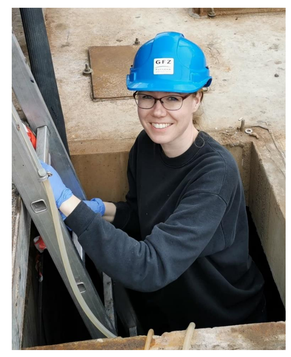
julia.mitzscherling@gfz-potsdam.de
or follow on X @JuliMi87
@GeoBioGFZ



Microbial diversity in a saline siliciclastic aquifer at the ATES exploration site Berlin-Adlershof

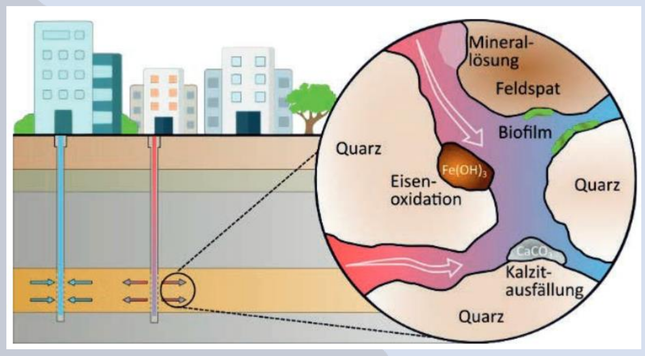
Julia Mitzscherling[1], Lioba Virchow[2], Martin Gitter[3], Armando Alibrandi[1], Simona Regenspurg[2], Stefan Kranz[2] and Dirk Wagner[1,4]

[1]GFZ German Research Centre for Geosciences, Section Geomicrobiology, Potsdam, Germany; [2]GFZ German Research Centre for Geosciences, Section Geoenergy, Potsdam, Germany; [3]Technische Universität Berlin, Department of Applied Geochemistry, Berlin, Germany; [4]University of Potsdam, Institute for Geosciences, Potsdam, Germany

Motivation

- **Aquifer Thermal Energy Storages (ATES)** can **store** excess **energy (heat)** and **provide** it when required
- **microbial activity** can **impair** the **efficiency and integrity** of ATES facilities in different ways

➢ **crucial to identify microbial key players and monitor their activity**



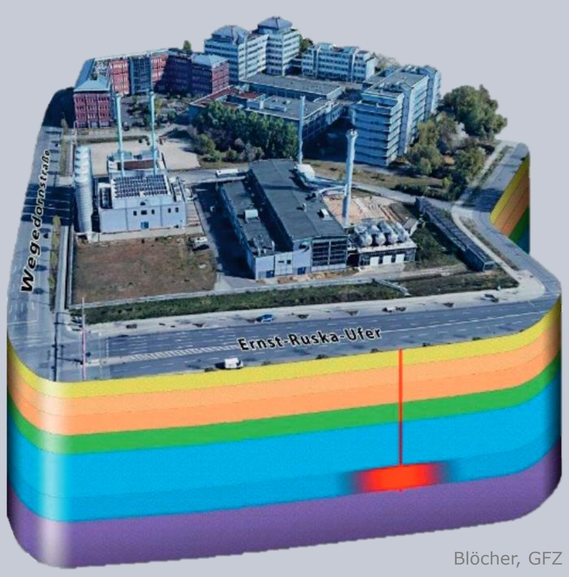
Objectives

- **explore microbial community** composition, behaviour and potential functions in a siliciclastic aquifer at the **ATES exploration site** over 2 years after drilling

Take home

- **Aquifer microbial community** is characterized by **syntrophic** relationships between **fermentative** and acetogenic bacteria with **sulfate reducing bacteria** (SRB) and **methanogens**
- Community undergoes **succession over time** – fermentation → sulfate reduction → methanogenesis
- **Higher temperature** selects for **SRB, *in situ* temp.** for **acetogens**
- **Potential key consequences on ATES:**
  - H_2S formation → **corrosion** of metal components
  - Iron sulfide scales → pipe **clogging**
  - CH_4 formation → **gas buildup**/pressure changes/safety hazard
  - Biofilm formation → permeability/**effiency reduction**

Study Site & Methodology



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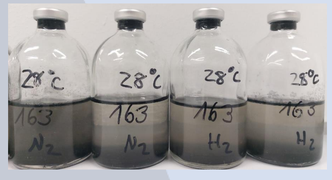
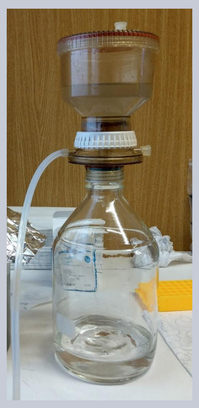
ATES exploration site* in Berlin-Adlershof (BTB GmbH, Berlin)

Water sampling
- **2 months**
- **14 months**
- **24 months**
- **28 months after drilling**

Origin of groundwater at ~225 mbs



Enrichment for sulfate reducers (SRB): +/- NaCl, N_2 or H_2 at 16/28/55 °C



Microbial community analysis based on amplicon sequencing of 16S rRNA gene

Hydrochemistry

Table 1: Groundwater characteristics. Saline water (~2%) is dominated by Na and Cl. Sulfate can act as electron acceptor for anaerobic respiration by SRB. The presence of organic acids indicates fermentative microbial metabolism. *Standing water in the annulus of the production well as indicated by higher pH, lower temperature and different microbial community (see Fig. 1 & 2A).

sampling	sample no.	pH	EC [mS cm^{-1}]	Temp [° C]	[mg L^{-1}] Na	K	Mg	Ca	F	Cl	SO_4	Lactic acid	Acetate	Propionate	Valerate
2 months	1	n.m.	31.9	15.9	6970	220	146	166	1	11688	270	n.a.	0.4	n.a.	n.a.
14 months	1*	**9.5**	**26.4**	**11.8**	6615	259	109	71	1	11163	270	<1	1.8	n.a.	<1
	2-5	7.7	31.9	13.6	6656	283	130	139	1	11060	250	3.6	4.0	0.6	0.9
24 months	1-3	7.6	31.4	14.1	5401	110	60	54	1	10457	235	0.3	<0.1	<0.1	n.a.
28 months	1-3	7.7	31.7	15.3	6843	152	151	190	n.a.	10770	225	<0.1	0.8	0.1	n.a.

Table 2: Dissolved gas composition – dominated by H_2 2 months after drilling, but N_2 14 months after drilling.

[%]	H_2	N_2	CO_2	Ar	O_2	He	CH_4
2 months	**91.6**	7.0	1.3	n.a.	n.a.	n.a.	n.a.
14 months	0.1	**95.8**	0.5	2.6	0.7	0.0	0.2

Aquifer Microbial Community Composition and Dynamics

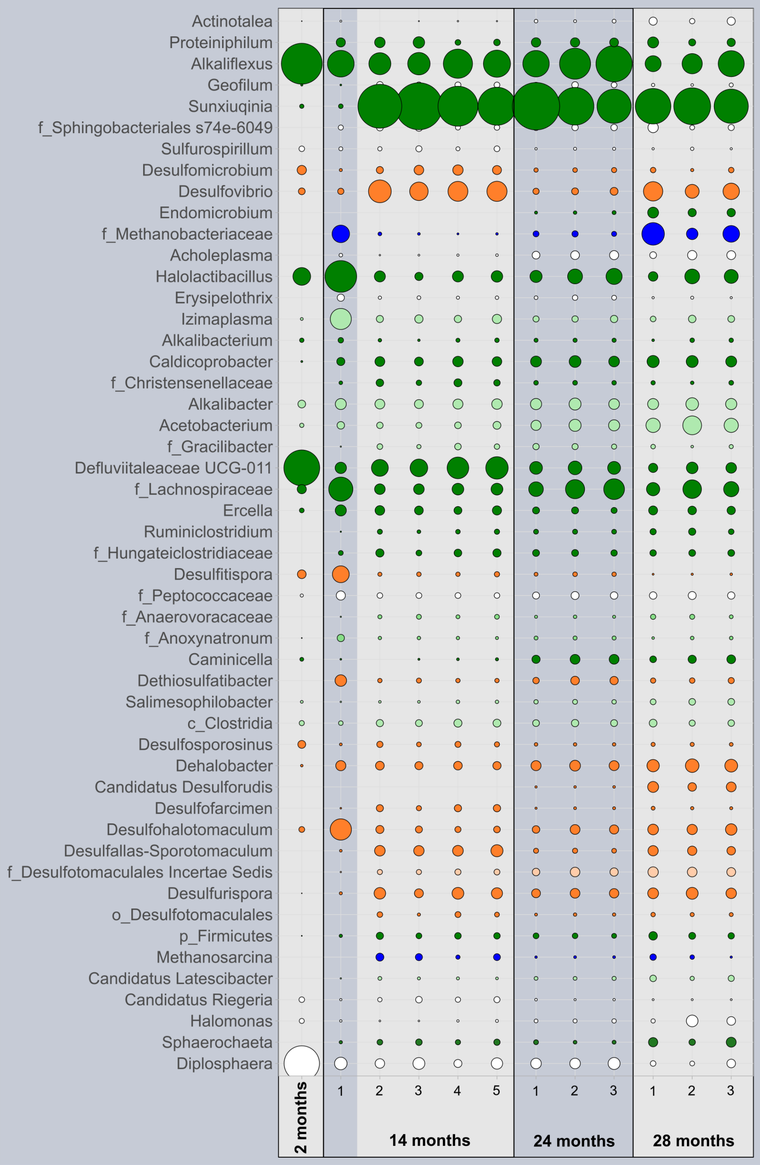


Fig. 1: Top 50 most abundant genera and their classification into fermentative, sulfate reducing and methane producing microorganisms.

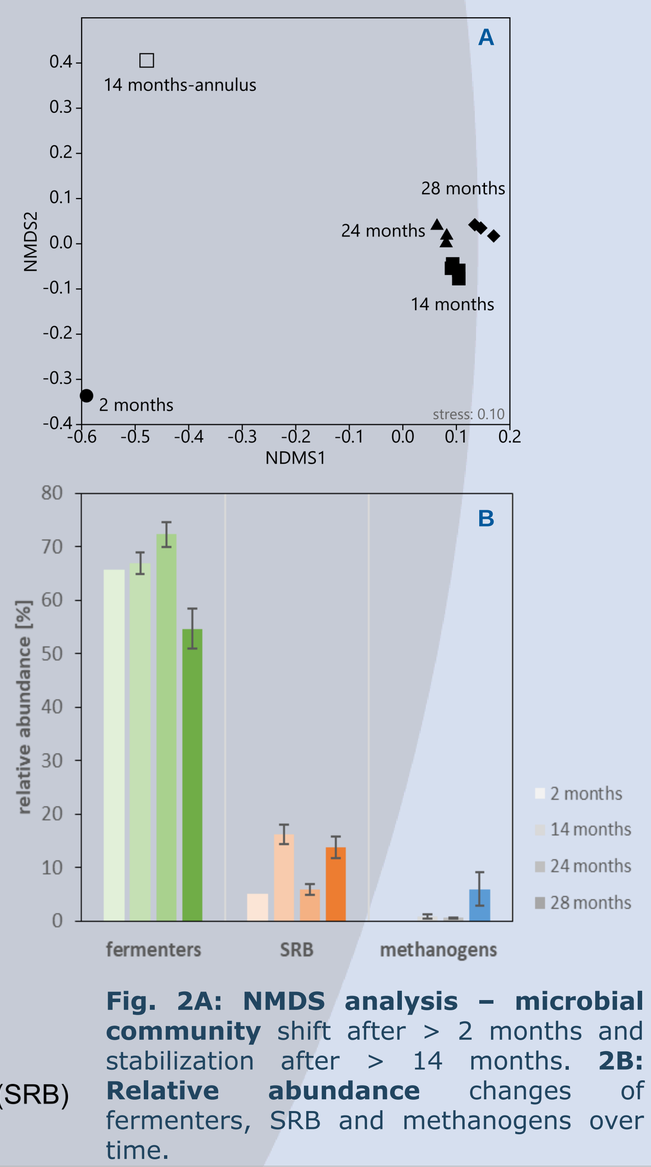


Fig. 2A: NMDS analysis – microbial community shift after > 2 months and stabilization after > 14 months. **2B: Relative abundance** changes of fermenters, SRB and methanogens over time.

Enrichments

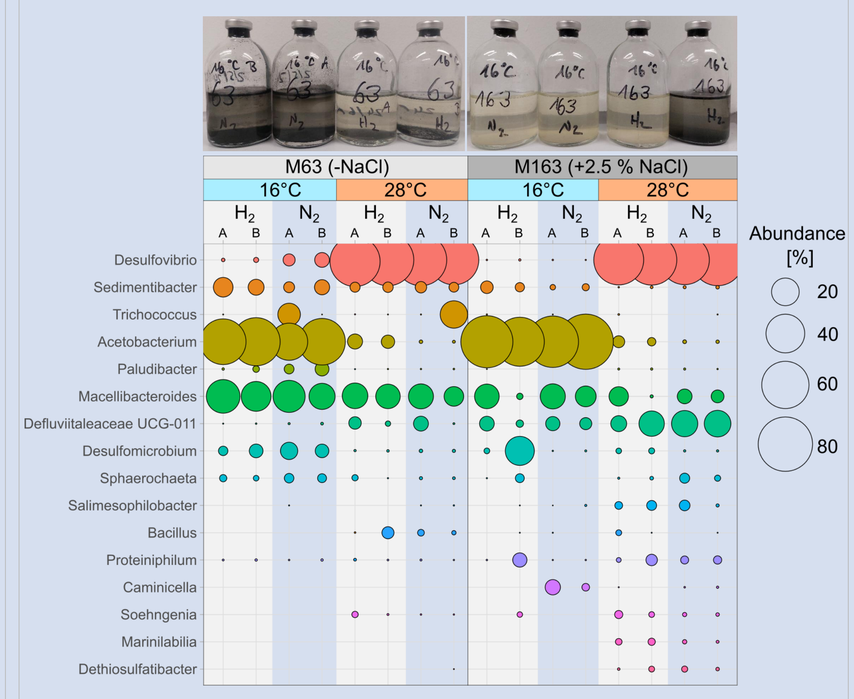


Fig. 3: Composition and relative abundance of taxa after enrichment for sulfate reducers at different temperatures and head spaces with and without NaCl.

- Abundance of SRB correlates with formation of black precipitates (most likely Fe-sulfide)
- Temperature controls the type of organisms being enriched
- No enrichment at 55 °C
- Salinity and head space composition have no significant impact

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*The drilling was performed in the frame of the GeoFern project https://www.gfz-potsdam.de/sektion/geoenergie/projekte/2019-2022-geofern