## Aseimic zone between GPK3 and GPK4 (all events)

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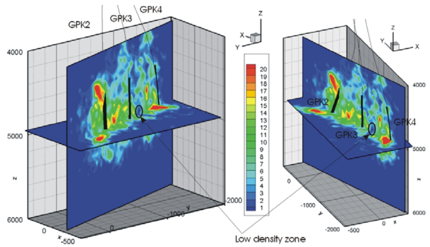
**Step 1 :**
definition of a low density point :

*X= 165 m*
*Y= -1175 m*
*Z= 4975 m*

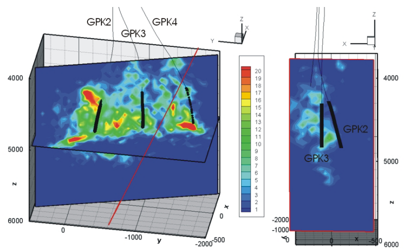



Number of events per 50m side lengh cube

**Step 2 :**
Calculation of the lower density plane orientation:

*N96p64E*

*643* microseisms at a distance of less than 25 m of the plane






## Growth of microseismic cloud (1/3)

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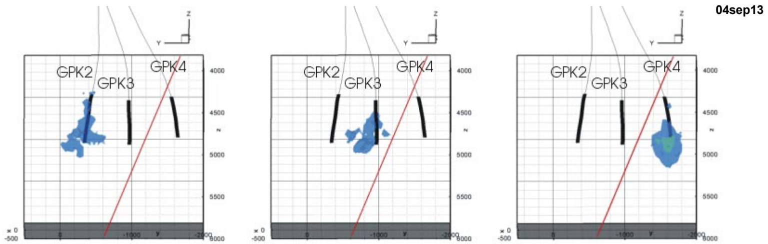
04sep13

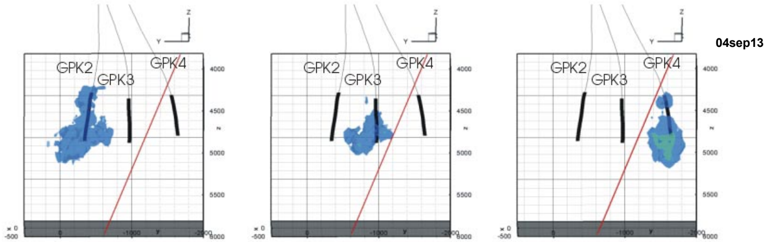
T= 1 day




Number of events per 50m side lengh cube: blue enveloppe=3 evts/cube; green enveloppe=15 evts/cube

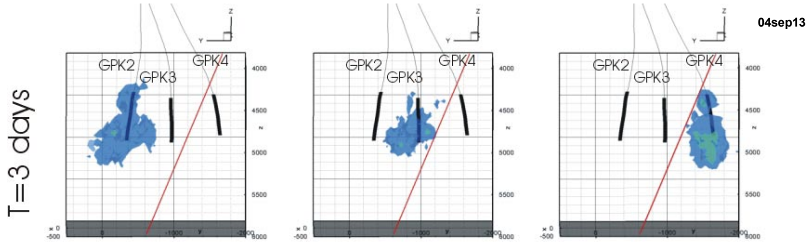
04sep13

T=2 days

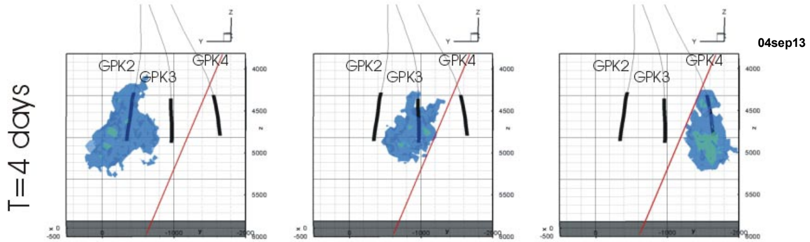


## Growth of microseismic cloud (2/3)

GEOWATT AG



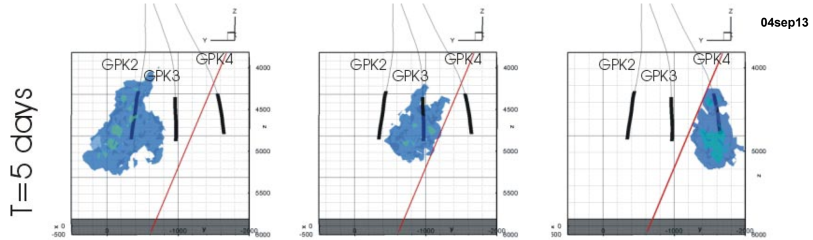

Number of events per 50m side lengh cube: blue enveloppe=3 evts/cube; green enveloppe=15 evts/cube



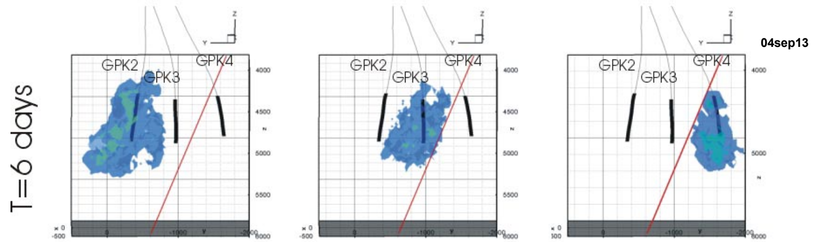



## Growth of microseismic cloud (3/3)

GEOWATT AG




Number of events per 50m side lengh cube: blue enveloppe=3 evts/cube; green enveloppe=15 evts/cube



## Growth of microseismic cloud Stim.GPK4 Feb.2005

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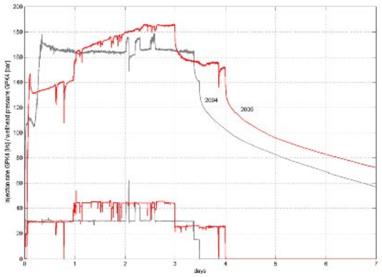

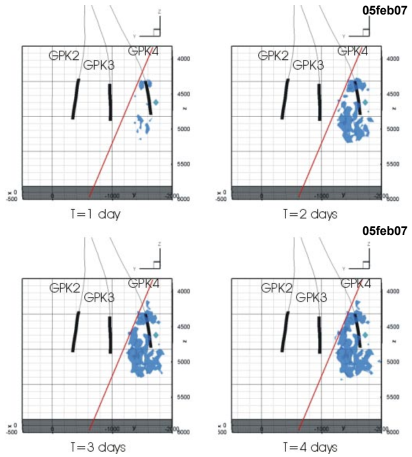




## Nature of the aseismic zone GPK3-GPK4?

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### Highly conductive?

- Fingering of microseismic density
- No increase of the density of microseismic events once zone reached and injection continunes
- Tracer diffusion in great storage zone explaining small tracer recovery in GPK4 ?
- High-loss structure when drilling

### No flow boundary?

- GPK4 shut-in
- No hydraulic connection between GPK3 and GPK4
- Hardly no tracer recovery between GPK3 and GPK4
- High seismic density between GPK4 and aseismic zone
- Orientation nearly perpendicular to SHmax

## Hex-S Model; faults analysis

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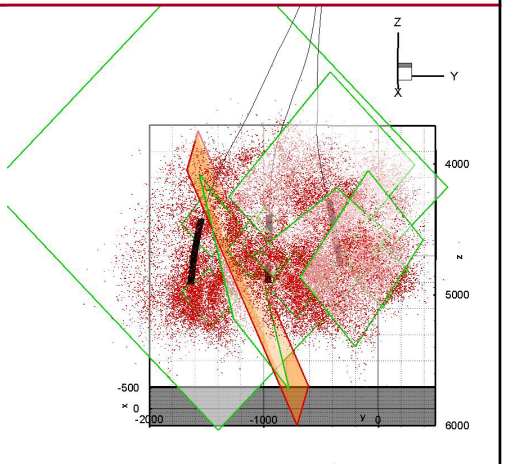
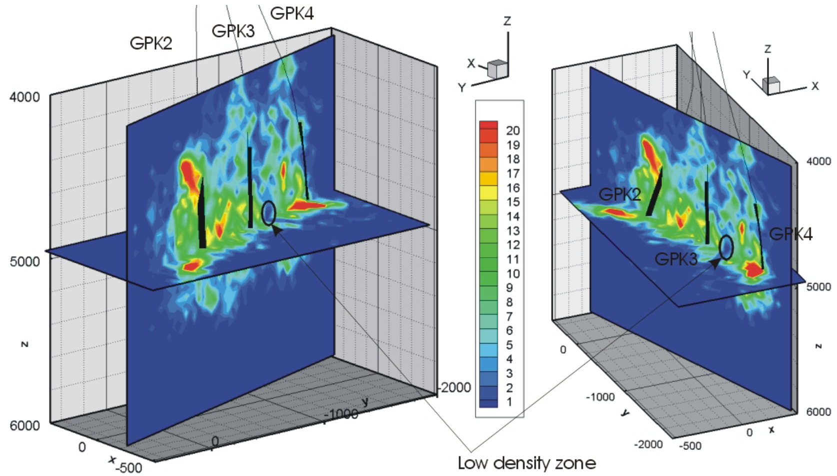
Microseismic events density analysis:

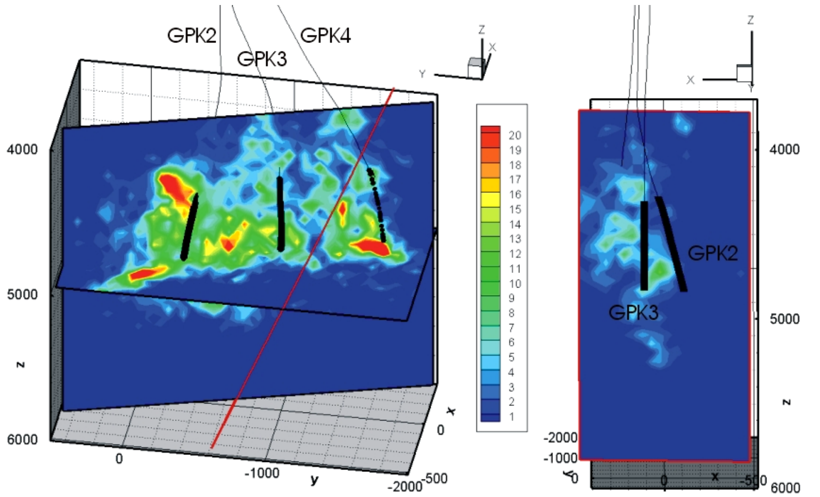
- Localisation of 10 points of highest microseismic density
- Calculation of the higher density plane orientation and radius going through these points
- Selection of 8 planes of various orientation and radius
- Taking in account Soultz fault (West of the model), 6 other deterministic faults isolated Maurer.
- Deterministic fractures at the well, based on UBI-log analysis (BRGM)





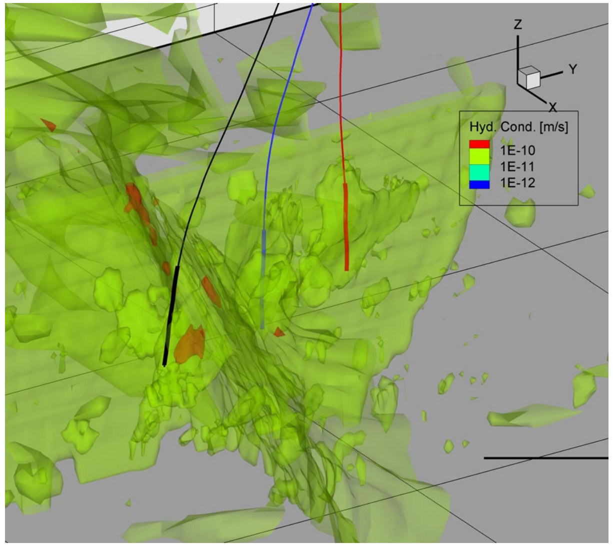

GEOWATT AG



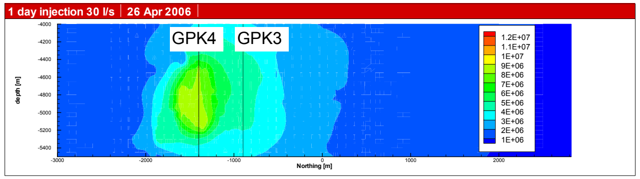

GPK2
GPK3
GPK4
4000
5000
6000
z
0
-1000
y
-2000
-500
x
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
GPK2
GPK3
4000
5000
6000
-2000
-1000
0
-500



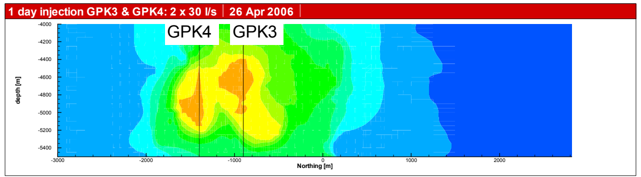



Z
Y
X
Hyd. Cond. [m/s]
1E-10
1E-11
1E-12

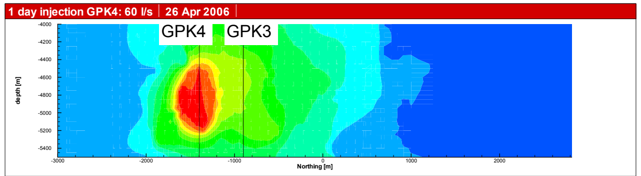
1 day injection 30 l/s | 26 Apr 2006




1 day injection GPK3 & GPK4: 2 x 30 l/s | 26 Apr 2006



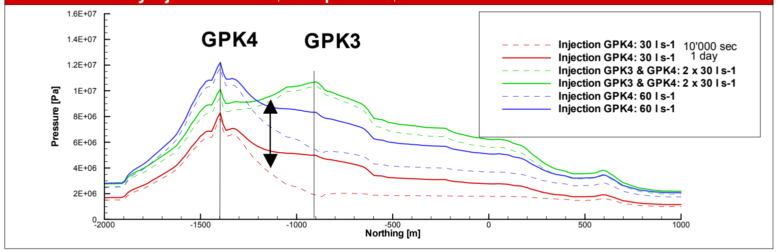

1 day injection GPK4: 60 l/s | 26 Apr 2006



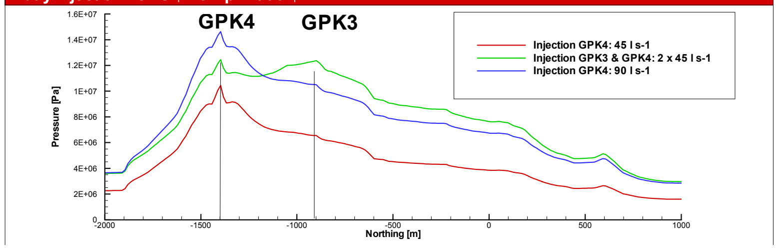





10'000sec / 1 day injection: 30 l/s | 26 Apr 2006




1 day injection 45 l/s | 26 Apr 2006



| Phase | Hydraulic pressure | Impact on effective stress on fracture plane |
|---|---|---|
| 1. Initial state | Hydraulic pressure in fracture and pores corresponds to hydrostatic conditions | $\sigma_{eff} = \sigma_n$ |
| 2. Injection (short term) | Pressure builds up in fracture system, but not yet in pore pressure in matrix | $\sigma_{eff} = \sigma_n - P_f$ <br> The effective stress will reduce. Under stress field in Soultz shearing will result |
| 3. Injection (long term) | Pressure slowly builds up pores. The impact on stress is calculated from Biot Law | $\sigma_{eff} = \sigma_n + \sigma_{Biot} - P_f$ <br> $= \sigma_n + \alpha \cdot P_f - P_f$ <br> The effective stress starts increasing again. Shearing will slowly stop. |
| 4. Shut-in | Fracture will drain fast, whereas pore pressure drains in the same time constants as it has build up. | $\sigma_{eff} = \sigma_n + \sigma_{Biot}$ <br> $= \sigma_n + \alpha \cdot P_f$ <br> The effective stress is even larger than at initial state. The danger of reversing the shear slippage may occur at distinct points. The seismic moment attributed to these reversed events may even be higher due to larger stress drop. |