

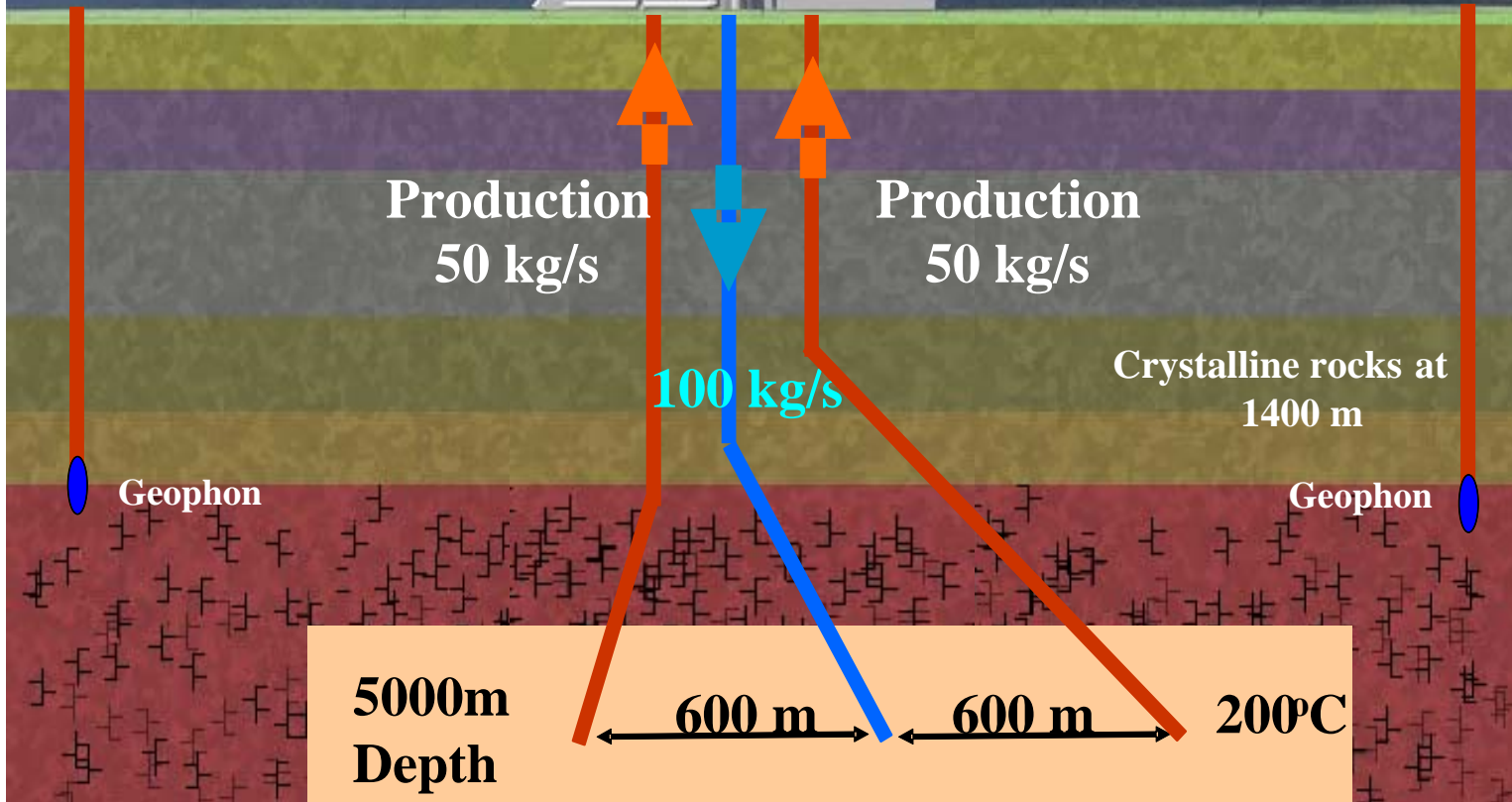
**Hydraulic stimulation  
and  
microseismic fracture monitoring  
within  
the deep granite holes  
at the  
Soultz-sous-forêts geothermal site**

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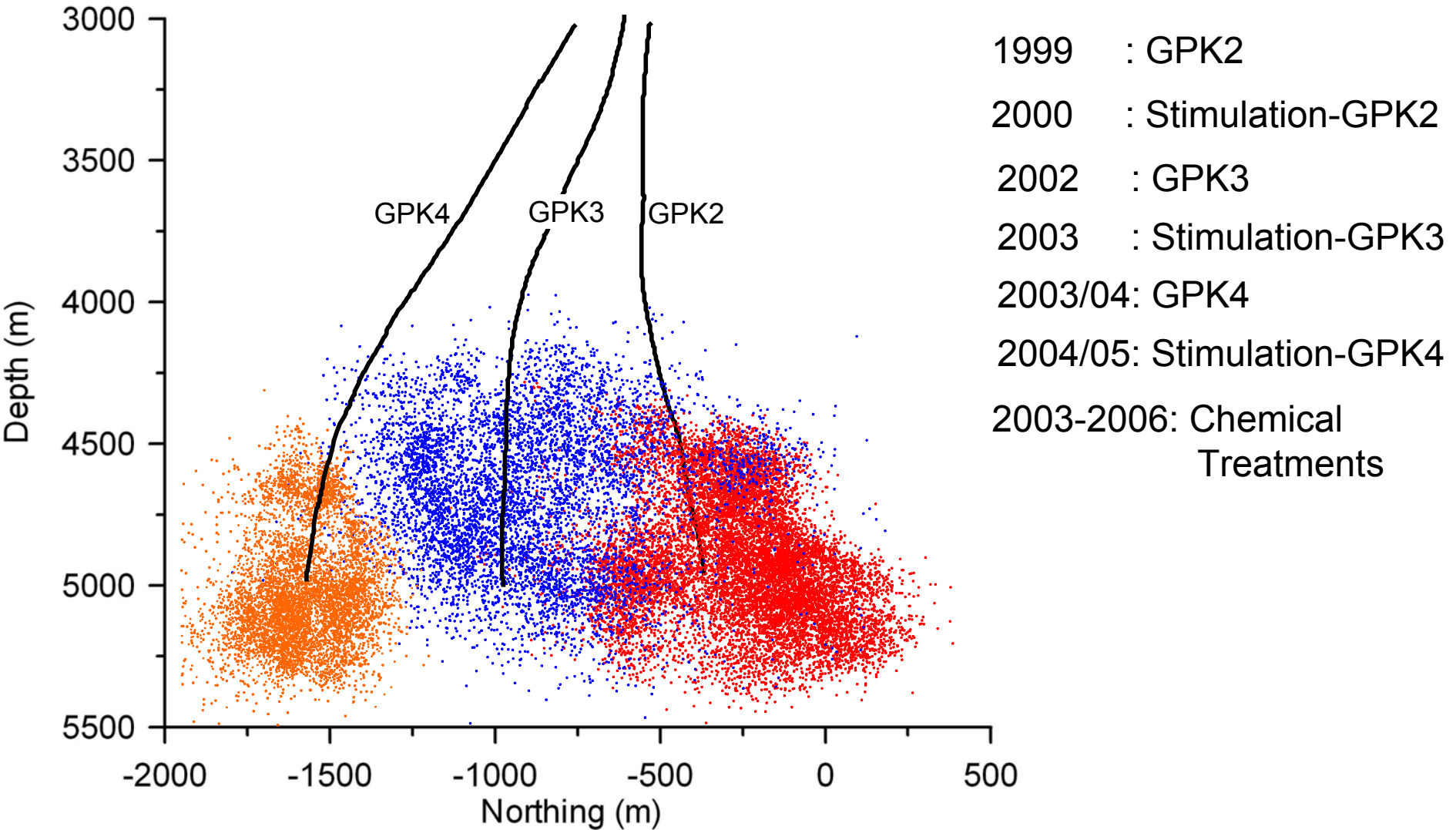
- Introduction
- Hydraulic Stimulation and Productivity Enhancement
- Microseismic Monitoring
- Acidification
- Conclusions

# HDR/EGS Pilot plant in Soultz

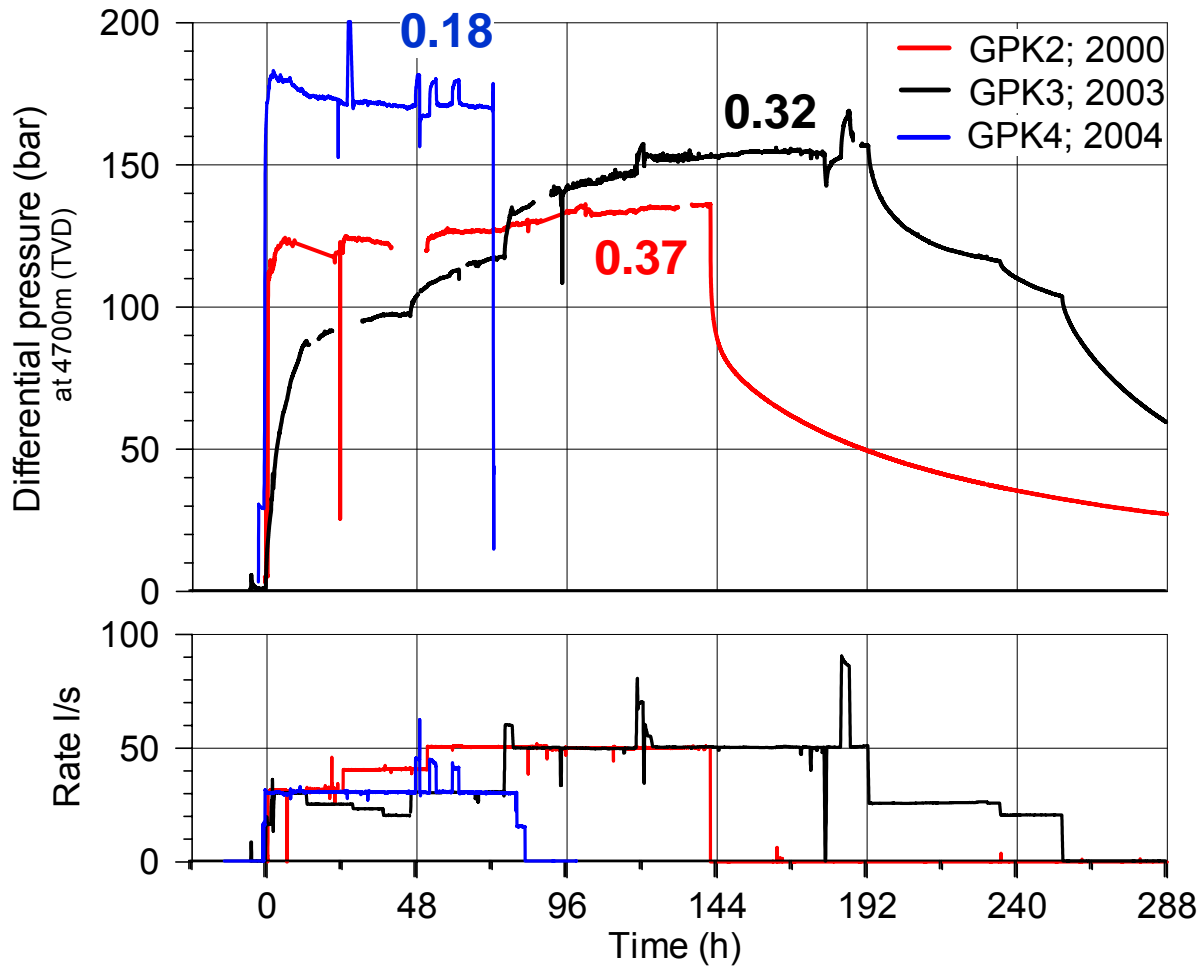
1.5 + 4.5 MWe



# Development of the deep reservoir at 5000 m



# Pressure and productivity during stimulation



Injection volume:

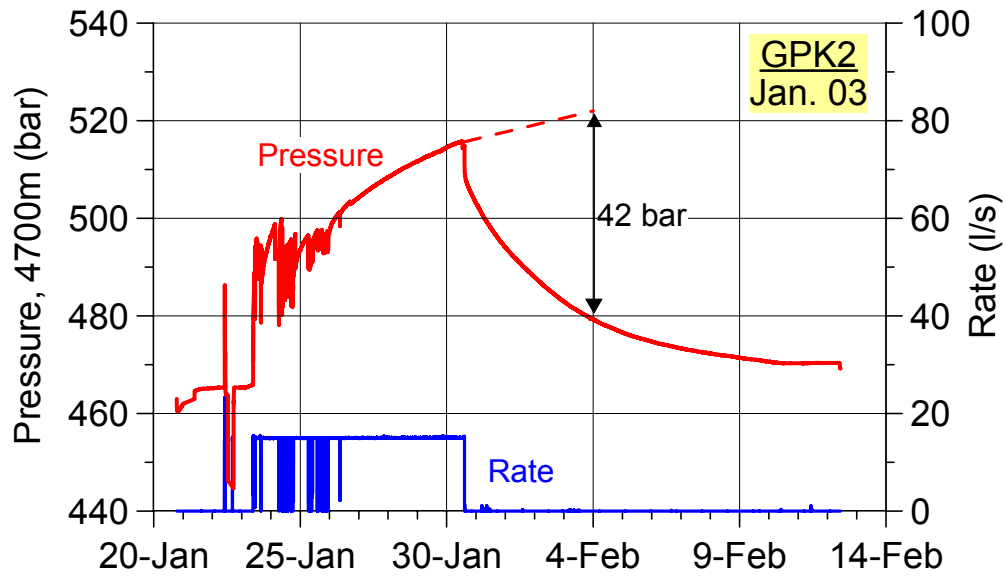
GPK2: 23400 m<sup>3</sup>

GPK3: 34000 m<sup>3</sup>

GPK4: 9300 m<sup>3</sup>

(Productivity in l/s/bar)

# Injection tests after stimulation



Productivity:

GPK2 (4 d): 0.36 l/s/bar

## Comparison of productivities

<b>Productivity (l/s/bar):</b>	<b><u>GPK2</u></b>	<b><u>GPK3</u></b>	<b><u>GPK4</u></b>
During Stimulation	0.35 (4 d)	0.30 (4 d)	0.20 (3 d)
After Stimulation	0.35 (4 d)	0.30 (4 d)	0.20 (3 d)
<i>Before Stimulation</i>	$\approx 0.02$	$\approx 0.2$	$\approx 0.01$

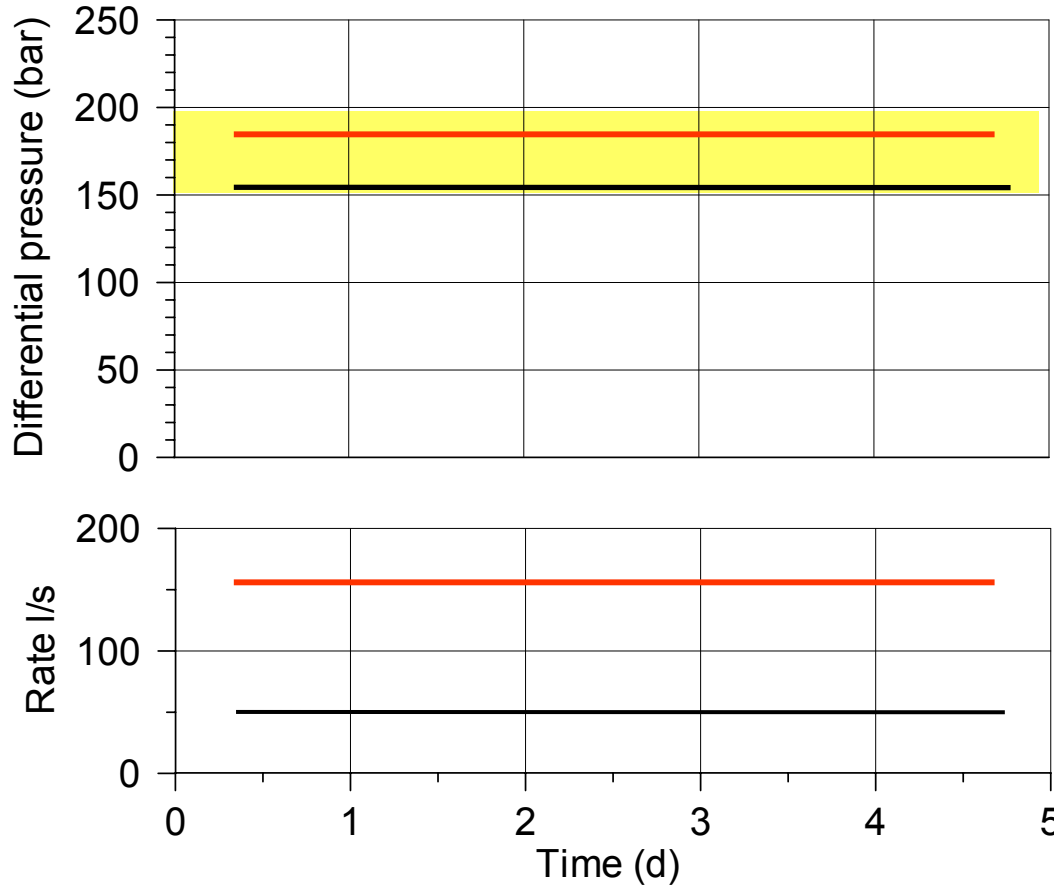


**Productivity during stimulation has been retained after stimulation !**



**Productivity enhancement can be predicted !**

# Prediction of productivity enhancement



pressure controlled by rock stress !

## Productivity:

1.  $\approx 0.3$  l/s/bar

2.  $\approx 0.9$  l/s/bar



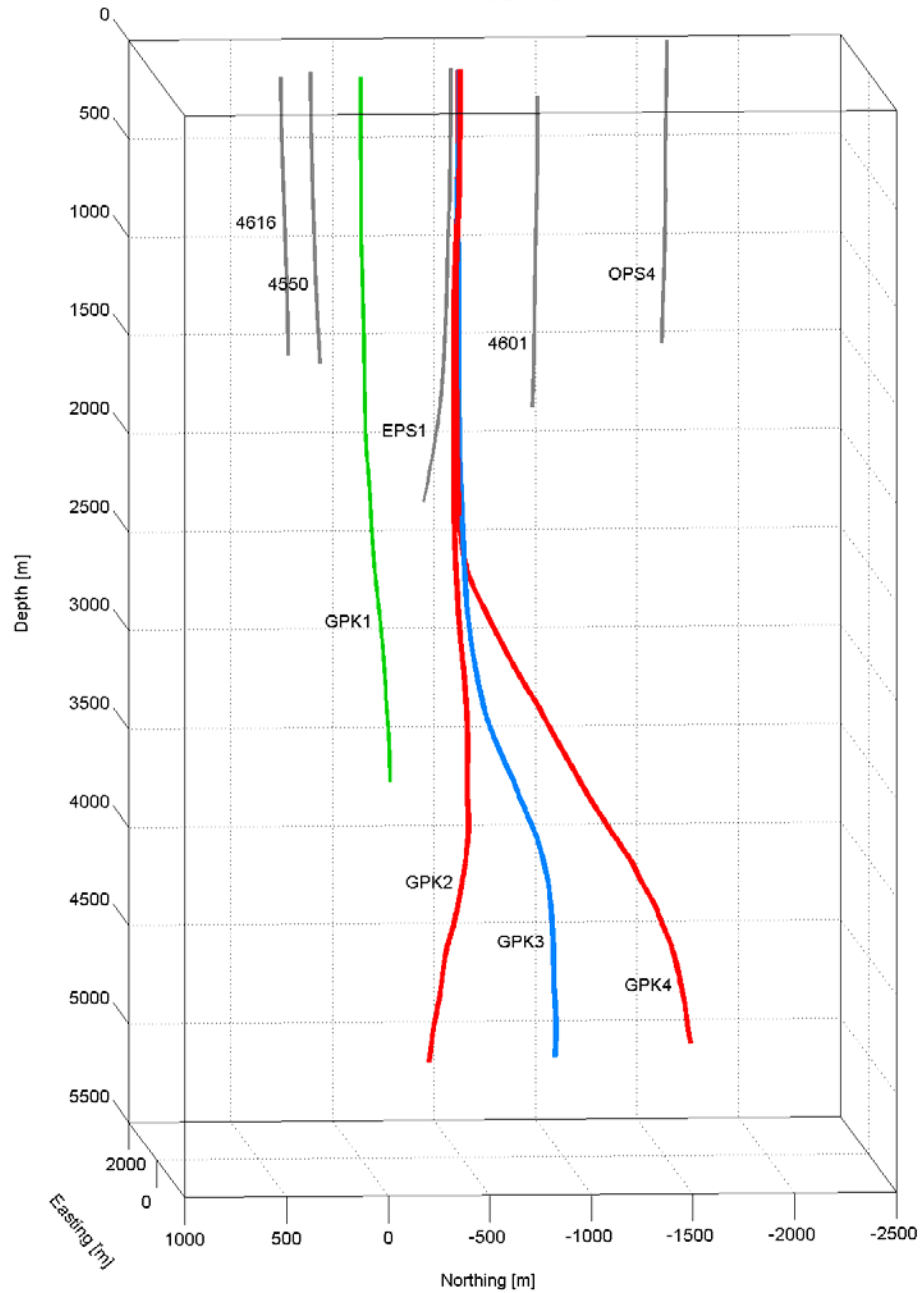
## Productivity und hydraulic communication

- Productivity only characterises single wells
- Hydraulic communication between the wells is necessary



Microseismic monitoring !

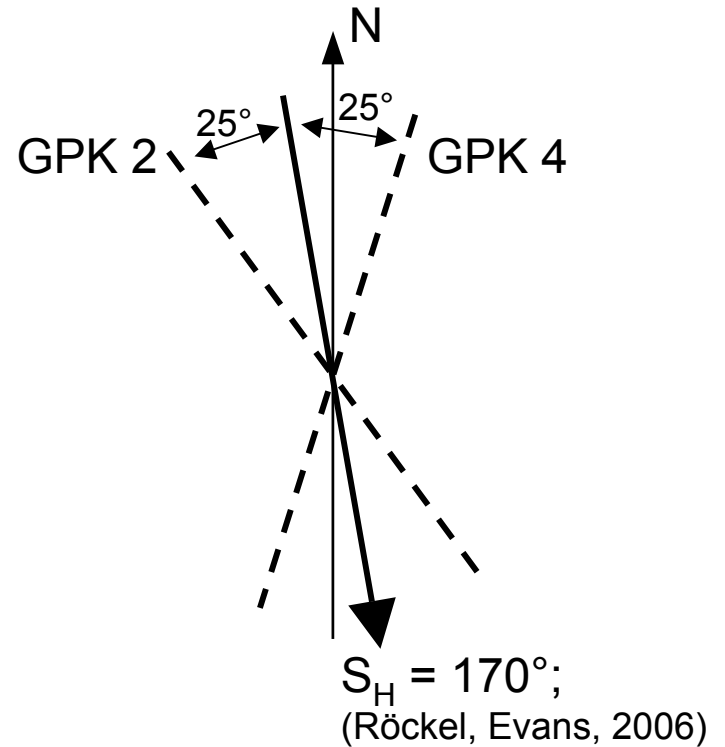
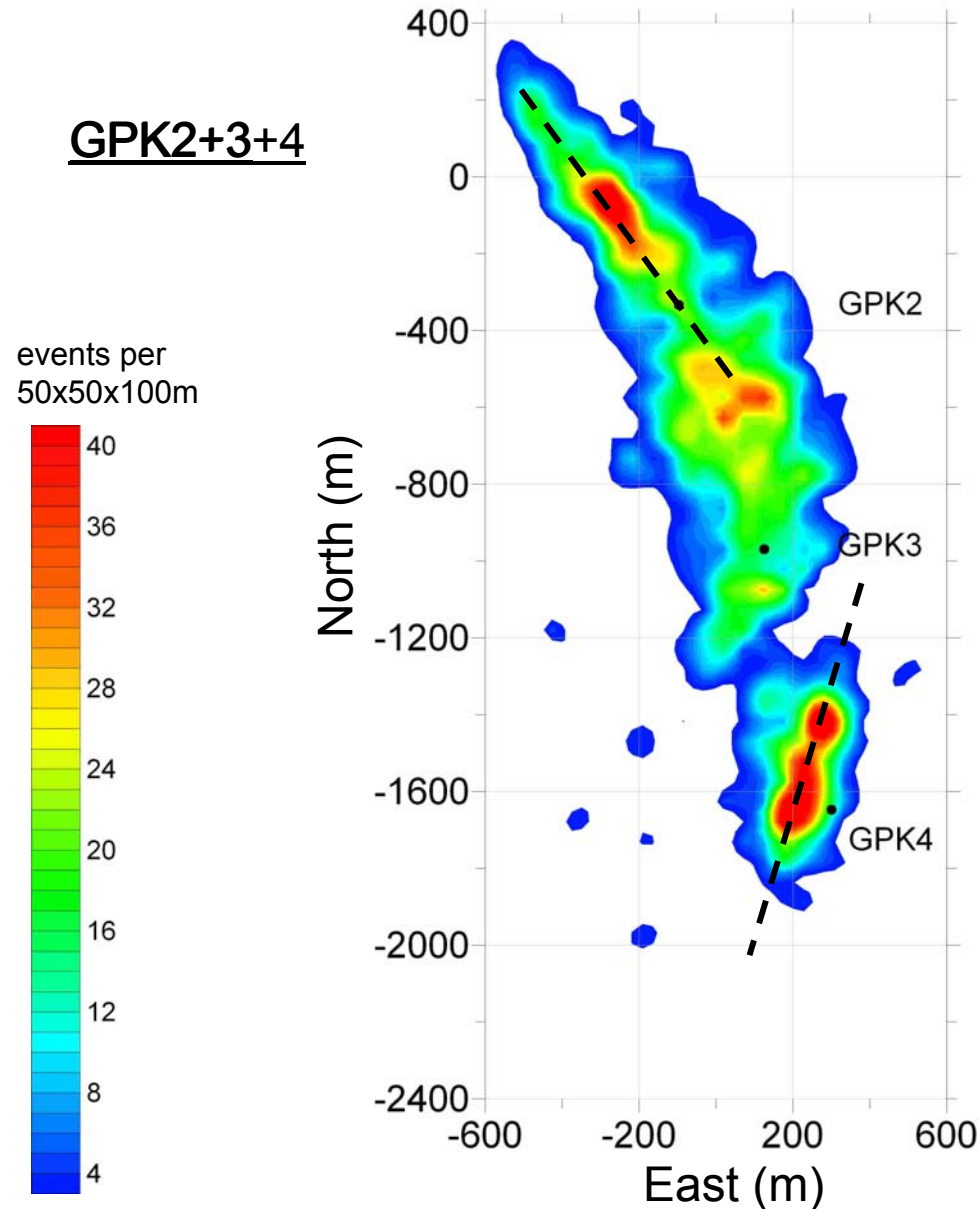
The Soultz Site 2005



6 seismic observation wells

# Seismic events (4900-5000m)

GPK2+3+4



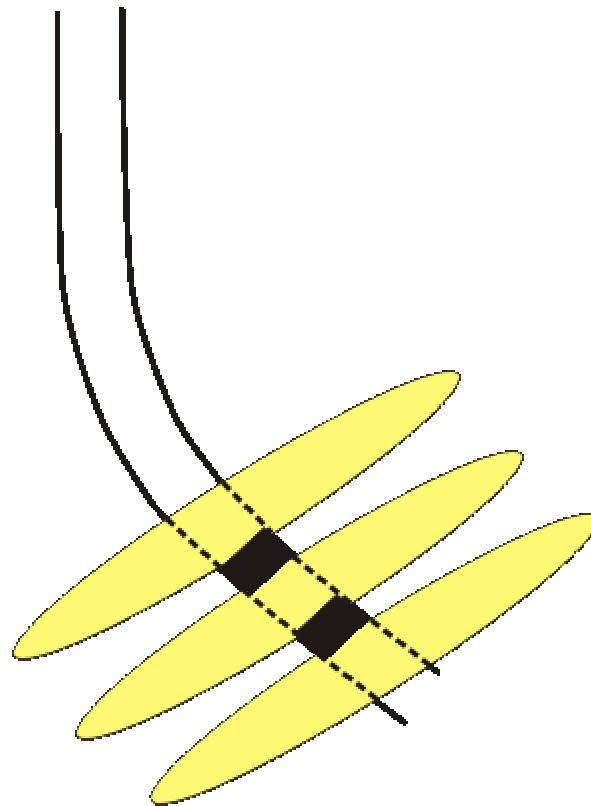
## Microseismic monitoring

Inside into the reservoir development:

- stimulation of planar structures
- good hydraulic connection between GPK2 and GPK3
- poor connection between GPK3 and GPK4 (boundary ?)
- orientation of seismic events along preferred shear directions (N15°E, N145°E)
- control of seismic risk (magnitudes up to 2.9)

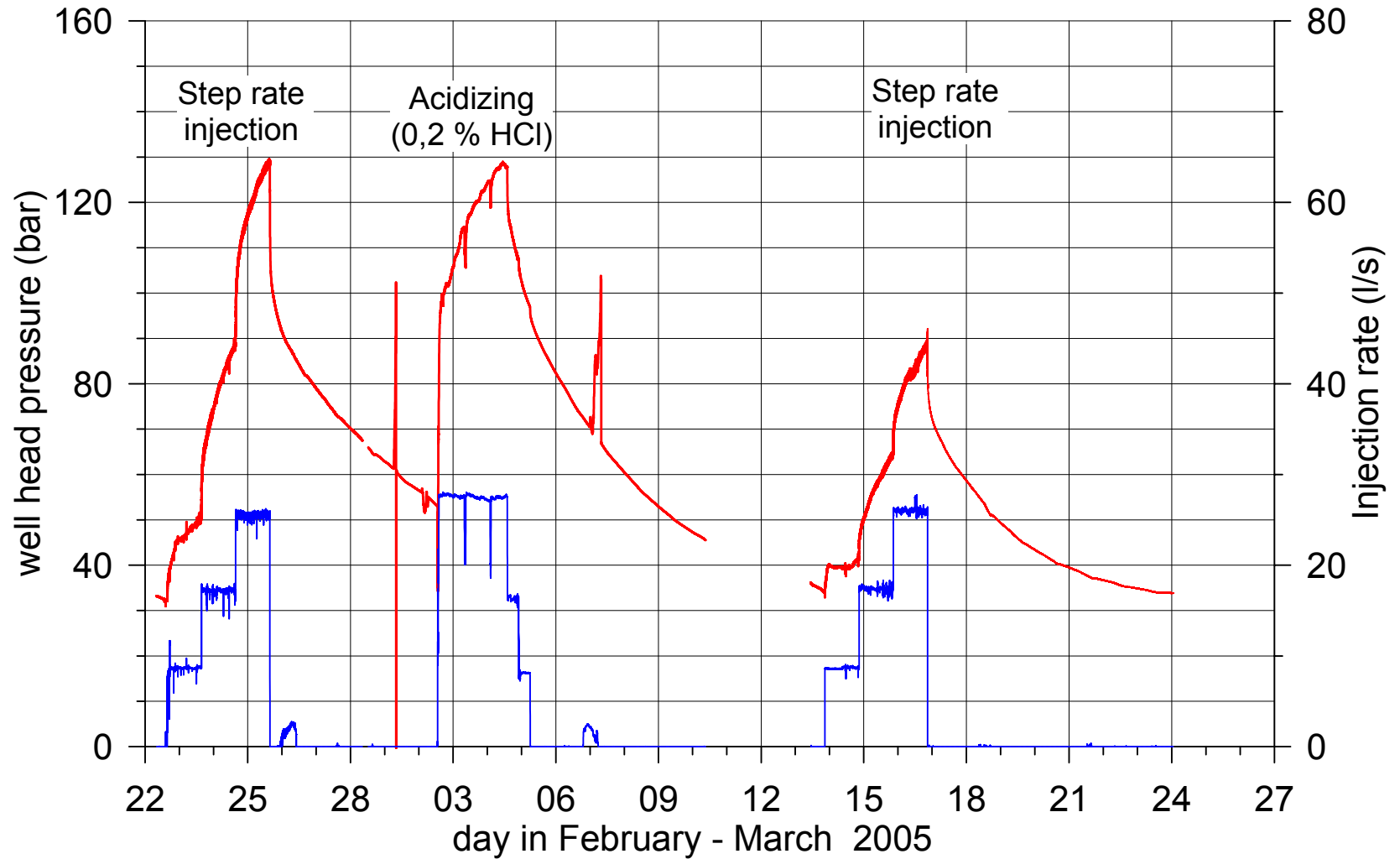
## Means to reduce seismic risk

- Reservoir development at shallower depth ( $\leq 4000\text{m}$  - Upper Rhine Graben)
- Application of multifracs (lower injection volume - less seismicity, volumetric stimulation)



# Acidification

GPK4 (2005)



## Summary

- Productivity during stimulation = Productivity after stimulation !  
Productivity enhancement can easily be predicted
- Development of EGS projects under similar conditions as in Soultz (granite..., high shear stress..)
- Multifrac concept/development of shallower reservoir(<4000m) to minimize seismic risk

## Outlook Soultz

- Power plant ordered: 1,5 MW<sub>el</sub> (30 l/s bei 180°C) - Delivery end of 2007
- Additional (hydraulic) stimulation of GPK4 and/or GPK3



**Thank you for your attention !**

