

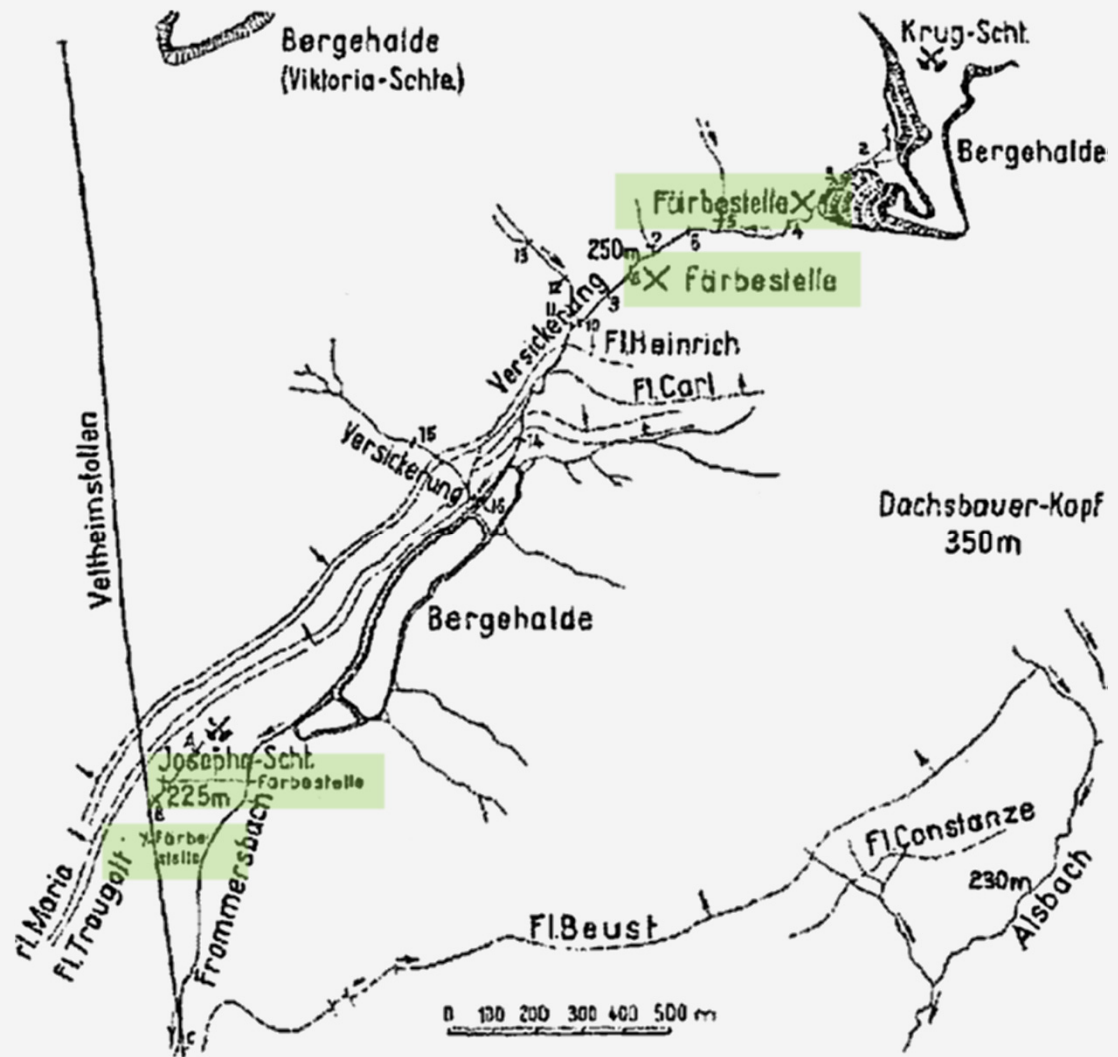
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TRACER TESTS IN THE MINING ENVIRONMENT

Why? – How? – What?

www.wolkersdorfer.info

- Why?
 - Reasons for Tracer tests
- How?
 - Tracers and their Usage
- What?
 - Examples
- Conclusions



- **Minimize Costs**
 - Water Treatment (e.g. mean residence times)
 - Pumping (e.g. seepage into mine workings)
 - Diverting Flow
- **Research**
 - Stratification within underground mines or pit lakes
 - Hydrodynamics (flow through mine workings)
 - Hydrogeochemistry
- **Legal Aspects**
 - Flow Paths (“where does water originate from”)

- testing the effectiveness of bulkheads dams
- investigating hydrodynamic conditions
- tracing connections between a mine and the surface
- clarifying reasons for inundations
- assessing contaminant mass flow
- estimating the decrease or increase of contaminants

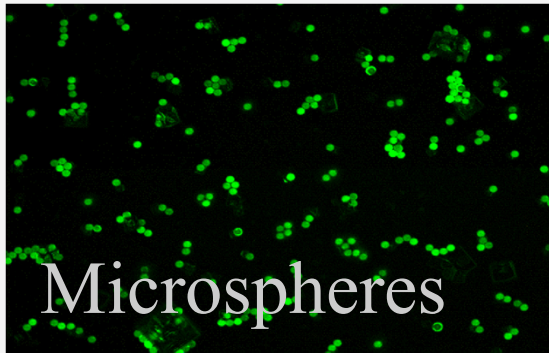
- Transport with velocity of transport medium
- No natural occurrence of the tracer used
- Good analytical detection (even in big dilution)
- Water soluble or used in dispersion
- High resistance (chemical stability)
- No interaction between tracer and medium
- Economic (reasonably priced according to buying, handling and analytical procedures)
- Physiological safe (non toxic)
- No lasting negative effects on (ground) water quality

- Suitable tracer for mine water
 - Large water volumes
 - Low pH values
 - Elevated background values
- More than one injection point within mine
- Injection without contamination of water
- As deep as possible into shafts
- Tracer test must be repeatable
- Cheap and easy to handle

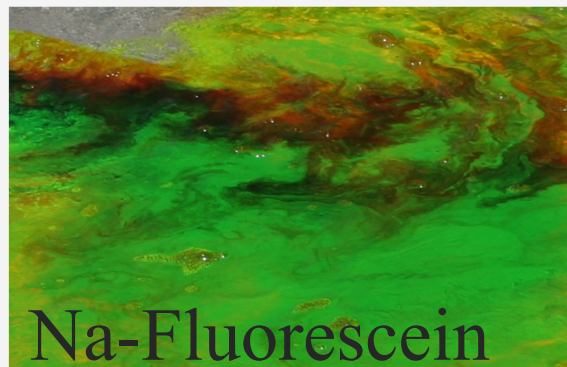
- “Natural” Tracers
 - Environmental Isotopes
 - Environmental Chemicals
 - Organisms
 - Physical Effects
- Artificial Tracers
 - Water Soluble
 - Water Insoluble

- Stable Isotopes
 - ^{18}O , ^2H , Sr
- Radioactive Isotopes
 - Tritium
- Rare Earth Elements
- Chlorofluorohydrocarbon (CFC)
- Temperature
- Electrical Conductivity

- Solid Tracers



- Water Soluble Tracers

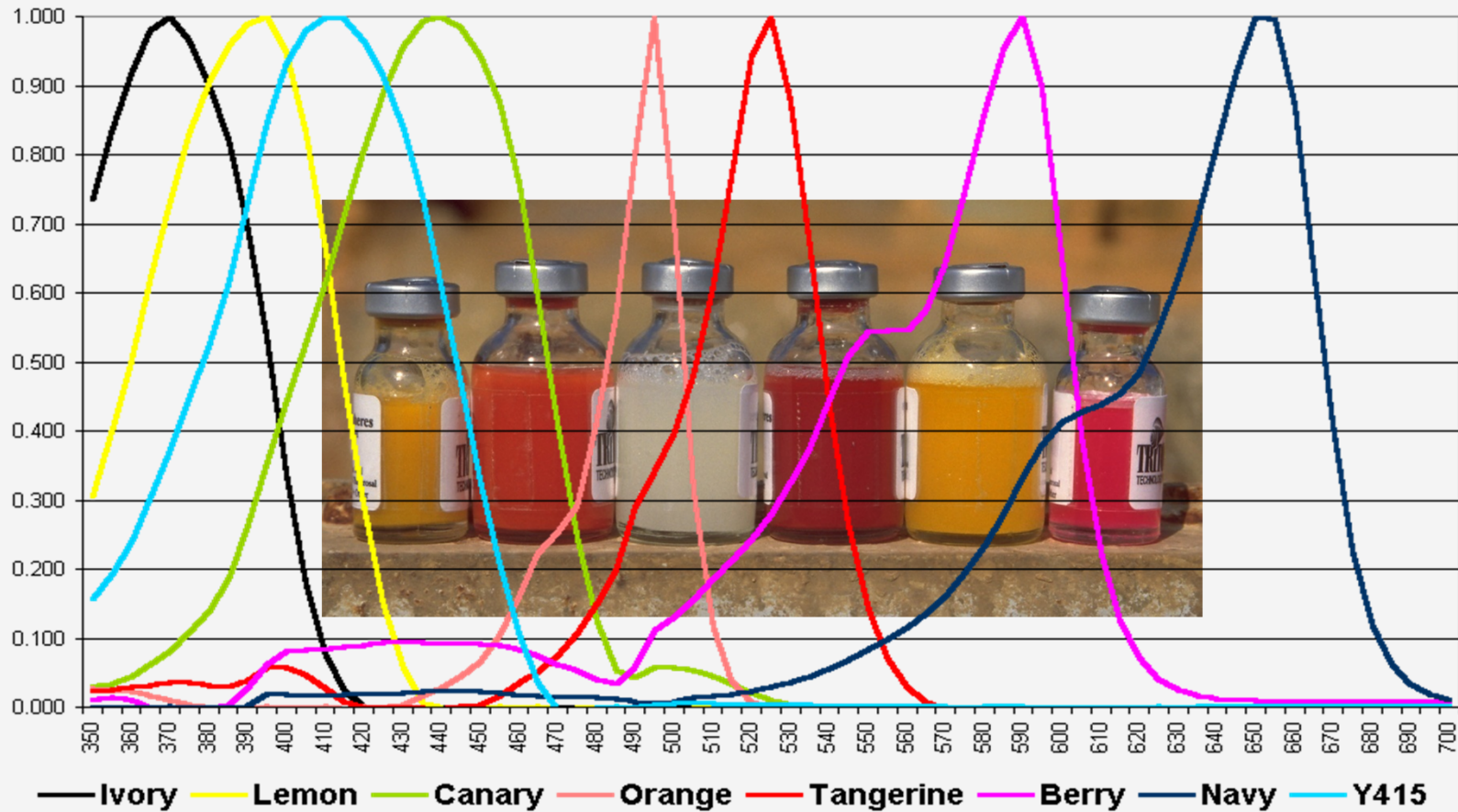


- Bromide
- Lithium

- Test potential tracers with your mine water
- Duration at least as long as expected duration of your tracer test
- Tracers are pollutants! Therefore:
- First think about potential flow paths
- Establish conceptual model using geochemistry or natural tracers (e.g. temperature, electrical conductivity)
- THEN use tracers to prove your conceptual model
- Avoid to use tracers before you have a conceptual model

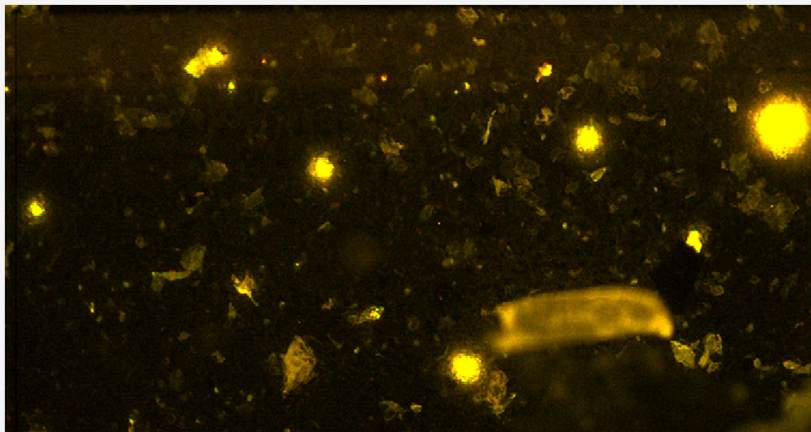
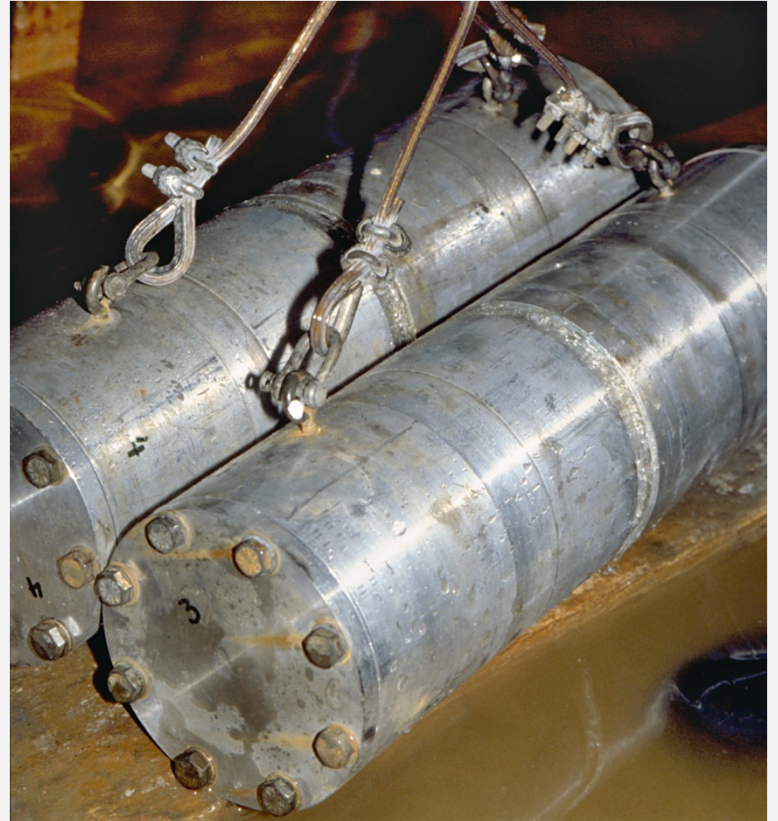
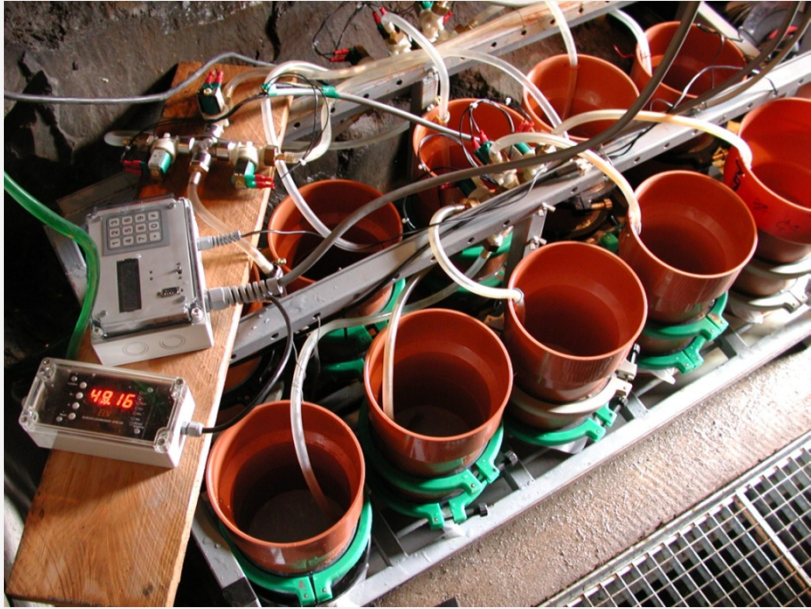
How? – Microspheres

Dye Trak VII+ in Cellosolve Acetate



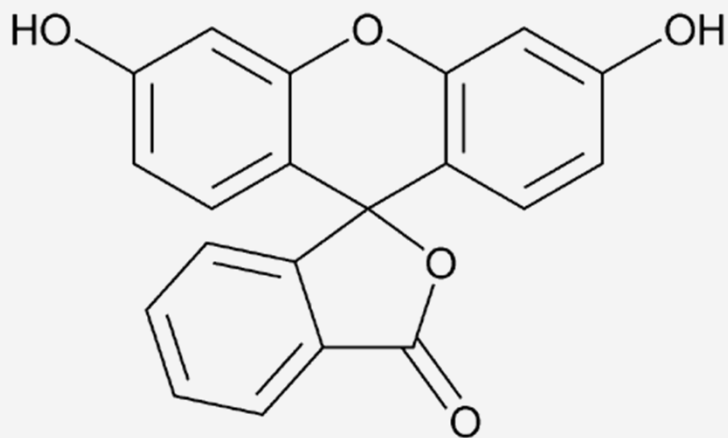
Composite absorbance spectra

What? – Microspheres

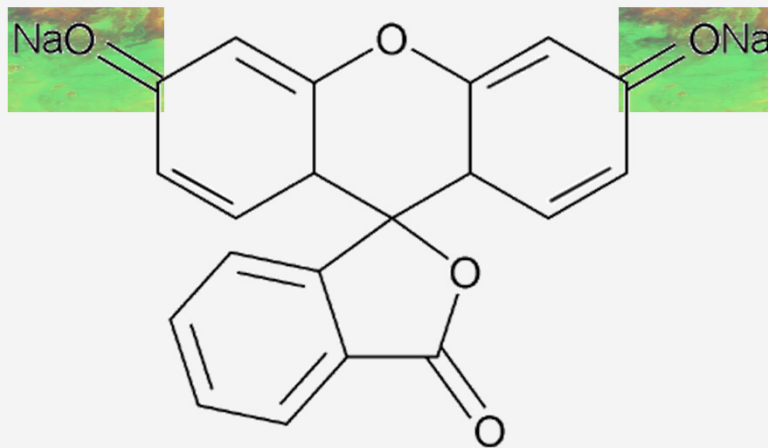


- Questions I had when reading about tracer tests in the English speaking world
 - Why did “fluorescein” fail in some cases?
 - Why does the English speaking world use Rhodamin WT so often?

- Answer:
 - Fluorescein **IS NOT** Na-fluorescein
 - Unfortunately, in both cases C.I. is 45350
 - In German the term “Uranin” is used

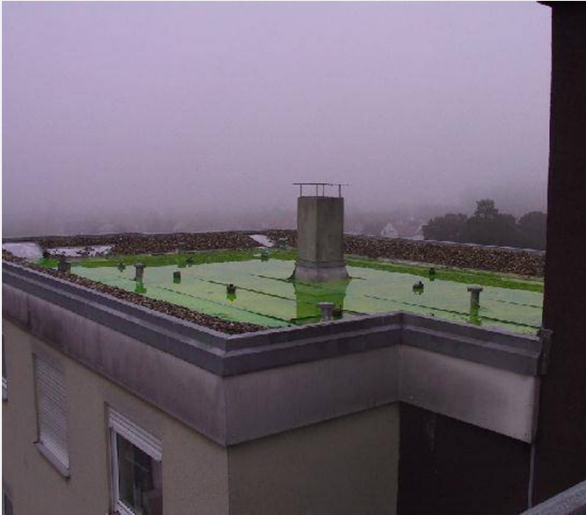


Fluorescein
CAS 6417-85-2



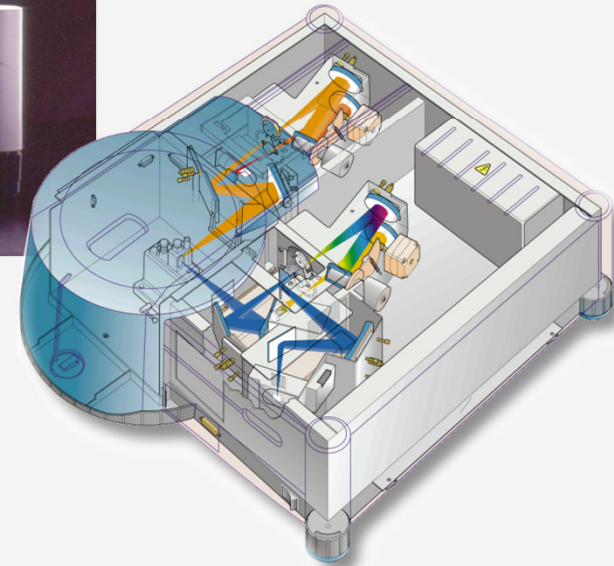
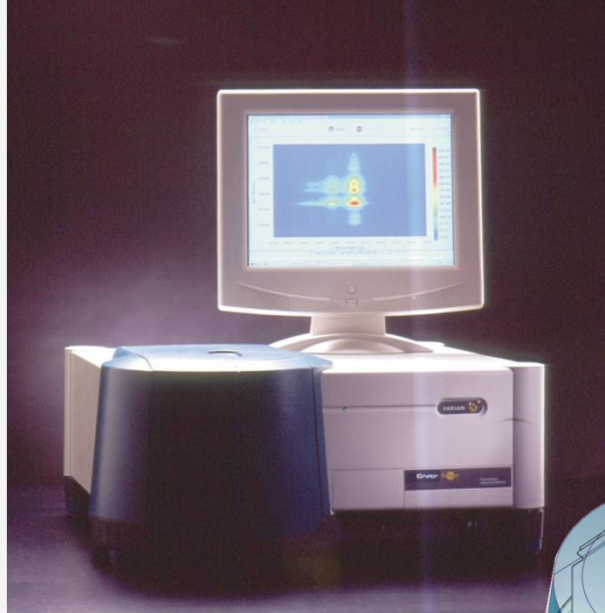
Na-Fluorescein
CAS 518-47-8

How? – Not like that!



- Na-Fluorescein is a fluorescent tracer
 - Never use it for visual detection
 - It is NOT biodegradable
- Use “Efficient Hydrologic Tracer-Test Design” (EHTD) software to calculate amount
- Visibility limit is ca. 200 $\mu\text{g/L}$
- Detection limit is ca. 2 ng/L
 - 0.000 000 002 g/L !!!!!
- Rough estimation
 - 1–5 mg per 1000 L of water

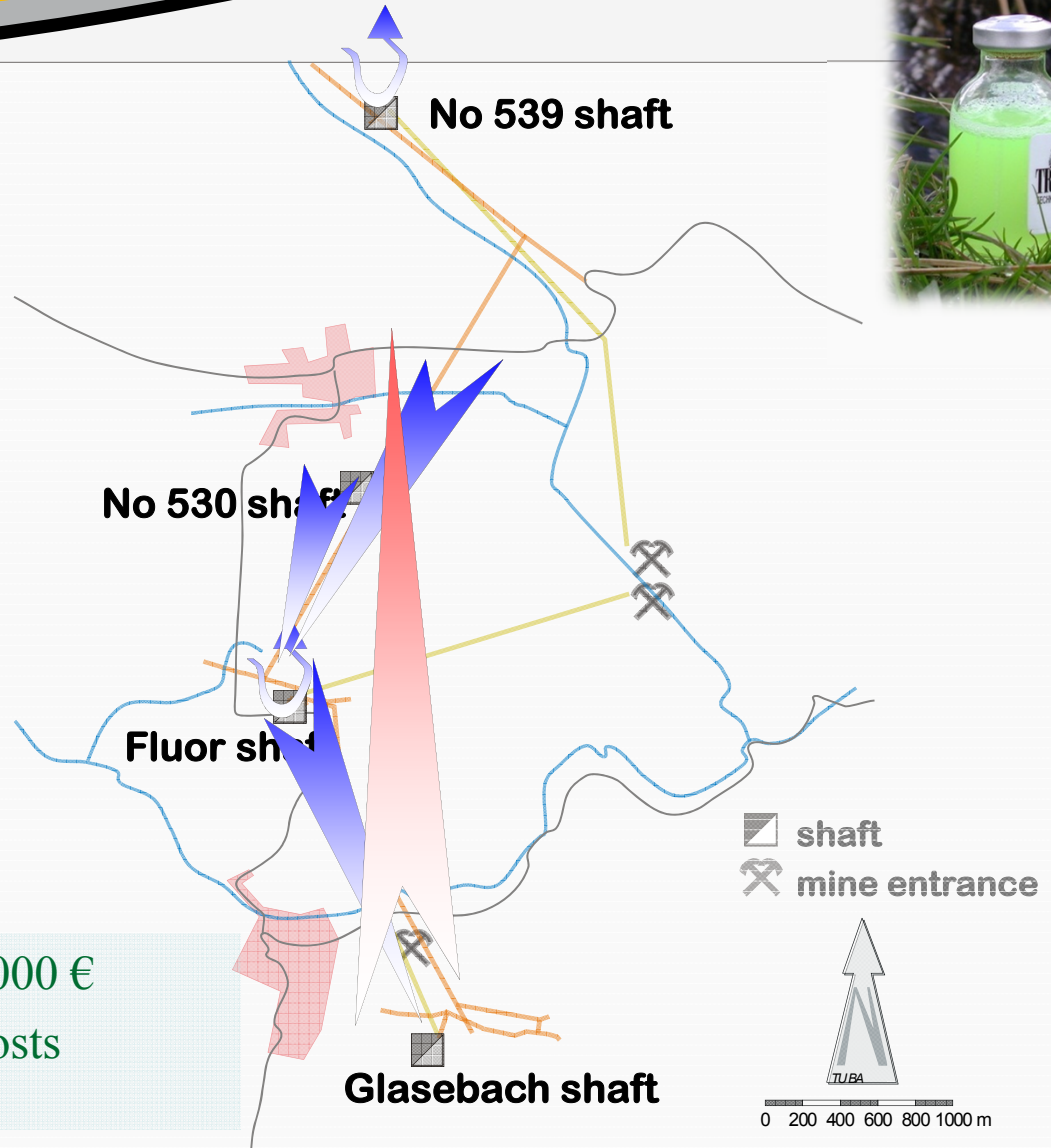
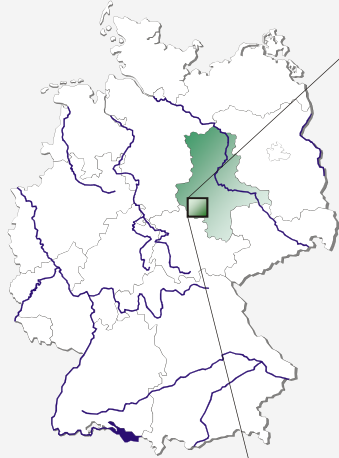
- Autosampler and Laboratory Fluorometer



- On-site Fluorimeters



What? – Straßberg Microspheres



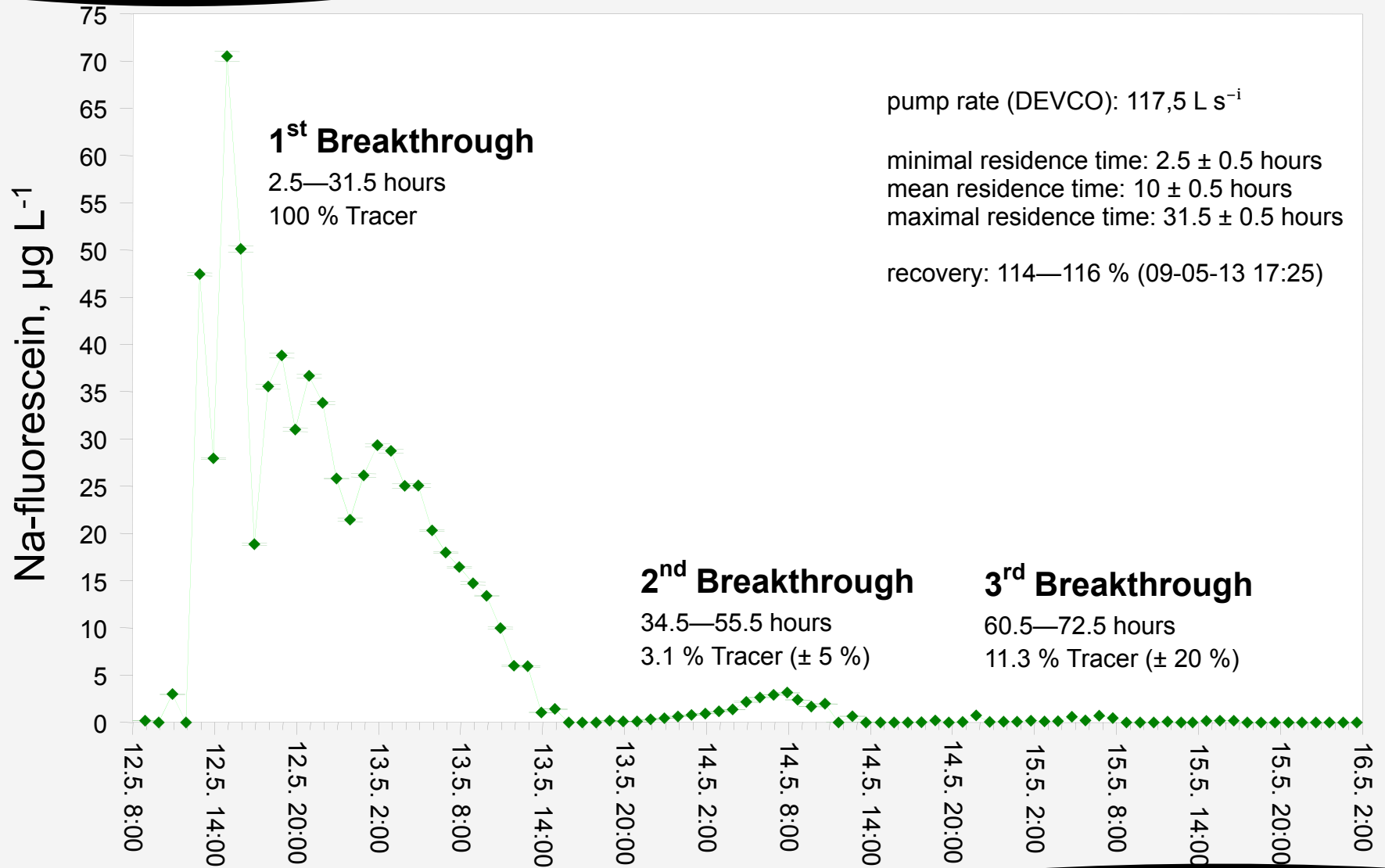
- Cost of Tracer test 50.000 €
- Savings in treatment costs $\geq 2.000.000$ €

- „Why are the design criteria of the settling pond in the passive treatment system of the 1B mine pool not met?“
- Design Criteria:
 - Fe_{tot} at point of discharge $< 1 \text{ mg L}^{-1}$
 - Minimal residence time: 15–18 hours
 - Low filter residue (which means high iron oxide content in discharge water)

What? – Settling Pond Passive Treatment System



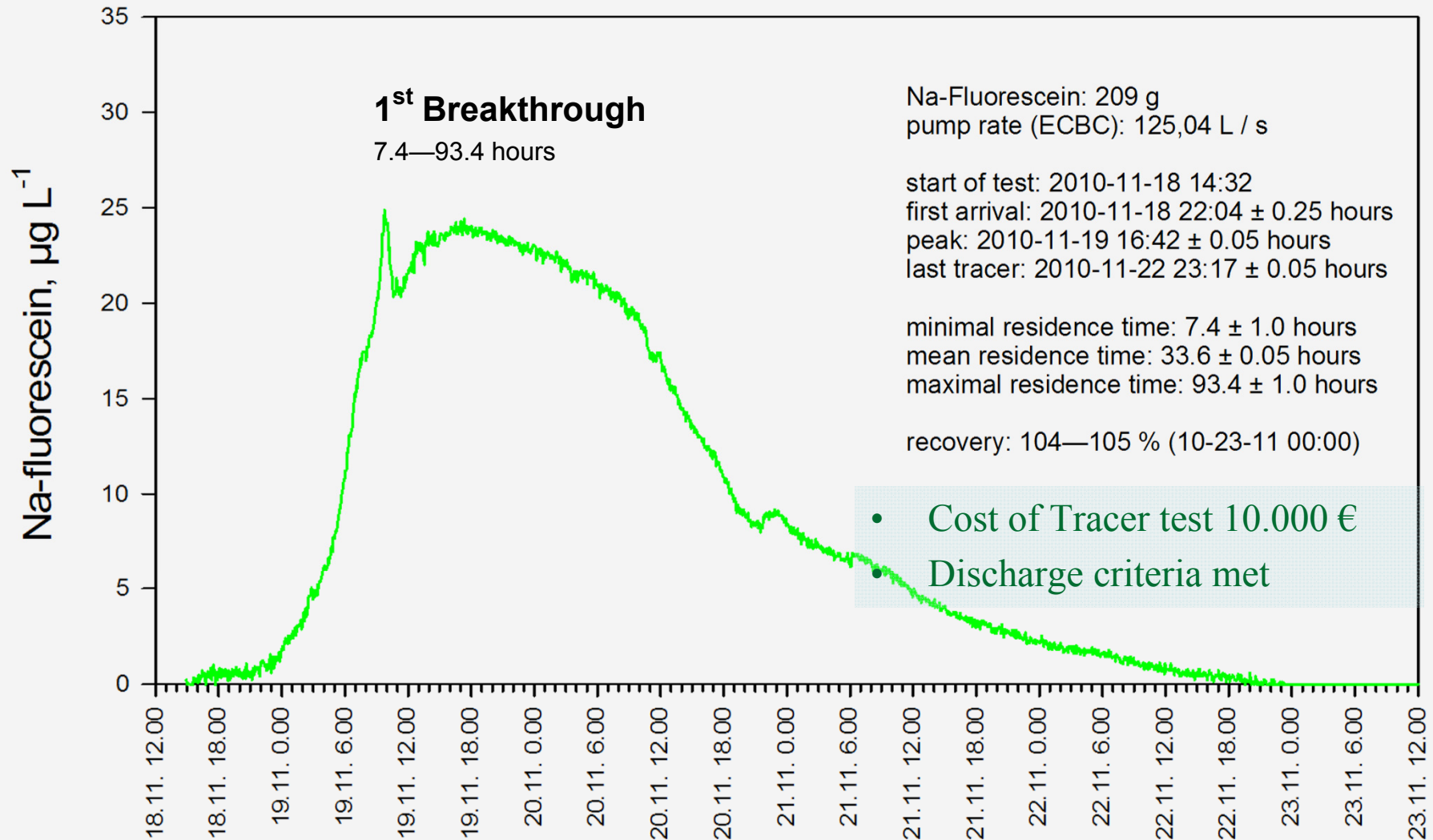
What? – Settling Pond Passive Treatment System



What? – Settling Pond Passive Treatment System — With baffle sheets



What? – Settling Pond Passive Treatment System – 2nd text



- Several tracers groups are available for mine water tracing
- Tracers have to be chosen on a case to case basis
- Avoid use of extensive amounts of tracers
- Visibility limits are more than ca. 10.000 times above detection limits
- Tracer tests can reduce treatment costs
- Tracer tests help to understand flow characteristics

The End!

Thanks and
“Glückauf”

