Schatzalp 4th Induced Seismicity Workshop

Investigating the Influence of Coupled Physical Processes on Induced Seismicity in EGS

Gaëlle Toussaint[1], Reza Sohrabi[2], Benoît Valley[1]

[1]Center for Hydrogeology and Geothermics (CHYN), University of Neuchâtel, Switzerland
[2]Groupe Grisoni, Fribourg, Switzerland
gaelle.toussaint@unine.ch

Motivation

Enhanced Geothermal Systems (EGS) enhance low permeability reservoirs through hydraulic stimulation to harness geothermal energy. While micro-seismicity is expected, larger induced events, such as those in Basel (2006) (Figure 1) and Pohang (2017), pose a major challenge to geothermal development, emphasizing the need for better seismic control. The complexity of fault behaviors and the interplay of multiple physical processes make seismicity assessment difficult. This study aims to evaluate the relative influence of these physical mechanisms and assess their impact on the magnitude of induced seismic events.

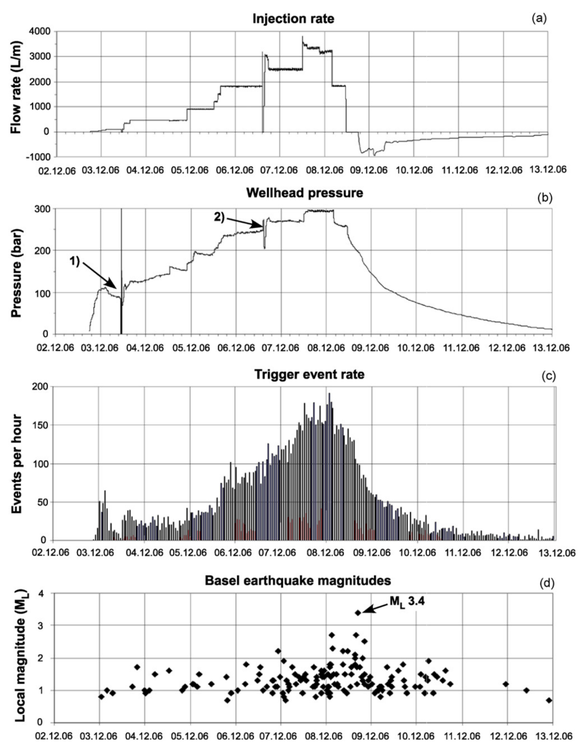


Figure 1: Data on the hydraulic stimulation of the well of the EGS project in Basel, Switzerland [1].

Conceptual Model

Earthquakes result from the interaction of multiple physical processes, which can be described in terms of thermo-hydro-mechanical (THM) coupling. Figure 2 illustrates the key coupled processes incorporated in our numerical model.

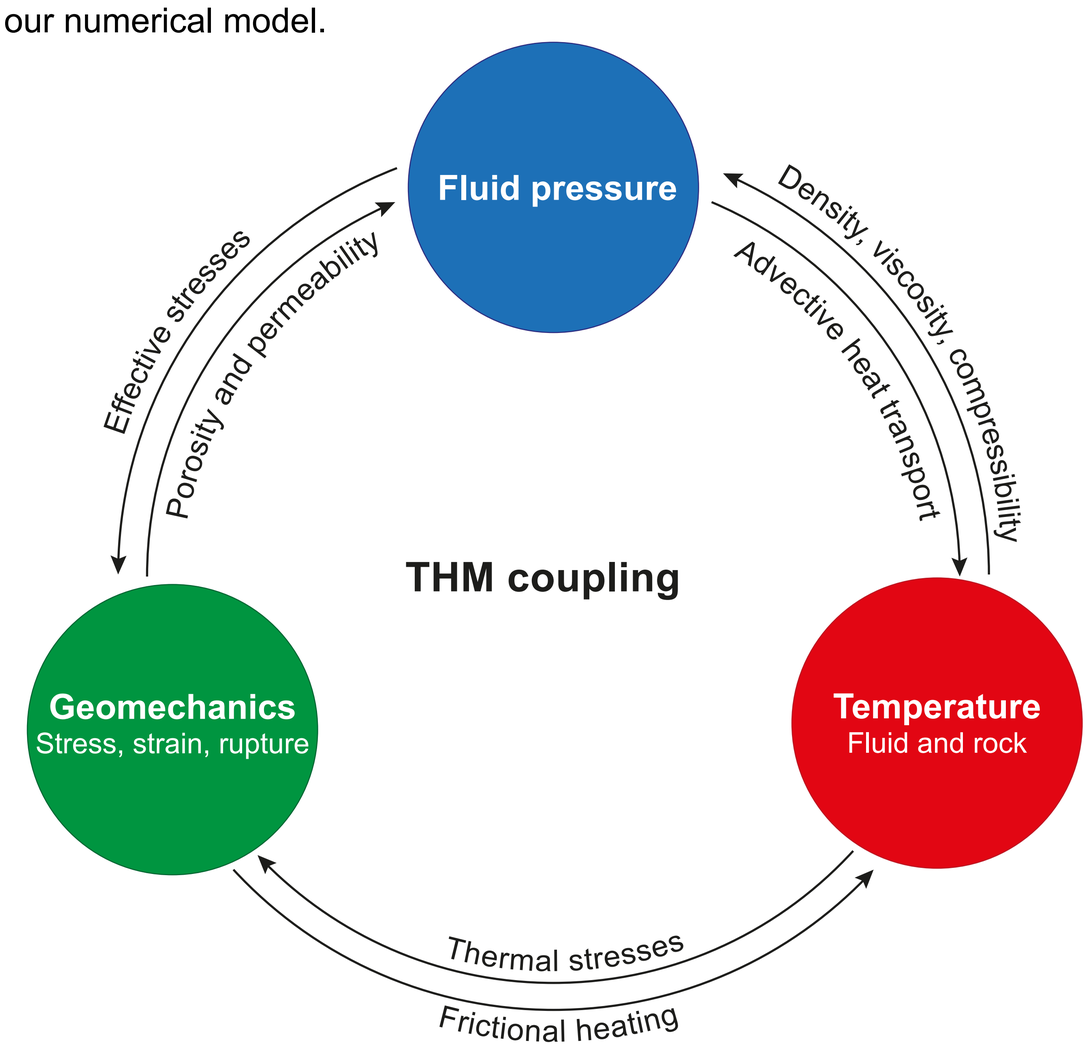


Figure 2: Diagram of the coupled physical mechanisms included in the thermo-hydro-mechanical model.

Numerical Earthquake detection

To identify seismic events in our numerical model, we use the deviatoric strain rate computed by the model as a proxy, as high values indicates shear failure [2].

Event detection :

- Peaks in deviatoric strain rate signal seismic event.
- Consecutive drop in the yield function due to the stress drop.
- Excitation time window is defined by tracking changes in deviatoric strain rate between consecutive time steps.

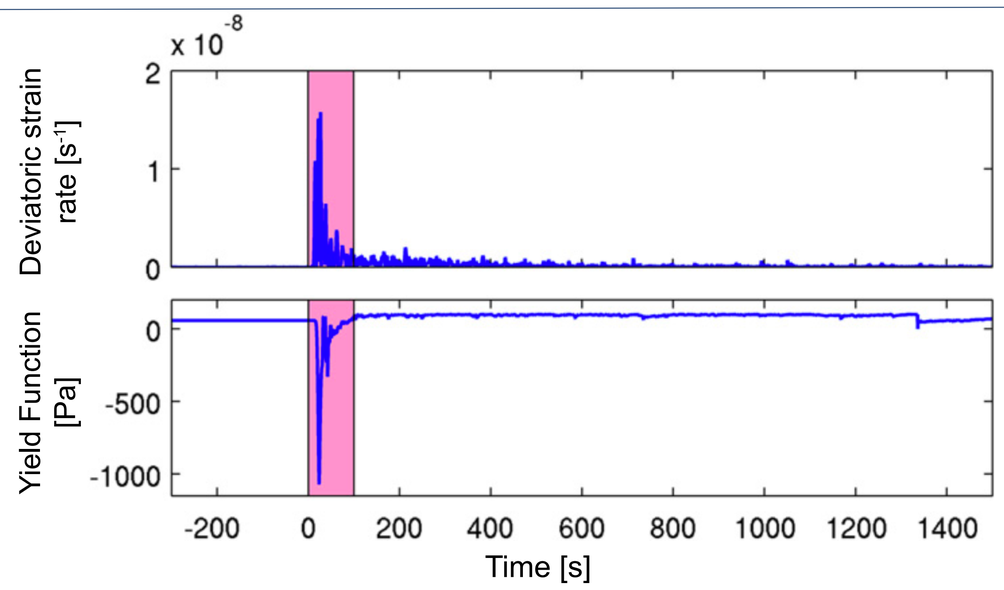
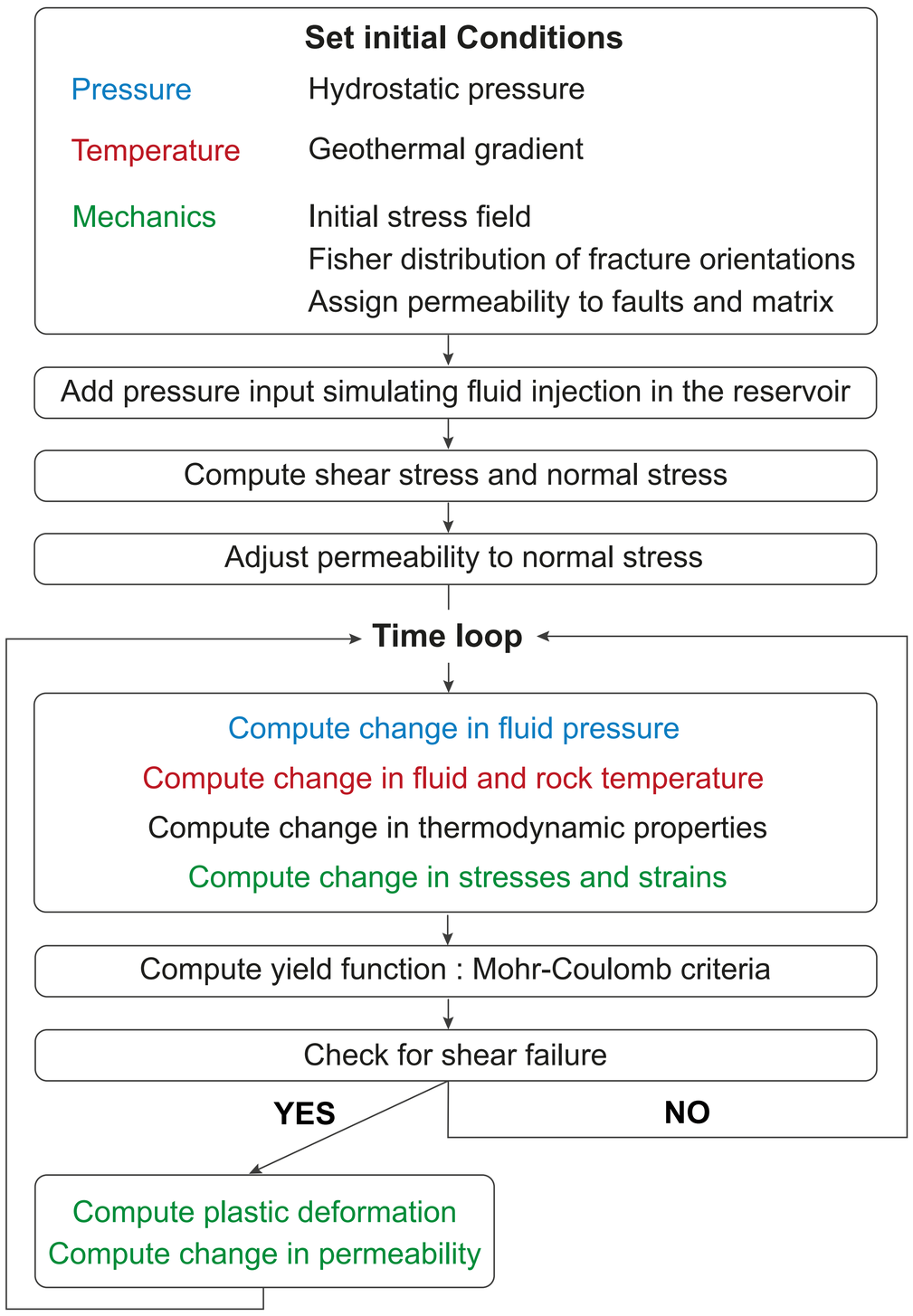


Figure 3: Deviatoric strain rate and yield function over time of one grid point during a rapid shear movement. The pink interval gives the excitation time window which define a slip event (modified from [2]).

Magnitude calculation :

- Neighbouring cells activated during the same time window define the slip area.
- Total displacement from the activated neigbouring cells.

Numerical Workflow



Expected results and Applications

- Calibrate the model against data (e.g. Basel) and investigate the relative importance of the different physical mechanims.
- Assess the impact of different injection scheme on the magnitude distribution and the maximum magnitude of induced events.

References

[1] Häring, M. O., Schanz, U., Ladner, F., Dyer, B. C. 2008: Characterisation of the Basel 1 enhanced geothermal system. Geothermics, 37 (469-495).

[2] Heinze, T., Galvan, B., Miller, S. A. 2015: A new method to estimate location and slip of simulated rock failure events. Tectonophysics, 651-652 (35 - 43).