Thermal stability of fluorescent tracers at elevated p/T-conditions

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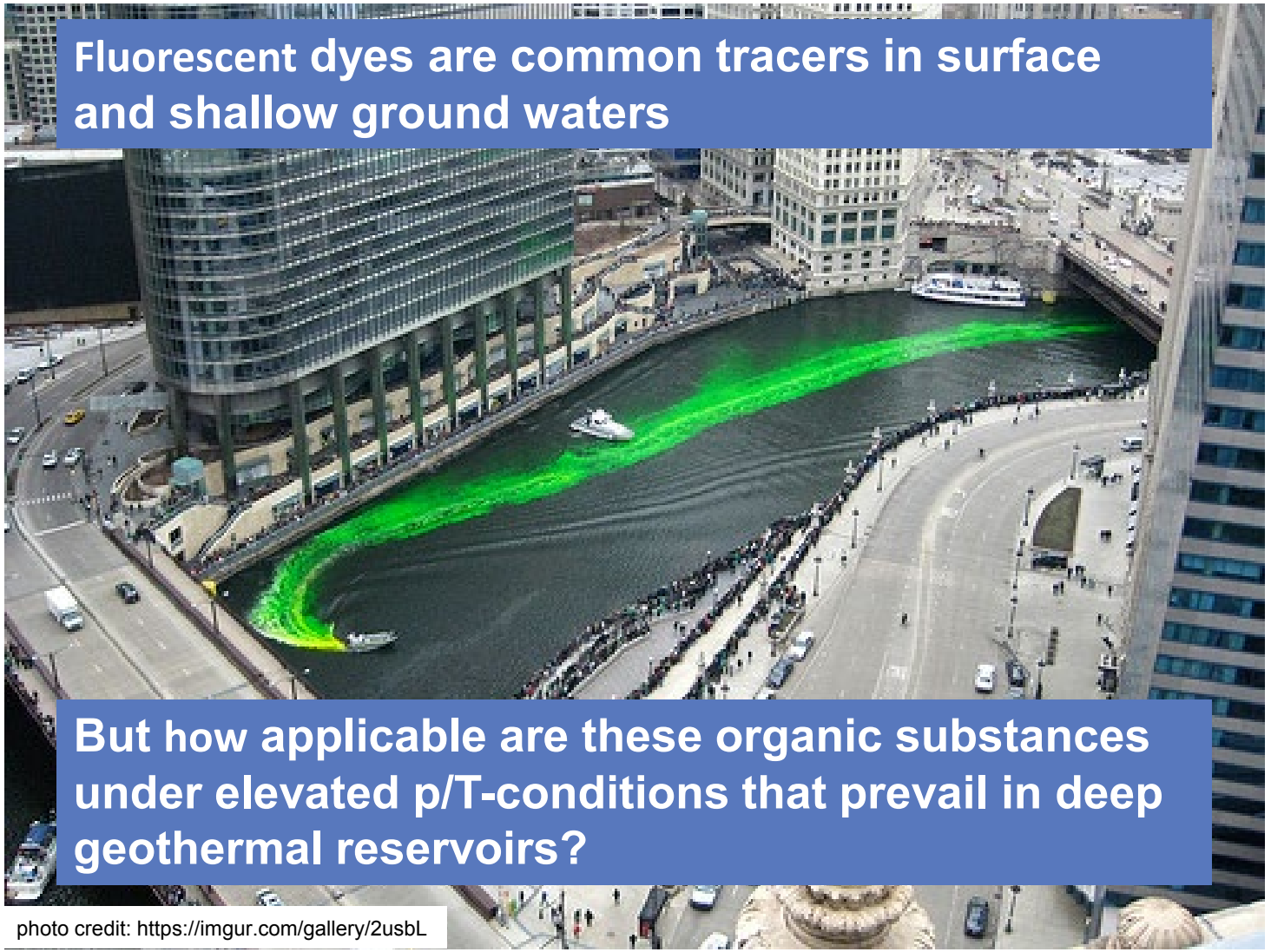
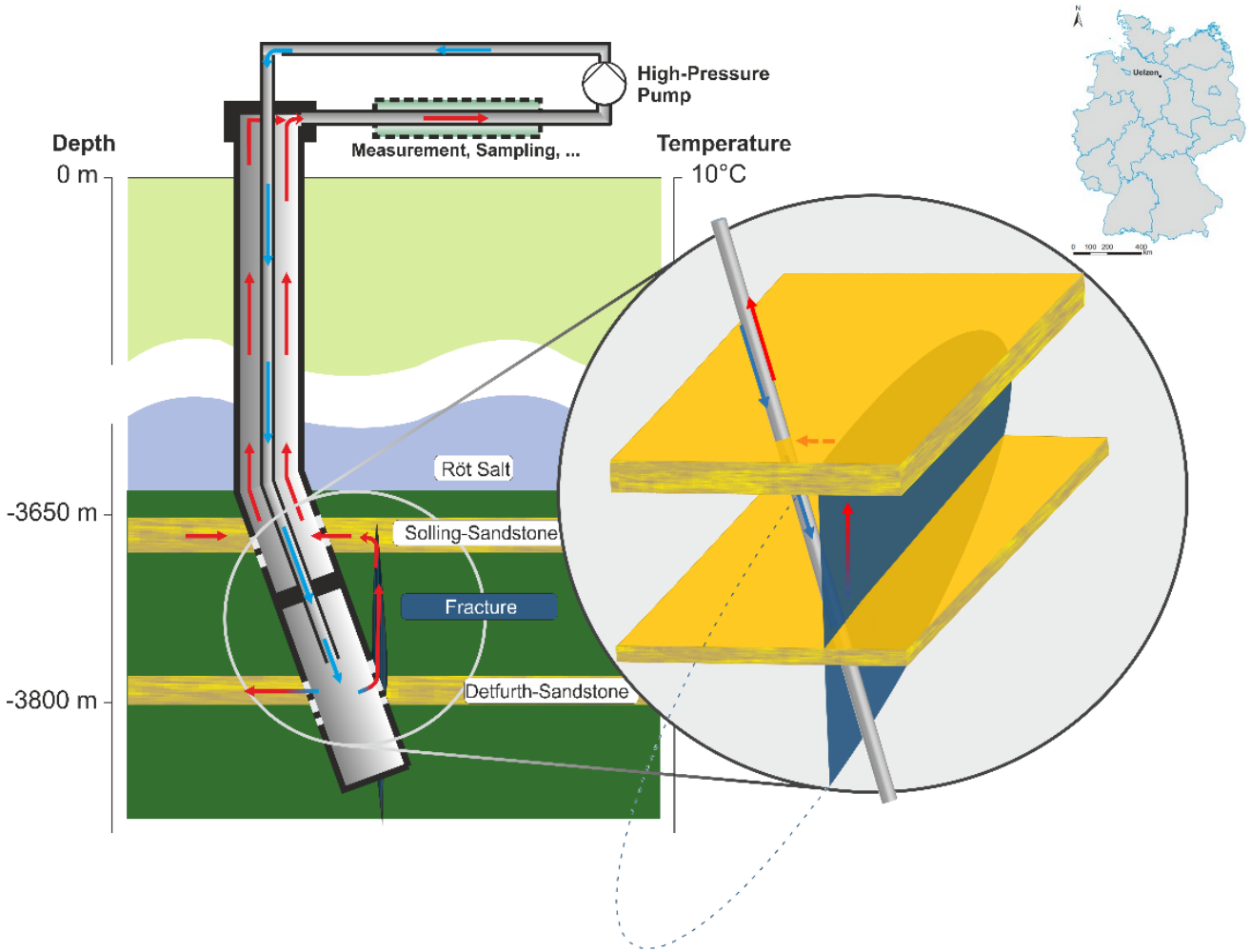


photo credit: https://imgur.com/gallery/2usbL

Horstberg Research Well – Reservoir Characterisation

Design
single-well concept for direct heat production

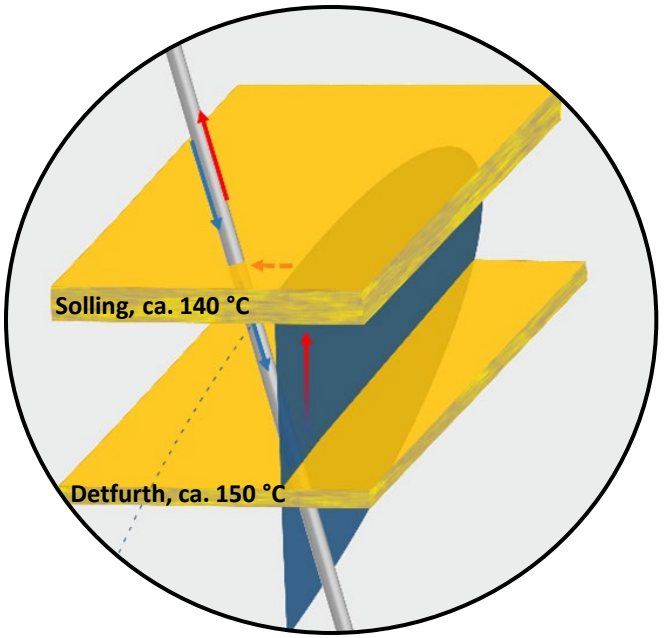
Field-Tests
closed circulation with flow rates of 1 – 10 l/s



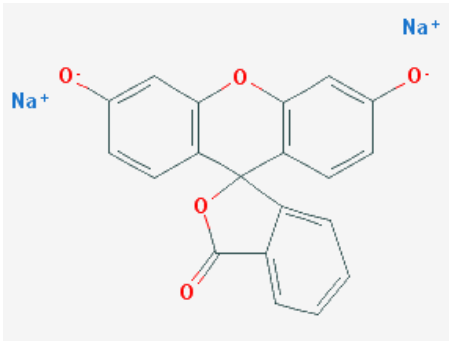
Horstberg Research Well – Reservoir Conditions

- max. depth at 3800 m
- vert. dist. ca. 150 m
- 140 – 150 °C
- 580 – 600 bar
- 330 g/l TDS
- pH 5 – 6 @atm press.

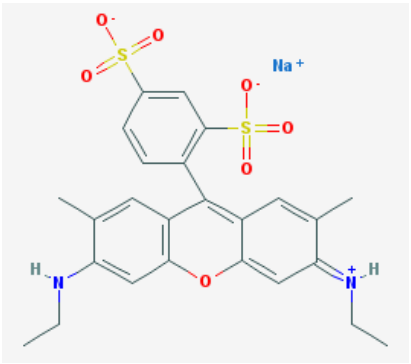
…to the lab



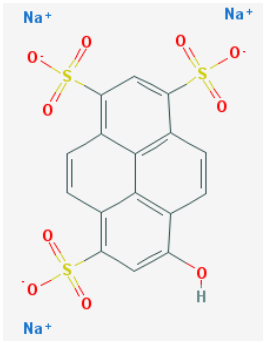
Selection of Fluorescent Tracers



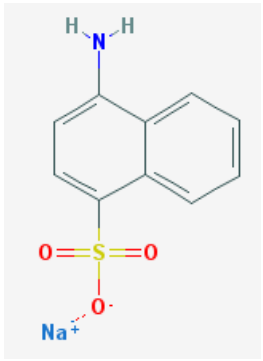
Uranine



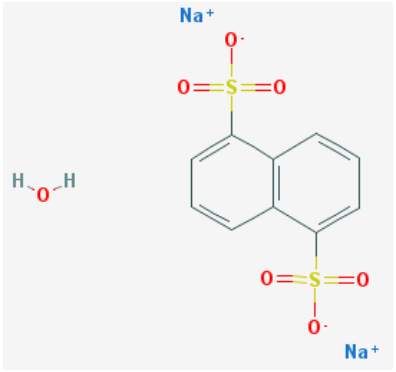
Sulforhodamine G



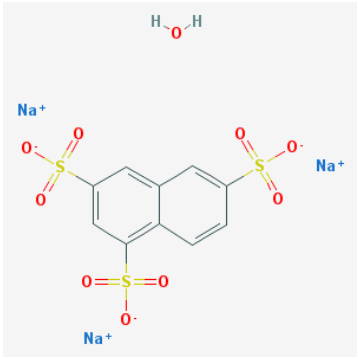
Pyranine



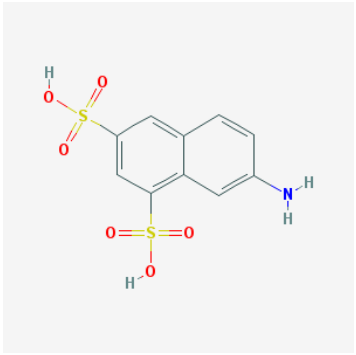
Naphtionate



Naphtalene-Disulfonic acid (NDS)



Naphtalene-Trisulfonic acid (NTS)



Amino G acid

Credit: PubChem library

Selection of Fluorescent Tracers

Selection criteria

- affordable in large amounts
- low detection limits
- simple handling and analyses

- existing data from previous lab experiments and field applications

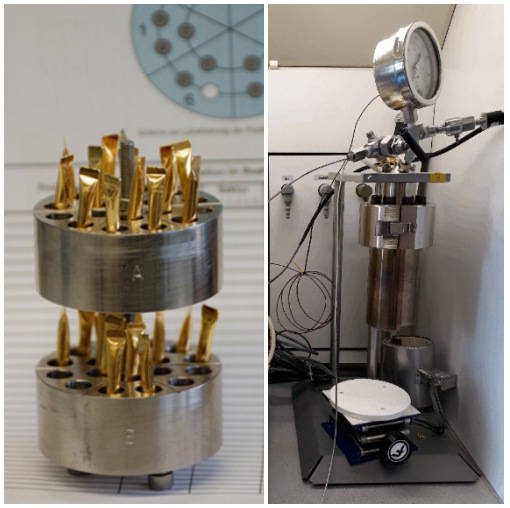
Literature review

- temperature studies
- pH dependencies
- sorption effects

- mostly single parameters
- NO pressure maintenance

→ Lack of information under elevated p/T-conditions (reservoir conditions)

Design of Laboratory Experiment



Sample preparation (per gold capsule)

- 0.5 ml synthetic brine + tracer
  (brine: 300 mg/l TDS, tracers: 4 – 9 µg/l)
- 200 mg of rock powder in half of samples
- pH adjusted to 5.8
- N_2-atmosphere (no inital CO_2)

Monitored parameters

- tracer concentrations (before/after)
- pH values (before/after)
- TDS (before/after)
- CO_2 content (after)

Experimental set-up

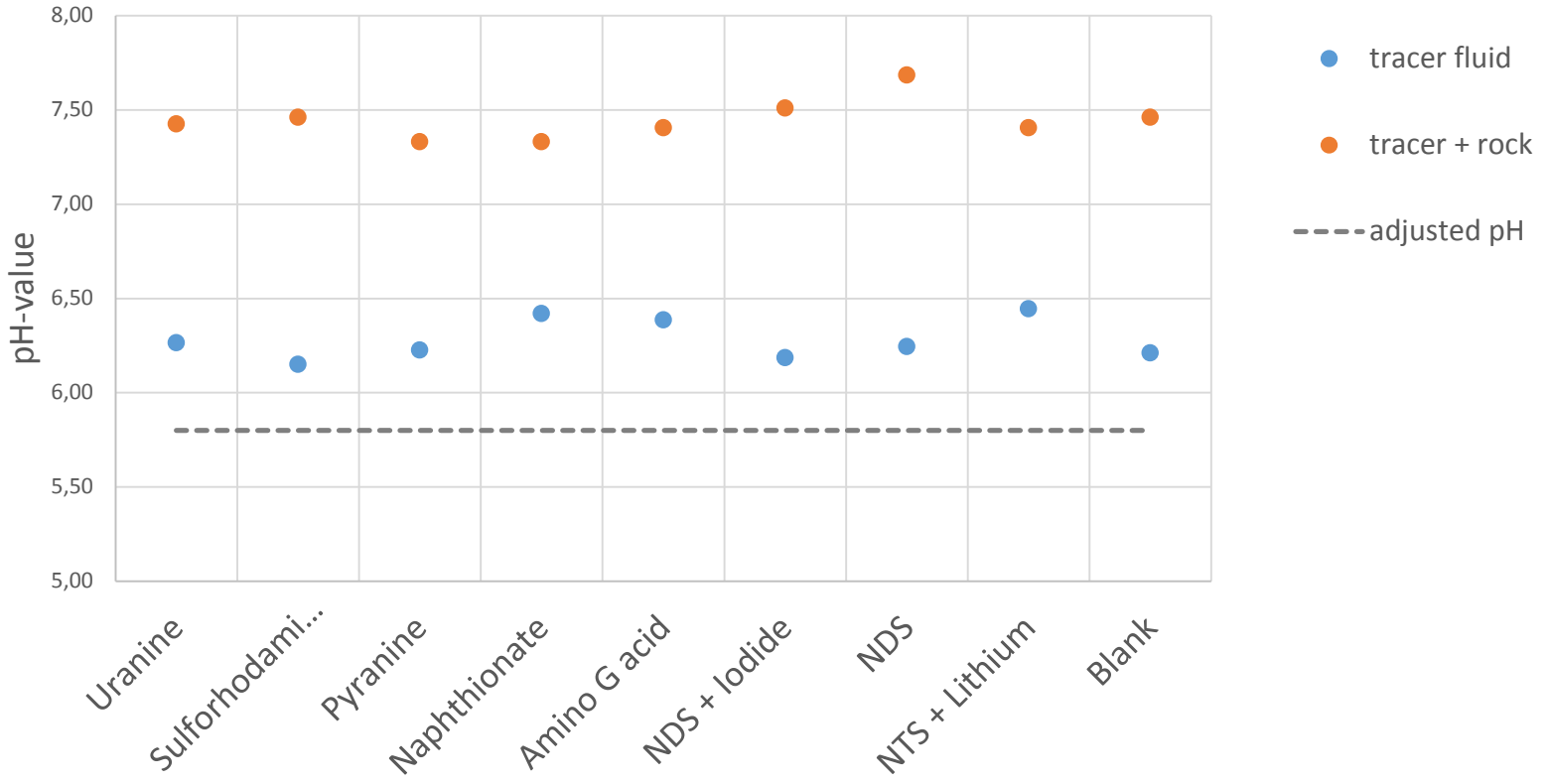
- 32 gold capsules
- 7 fluorescent tracers
- 150 °C, 300 bar
- 40 days

Tracer (non-)recoveries

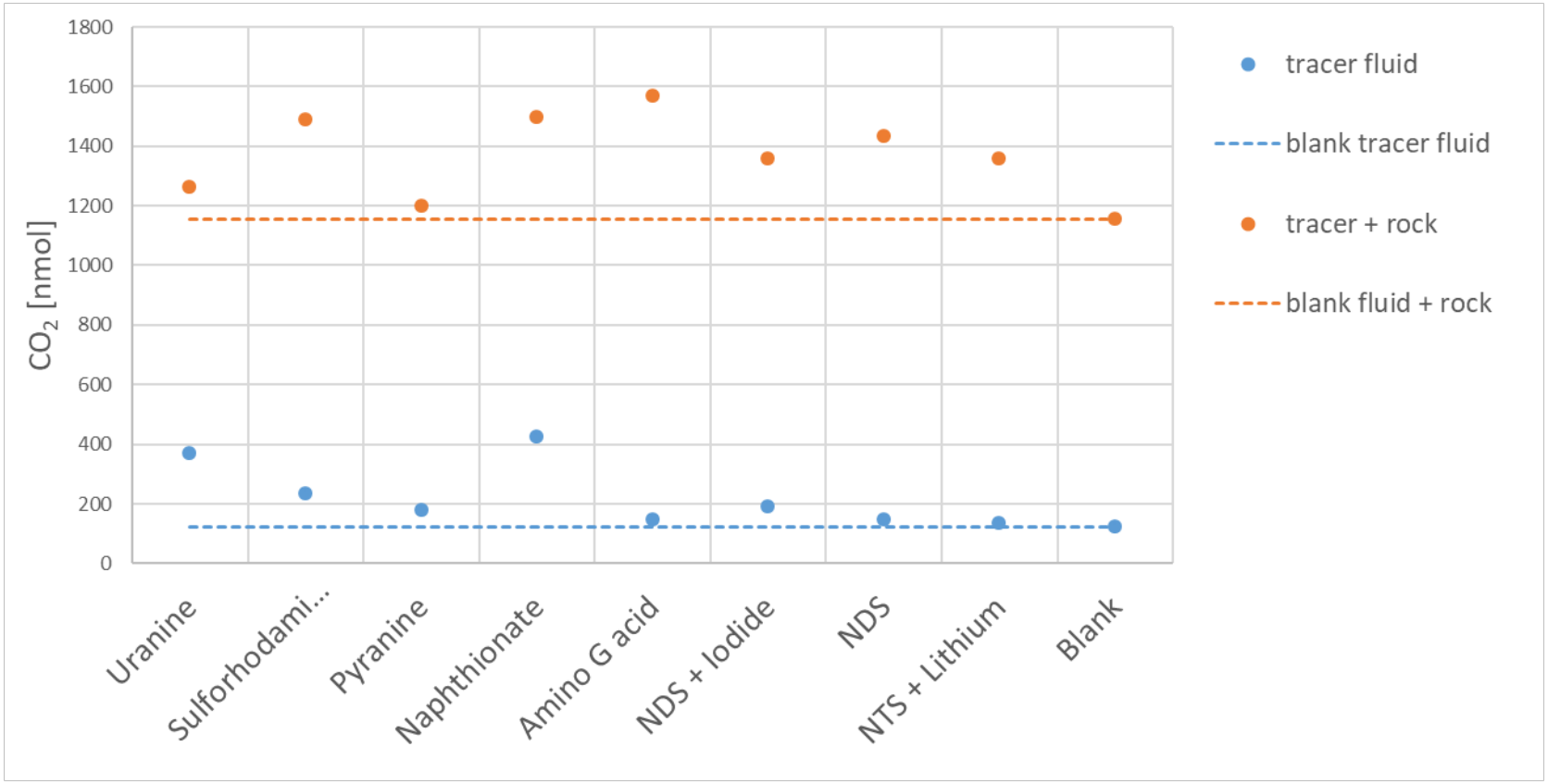
Tracer	Fluid	+ Rock
Uranine	none	low
Sulforhodamine G	none	none
Pyranine	none	none
Naphtionate	none	none
Amino G acid	none	none
NDS	low	high
NTS	high	medium

Class	Recovery-%
none	< 5 %
low	5 - 50 %
medium	50 – 75 %
high	75 – 90 %
complete	> 90 %

Evolution of pH values



CO_2 monitoring – Tracer decomposition?



Conclusions

- elevated p/T-conditions lead to unreliable recoveries of the tested fluorescent tracers → except NTS?
- presence of formation rock powder shifts pH to more alkaline values AND increases CO_2 content → contradictory?
- ‚excess'-CO_2 indicates decomposition of tracers

→ pilot study raised more questions than it was able to answer, but it clearly suggests all fluorescent tracers to be reactive

Thanks…

… for your attention!

… to BGR labs for providing the data!

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