Swiss Centre of Competence
for Deep Geothermal Energy
for power and heat production

GEO ENERGIE SUISSE

Reservoir engineering for heat exchange Haute-Sorne

SCCER-SoE Jahreskonferenz
Tuesday 13th of September 2016, HES-SO Valais Sion

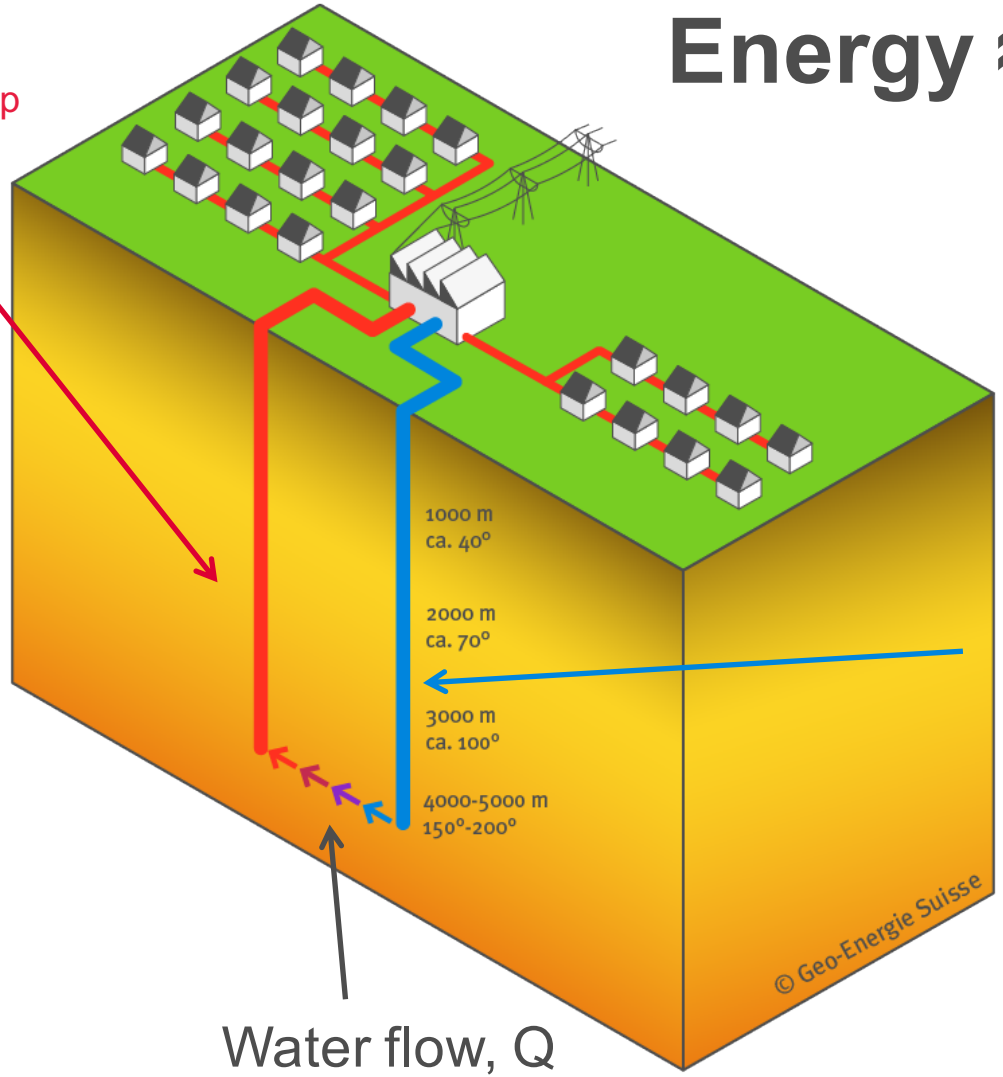
Dr. Peter Meier, CEO Geo-Energie Suisse

aet ebl EOS HOLDING ewb ewz Die Energie GVM Gasverbund Mittelland AG IWB

The Geothermal Energy

Production Temperature, T_p

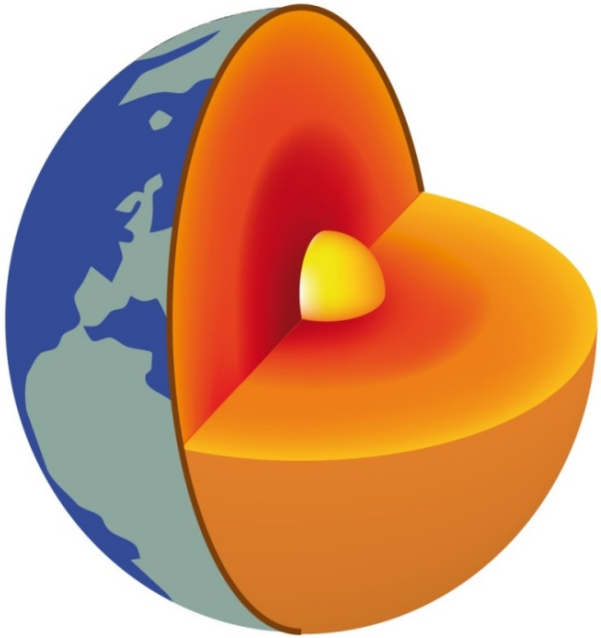
$$\text{Energy} \approx Q^*(T_p - T_i)$$



Re-injection Temperature, T_i

Water flow, Q

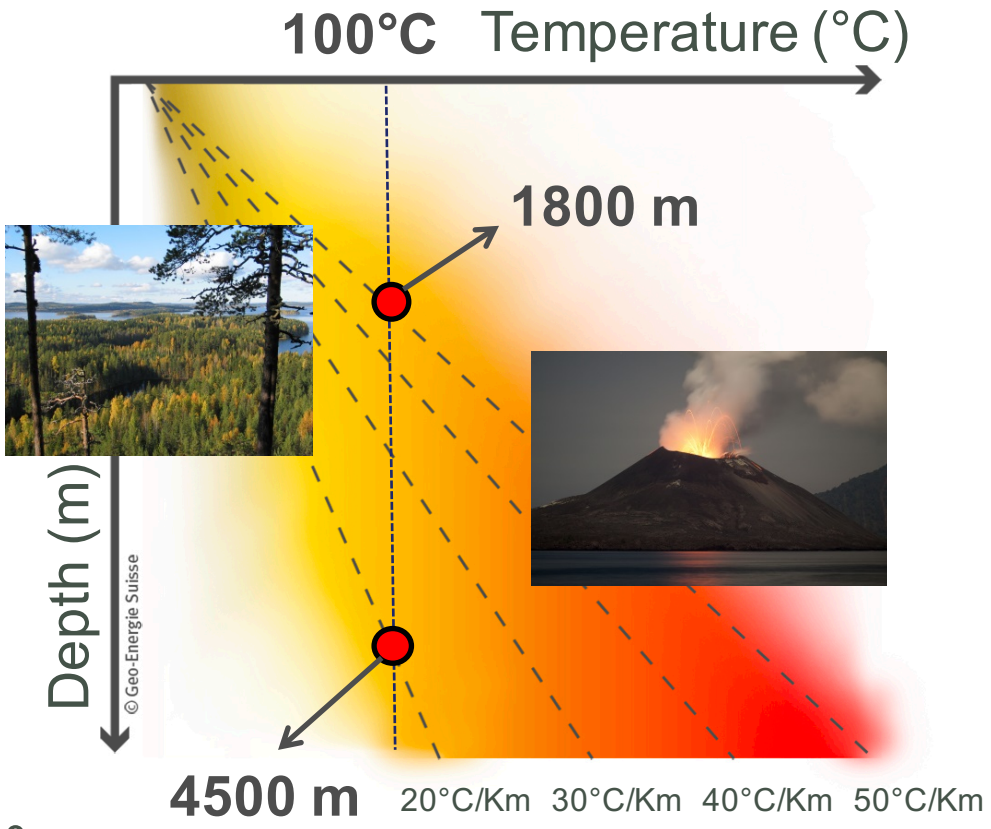
The Heat



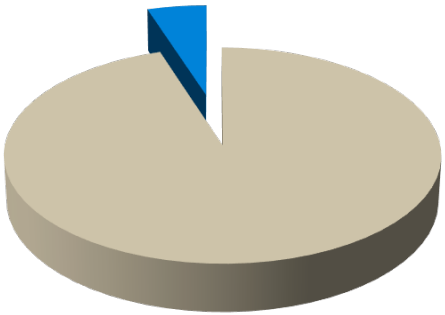
99%

of its volume is above 1000° C

The geothermal gradient



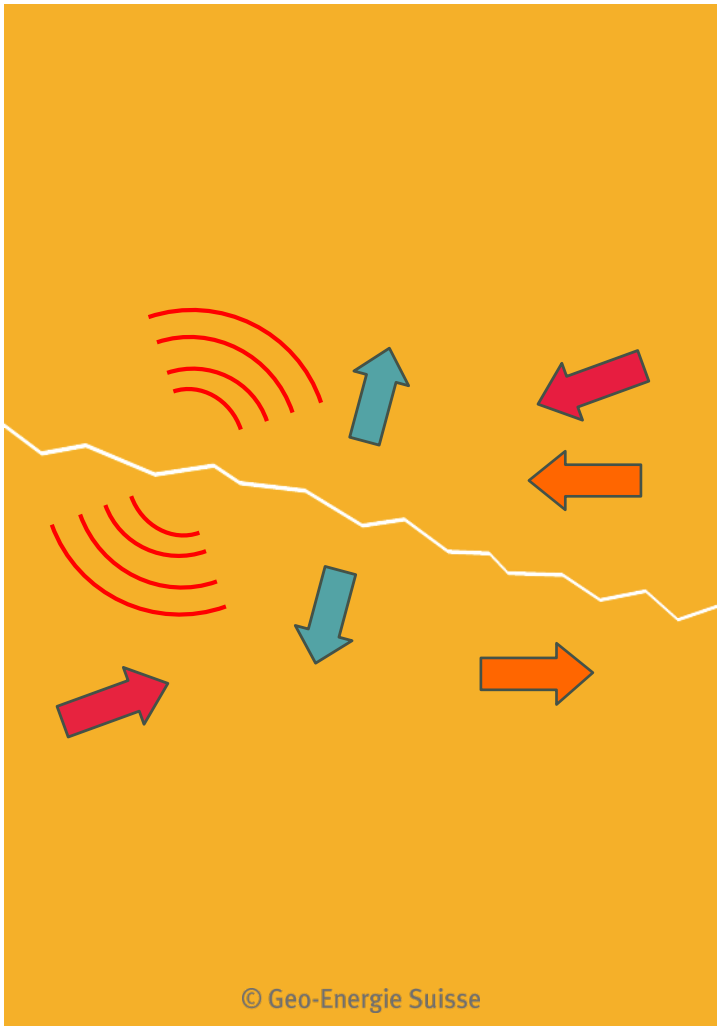
The Water Flow



Message

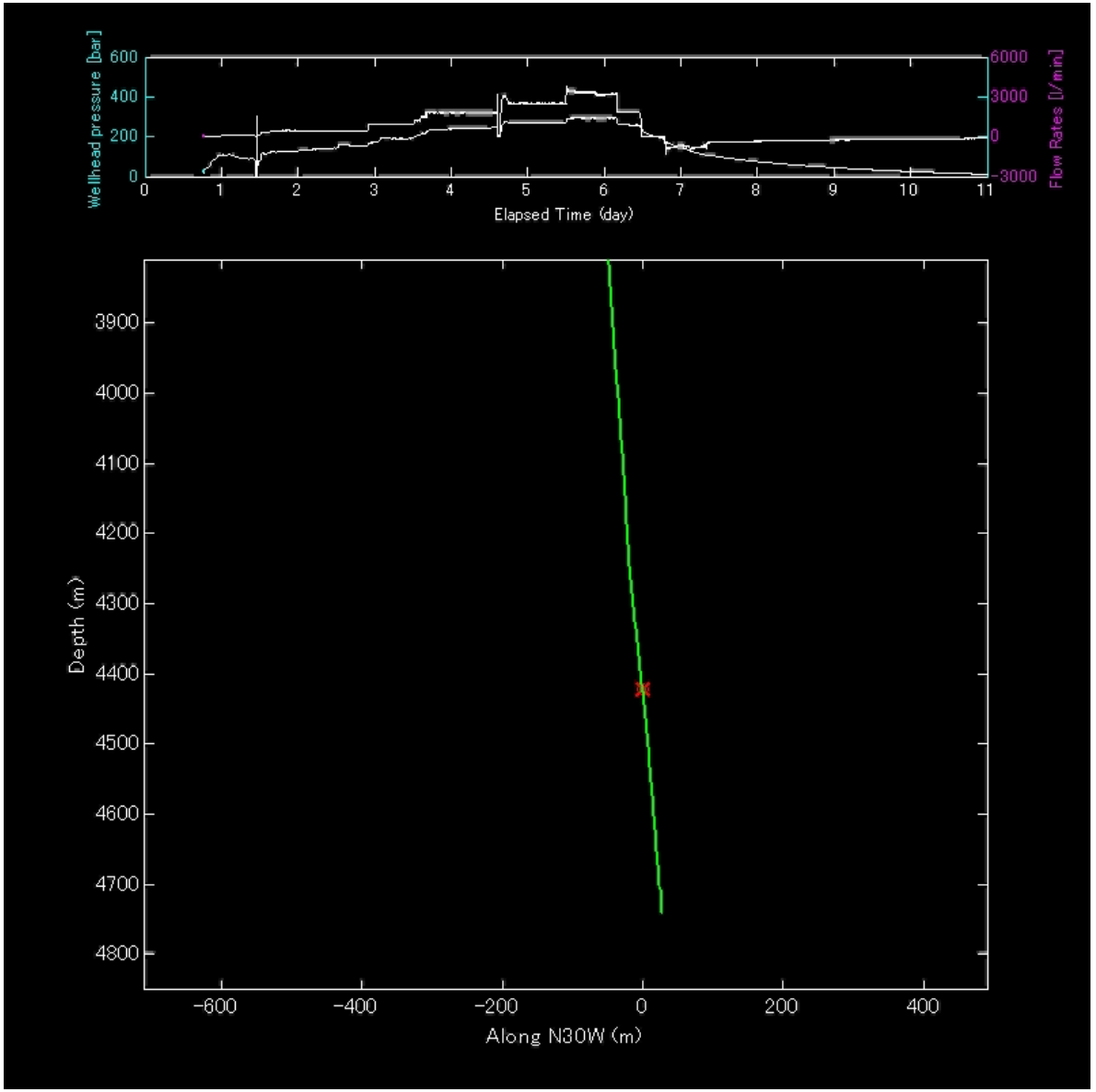
- Sufficient temperature will always be found. It is only a matter of depth (and costs)
- Large water flows at depth are rare. **Technology is therefore required to extract the heat in most cases**

EGS – Principle of hydraulic stimulation

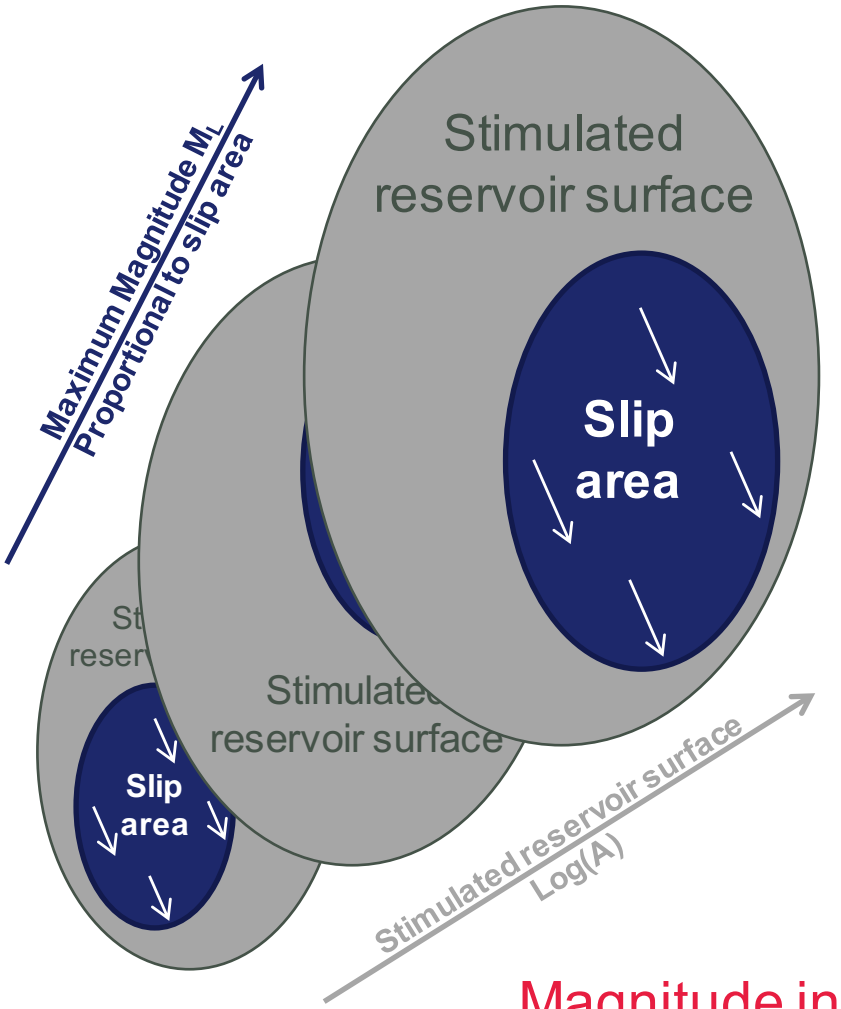


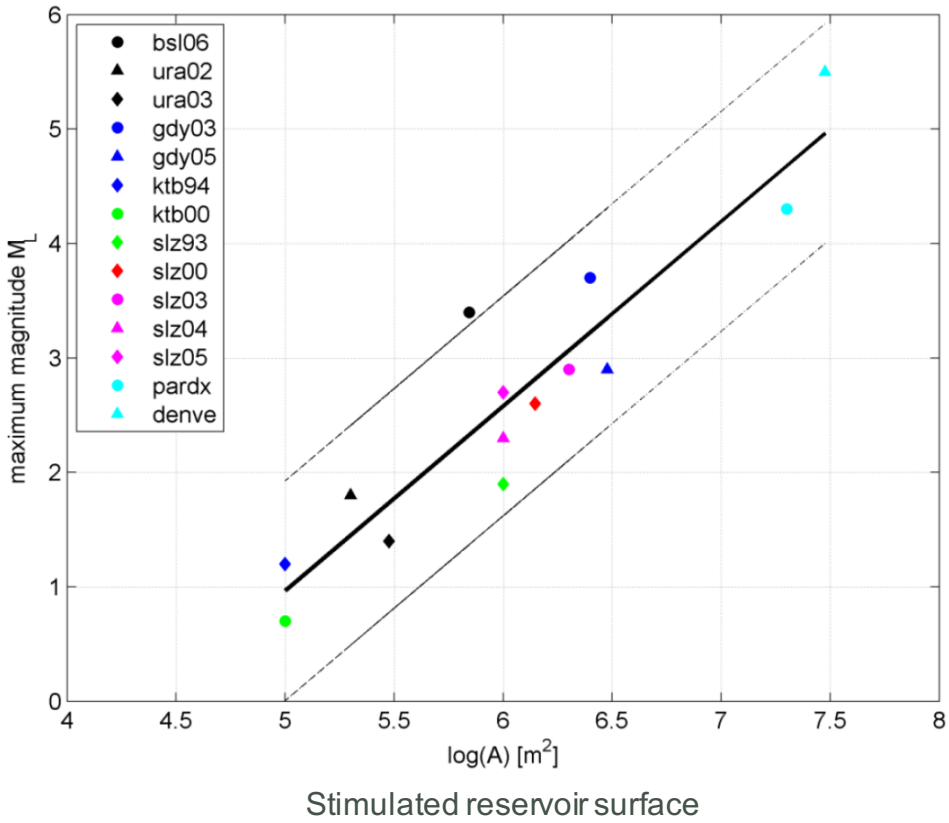
- Natural fissures represent weaknesses in the rock mass.
- Differential stresses permanently apply on them.
- The injection of water in a fissure reduces the friction preventing it from slipping.
- This causes a displacement along the fissure.
- Seismic energy is released, which allows the event to be located.
- The walls of the fissure don't match anymore. The permeability has been permanently enhanced.

Seismic dataset from the Basel project during the massive stimulation in large open wellbore section



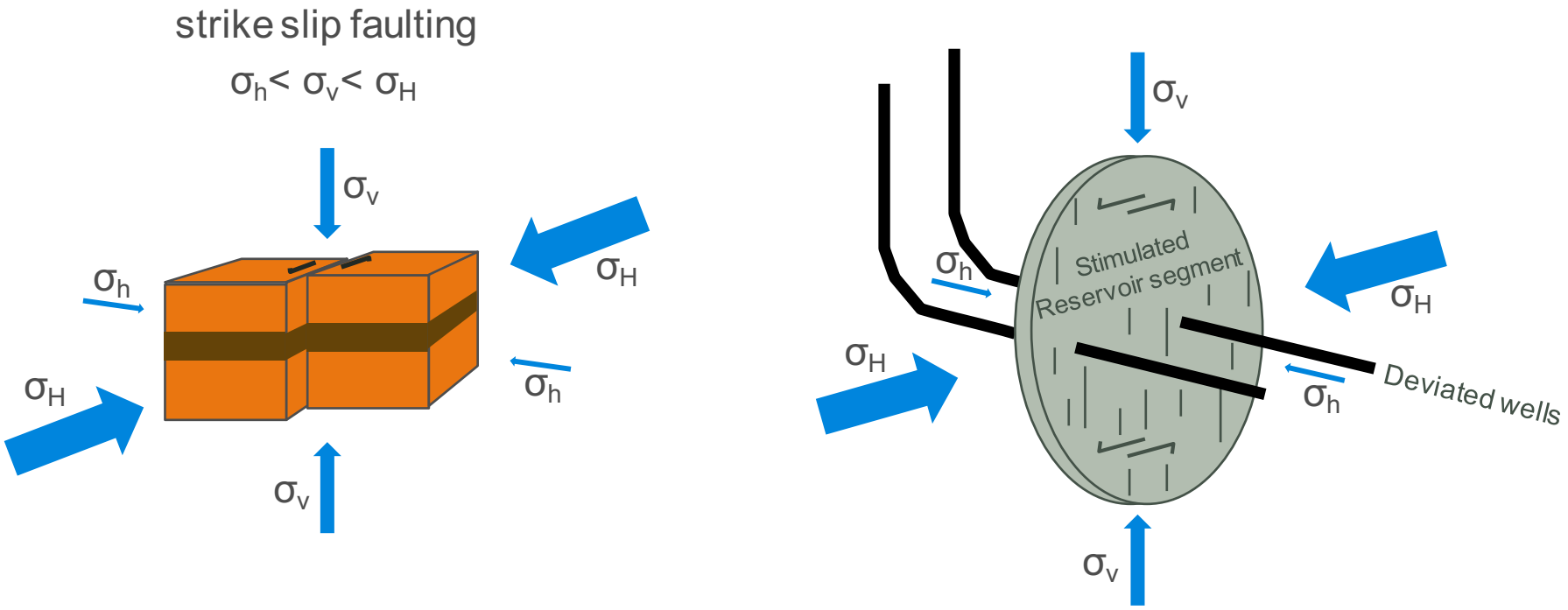
Basel: Key findings on induced seismicity





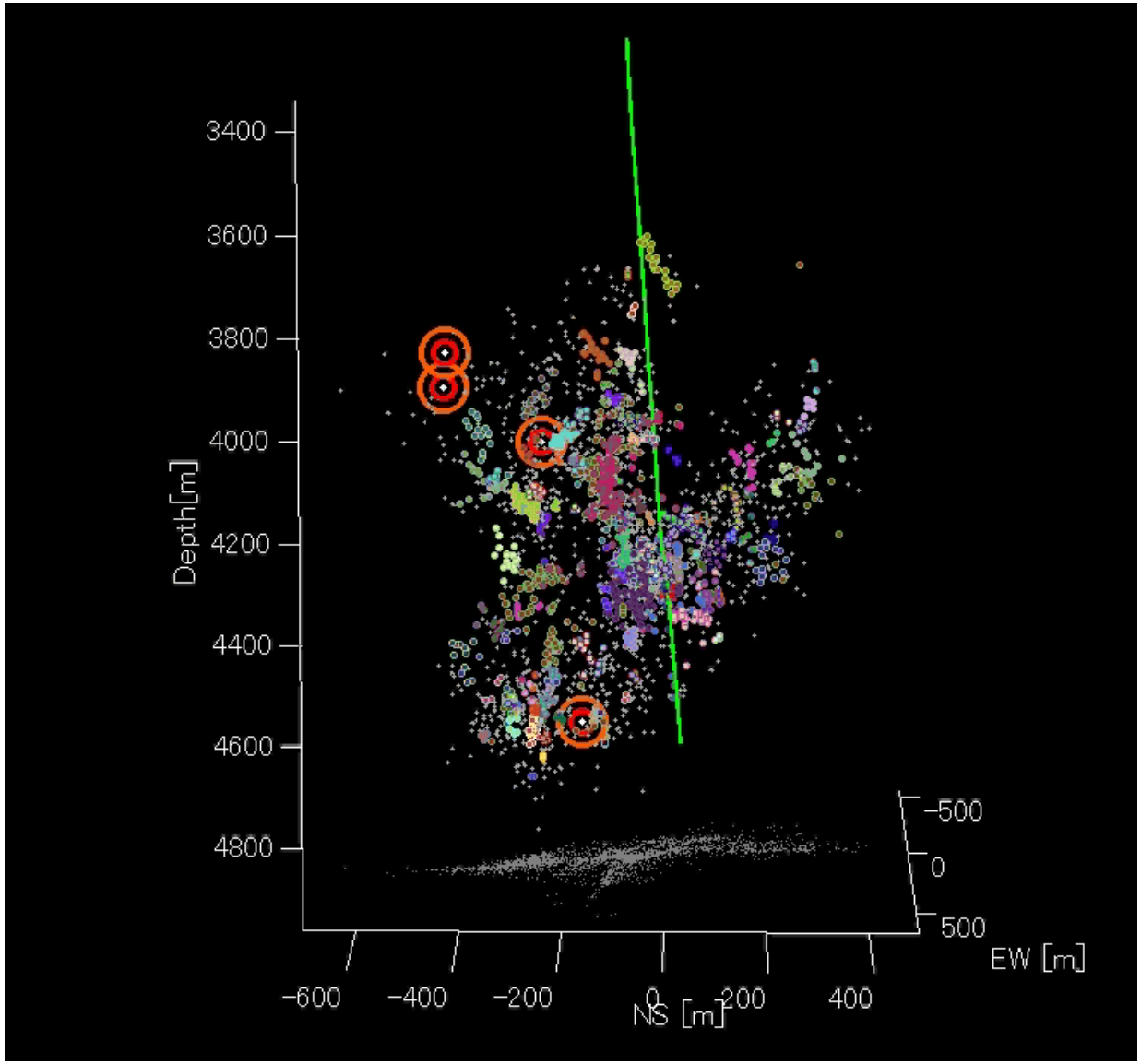
Magnitude increases with stimulated reservoir area (Serianex, 2009)

EGS – Orientation of the stimulated reservoir

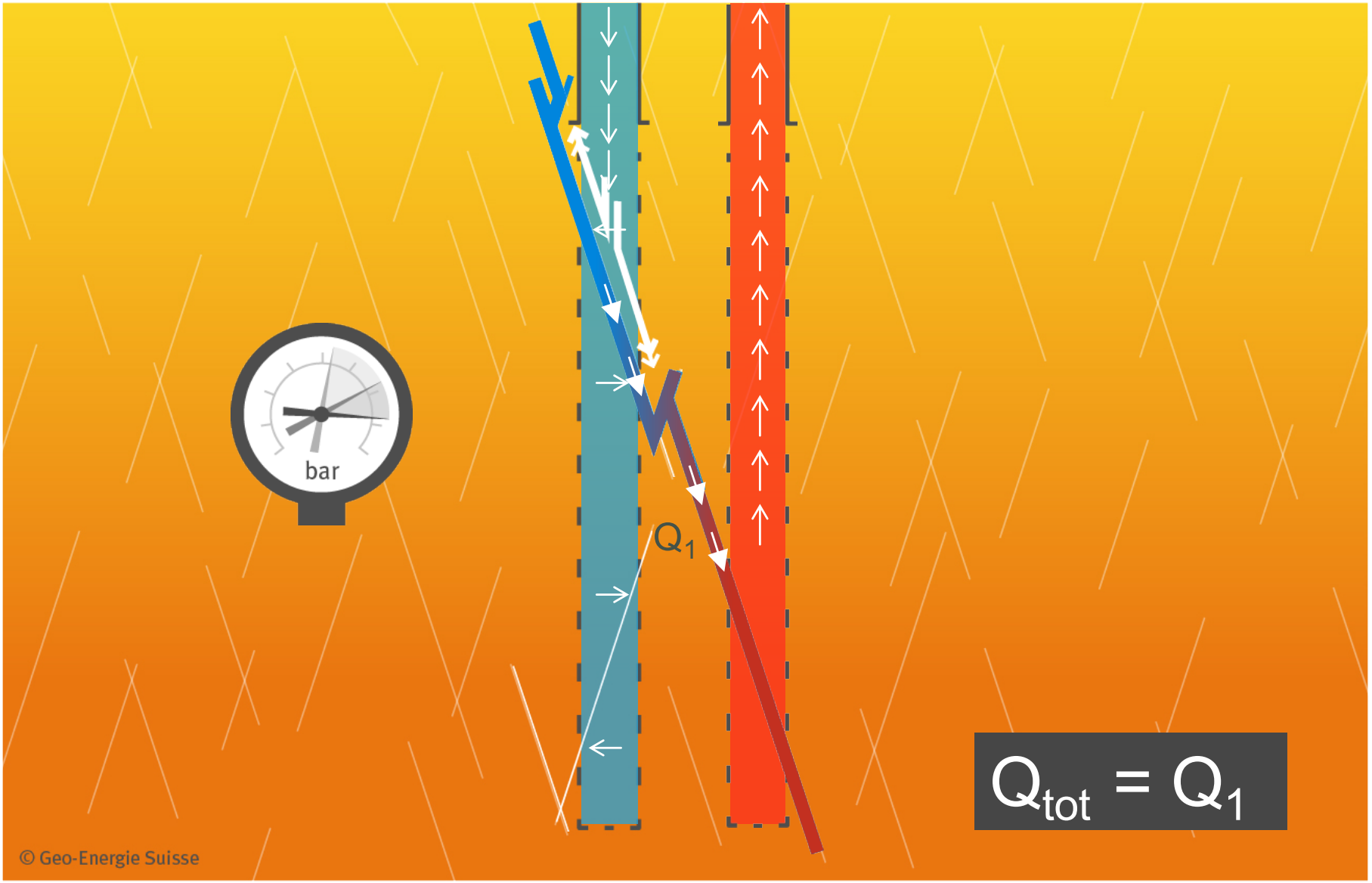


- In a strike-slip stress regime, a vertical disked-shaped reservoir develops during stimulation
- **→ In such stress regimes, the drilling of deviated wells is required**

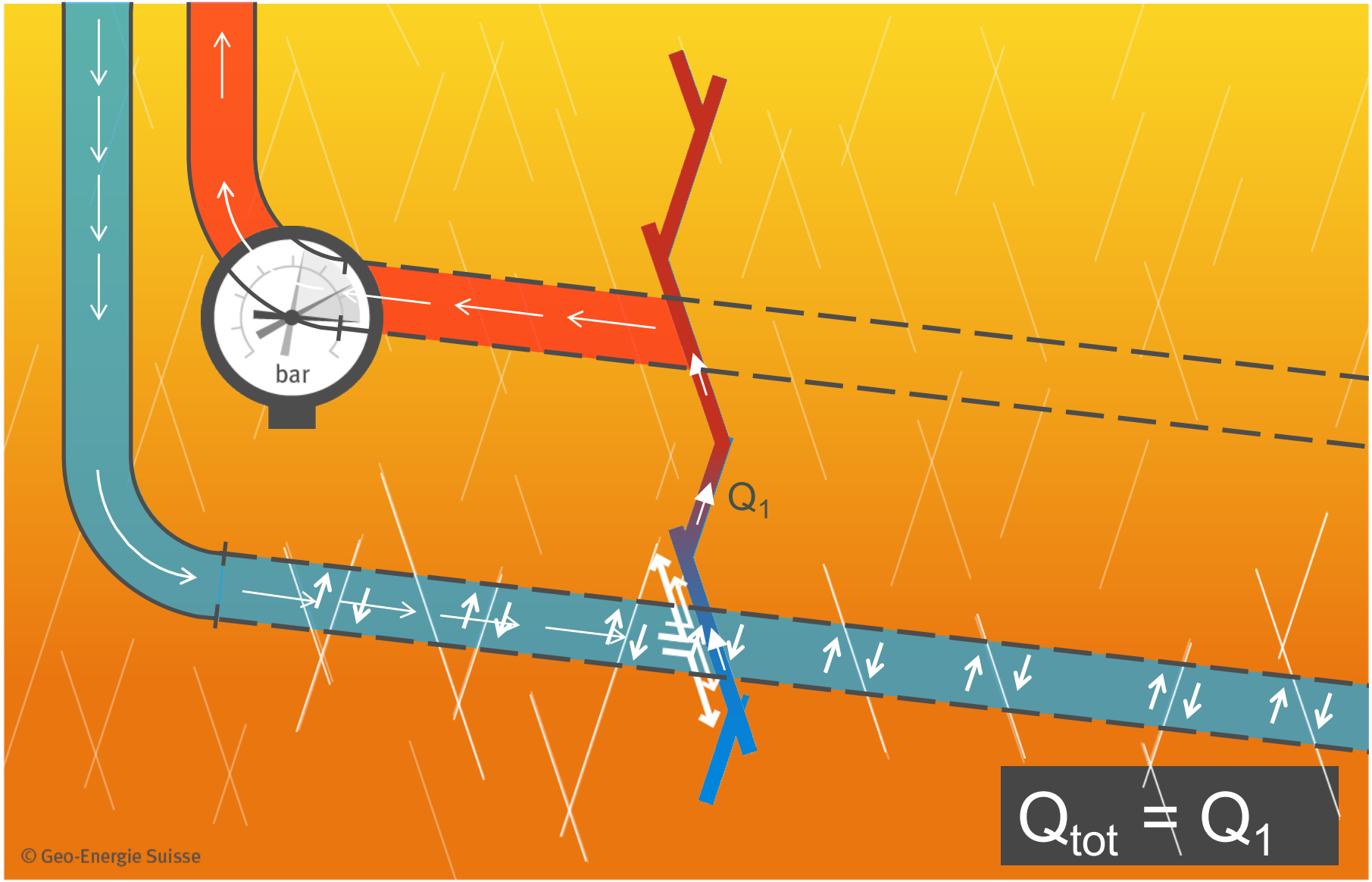
Seismic dataset showing the 3D geometry of the Basel reservoir after 3 months



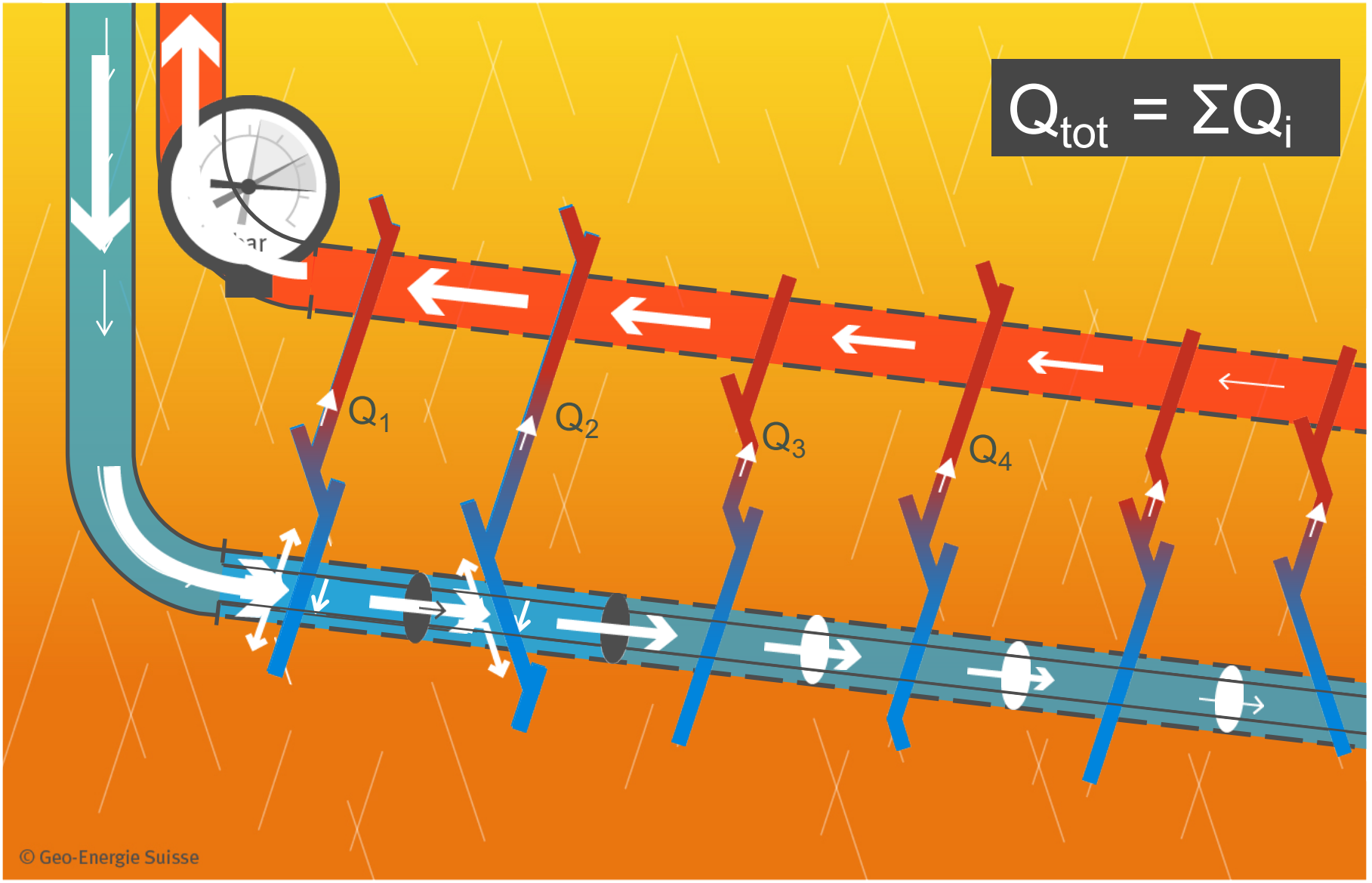
Stimulation of an open-hole vertical well



Stimulation of an open-hole deviated well



Multi-stage stimulation of isolated segments



DESTRESS

Partners

TRIAS WESTLAND
GFZ Helmholtz-Zentrum Potsdam
EnBW
KICT Korea Institute of Civil and Building Technology
esg és géothermie
GEO ENERGIE SUISSE
University of Glasgow
ECW Netwerk
TNO innovation for life
SEOUL NATIONAL UNIVERSITY
ETH zürich
nexGeo NEXGEO Inc.
TU Delft Delft University of Technology
Ecole et Observatoire des Sciences de la Terre
GEOTERMA
GTN

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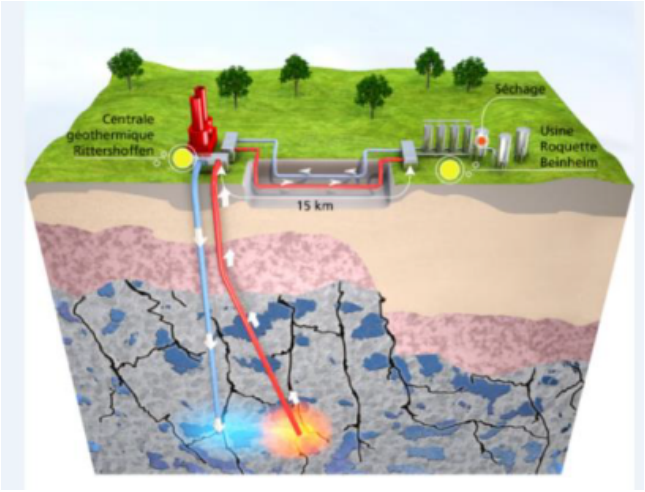
Pohang in Korea

Pohang (KR)	Granodiorite formation	fractured granite/granodiorite	Depth 4348 m	Reservoir-thickness >1000 m	Temp. 140 @ 4.2 km	Salinity <1 g/L	2016: 2 wells (PX-1 & PX-2)
Foreseen stimulation techniques: cyclic hydraulic stimulation (optional: multi-stage fracturing)			WP5	Provision of electricity			

Rittershoffen in France



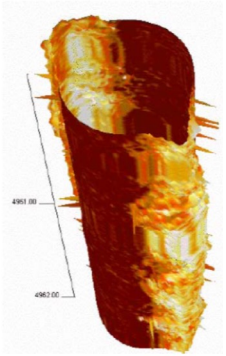
Rittershoffen (FR)	Fractured clastic rocks (SS) and fractured granite with high temperature geothermal resources	Fractured Triassic sandstone and Carboniferous fractured granite	Depth 2600m	Reservoir-thickness 680 m	Temp. >160	Salinity ~100 g/L	2014 2 wells finished and stimulated
THMC-Stimulation techniques performed 2013 Evaluation within DESTRESS			WP4	Heat for (green) chemical industry			esg és géothermie

Westland in the Netherlands

Westland (NL)	Clastic (fractured) rocks (SS) with low-enthalpy geothermal resources (cores available)	Triassic Sandstone	Depth 4000 m	Reservoir-thickness 175 m	Temp. 140 °C	Salinity ~70 g/L	2017 Start drilling to Triassic
Foreseen stimulation techniques: Acid (HCL and/or HCL-HF) Option: (tensile) fracturing or thermal stimulation			WP4	Heat for greenhouses			TRIAS WESTLAND

Project DESTRESS / EU-Horizon 2020
Multi-stage and cyclic stimulation

Objectives
Demonstration of soft stimulation treatments of geothermal reservoirs.



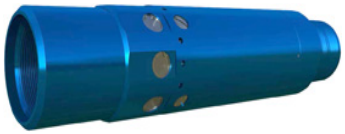
Project description
16 Partners from research and industry from 6 European countries and South Korea will demonstrate soft stimulation in existing or planned boreholes at up to 7 sites in sedimentary and crystalline rocks.

Significance
Geo-Energie Suisse focuses on the development and testing of zonal isolation techniques and multi-stage shear stimulation treatments at the Haute-Sorne site.


Swellable packers

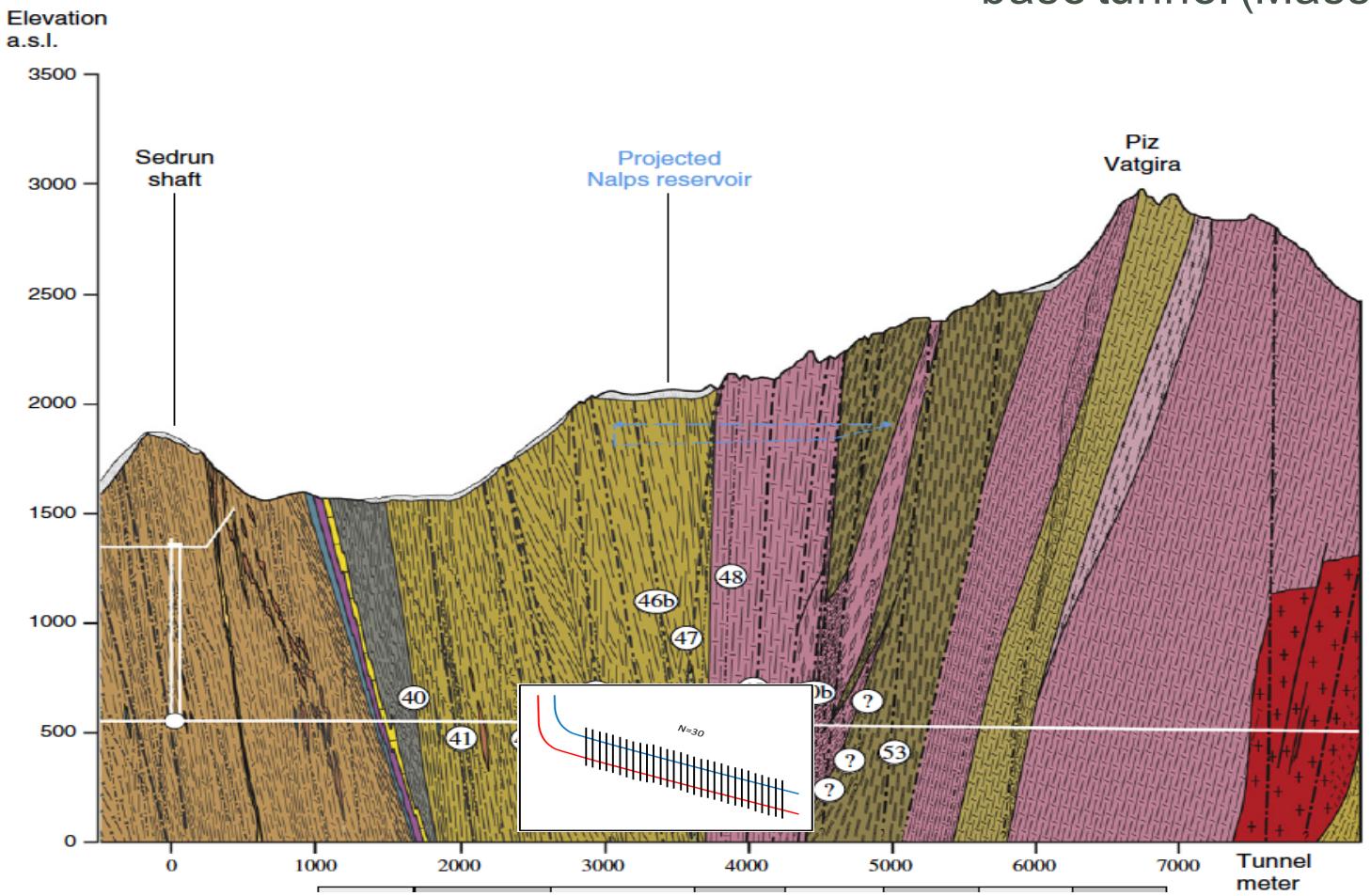
Budget
Total budget Euro 25 Mio., Geo-Energie Suisse CHF 5.6 Mio.

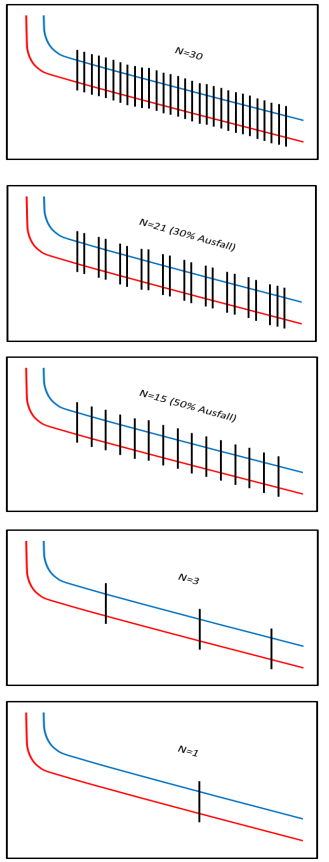
Project duration
March 2016 – February 2020



MC simulations to show chances of success

assuming rock conditions of the Gotthard base tunnel (Masset & Loew, 2013)





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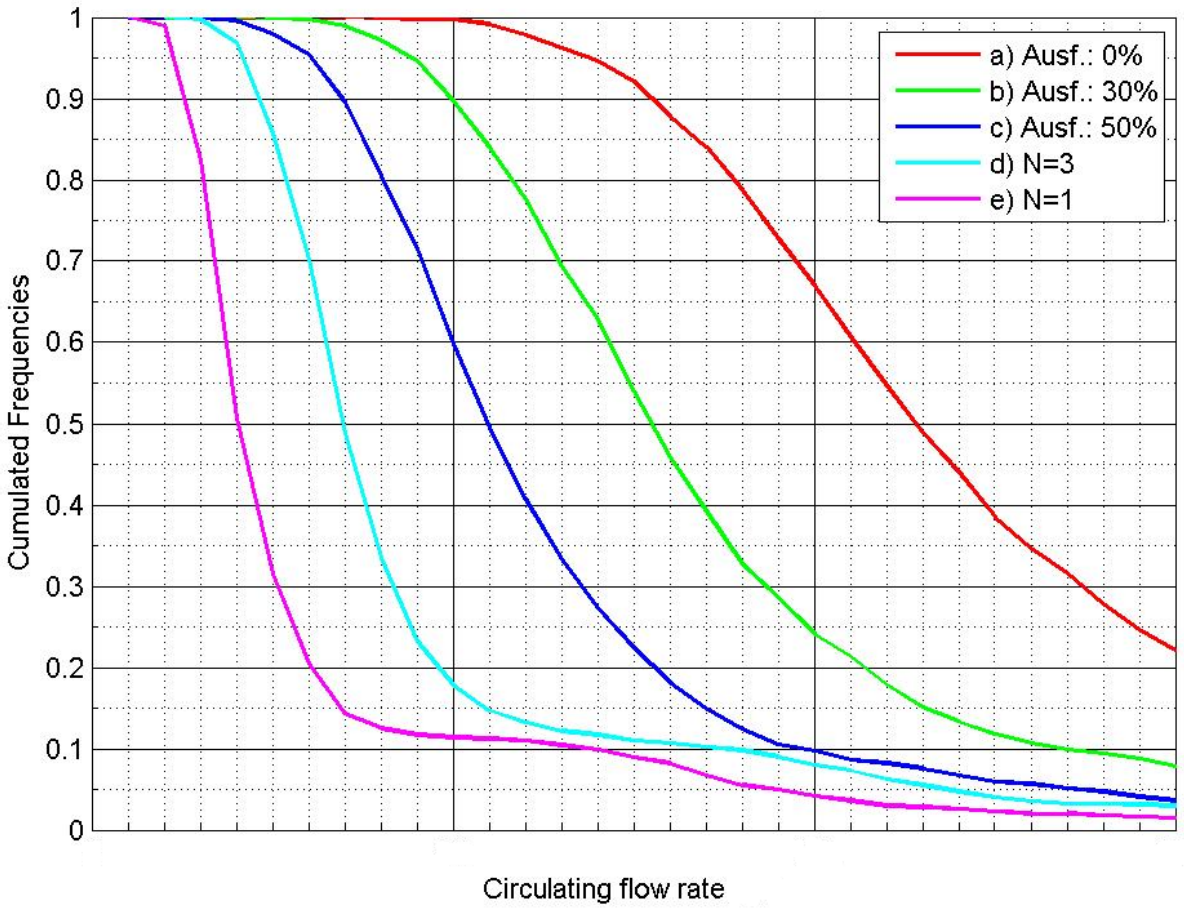
MC simulations demonstrate the improvement of circulation rates using a multi-stage stimulation system instead of a stimulation in an open borehole



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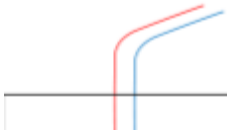
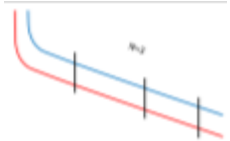
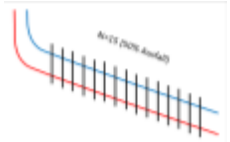
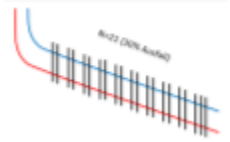
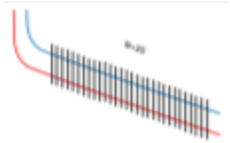
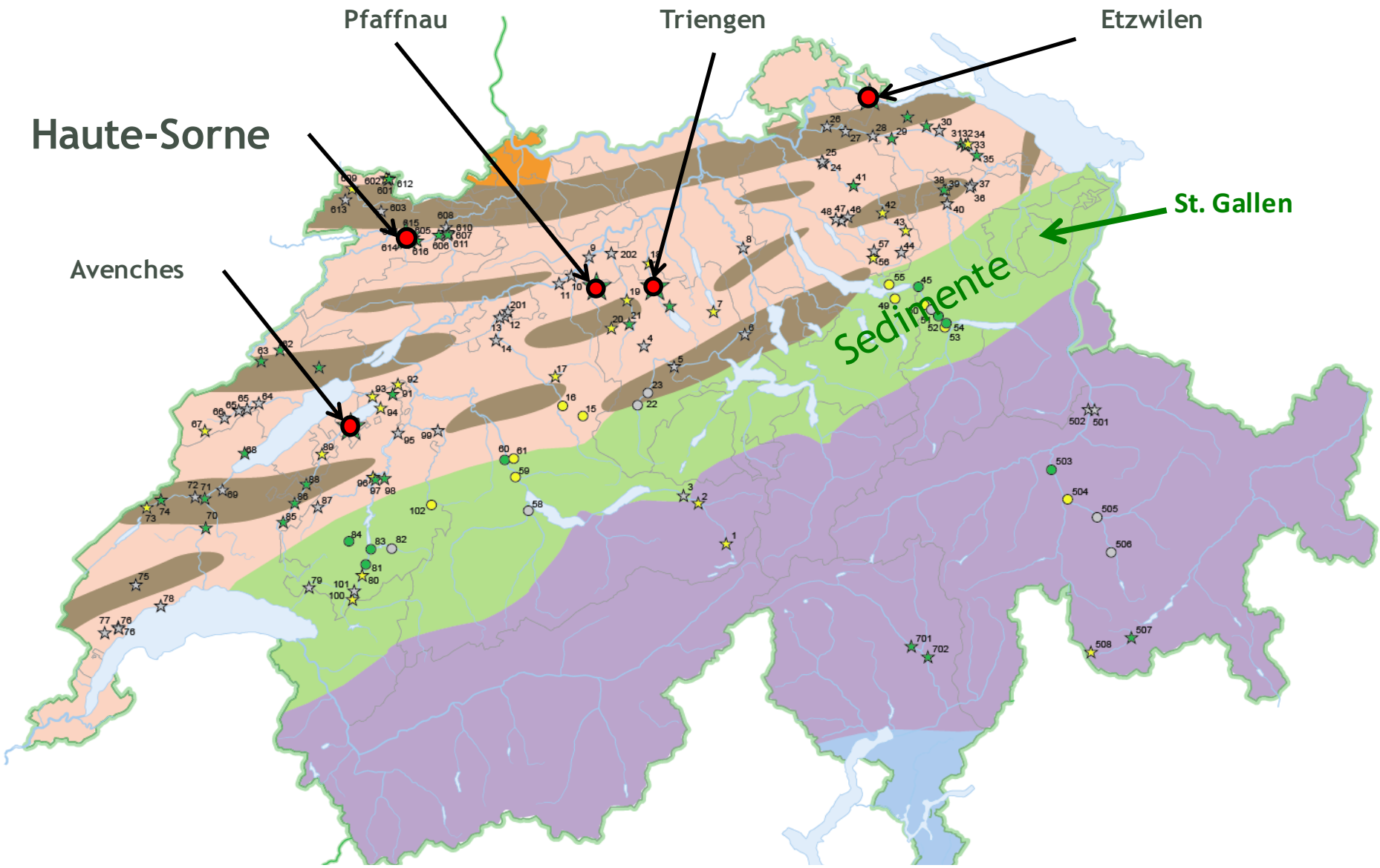
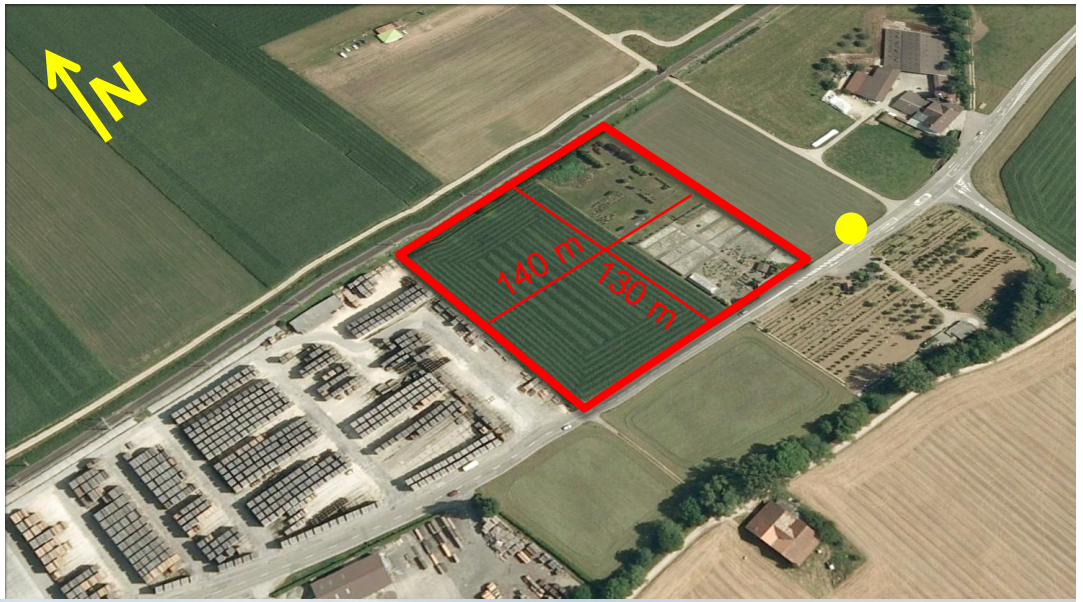
What are the economics?

	Utilisation System	Increase Factor of: El. Power	Increase Factor of: Costs
	**Vertical Single-Open-Hole-System**, 1 fracture	**1**	**1**
	Single-Open-Hole-System, 3 fractures	1.8	1.2
	Multi-Stage-System; 50% failure rate of stages	2.9	1.6
	Multi-Stage-System; 30% failure rate of stages	4.2	1.6
	**Multi-Stage-System**; 0% failure rate of stages	**6.2**	**1.6**

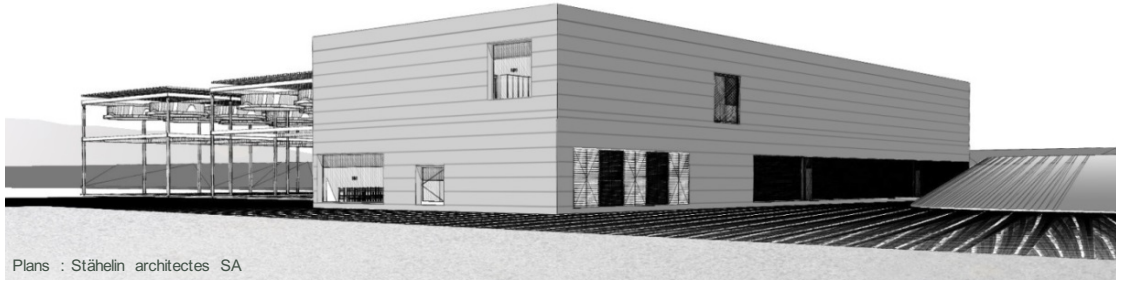
130 potential sites for pilot projects were evaluated within different plays within crystalline basement and sediments



Haute-Sorne, Canton Jura



The Haute-Sorne EGS Pilot Project

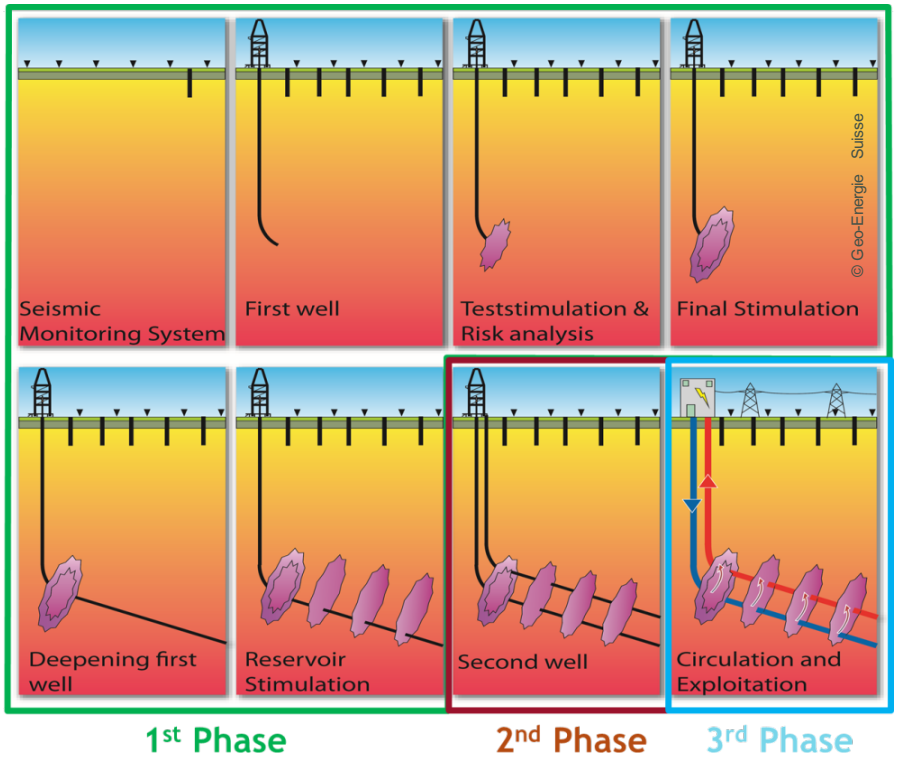


Agenda

- 1st Phase: 2016-2018
- 2nd Phase: 2018-2019
- 3rd Phase: 2019-2020

Project Summary

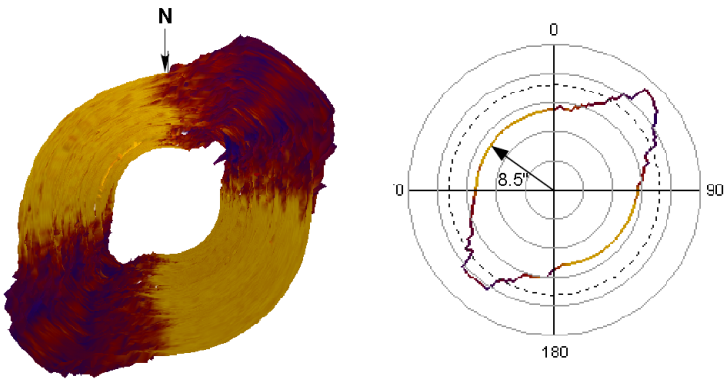
- The Haute-Sorne pilot project in Canton Jura, Switzerland, is the first project worldwide that foresees multistage stimulation to achieve water circulation between two deep boreholes drilled trough the crystalline basement.
- The project is in the final phase of obtaining the risk guarantee from the State that covers up to 60% of the exploration costs in case of failure.
- As a pilot and demonstration project, subsidies from the State can be expected.



JURA CH RÉPUBLIQUE ET CANTON DU JURA

Deep Geothermal Well Optimization Workflow (DG-WOW)

Objectives: Zonal isolation is a key enabling technology for the development of deep geothermal resources. Optimal well control is central to the success of such technology. Brittle failure of borehole walls must be carefully assessed and measures must be taken to limit them in order to enable successful well completion with zonal isolation. The objectives of the project is to provide the adequate workflows to limit the risks and maximize the chances of success.



Project description

Within this project a workflow to make decisions on the optimal drilling direction will be developed and tested on existing and newly acquired datasets. This workflow will support efficient decision making during the drilling operation and reduce project risks.

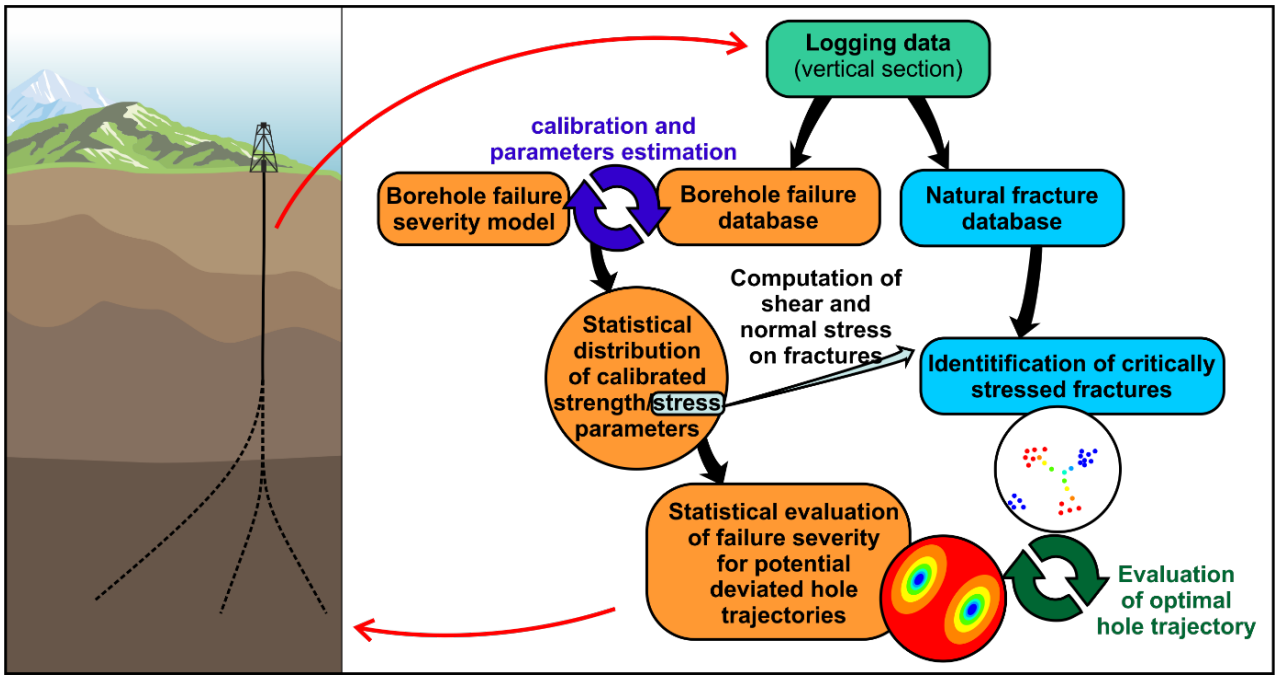
Significance

Enabling zonal isolation is key to efficient stimulation

Project duration

2015 – 2018

Funding Agent: KTI



Partners: CHYN / UniNe; Geo-Energie Suisse AG

Contact: Benoît Valley, benoit.valley@unine.ch

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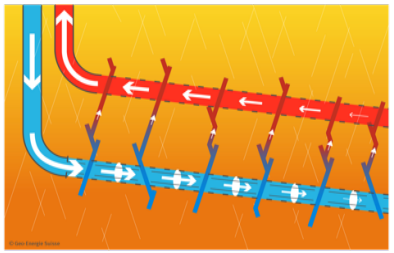
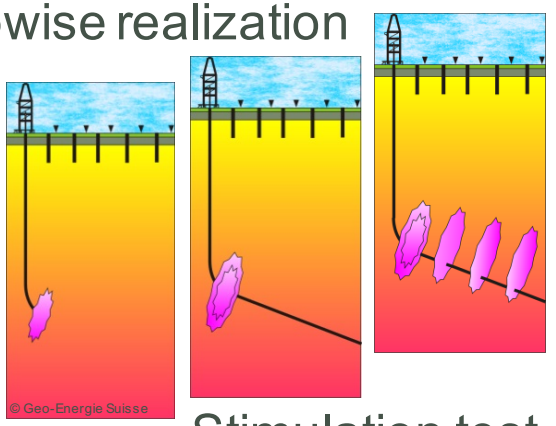
What's about the seismic risk?



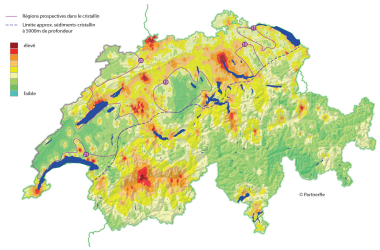
Safer concept

Risk studies

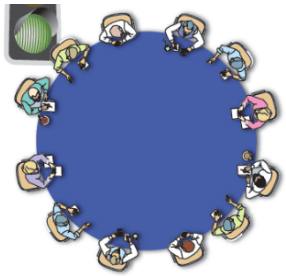
Stepwise realization



Stimulation test



Site selection



Continuous risk evaluation

Conservative traffic light system

Real-time monitoring

Permit delivered June 15, 2015

Peter Meier,
CEO
Geo-Energie Suisse

Philippe Receveur,
Minister
Canton of Jura

Jean-Bernard Vallat,
President
Commune of Haute-Sorne

Time plan Haute-Sorne

2012

Preliminary impact and risk studies

-Accompanying groups / public information

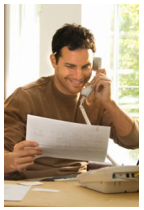
-Application of construction permit and main environmental impact and risk studies

2013

Examination by authorities

Permit 15.6.2015

2014



Risk guarantee BFE/Swissgrid (Autumn 2016)

2015

New Energy Law/Swiss Parliament (Sept. 2016)

2016

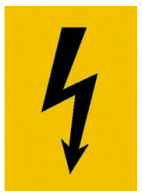
Tendering Rig (Autumn 2016)

Appeal Administrative court (Autumn 2016)

2018

Drilling (180 days), Completion & Stimulation (150 days)

2019



2020+

Power plant working

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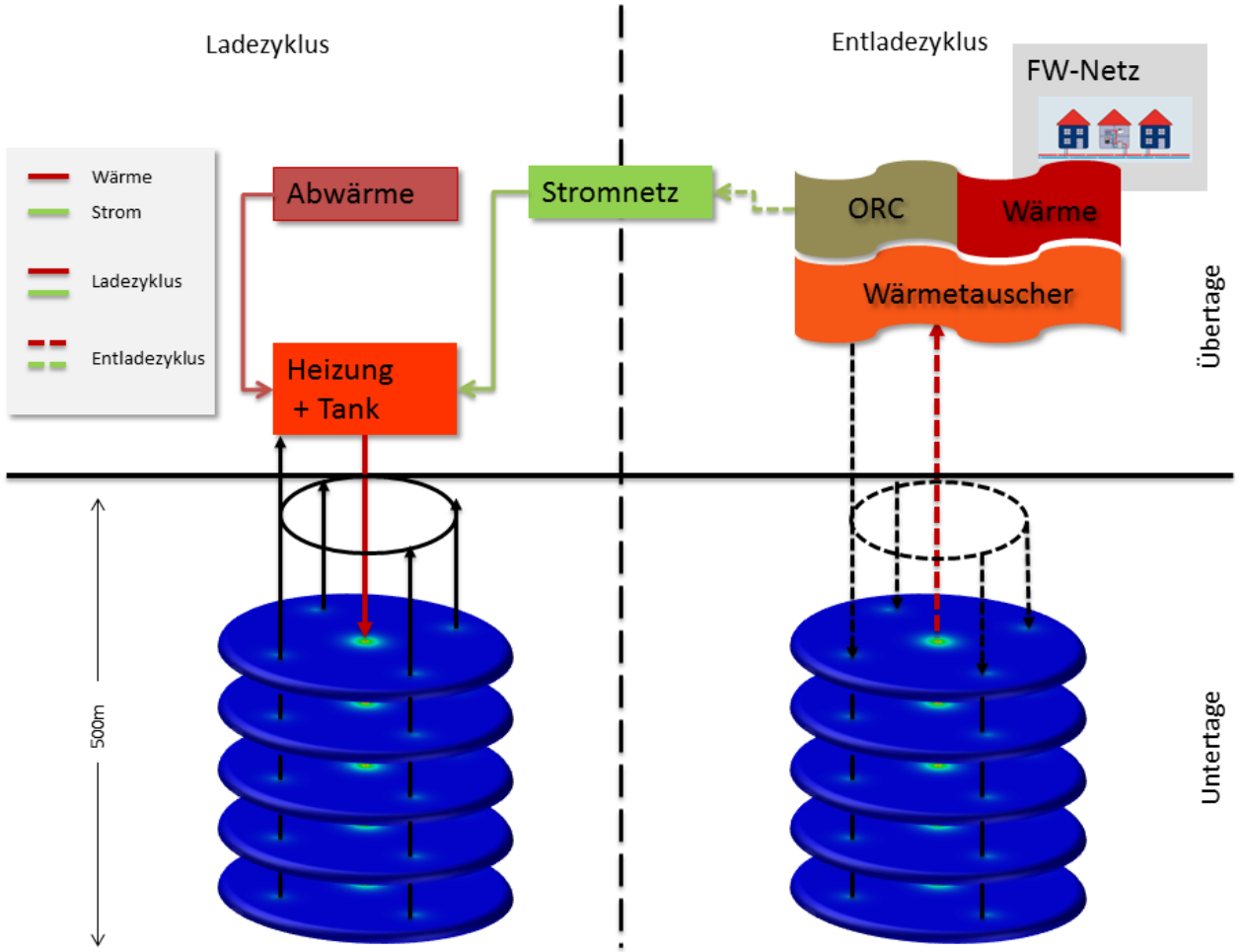
Other applications using EGS / fracturing technology: Underground heat storage



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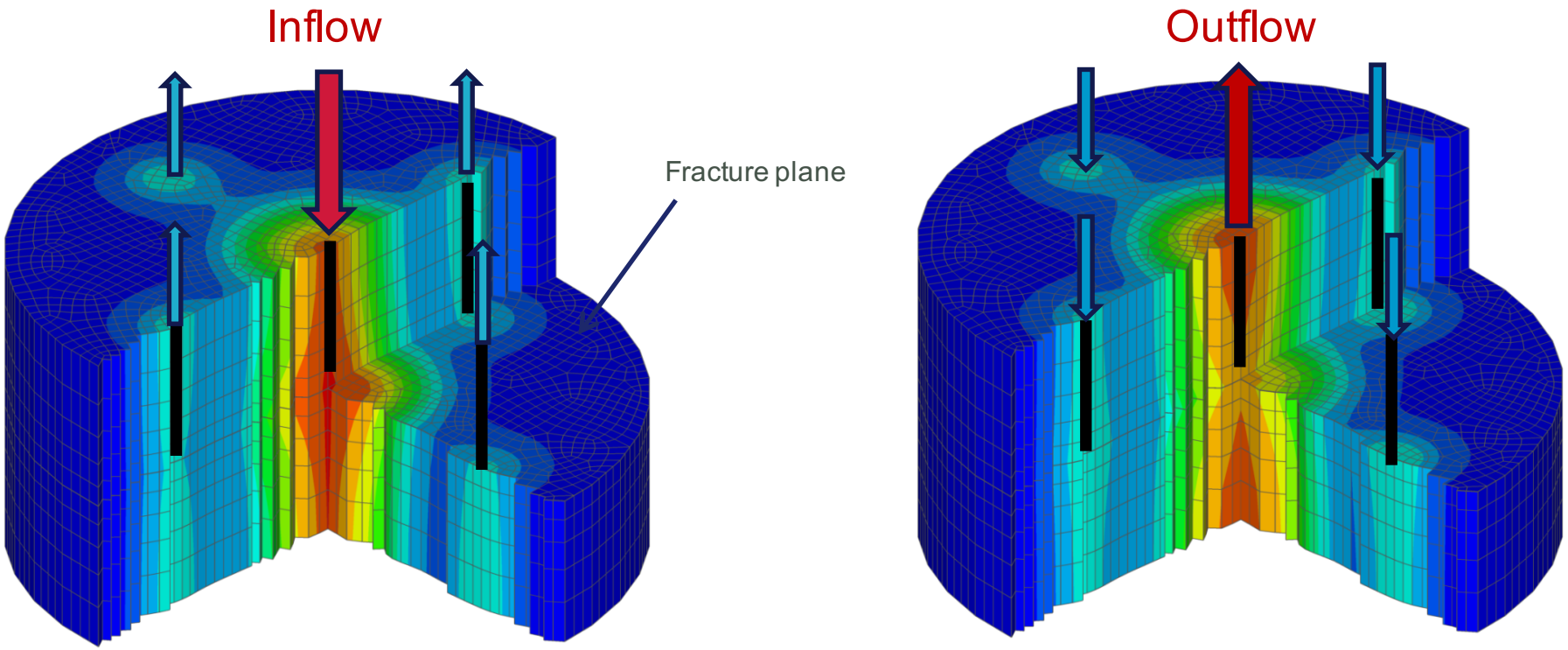
Loading / unloading of single fracture



Load Cycle

Unload Cycle

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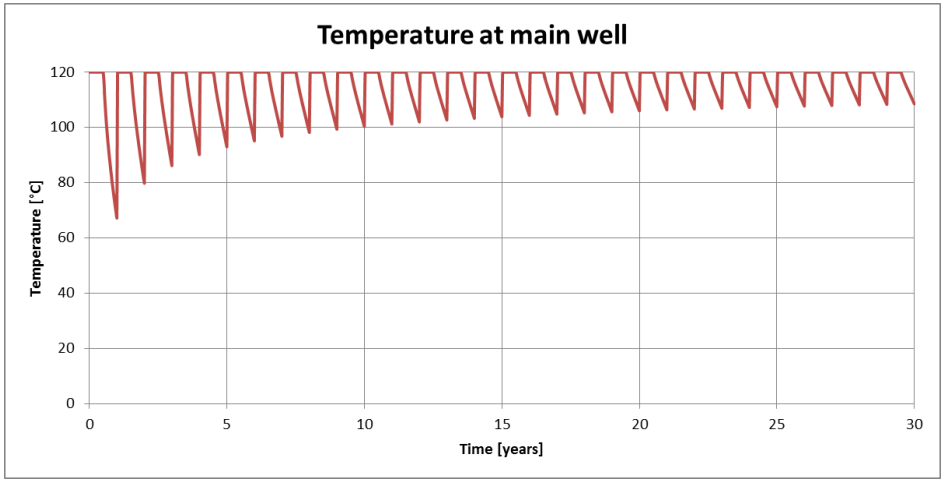
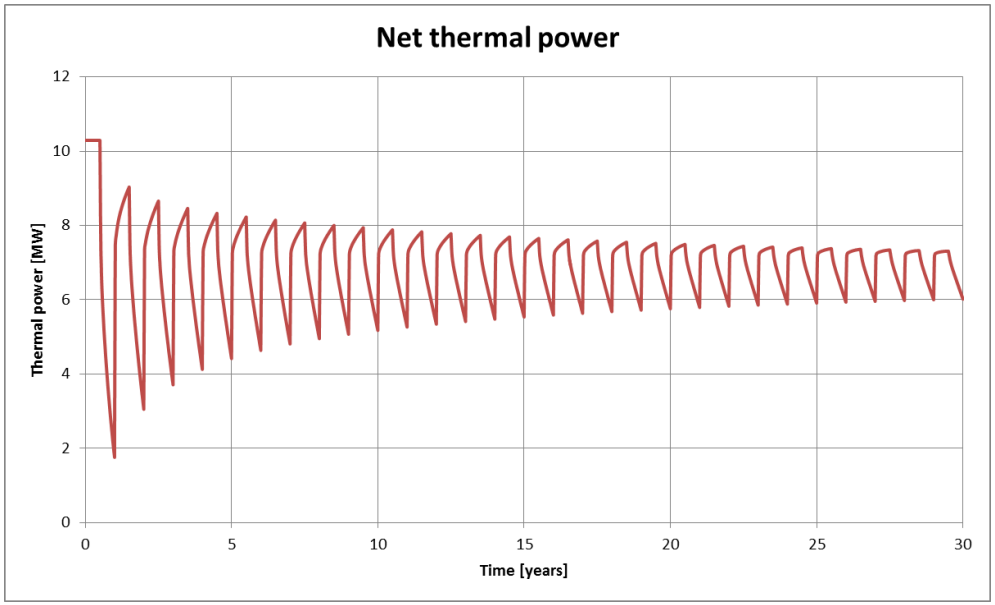
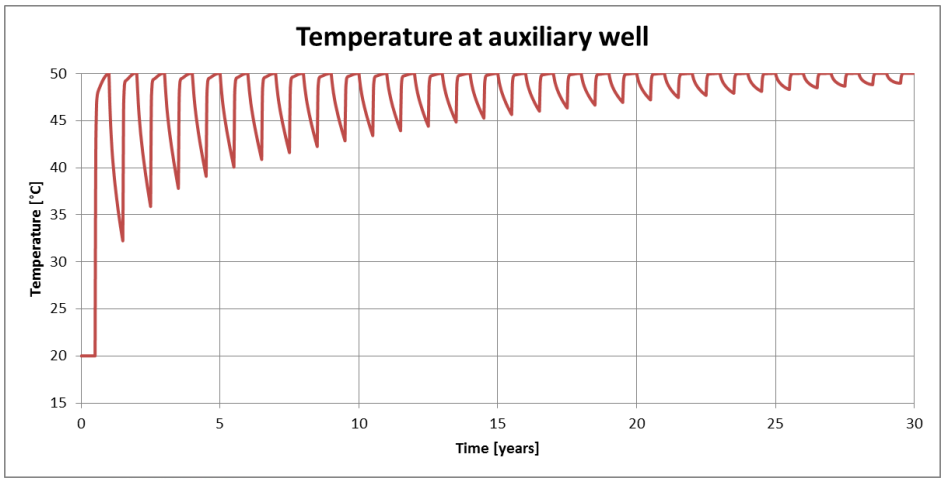
Temperature and power







IEA Geothermal Annex 13, Task C “Reservoir creation”

Swiss participants under the patronate of BFE (Gunter Siddiqi) and Swisstopo (Christian Minnig)

- Geo-Energie Suisse AG (project developer, P&D test sites)
- Number of professors and senior researchers:
  - Brice Lecampion (EPFL)
  - Benoit Valley (Uni NE)
  - Keith Evans (ETH Zurich)
  - Florian Amann (ETH Zurich)

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for Deep Geothermal Energy
for power and heat production

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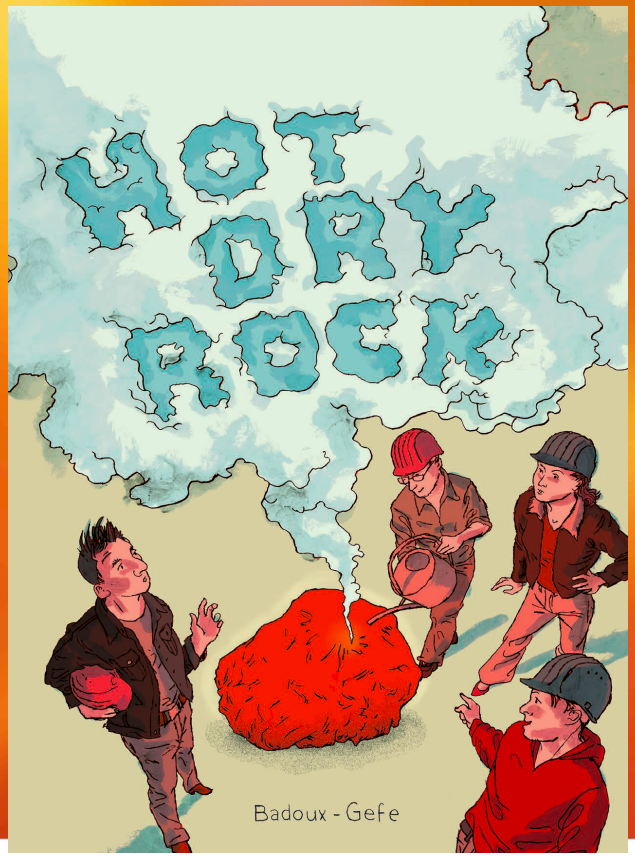

Thank you for your attention!