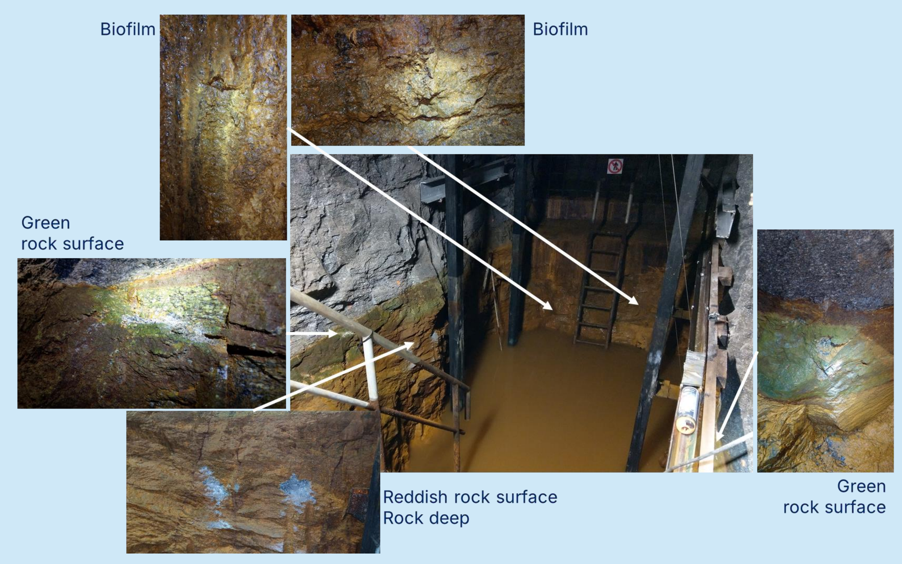


Mine water characteristics:

Parameter	Value incl. unit
Temperature	11.6°C
pH (water)	2.6
Redox potential	556 mV (Eh) → oxidizing
O_2 - dissoved	9.56 mg/l (93.5%)
Fe^{2+} (total)	0.39 mg/L (22.65 mg/L)
SO_4^{2-}	552 mg/L

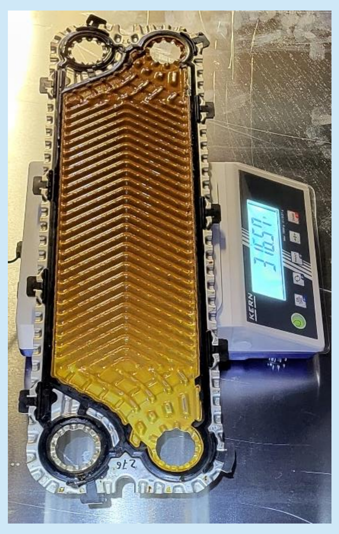
Microbiological Sampling & Community Characterization (16S rRNA gene)

Rock & rock-attached biofilms

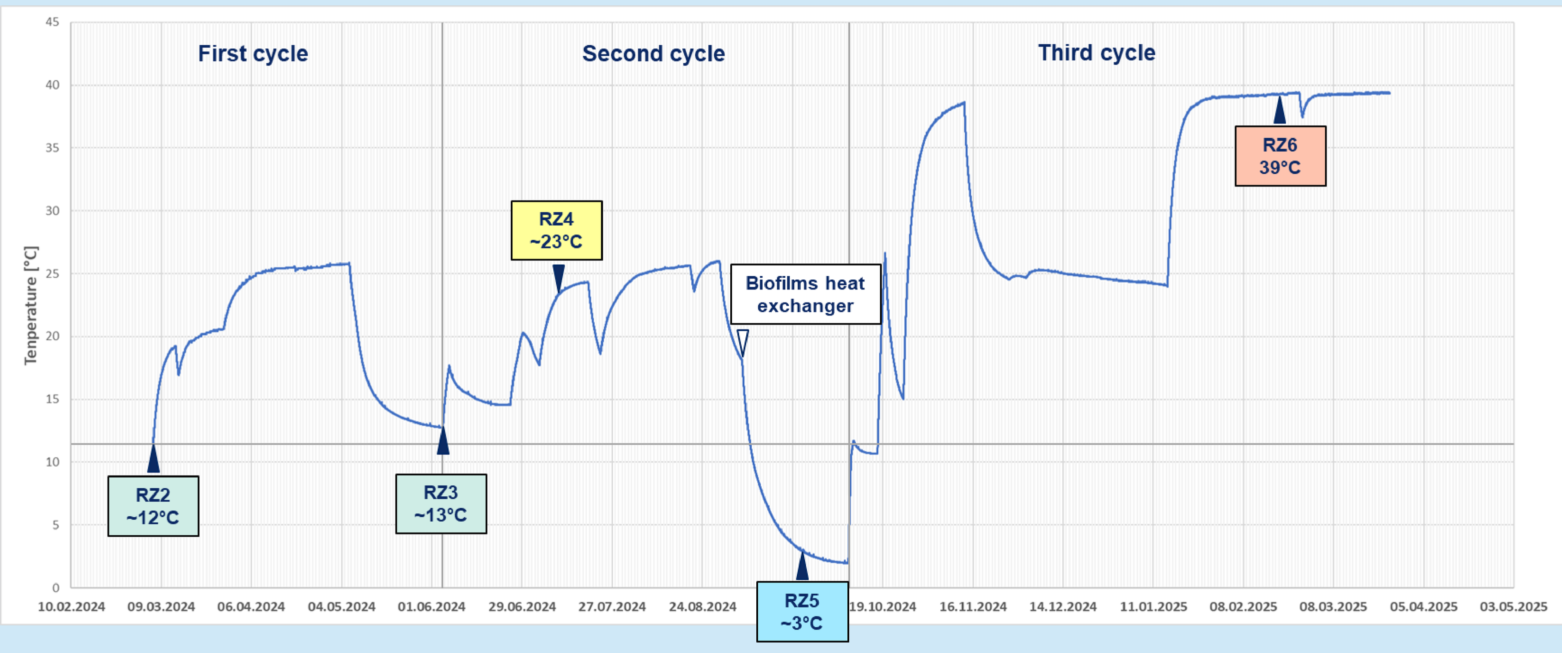


Water

Heat exchanger (HE) biofilms



Water Temperature Cycles and Sampling Times



Summary and Take Home

Water microbial community composition

- Impacted not only by temperature, but also by accompanied hydrochemical conditions of the mine water (A)
- Community generally dominated by iron oxidizers (C), with increasing relative abundance upon **slight warming (RZ2 → RZ4)**
- **Cooling (RZ5)**: dominant iron oxidizers decreased although general bacterial abundance increased (B)
- **Heating, rising pH, lowest Fe^{2+} and O_2 contents (RZ6)** further reduced iron oxidizers, but selected for *Acidithrix* and *Thiomonas* – capable of also **iron reduction** or **sulfur oxidation**
- **iron oxidizers** less competitive at higher pH and temperature
- **sulfur oxidation** by *Thiomonas* is preferred process at acidic pH and when Fe^{2+} is oxidized
- **Iron reduction** by *Acidithrix* is preferred process at anaerobic or low oxygen conditions and when Fe^{3+} is present

➢ Switch of community = switch of metabolic processes?

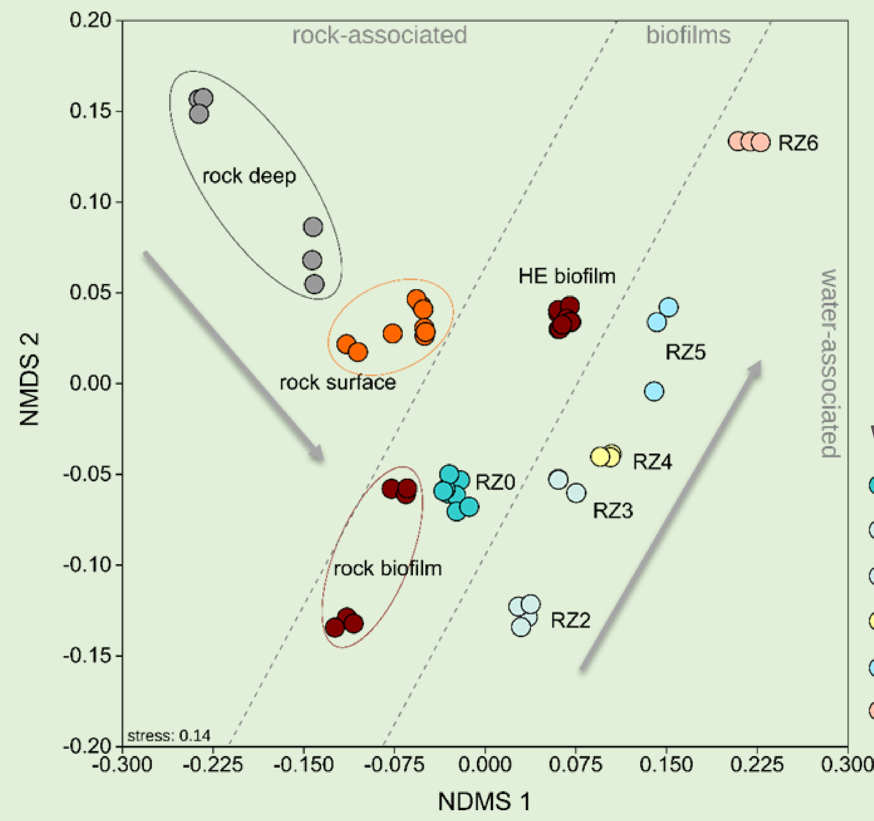
Conclusions:

- Assumed that processes are active at higher temperature
  - Iron reduction could reduce scaling
  - Sulfur oxidation could mitigate fouling
- But biofilms can still impair heat transfer on heat exchangers

Microbial Community Structure

Structuring according to habitat type:

- Rock-associated
- Biofilms
- Water-associated



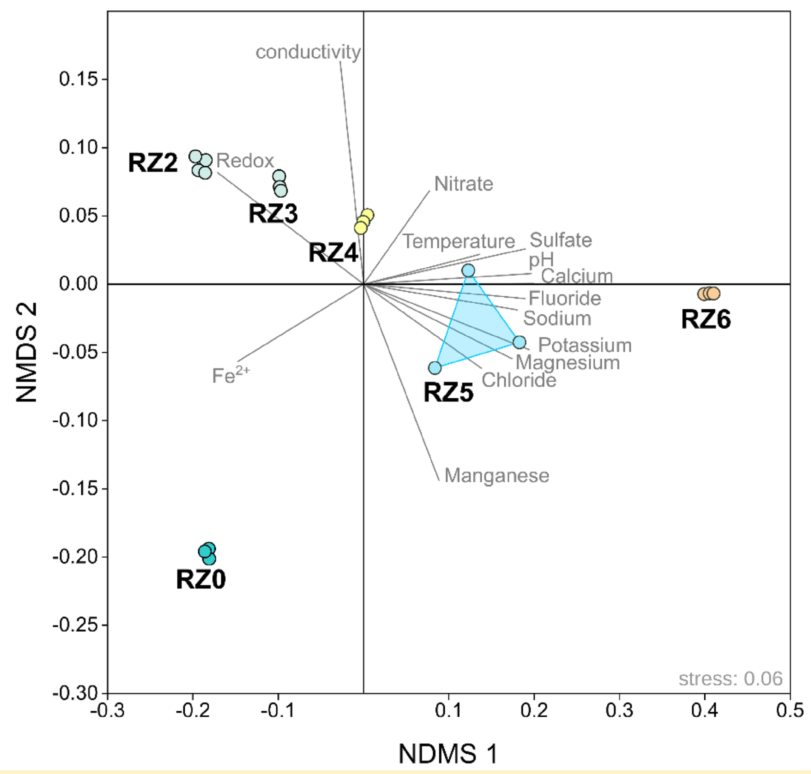
Succession of water community over time with changing physico-chemical conditions

Water samples:

- RZ0 - initial, prior to construction
- RZ2 1st cycle - 12 °C
- RZ3 2nd cycle - 13 °C
- RZ4 2nd cycle - 23 °C
- RZ5 2nd cycle - 3 °C
- RZ6 3rd cycle - 39 °C

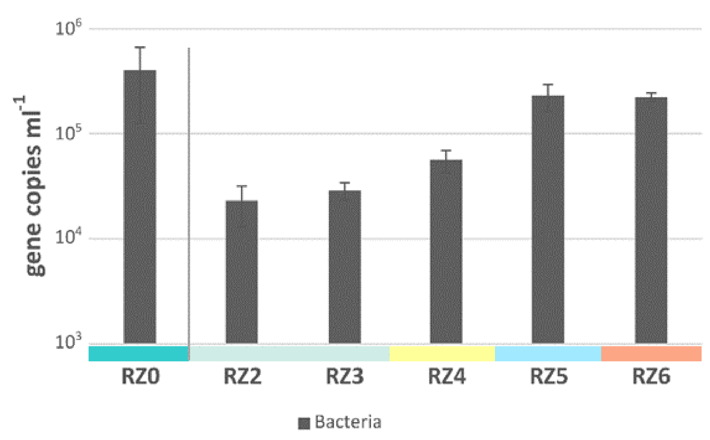
Impact of Temperature Changes on …

A …Hydrochemical conditions and water microbial community



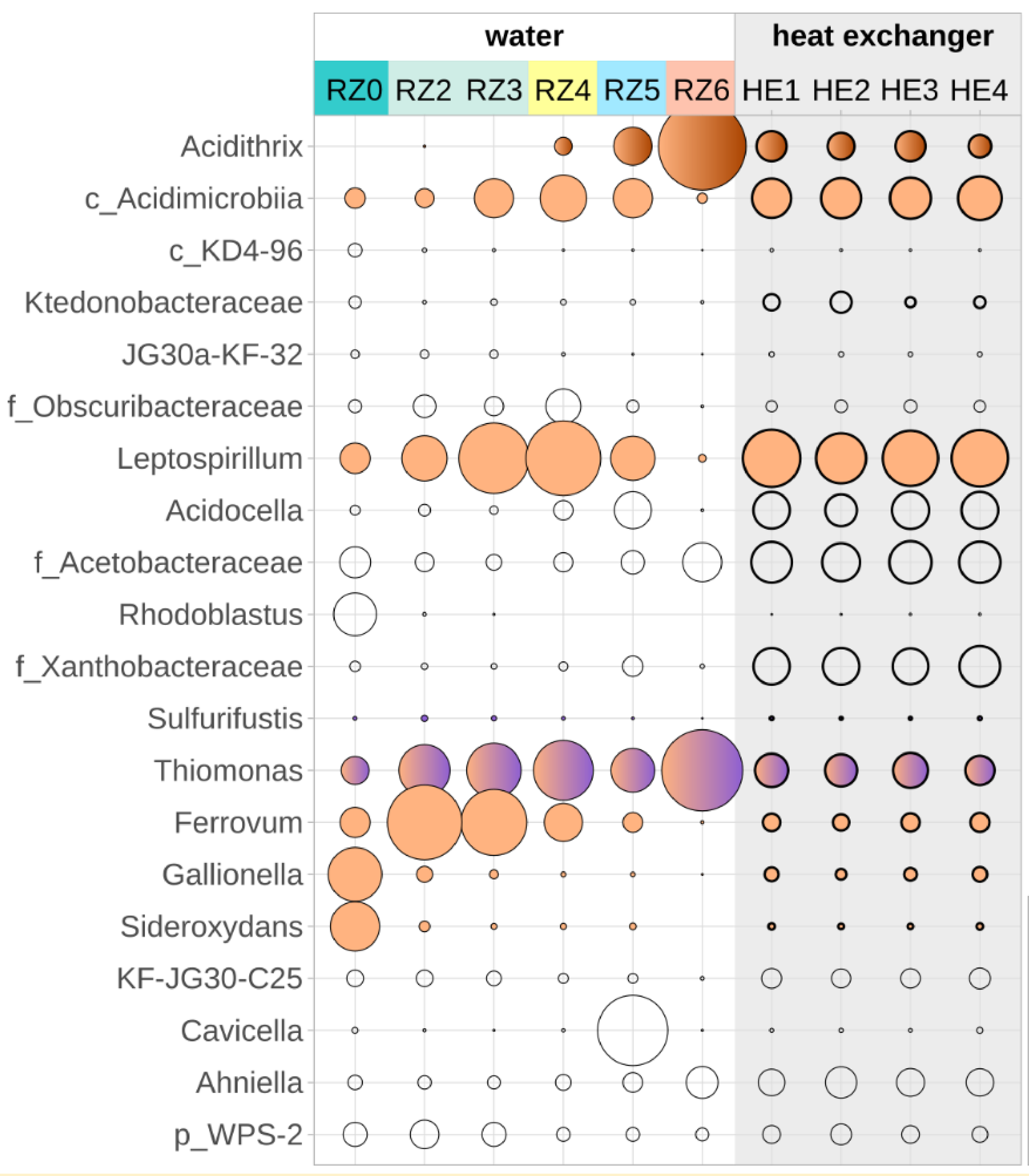
- **Temperature fluctuations cause changes of hydrochemical conditions**
- **Those are related with shifts in the microbial community**
- **Succession of water-associated community significantly correlates with:**
  - Temperature
  - Decreasing O_2 concentration (with increasing temperature 9.2 → 5.5 mg/L)
  - Decreasing redox potential (600 → 492 mV)
  - Increasing cat- and anion concentrations
  - Increasing sulfate content (663 → 956 mg/L)
  - Increasing pH (2.7 → 3.6)
  - Fluctuating but decreasing Fe^{2+} concentration (0.4 → 0.04 mg/L)

B … Bacterial abundance



- Reduced bacterial abundance at beginning of experiment (RZ2), presumably due disturbances during the construction works
- Constantly increasing abundance during the experiment **independent of temperature cycles**

C … Water microbial community composition



Metabolic capabilities

- iron oxidation + reduction
- iron oxidation
- iron + sulfur oxidation
- biofilm former