Evaluation of Scaling Inhibitors in Geothermal Fluids at High Pressures and High Temperatures in Laboratory Scale

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Workshop on the geochemistry of geothermal fluids
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Problem

Inhibitor Requirements

Scaling inhibitors for geothermal application:

- Effective in low concentrations (low costs)
- Effective at high pressures and high temperatures (HPHT)
- Effective and stable over several months BUT:
- Degradable, non-persistent (green inhibitors)
- Low toxicity, no eutrophication (no phosphates, no phosphonates)
- Non-aggressive/corrosive for geothermal installations

Evaluation of Inhibitors

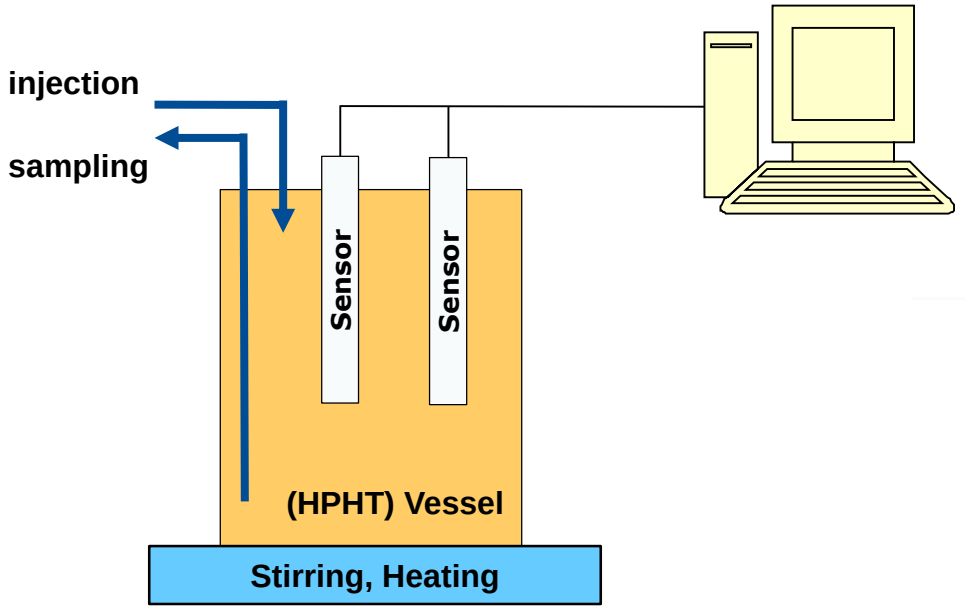
Evaluation of inhibitor efficiency:

- Determination of the minimal inhibitor-concentration (MIC),

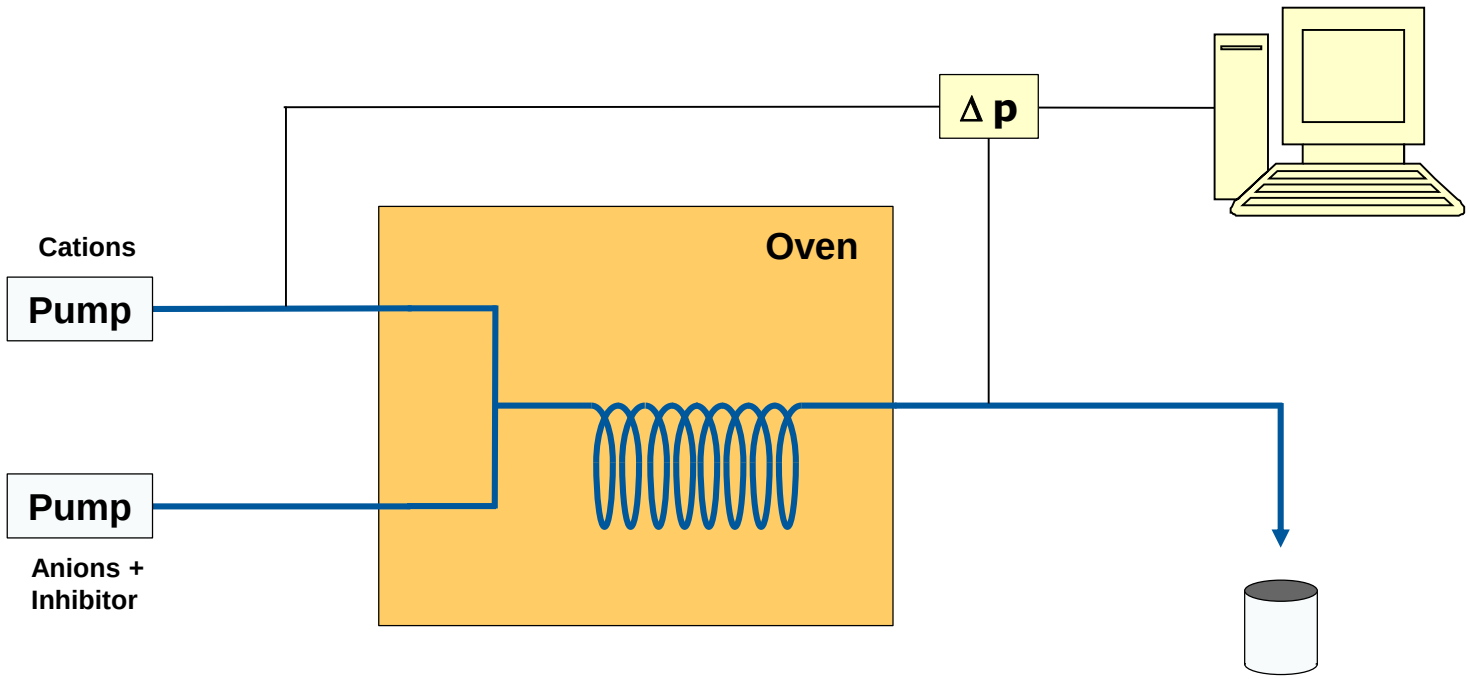
  Measure for mass related effectivity (ppm)

- Two test methods under HPHT:
  1. Static Batch Test (chemical equilibrium)
  2. Dynamic Tube Blocking Test (influence of flow and surfaces)

Static Batch Tests



Dynamic Tube Blocking



Research at GFZ

Fluid chemical laboratory:

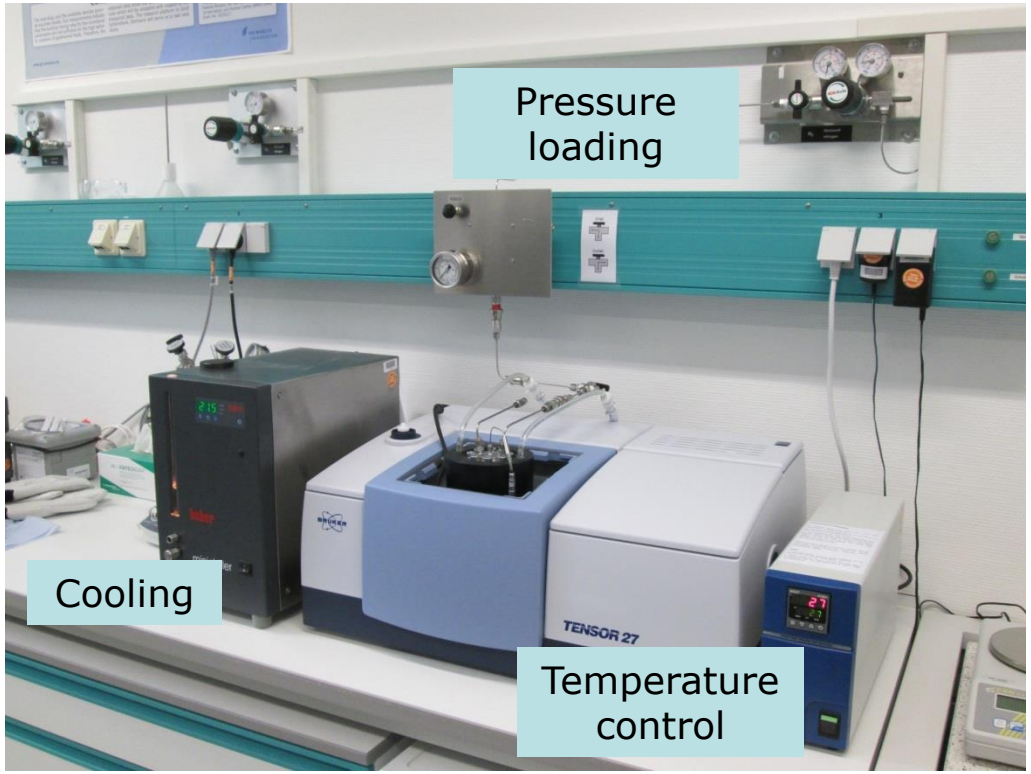
- static batch tests at HPHT conditions in autoclaves
- Investigation of inhibitor effectivity in dependence of p, T, pH, TDS (synthetic fluids and natural geothermal fluids)
- Investigation of thermal stability of inhibitors
- Characterisation of precipitated minerals

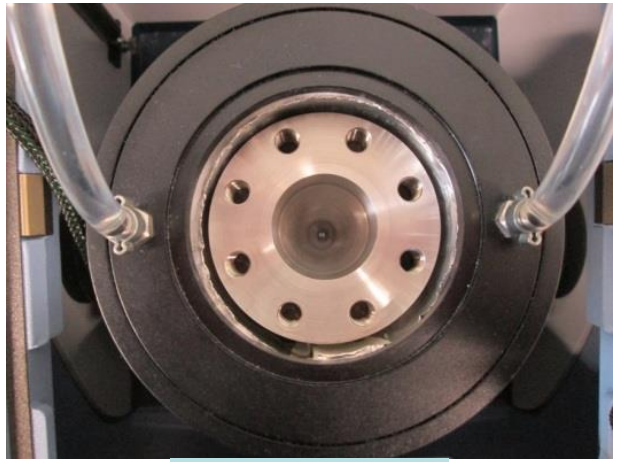
Analytical Methodology

- Online: Detection of inhibition in autoclaves by measurements of electrical conductivity, pH-value or redox potential at HPHT
- Offline: Effectivity evaluation by measurements of the mass of the precipitation and concentration of residual dissolved components (ICP-OES)
- Microscopic investigation of the scales (REM)
- Measurement of the thermal/chemical decomposition of the inhibitors at HPHT conditions by ATR-FTIR and LC-OCD

HPHT-Equipment

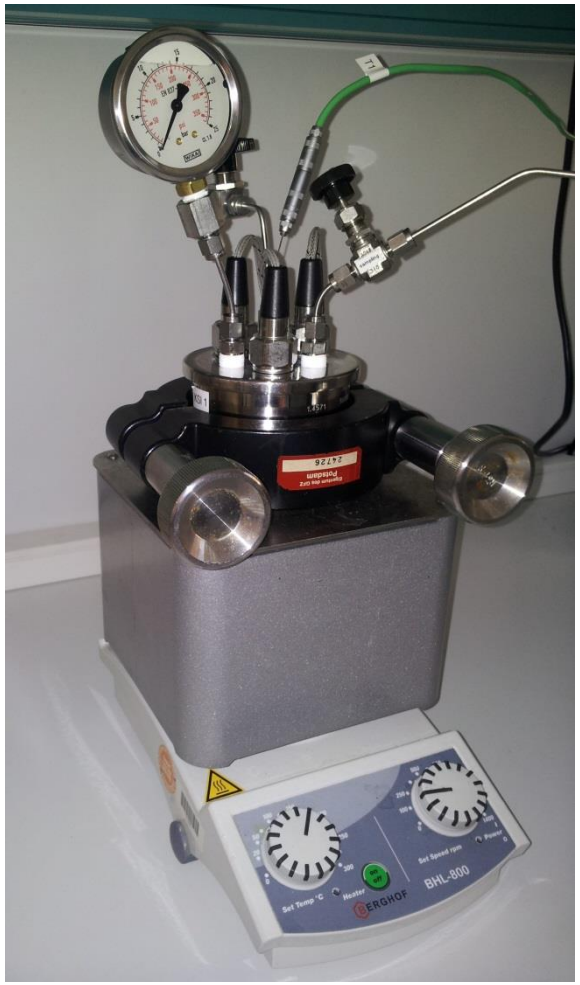
ATR-FTIR with HPHT measuring cell (200 bar, 200 °C)





Measuring cell

HPHT-Equipment

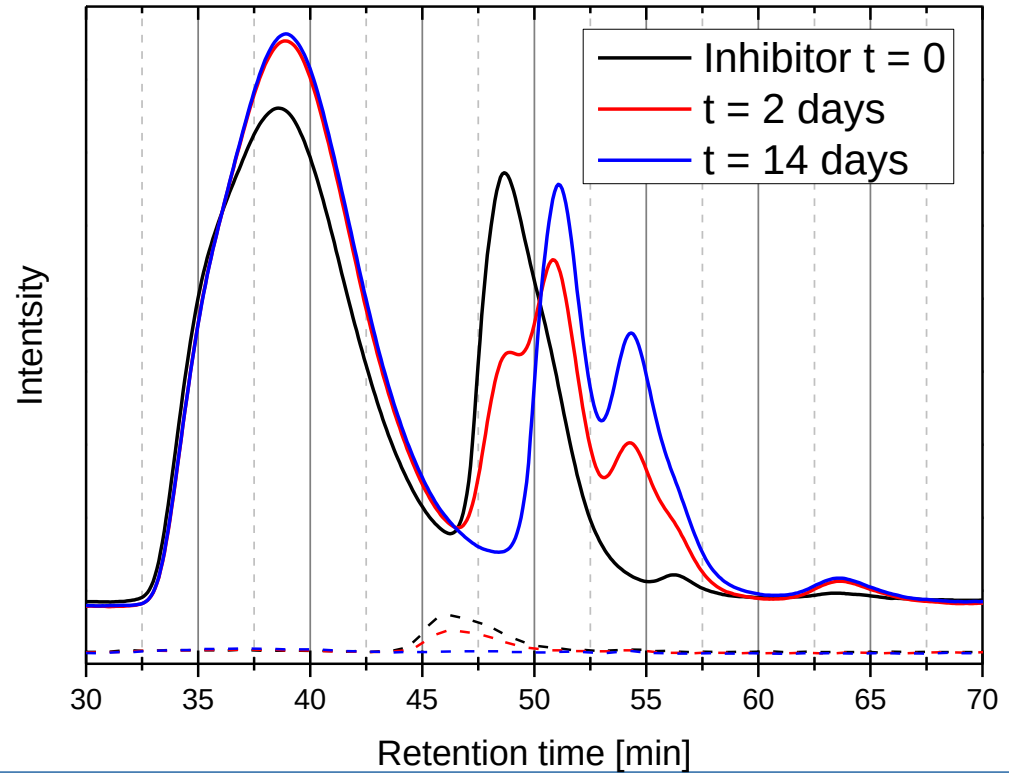


Stainless steel autoclaves (200 bar and 230 °C) with HPHT-analytical Sensors

2 Autoklavs coated with tantalum for highly corrosive fluids

LC-OCD Measurements

Degradation experiment: polycarboxylate inhibitor after 2 and 14 days treatment at HPHT-conditions



HPHT-Sensors

Detection of precipitation in static batch tests at HPHT
by monitoring physico-chemical properties of the fluid

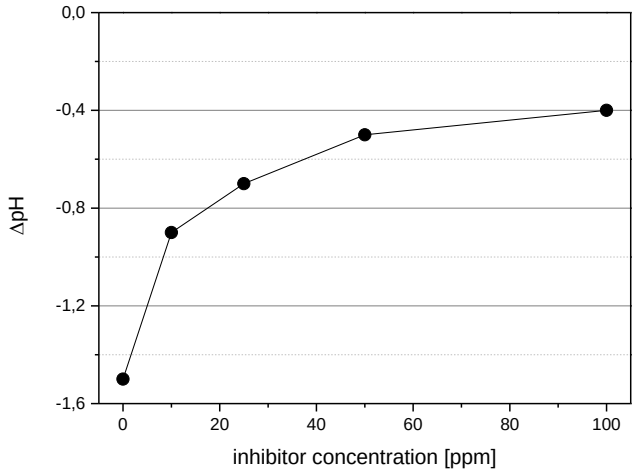
(150 bar, 125 to 200 °C)

Available HPHT-sensors for measurements of:

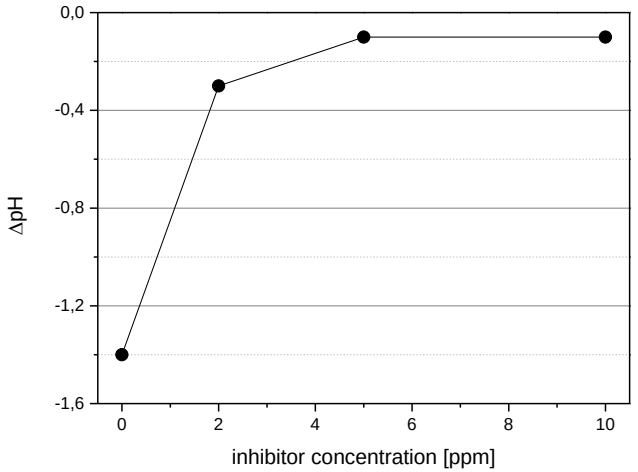
- Electrical conductivity (limited to low salinity)
- pH-value (limited to pH-changing scaling)
- Redox potential

Measurements

Inhibitor effectivity in batch tests by measurement of pH-values



Calcite precipitation at **120 °C** and **10 bar** with inhibitor
MIC (50%) = 25 ppm

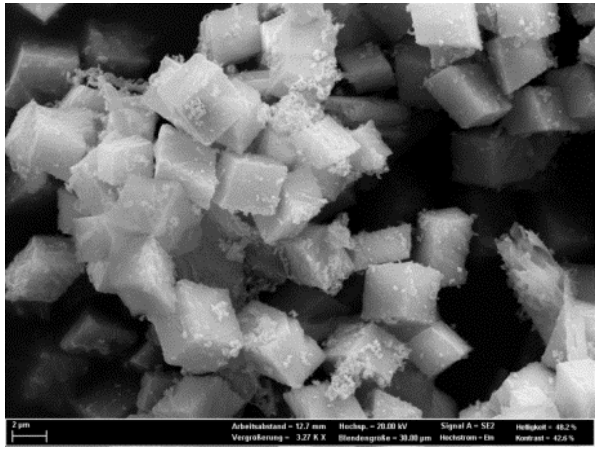


Calcite precipitation at **30 °C** and **ambient pressure** with inhibitor
MIC (50%) = 2 ppm

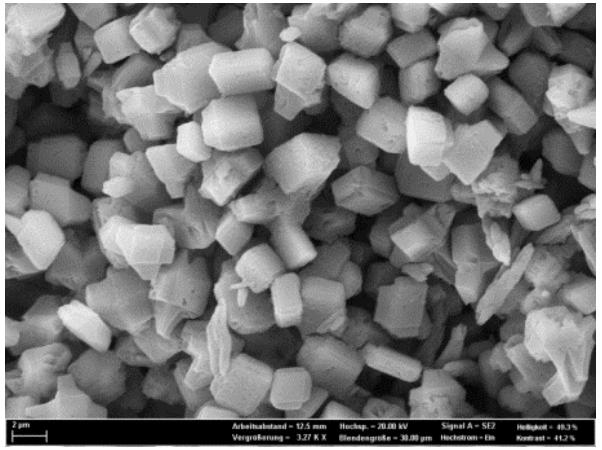
J. Zotzmann and S. Regenspurg, Evaluating the Efficiency of Scaling Inhibitors in Geothermal Fluids at High Pressures and High Temperatures, *Proceedings World Geothermal Congress*, Melbourne, Australia, April **2015**

Investigation of Precipitates

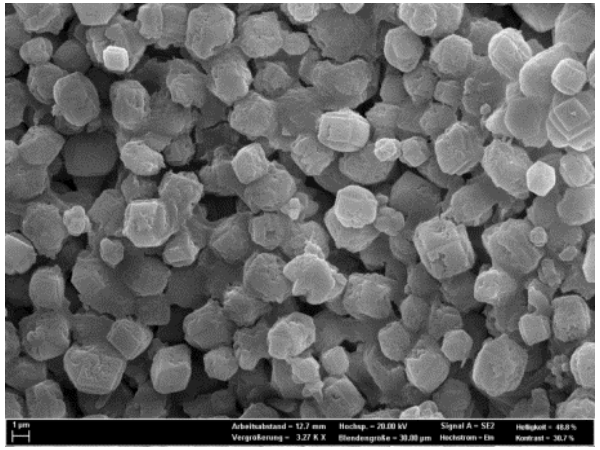
REM pictures of calcite scales from HPHT-experiments
(Magnification: 3270)



No Inhibitor



25 ppm Inhibitor



100 ppm Inhibitor

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Results To Date

- Investigation of inhibitor effectivity:
  online detection limited to fluids with low salinity and carbonate scales
- Evaluation of inhibitor effectivity by static batch tests:
  significant decrease of effectivity under HPHT-conditions
- Investigation of inhibitor stability over 4 weeks at HPHT:
  polyacrylate/polyamide inhibitor was partially stable

Thank you for your attention!