

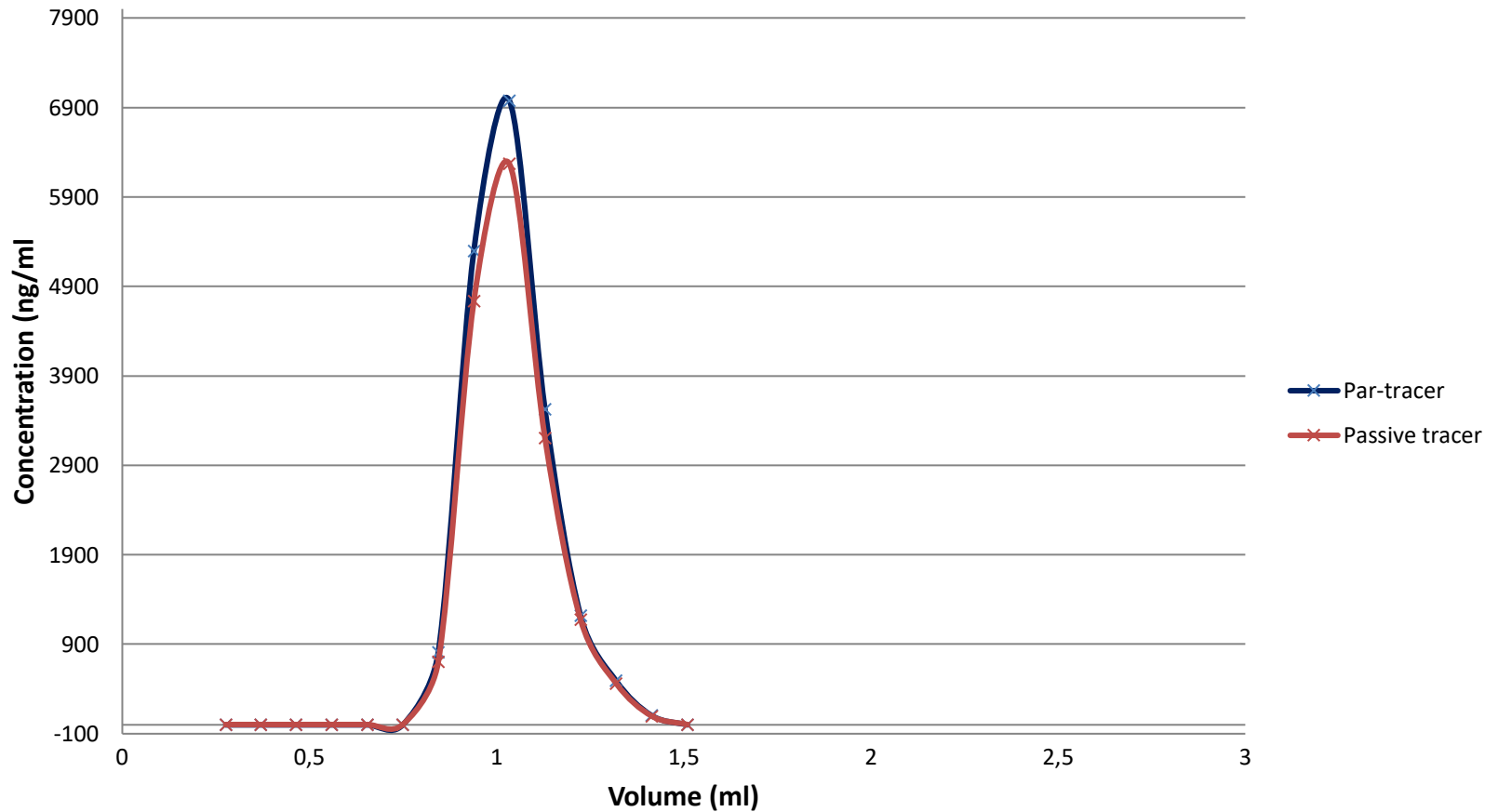
Development of new partitioning tracer

Helge Stray
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Introduction

- Preliminary tests have been performed for development of a new partitioning tracer for near well studies in petroleum fields and for studies of oil spill contamination in soil and sediments
- Such tracers have a certain affinity to the oil phase in petroleum sediment layers and to sediment layers or soil that have been contaminated with oil. The partitioning tracer will therefore move slower when a water phase is passing through such media compared to a passive water tracer
- The new partitioning tracer can be measured using high performance liquid chromatography with fluorescence detection (HPLC-FLD) and a detection limit of 1 ng/ml or even lower can be achieved
- The new tracer candidate was injected into a column of 4 mm internal diameter and 250 mm length packed with sea sand together with a traditional passive water tracer
- 4% NaCl solution was pumped through the column at a flow rate of 0.2 ml/min and fractions were collected every minute and analyzed for the concentration of the two tracers
- The elution profiles of the two tracers are shown in the next slide

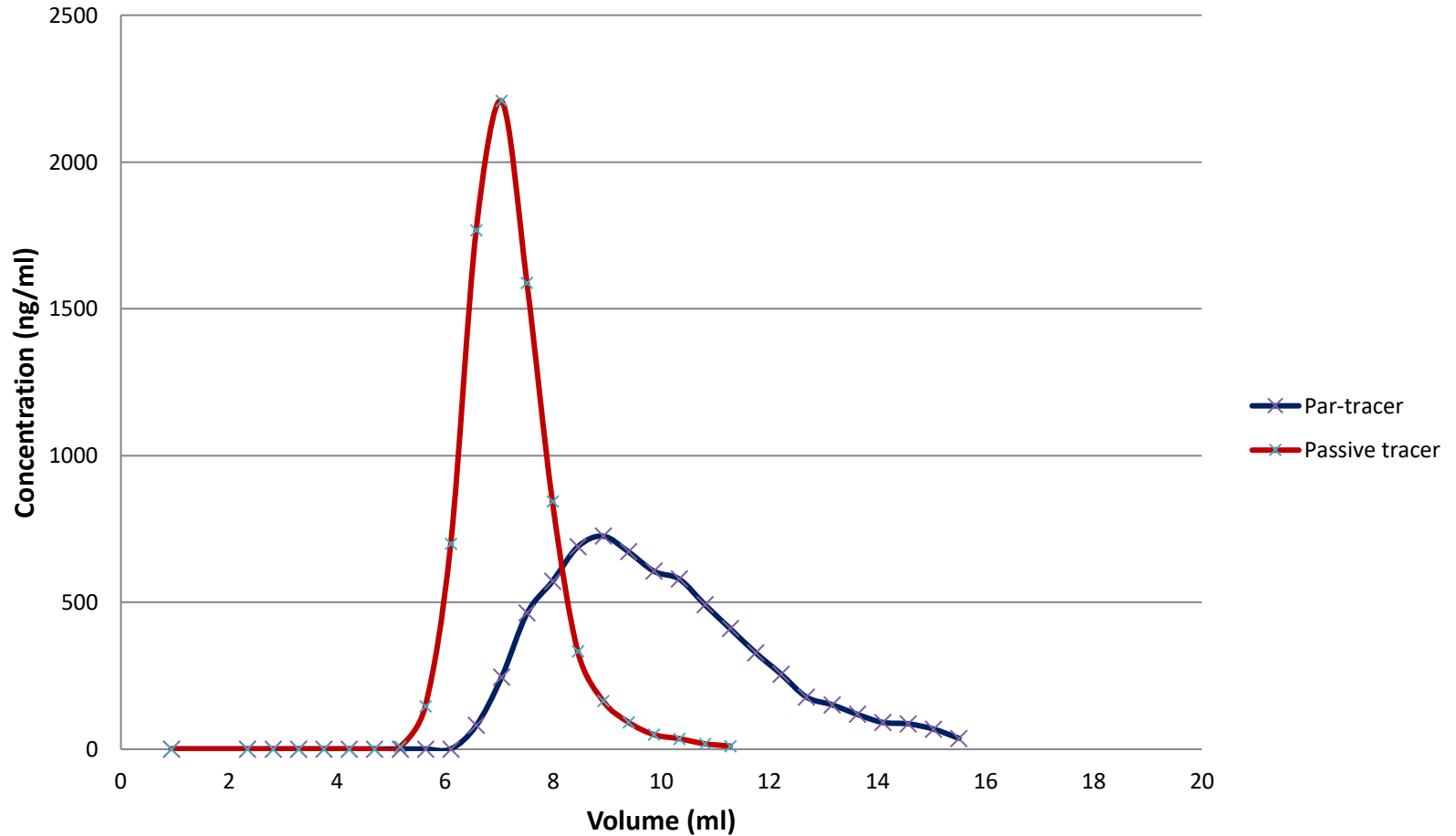
Flooding Experiment Partitioning Tracer and Passive Tracer Sand Packed Column



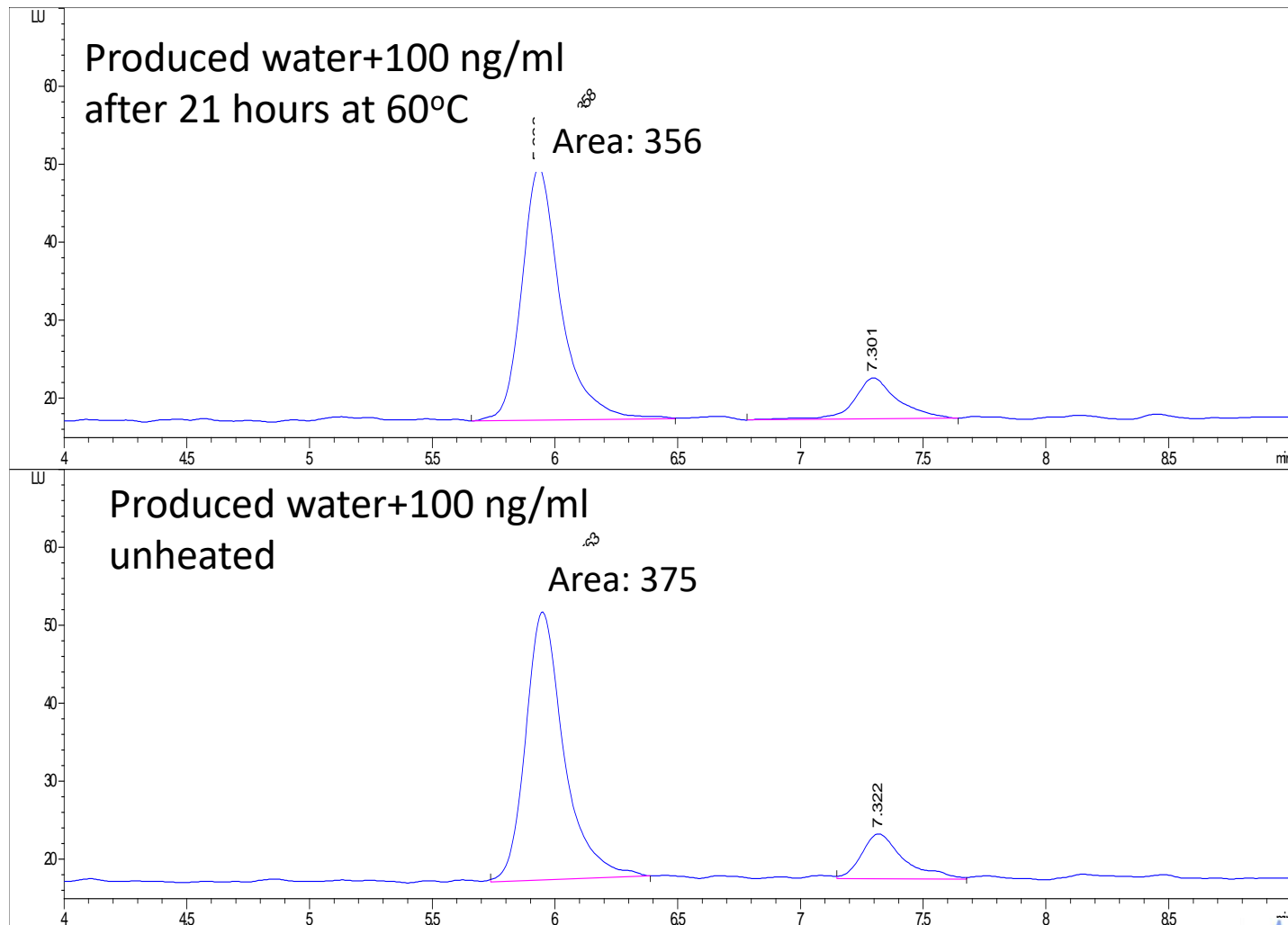
Flooding experiment with sand packed column saturated with crude oil

- A column with internal diameter 9 mm and 250 mm length was packed with sea sand and saturated with crude oil
- 4% NaCl solution was pumped through the column at a flow rate of about 0.9 ml/min at ambient temperature (20°C)
- A solution containing the partitioning tracer and the passive water tracer was injected and fractions of the eluting solution from the column were collected every 30 second
- The fractions were analyzed by HPLC-FLD for the concentration of the tracers
- Elution profiles for the tracers are shown in the next slide

Flooding Experiment Partitioning Tracer and Passive Tracer Oil saturated Sand Packed Column



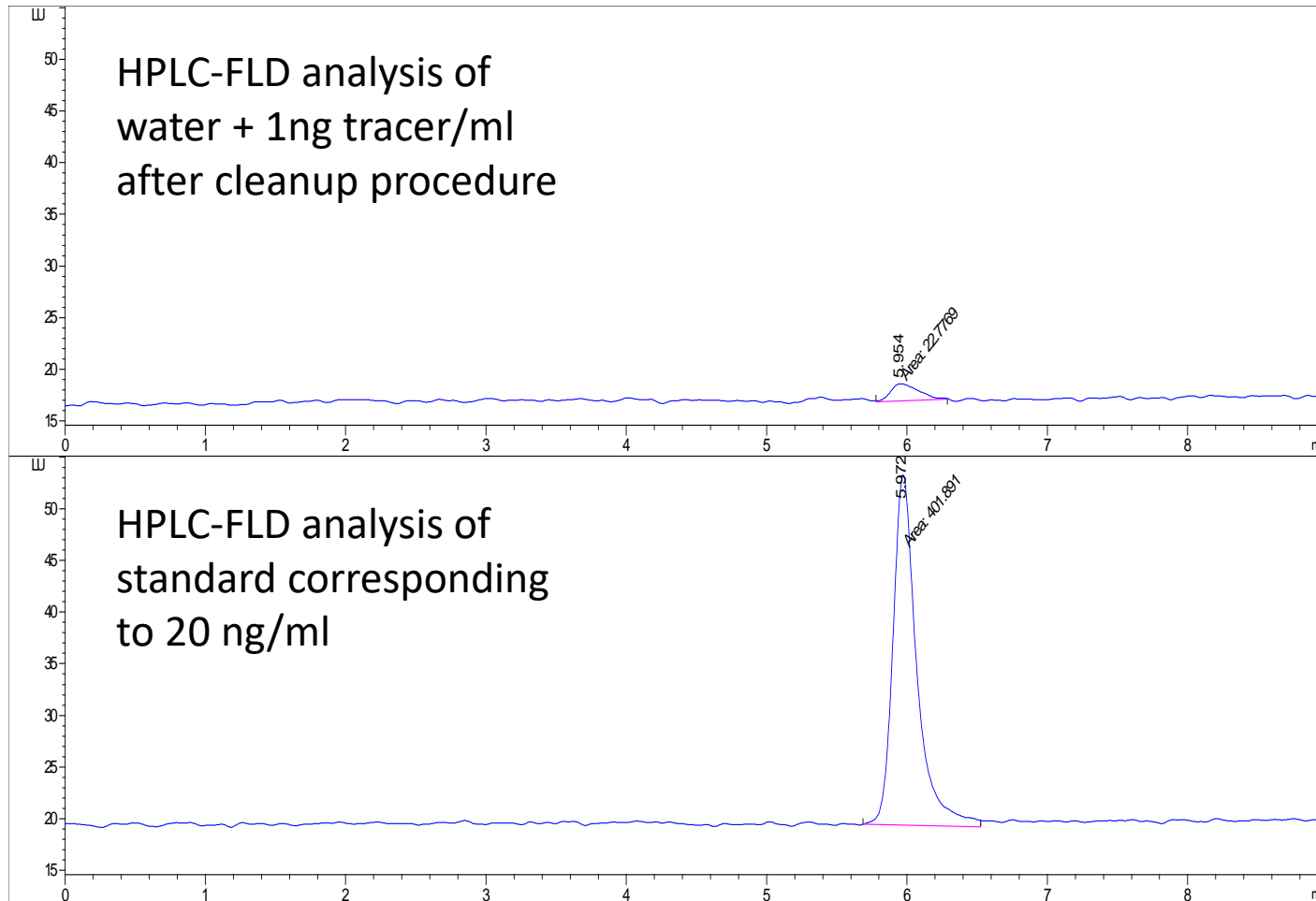
Thermal stability test of tracer in produced water



Determination of detection limit

- Water solution with 4% NaCl was spiked with 1 ng tracer per ml
- 20 ml solution was treated according to a simple cleanup and concentration procedure that can be easily performed in the field
- The sample was analyzed and the chromatogram is shown in the next slide
- Even lower detection limits (100 pg/ml) can be achieved by further concentration through evaporation of the extract

Detection limit after cleanup procedure



Conclusions

- The flooding experiment using a sand packed column showed that the partitioning tracer eluted in the same volume as the passive water tracer. The partitioning tracer therefore seemed to have no significant affinity or was not significantly adsorbed by the sand phase
- When the sand was saturated with crude oil, the partitioning tracer was retained compared to the passive water tracer
- The degree of retention will depend on the oil saturation. When the elution volume of the partitioning tracer and the passive tracer is measured, this information can be utilized to calculate the oil saturation percentage when the partitioning coefficient is known
- The partitioning coefficient ($K_{\text{crude oil/water}}$) for the tracer was measured by spiking produced water from a petroleum well (Ekofisk field) with the partitioning tracer and analyzing the concentration before and after shaking with equal volume of crude oil
- The K-value of the tracer at 20°C was calculated to 3.2
- The new partitioning tracer candidate has low toxicity and can be produced at an affordable price
- The thermal stability has not yet been fully tested for high temperature applications, but a preliminary test in produced water at 60°C showed good stability after 21 hours
- One advantage compared to other partitioning tracers is that the tracer can be measured using relatively simple and affordable analytical instrumentation that is robust and suitable for application on site in field studies. The results from the tracer study can be measured on site and will be available much faster than when samples have to be shipped to a laboratory for analysis

