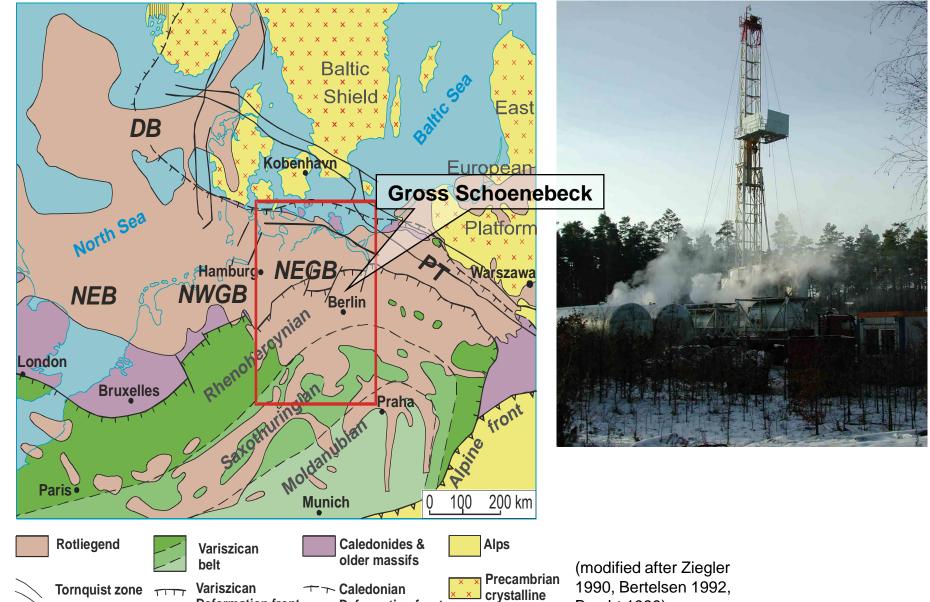




# In situ Geothermal Laboratory





Brecht 1999)

basement

**Deformation front** 

**Deformation front** 



# **Operations overview**



#### open hole proppant frac

#### Jan/Feb 2002

- production test / logging
- 4130-4190m (frac 1)
- 4080-4118m (frac 2)
- production test / logging

# open hole waterfrac start Jan/Feb 2003

- 3874-4294m, borehole instability
- production test

#### cont. Nov/Dec 2003

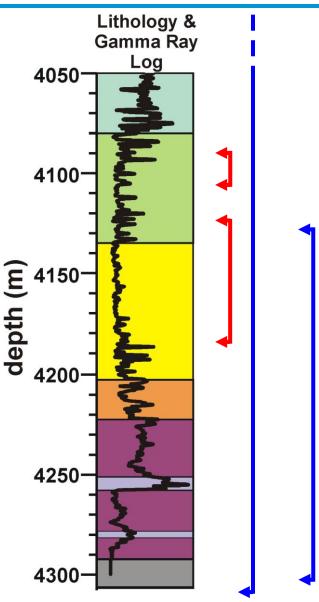
- 4135-4309m
- production test / logging

#### **Dec 2004**

injection test

#### April 2006 to Jan 2007

O drilling 2. well





# On the way to an operating doublet



## well path of second well

- designed as deviated well
- in direction of minimum horizontal stress
- to optimize performance of doublet

#### aim

- maximization of flow rate
- for 30 years
- avoid thermal short circuit

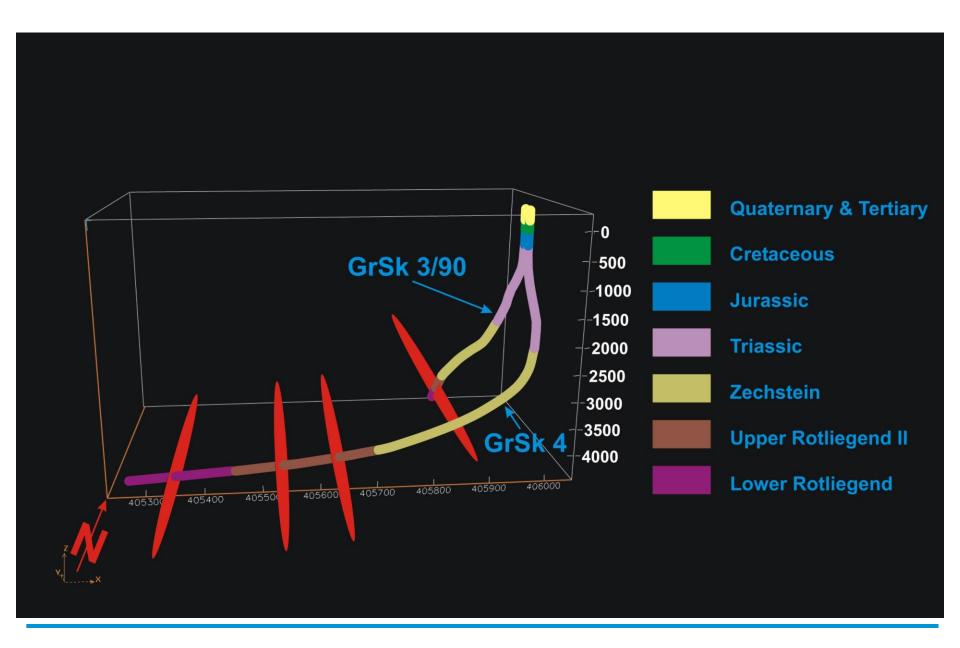
#### scheduled fracture treatments

- designed to achieve PI > 30 m<sup>3</sup>/(h\*MPa)
- sufficient for geothermal power production on economic level



#### **EGS Gross Schoenebeck**

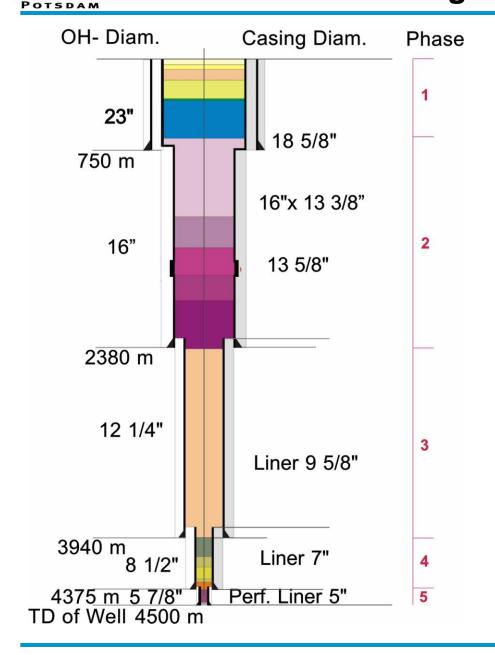


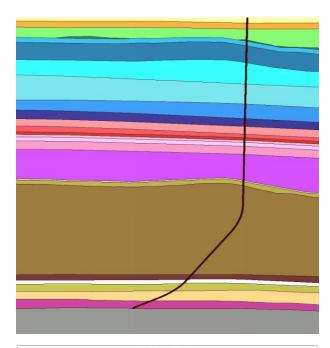


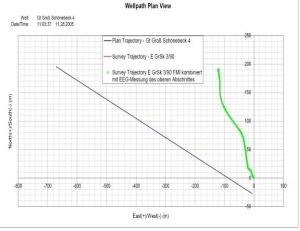


#### Borehole Design of the Research Well











#### **Lessons learned**



 drilling a large diameter borehole in sheet silicate bearing rocks (sequenzes of sand/sandstones and clay/mudstones)

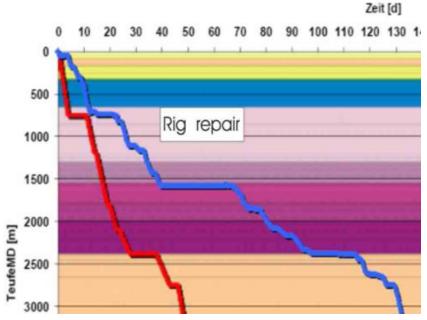
 directional drilling through and beneath rock salt formations with plastic behaviour

 Adaptation to encountered geological conditions requires the variability of mud concepts with the goal of minimized formation damage



#### Large top hole diameter affected ROP





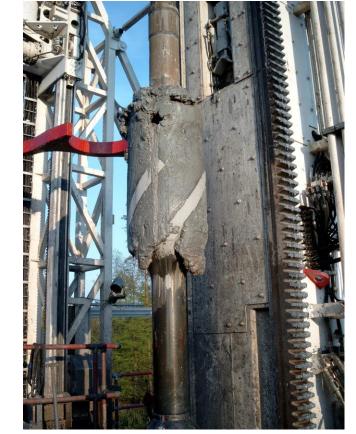
Insufficient pumping capacity in the top hole region (23") lead to bit balling resulting in a ROP of 4...7 m/h and an increased number of trips.

Improper bit selection reduced ROP in



the mesozoic section (16").





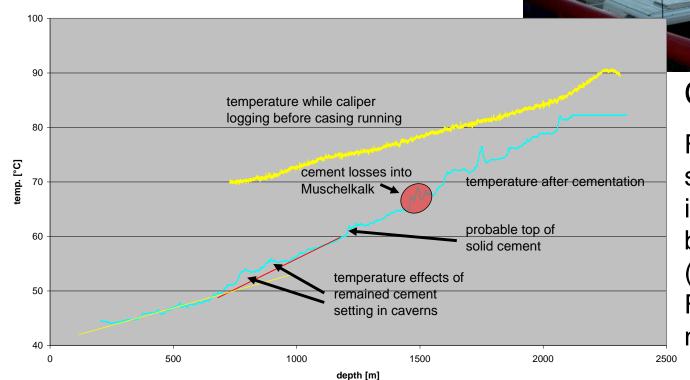


### disastrous cementation of 16"x13 3/8" casing



Total fluid loss occured during the cementation of the combined casing 16" x 13 3/8" despite of a slurry density of 1450 kg/m³ (Litefil by Schlumberger) due to plugging of the annulus by debris

temperature logs



#### Conclusion:

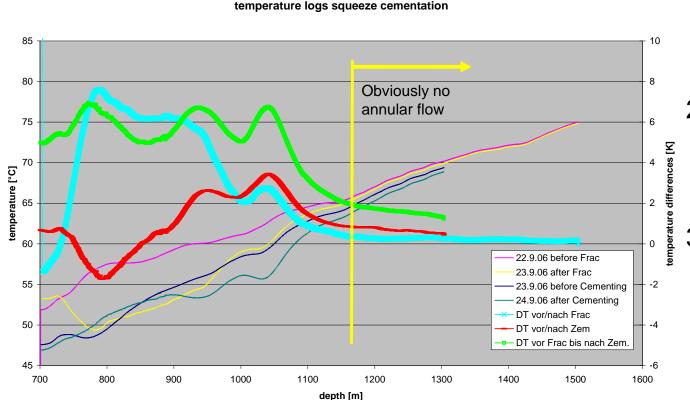
Free pipe will not stand the thermally induced stresses to be expected (buckling). Free floating pipe is not acceptable.



## Recovery of casing cementation



To prevent casing damage in the future of the production well a reverse squeeze cementation through the annulus was designed and successfully performed:



- 1. Free point
  estimation and
  cement bond
  log verified top
  of cement
  - Fluid loss
    during injection
    occurs near to
    top of cement
    Slurry density
    of squeeze
    cement with
    1,30 below
    density of mud

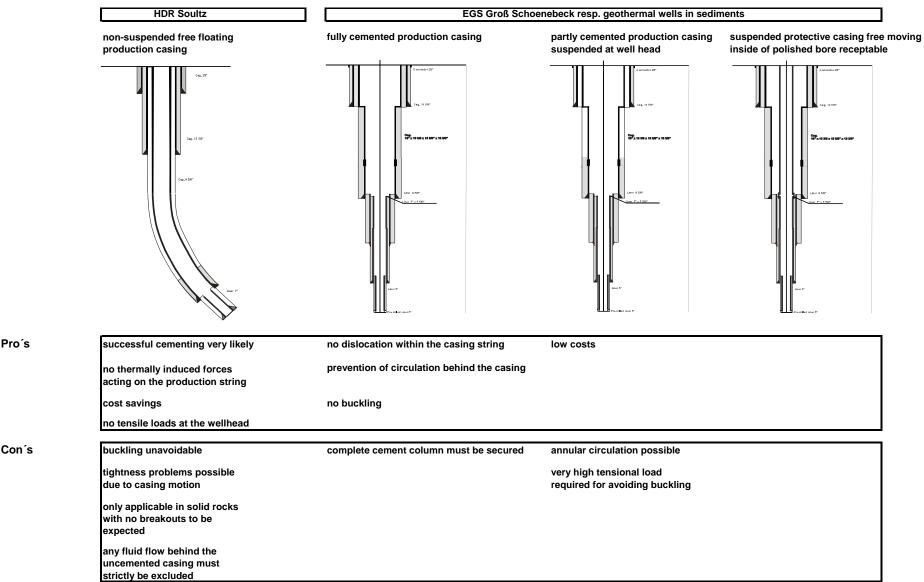
to be displaced



#### POTSDAM

# Well design concepts for deep geothermal wells

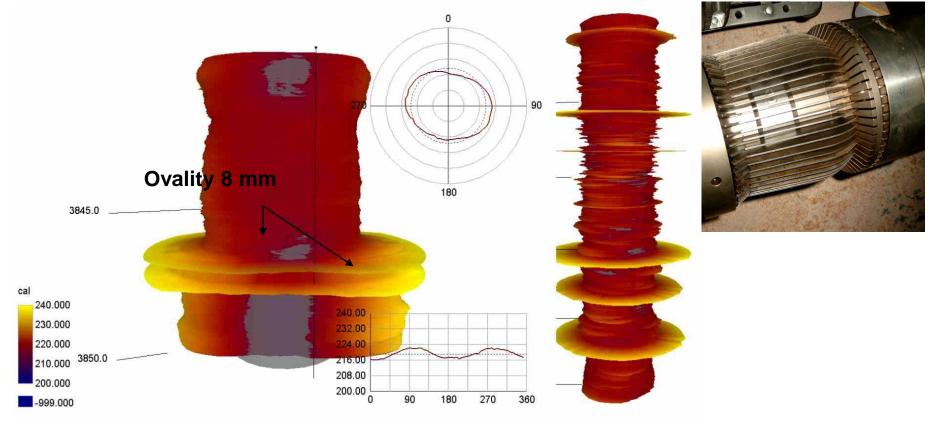






# Casing collapse within the rock salt





9 5/8" liner collapsed during drilling into the target formation after reduction of mud density from 2000 kg/m³ to 1060 kg/m³ (Heavy deformation between 3880...3200 m)



# Cause of collapse



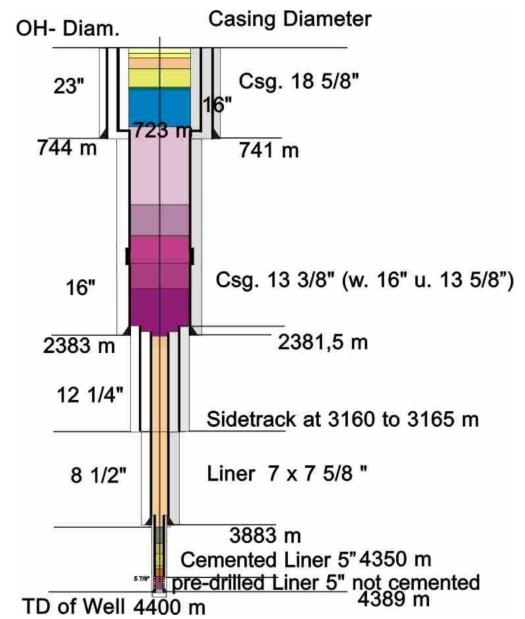
- Casing design according to the rules with an overburden pressure gradient of 2,3
- Casing material successfully inspected
- Anisotropic tension due to well path geometry unlikely according to cross-correlation
- Anisotropic tension due to rock salt inhomogenities within the salt dome in connection with the geomechanical impact of drilling not verifiable
- Anisotropic tension due to improper cementation of the deviated well not very probable due to no. and positioning of centralizers and cementing procedure strictly following the simulation



## Remedy for the collaps



The loss of one casing dimension forced to adjust the borehole design drilling of the Rotliegend section with 5 7/8" and running and cementing of an combined 5" liner with an uncemented section of preperforated pipes on bottom.





#### **Conclusions**



# Cost effective drilling of geothermal wells means

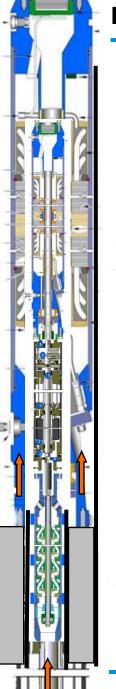
- Considering all costs emerging over the lifetime of the well
- #Design the well as tall as possible but leave one ace upon your sleeve
- #With highly corrosive fluids provide demountable coated or lined production/injection strings
- #Particularly to geothermal producers and injectors adapted repair technologies for casings should be available



# **Tubingless insert**

### nimizes well diameter





Is the geothermal "industry" strong enough to demand such developments?



# Repair of cemented casings



#### Reasons

- Internal corrosion due to air access during production/injection
- Closing of perforations etc. (e.g. after secondary cementing)

Means and technologies of expandables are to be worked out and assessed in cooperation with experienced players:

- # Cladded liners (casing patch)
- # Downhole coating of casing
- ## Downhole relining of casing with thin (folded) metallic liners

