Challenges of geothermal development – Contribution to the workshop on geothermal research/knowledge exchange

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How are the operators organised, what characterises their (research-)needs?

- At present, the geothermal community is organized in the **Bundesverband Geothermie – BVG** (Federal Geothermal Association of Germany) and the **Wirtschaftsforum Geothermie – WFG** (Economic Forum Geothermics) which will be united at the end of this year.

- There are also regional networks such as the GeoEnergy Celle e.V. and the Wirtschaftsvereinigungs Geothermie e.V. (integrated into Internationales Geothermiezentrum Bochum, GZB).

- There does not exist an association of operators only. The needs are quite different in the three geothermal regions North German Basin, South Bavarian Molasse Basin and Upper Rhine Graben.

- But in particular in Bavaria there are efforts being undertaken to establish fora for operators because of the big synergies expected therefrom. Compared to all the other stakeholders in the geothermal field operators benefit from the fact that there is hardly any competitive thinking as the “claims” are secured.

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How is the knowledge-development and -exchange organised?

- There is a national research program with priorities to be agreed upon with the associations and selected committees. In addition, there are several programs of the Federal States supporting research in the geothermal field.

- The exchange of experience is mainly via national geothermal conferences and sessions for which there is a surplus at present in my view.

- The results of the pilot projects of major research institutions are often of little relevance for operators.

- Geothermal energy systems/geothermal engineering has been implemented in academic education (Master degrees).

- A national geothermal information system (www.geotis.de) is available. The requirement to integrate data from geothermal projects in common data pools/platforms has been recognised.

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What issues were encountered in the past, are they solved and are the solutions relevant for others?

- Improved temperature models available (www.geotis.de)

- Regional 3D geological models partly available, but to date mainly useful as overview owing to limited resolution & precision.

- Development of monitoring of induced seismicity (recommendation of the FKPE, research project MAGS).

- Application of 3D seismic data to improve exploration risk.

- First (limited) experience in mechanical/hydraulic stimulation from research projects (no progress after 2011).

- Research/developments in drilling engineering (e.g. drilling at high temperatures, materials).

- Testing of the Kalina technology in the field of low-enthalpy geothermal energy use.

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What issues were encountered in the past, are they solved and are the solutions relevant for others?

- Minimization of the exploratory risk through comprehensive facies characterization

- Optimization of the sand control in geothermal wells through appropriate gravel packing, etc.

- The selection and testing of the material for highly saliferous thermal water loops (glass fibre reinforced epoxy pipes, coating, etc.).
- Best possible prevention or management of precipitations in highly saliferous thermal water loops (pressure upkeep, filter optimization) and the related long-term stability of the injection behaviour in sandstone aquifers.

- Improved experience in acidizing geothermal wells (acid stimulation).

- Optimization of the sand control in geothermal wells through appropriate gravel packing, etc.

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Waren GHP

Injection well:	in operation since1986!
Geological formation	Hettangian
Depth:	1,470 m
Production temperature :	61 °C
Injection temperature:	20 to 40°C
Mineralisation:	158 g/l
Injection flowrates:	up to 60 m³/h

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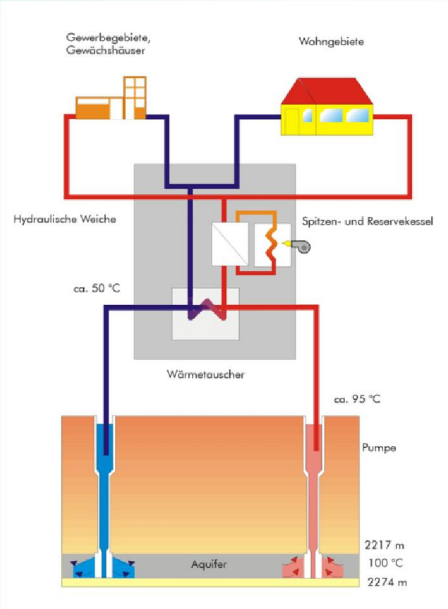
Neustadt – Glewe GHP

Injection well	*in operation since 1995*
Geological formation:	Contorta
Depth:	2,200 m
Production temperature:	98°C
Injection temperature:	40°C to 80°C
Mineralisation:	220 g/l
Injection flowrates:	up to 125 m³/h
Iron content (Fe^{2+}):	82 mg/l



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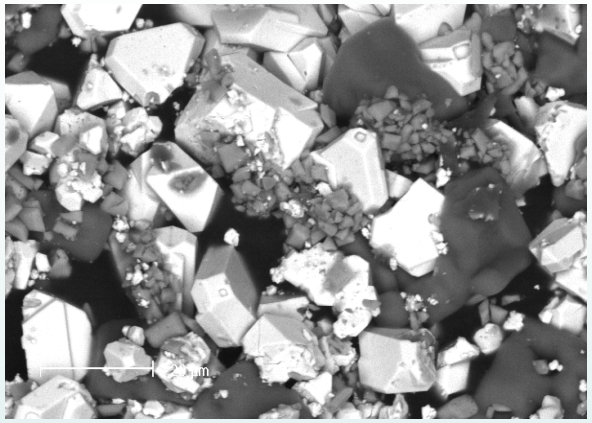
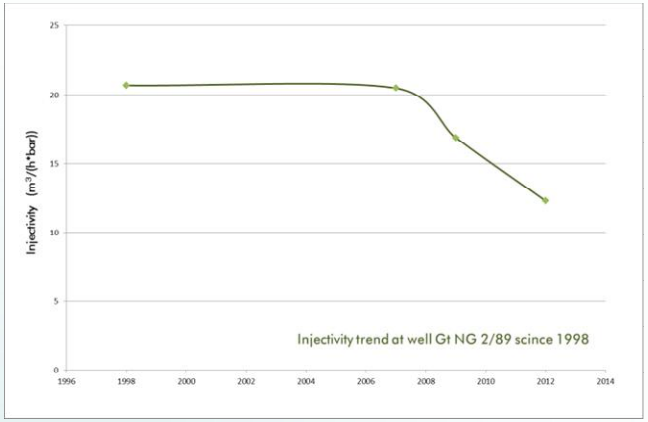
Monitoring of plant operation

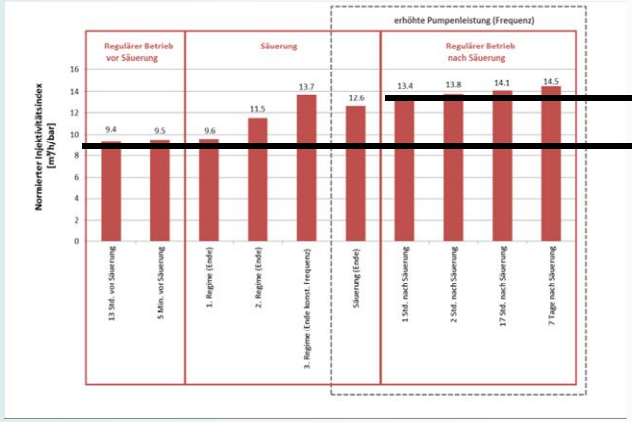


Mineral precipitation due to cooling/pressure degrease



Degreasing injectivity due to filter screen clogging

Soft acidzing



Injectivity $m^3/(h*bar)$

14.5 - after

9.4 - before

Significant injectivity rise

Filter screen clogging - Soft Acidizing

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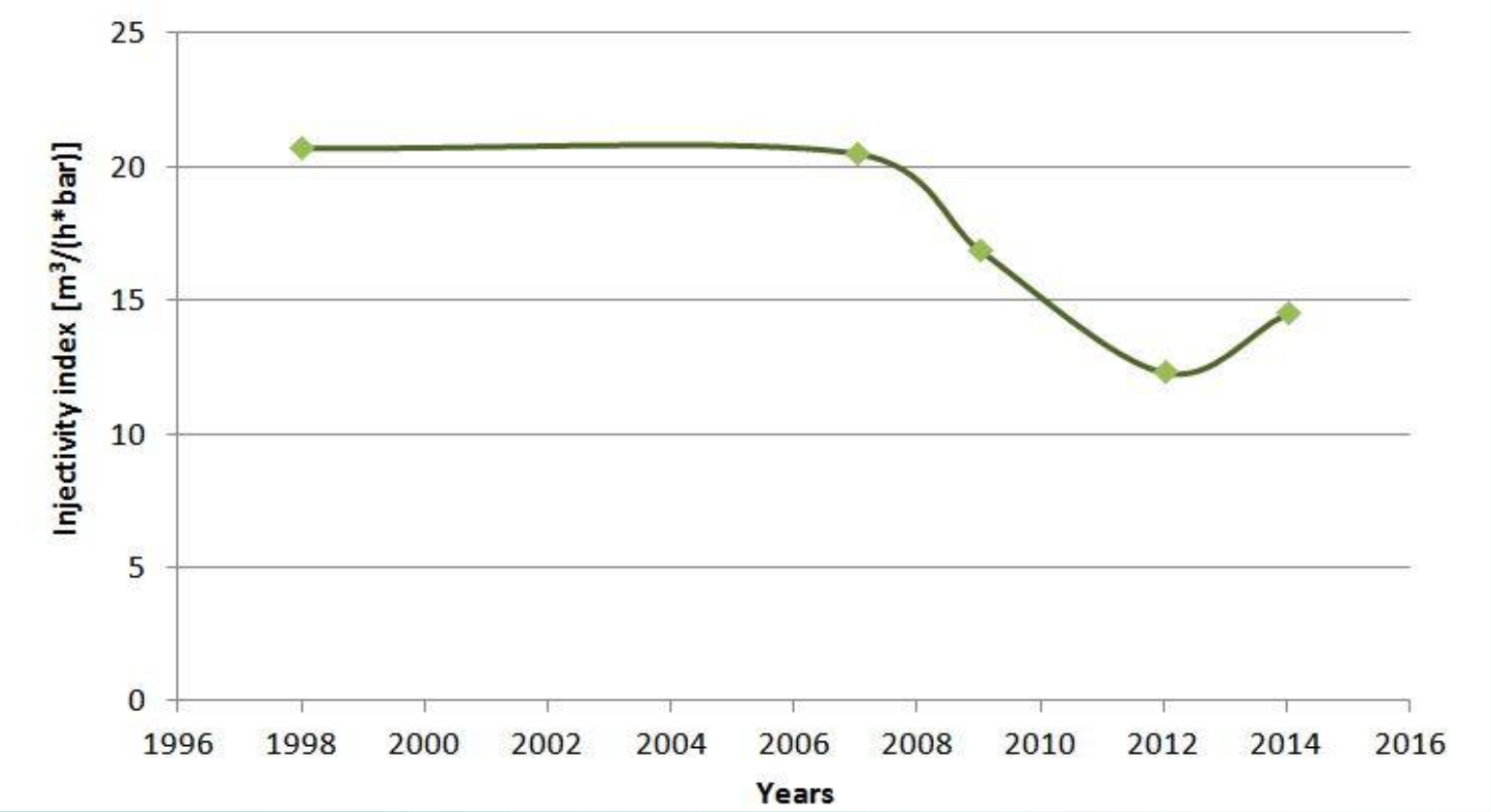
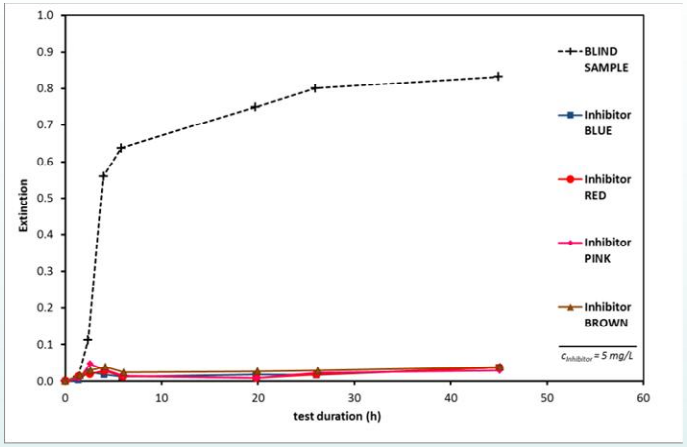
Decreasing injectivity due to precipitation of barite and galenite in the injection well



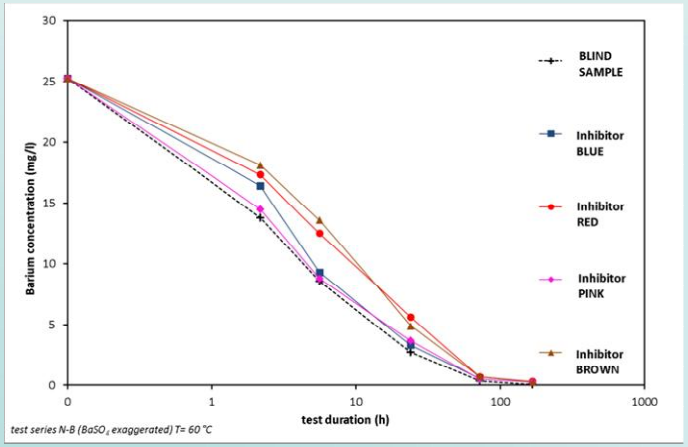
*Injectivity index (m³/(h*bar)) of the injection well at Neustadt-Glewe from 1998-2014*

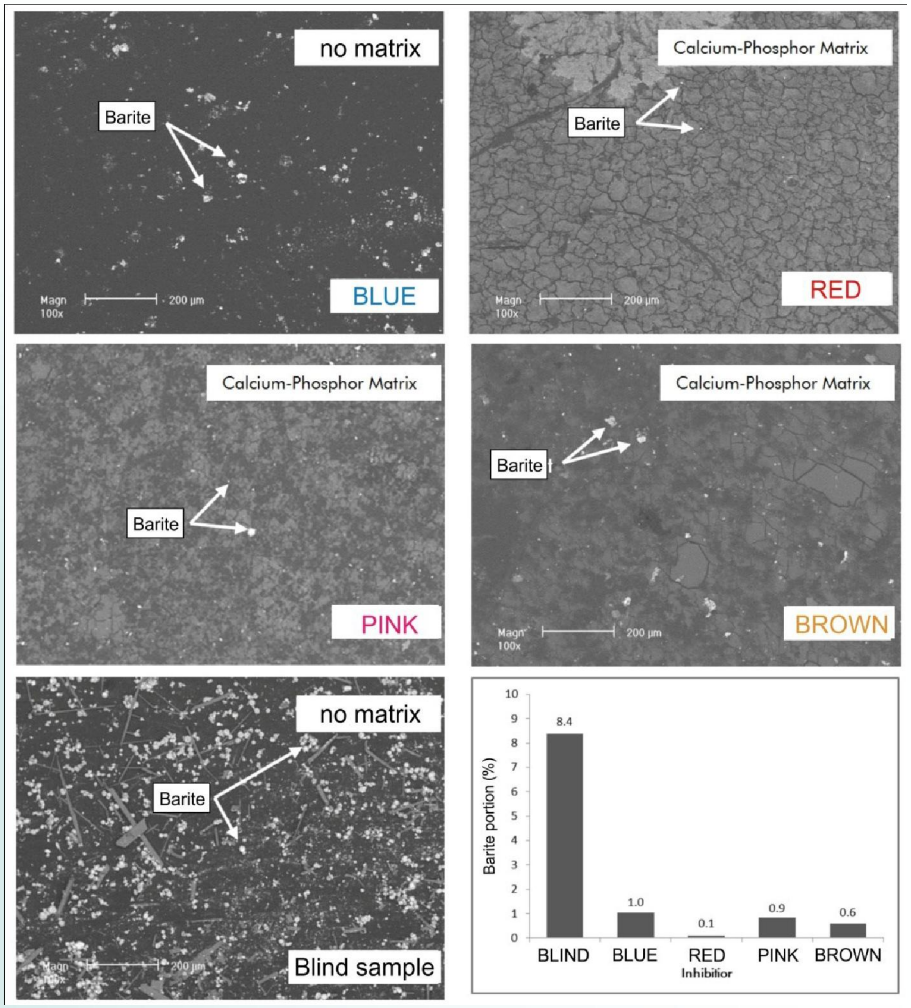
Scientific Task

Dynamic Bottle Tests: Inhibitor effectivity



Batch experiments: Long-term stability in the reservoir





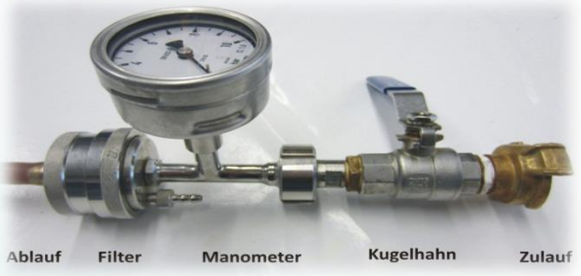
SEM images at 100-fold magnification and BSE-detector of the blind sample and the inhibitors BLUE, RED, PINK and BROWN.

Laboratory experiments
Selection and test of different scale inhibitors

Injectivity

A) Control of the particle load in the thermal water

- Concentration of the solids
- Type of solids
- Size and shape of solids

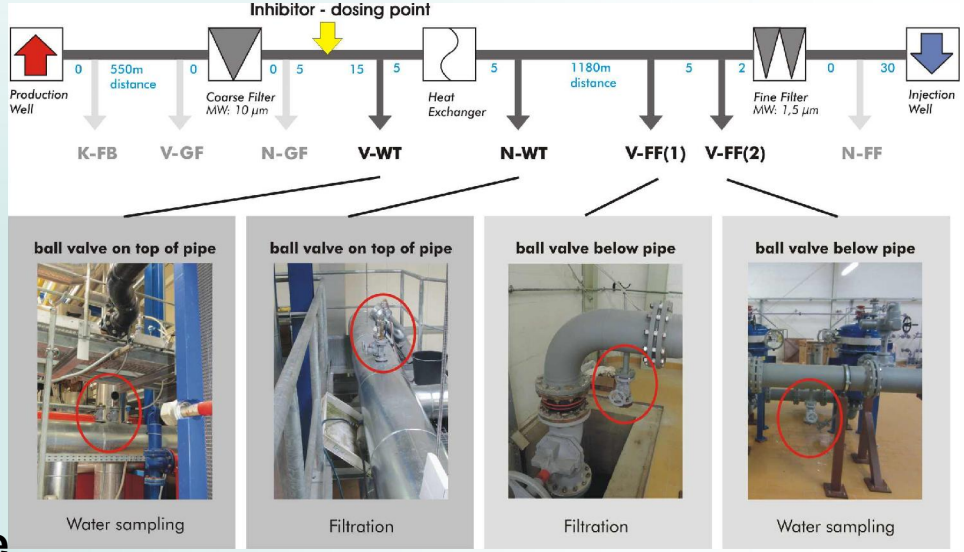


Filter unit for control of the particle load

B) Control of the water chemistry

- Sensors
- Electric conductivity (TDS)
- pH
- Redox potential

C) Control of the injection pressure

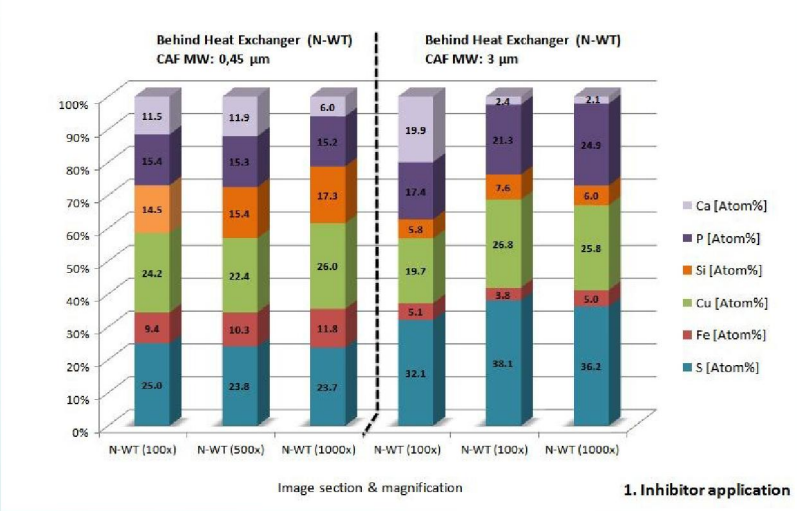


Sampling points in the Neustadt-Glewe geothermal plant

Experimental Application
Monitoring program for the period of inhibitor injection

Injectivity

Installations for the inhibitor injection



Analysis of EDX overview spectra of the samples behind the heat exchanger

Organic residues of the inhibitor on the filter bags at the injection well

Experimental Application
Inhibitor addition to the thermal loop