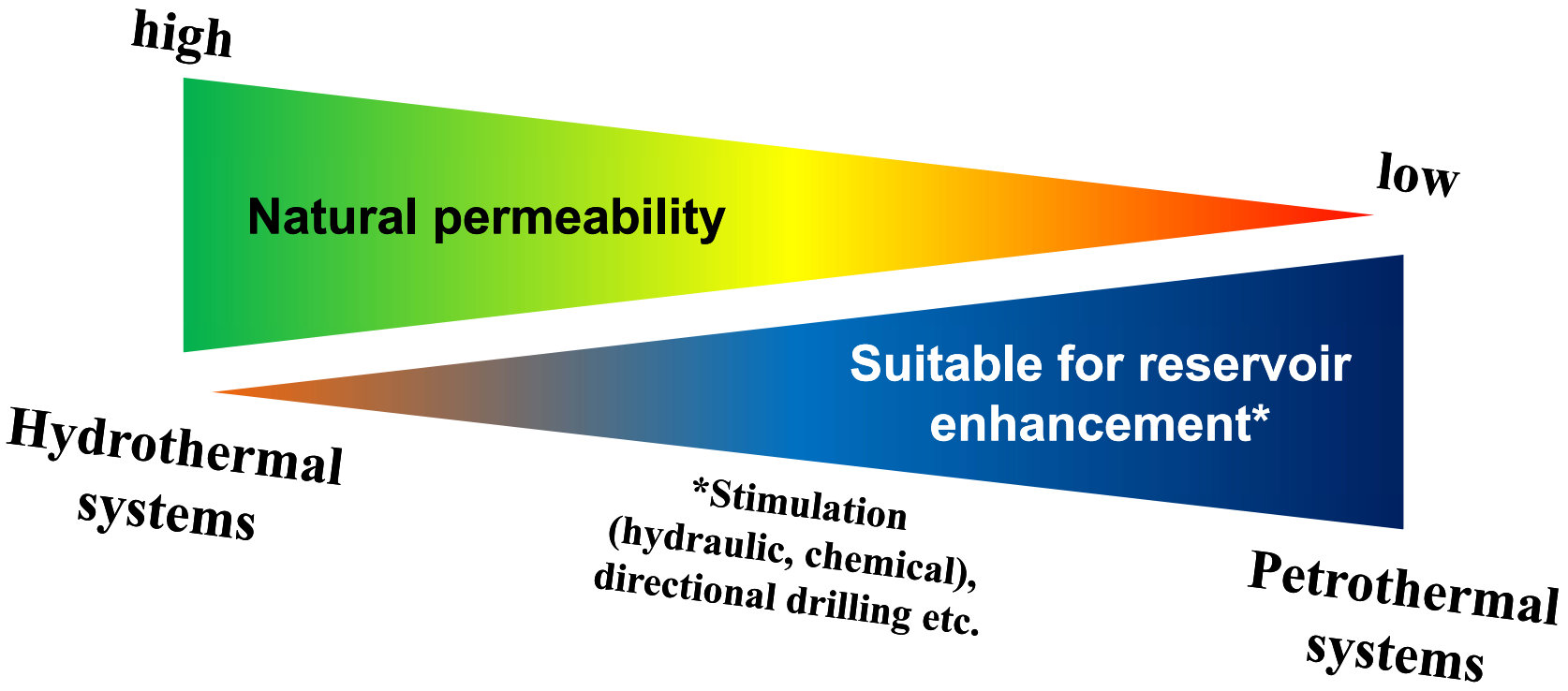
Enhanced Geothermal Systems (EGS)
- Potential und Stimulationsverfahren -

Günter Zimmermann, Guido Blöcher und Ernst Huenges
Helmholtz-Zentrum Potsdam
Deutsches GeoForschungsZentrum

Reservoir systems

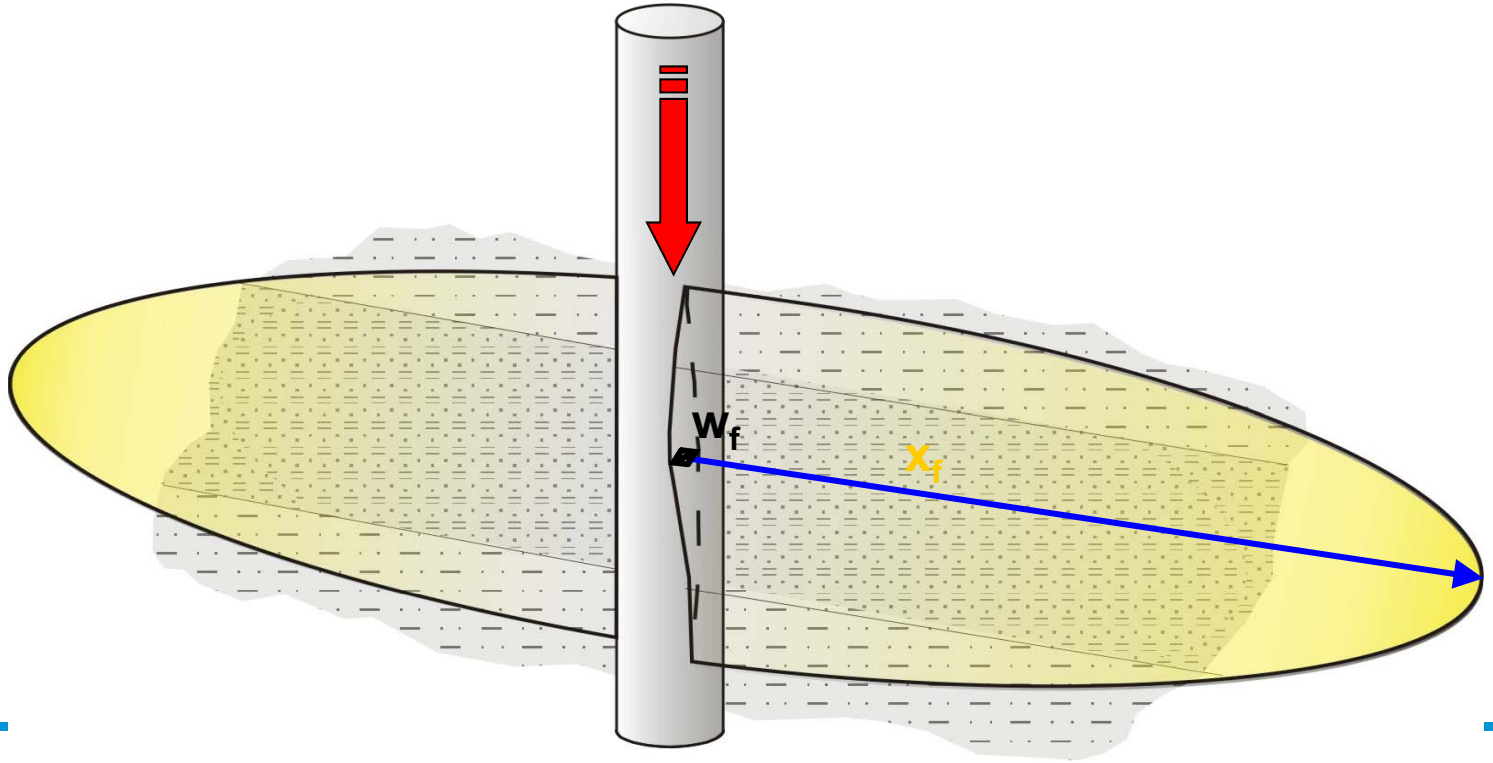
Enhanced geothermal systems



Hydraulic stimulation technique: waterfracs (WF)

water / low viscous gels:	η = 1 - 10 mPa s
without proppants or small proppant concentration: c	= 50 - 200 g/l
long fractures:	$x_f \leq 250$ m
small width:	$w_f \sim 1$ mm

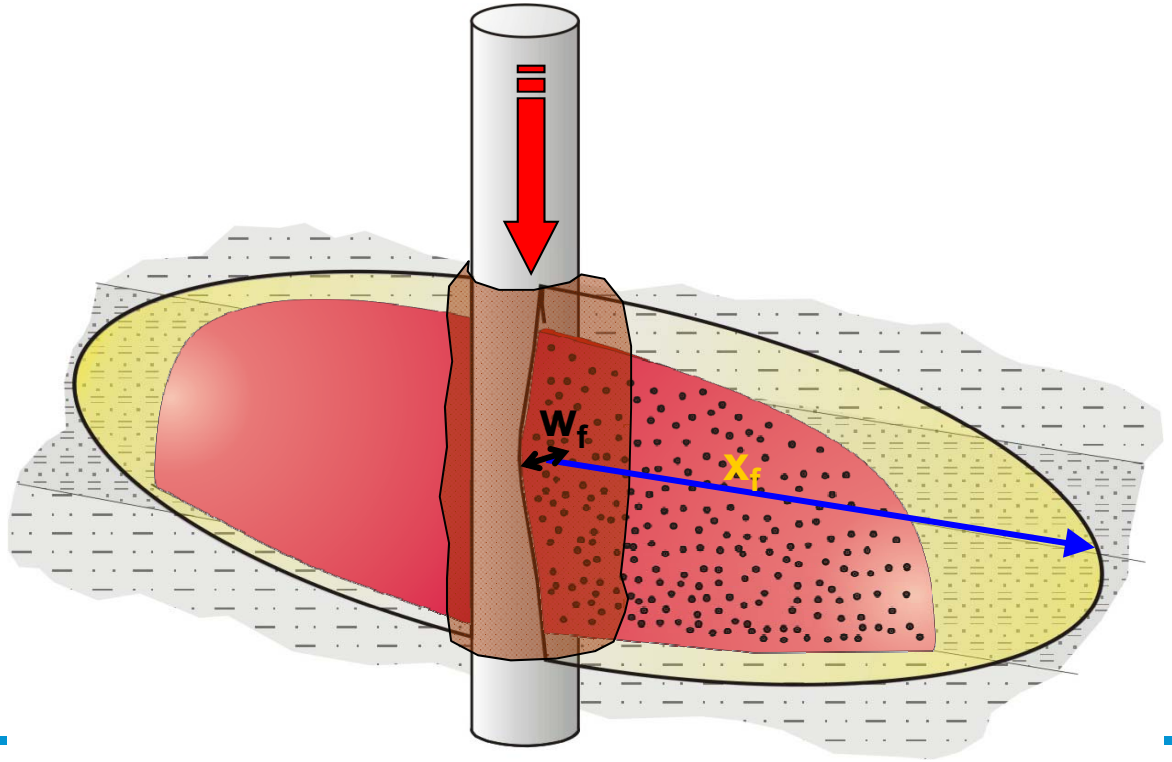
- reduction in costs compared or HPF
- application is limited to reservoirs with small permeability
- success is dependent on the self propping potential of the reservoir rock



Hydraulic stimulation technique: hydraulic proppant fracs (HPF)

high viscous gels:		η = 100 - 1000 mPa s
high proppant concentration:	c	= 200 - 2000 g/l
shorter fractures:		x_f = 50 - 150 m
big width:		w_f = 5 - 25 mm

- wide range of formations (permeabilities) can be treated
- good control of stimulation parameters
- wellbore skin can be bypassed
- treatments are more expensive

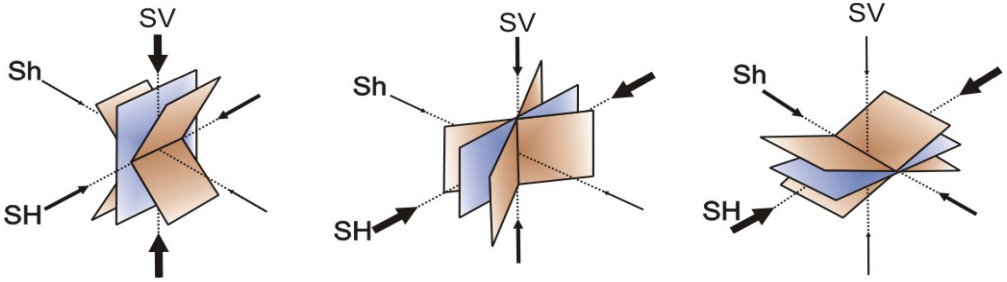


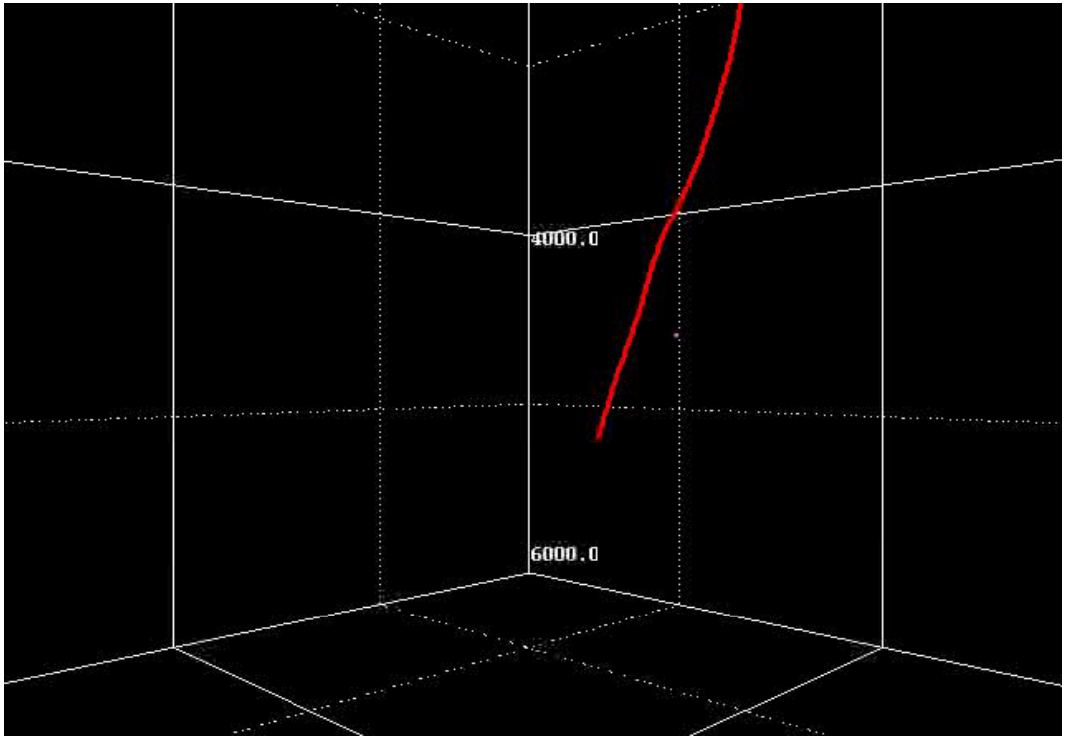
Reservoirtechnologies in crystalline rocks

Tensile or shearing?

induced seismicity :
mechanism (Major et al. 2007):

- Reduction of effective stress on shear face in deviatoric stress field





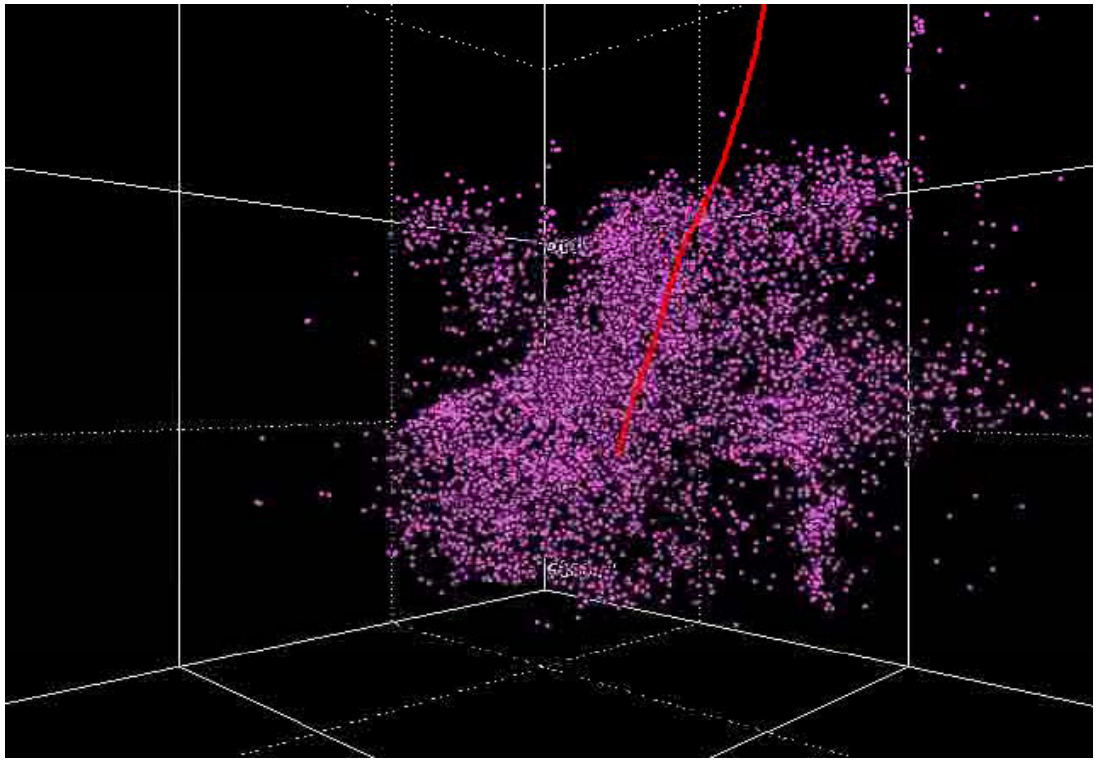
Asanuma et al. 2002

Reservoirtechnologies in crystalline rocks

Tensile or shearing?

induced seismicity :
mechanism (Major et al. 2007):

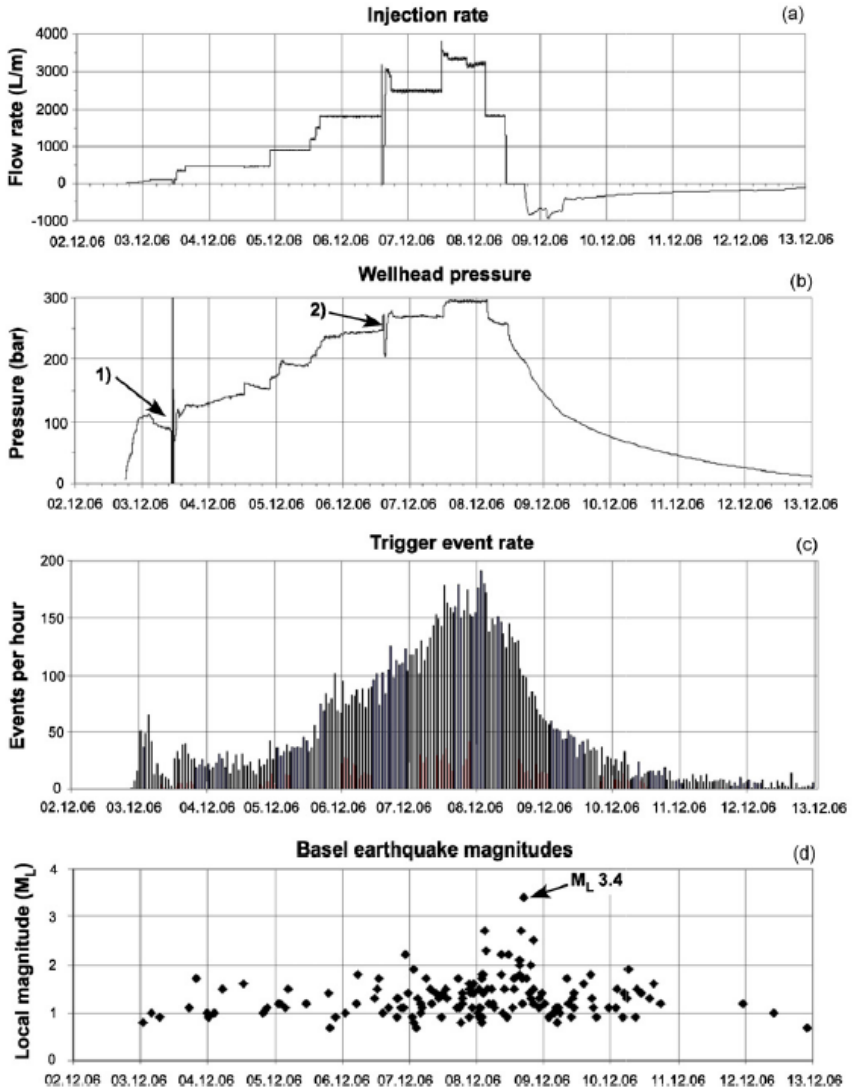
- reduction of effective stress on shear face in deviatoric stress field
- thermoelastic strain: temperature-induced friction at fracture face
- chemical alteration on fracture face and influence on friction



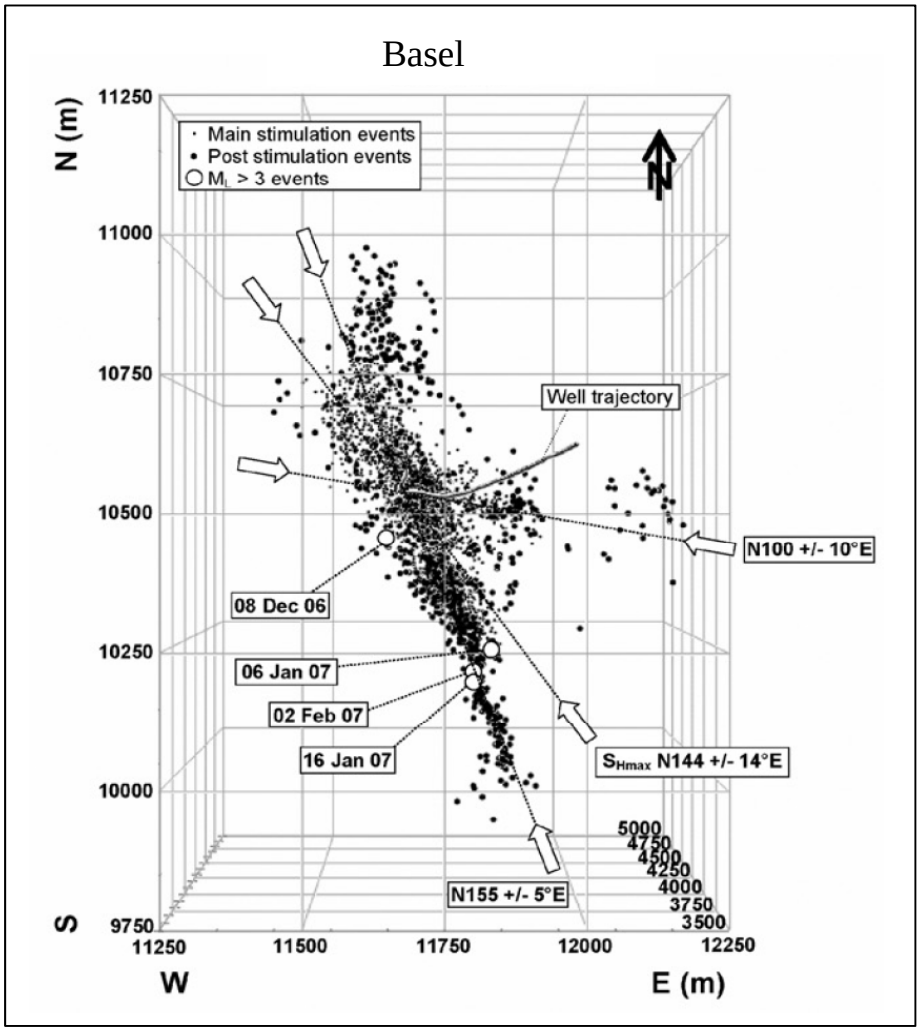
Asanuma et al. 2002

sustainability of fracture opening?
Proven by several experiments in Soultz (Jung et al. 2000)

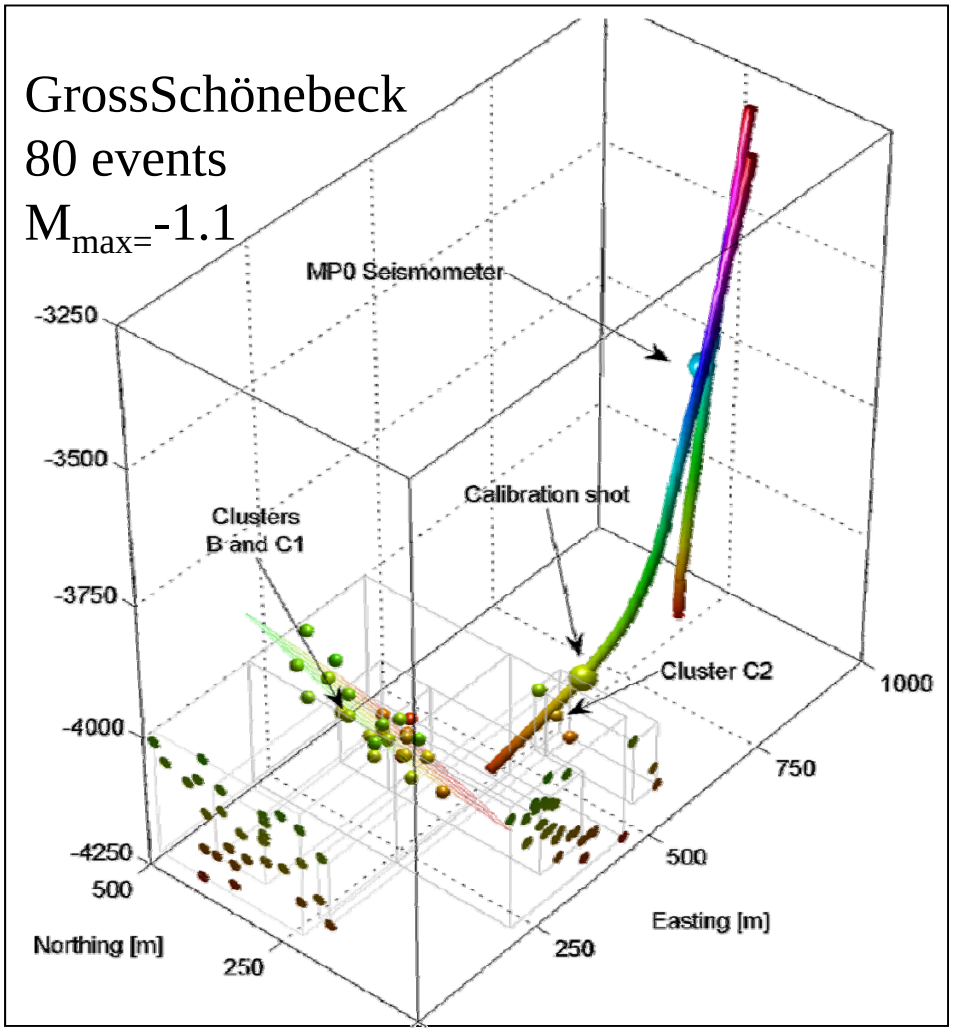
Geothermal project in Basel



Induced Seismicity: Useful for Reservoir Characterization

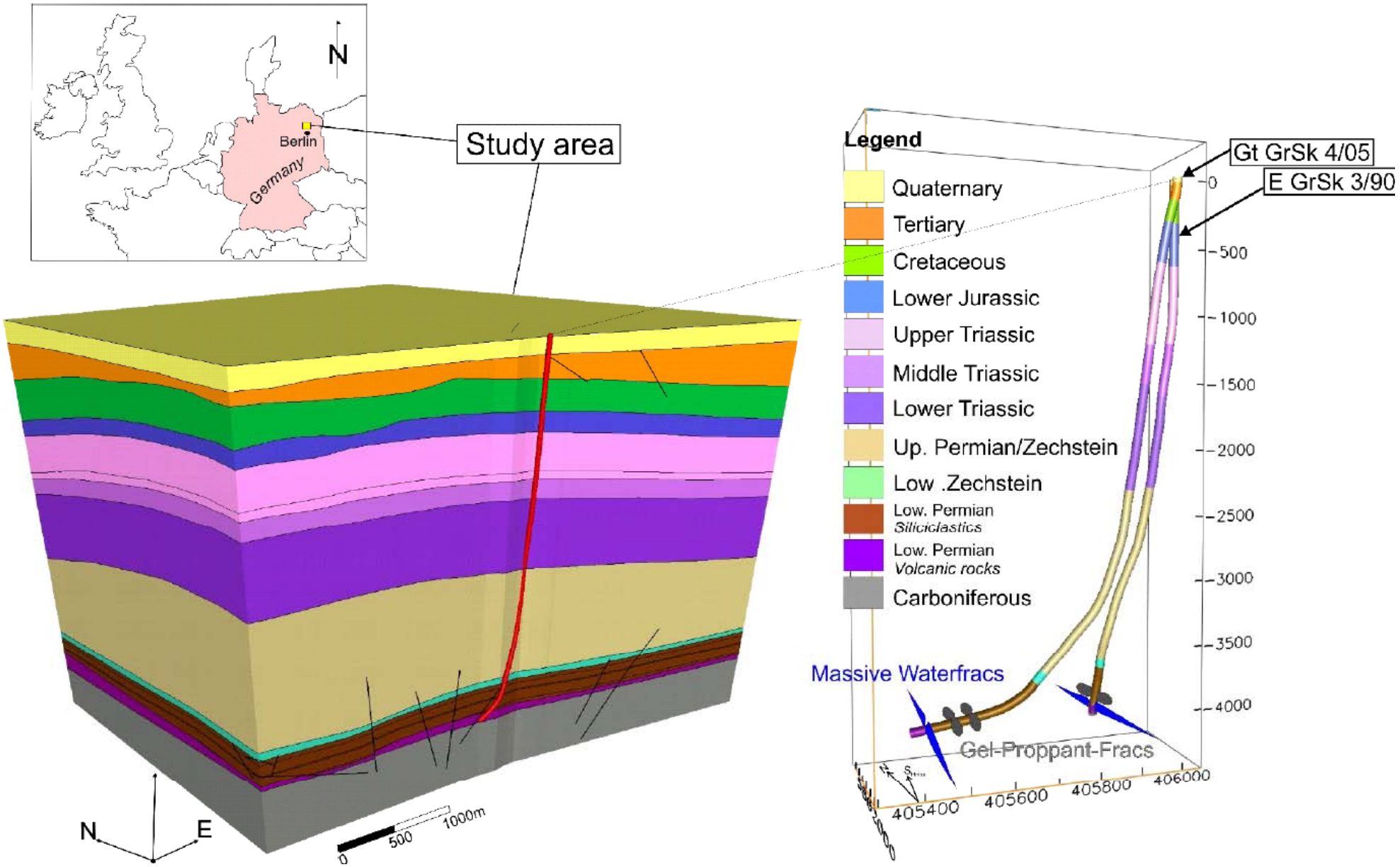


(Häring et al., 2008)

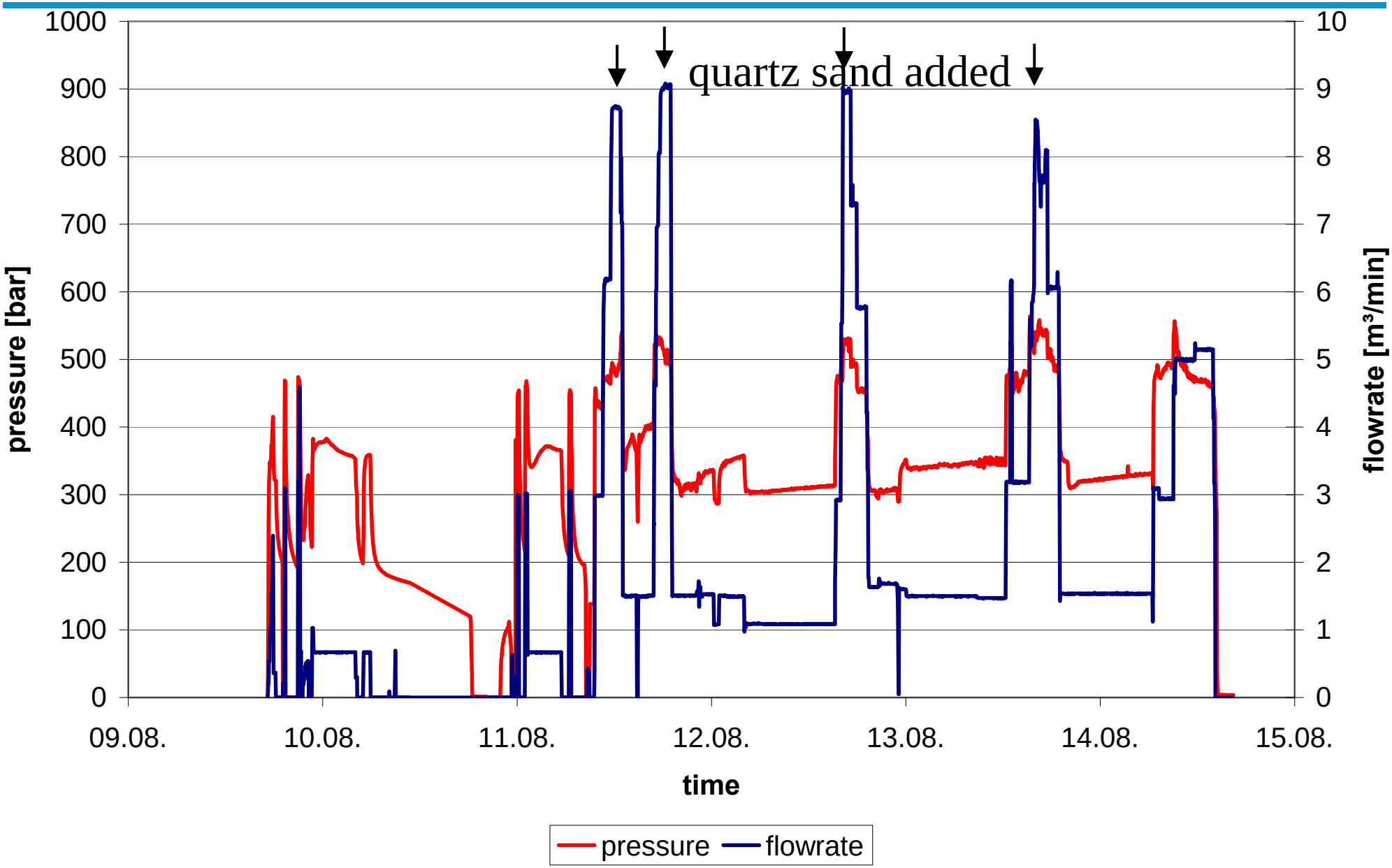


(Kwiatek et al., 2010)

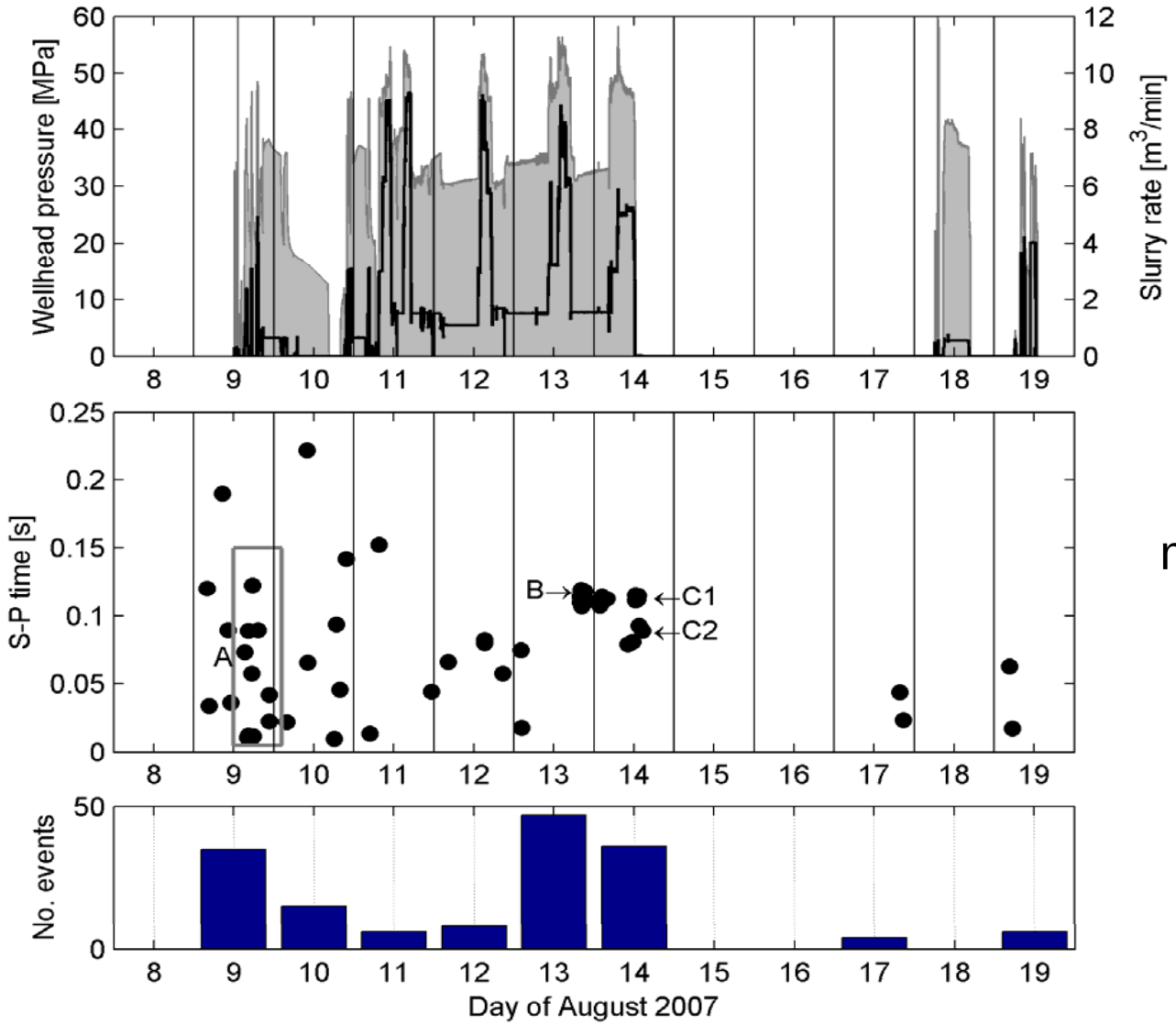
well paths and frac orientation Groß Schönebeck site



waterfrac treatment



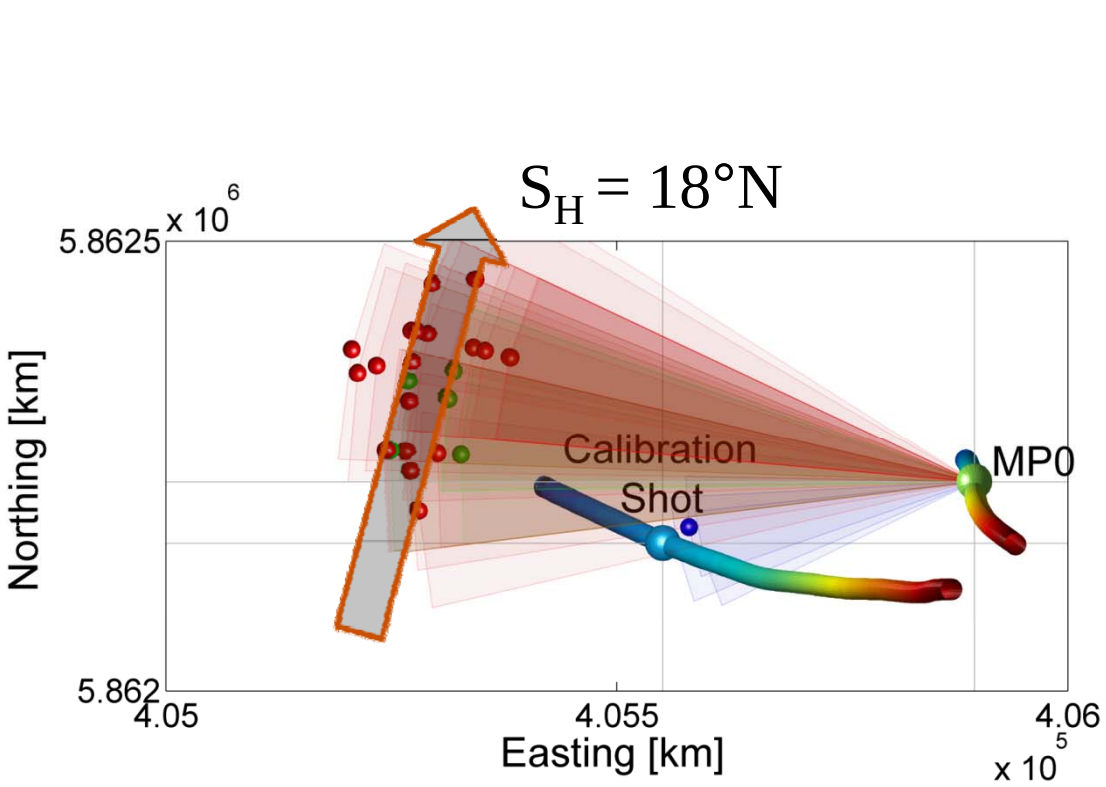
microseismic monitoring

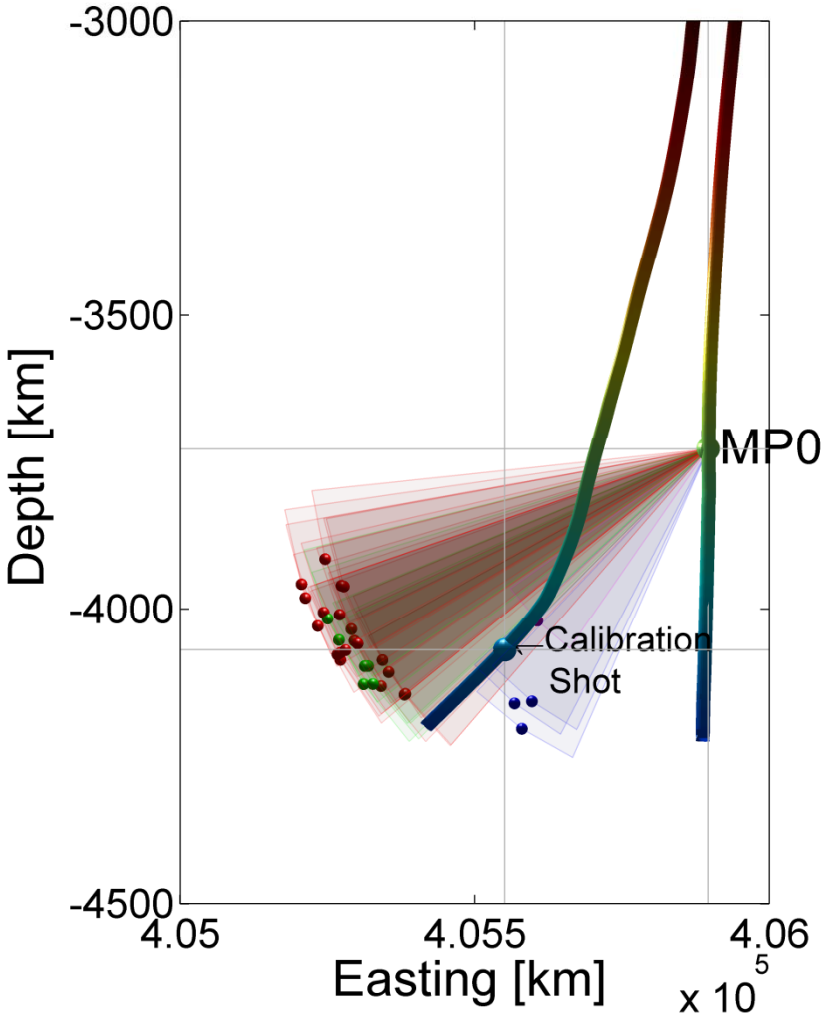


moment magnitude -1... -1.8

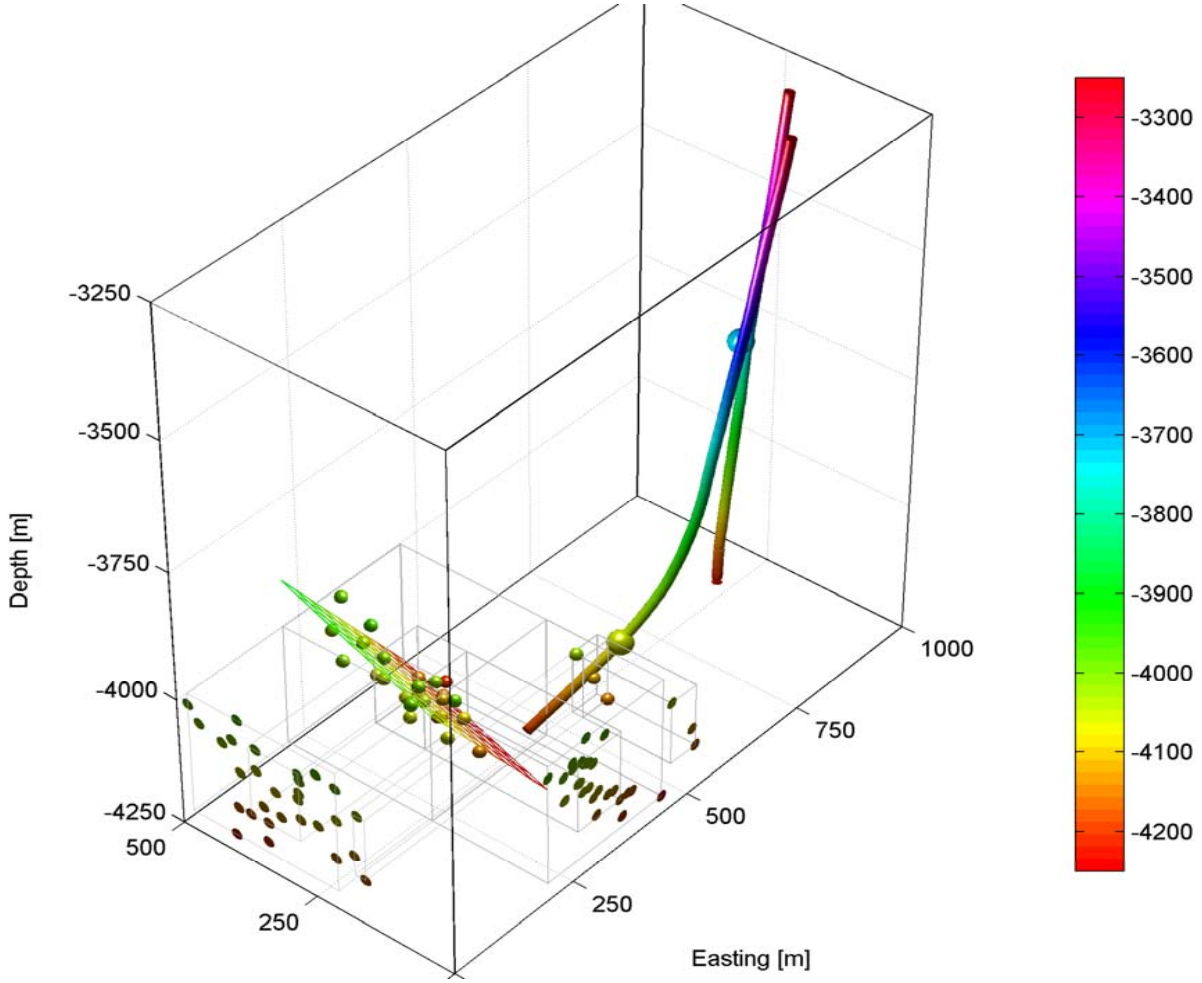
Kwiatek et al., 2010

microseismic monitoring



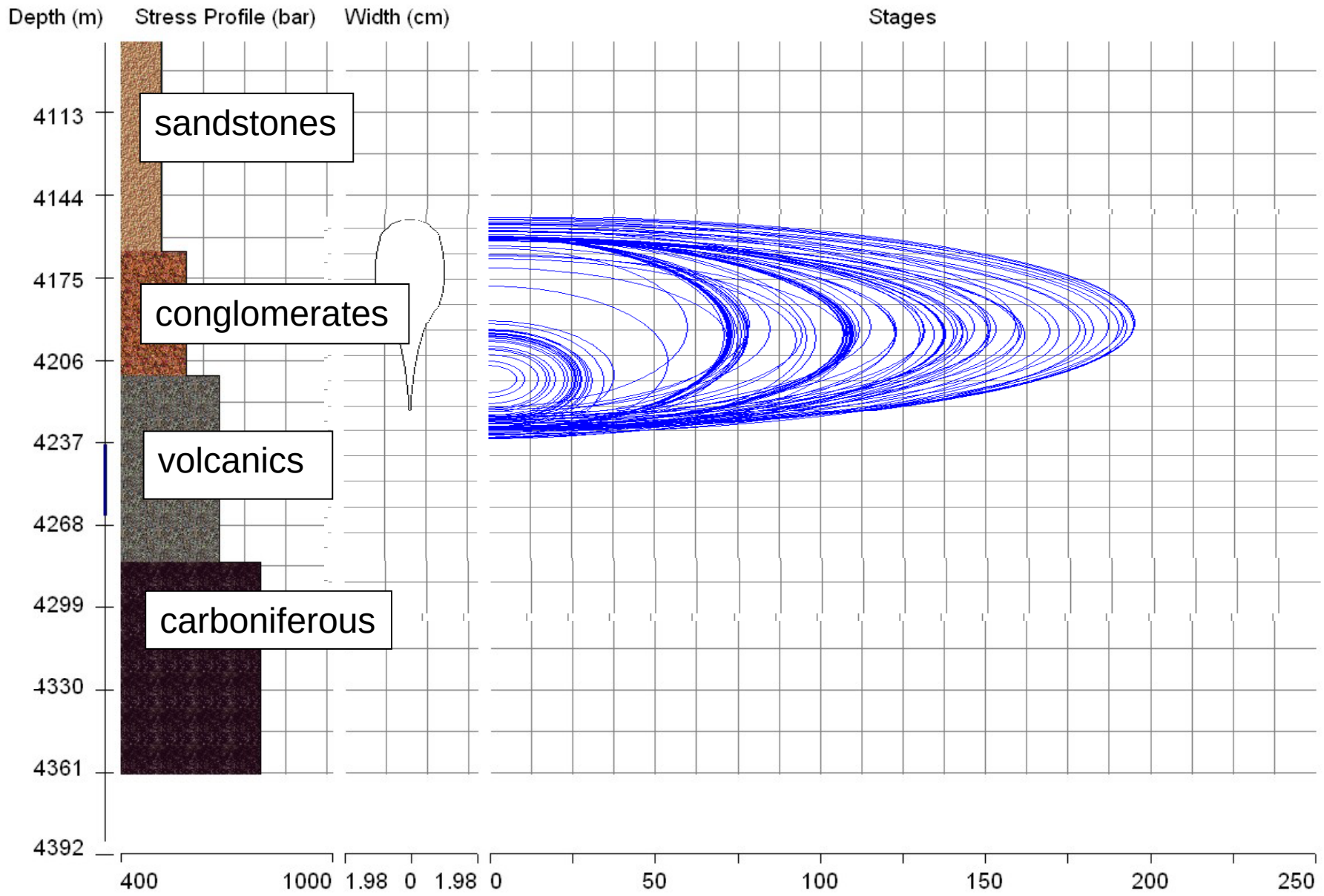


Kwiatek et al., 2010

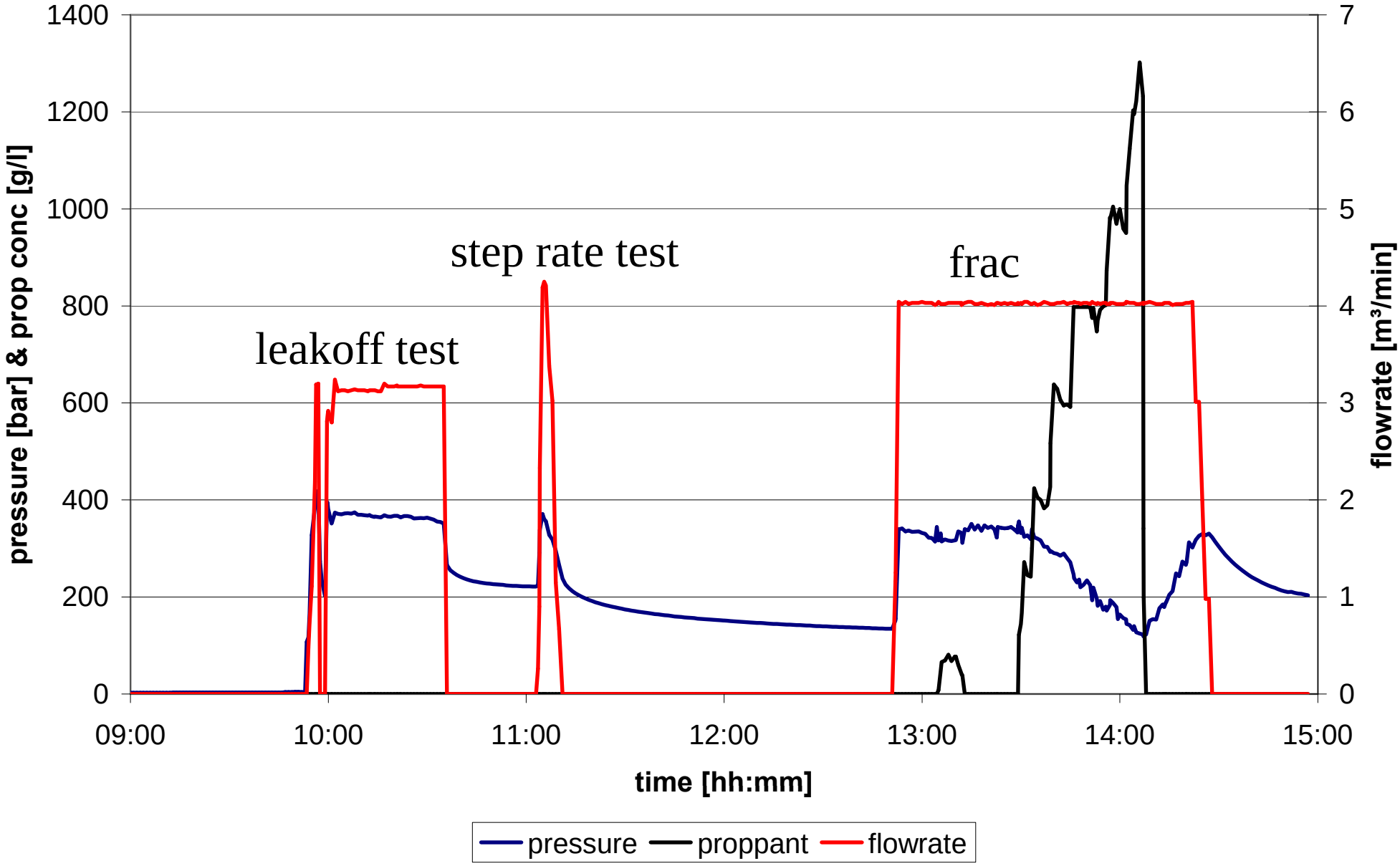


Kwiatek et al.
Acta Geophysica 2010

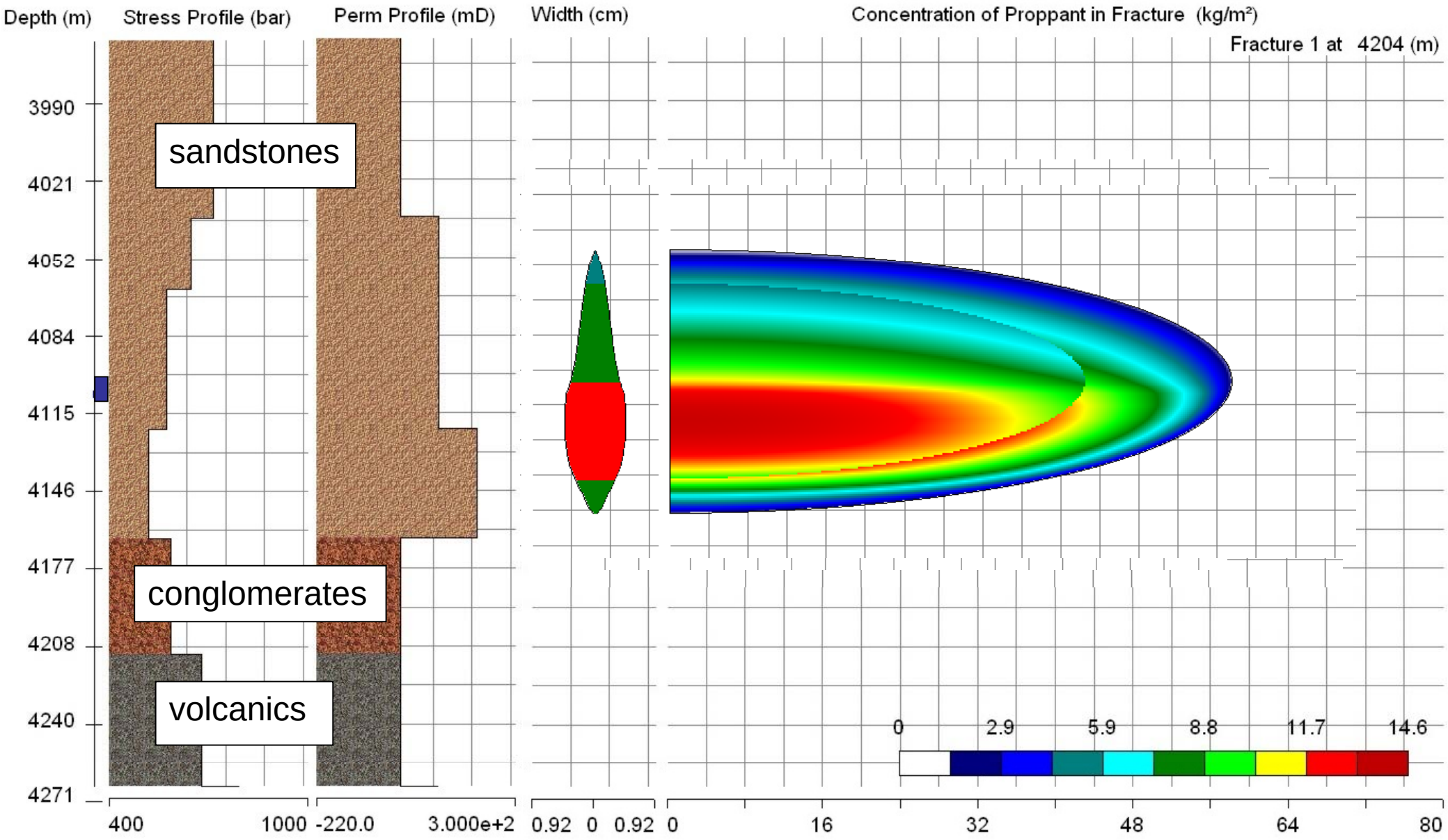
fracture propagation of waterfrac treatment



gel proppant treatment



fracture propagation of gel-proppant treatment



acidizing and testing (CLT) 2009

coil tubing unit

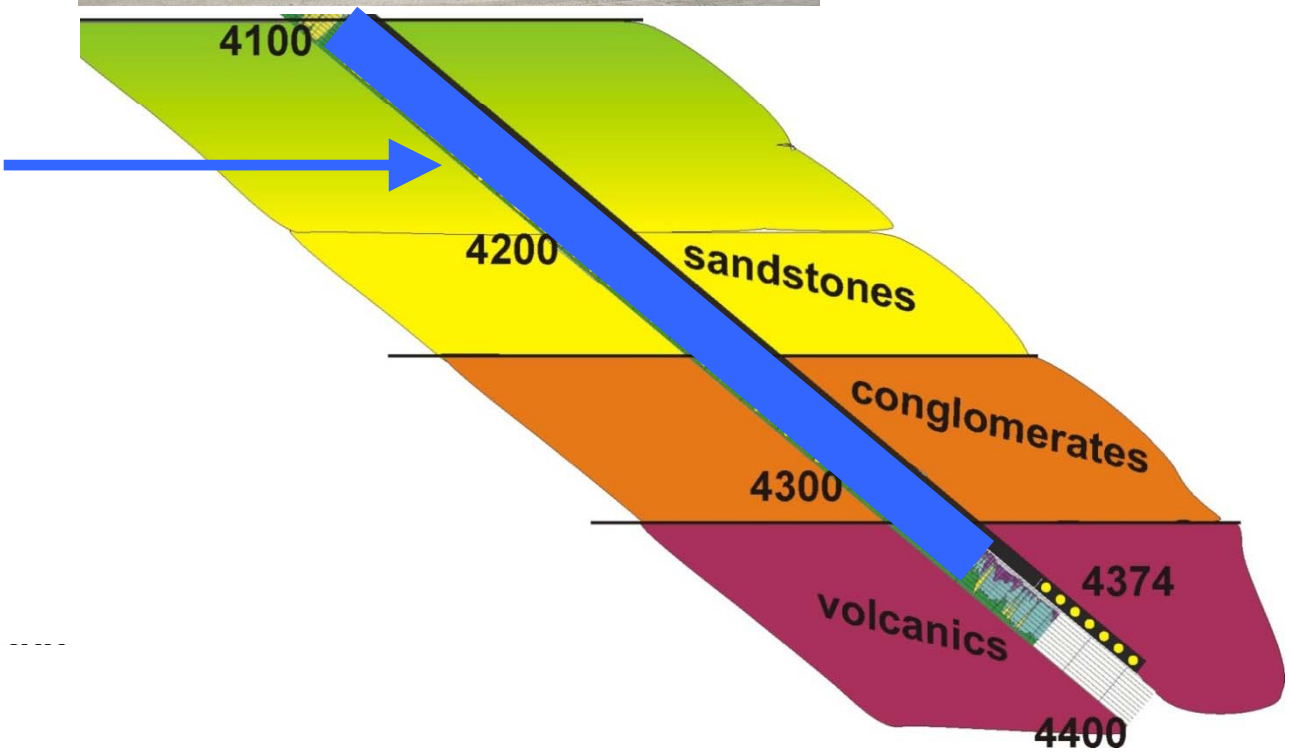
- reel diameter 2”
- reel length 5000 m

acid placement

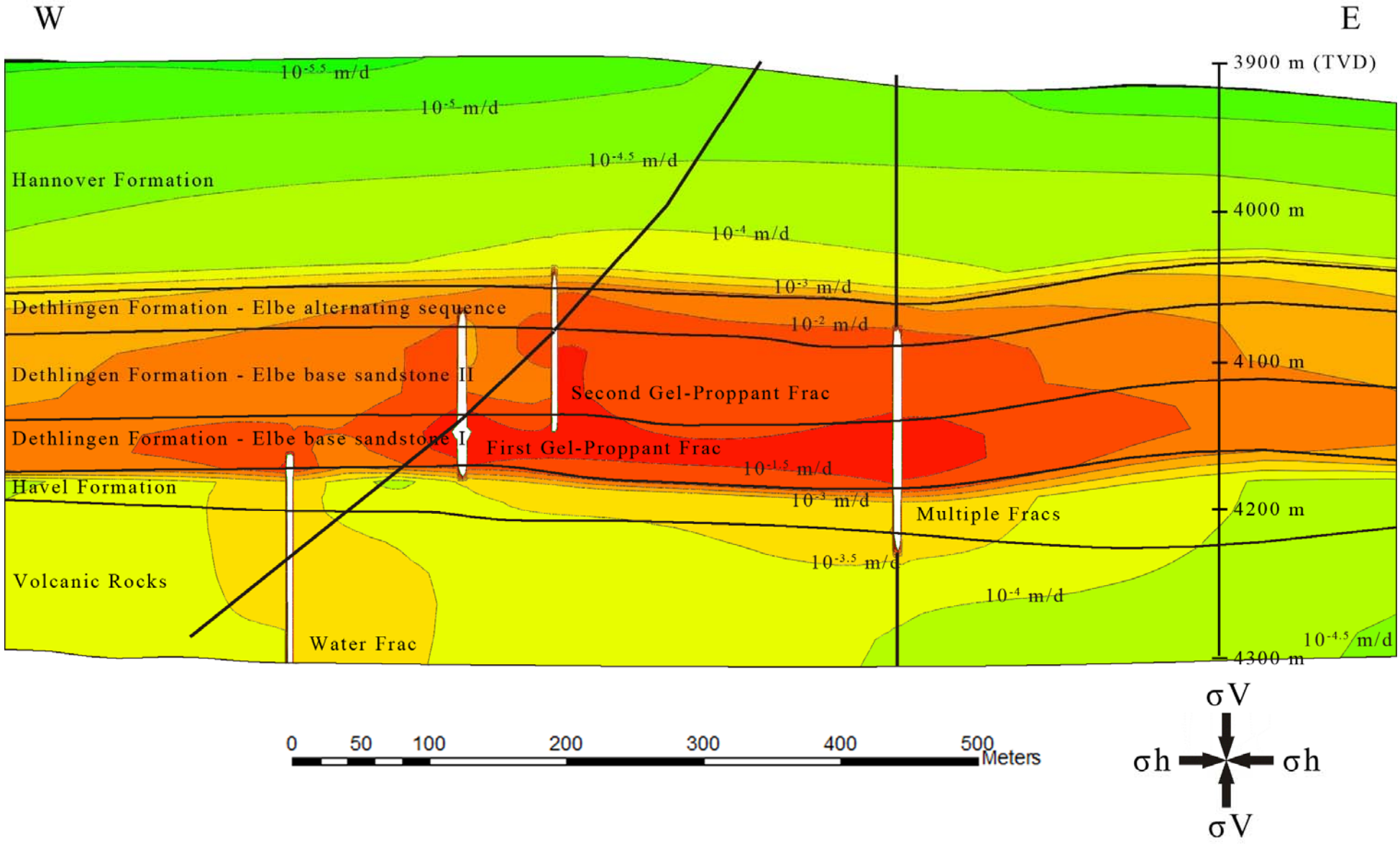
- 10 m³ of hydrochloric acid
- 7.5 % concentration
- between 4360 - 4100 m MD
- for 30 minutes

casing lift test (CLT)

- pressure gauge in 2350 m
- duration 4 hours
- total volume 140 m³



flow between doublet



conclusions

- Stimulation methods should be laid out individually depending on:
  - Rock properties
  - Stratigraphic sequences
  - Structural geological settings, stress field
  - Shear potential and self propping effect

- Induced seismicity mechanism:
  - reduction of effective stress in deviatoric stress field
  - temperature-induced friction at fracture face
  - chemical alteration on fracture face