MEET

Multi-sites EGS Demonstration

Geothermal Winter School 2021

Engineered Geothermal Energy Systems in Europe

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GFZ Helmholtz Centre Potsdam

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 792037

Outline

- Introduction (market; society-economy-technology, objectives EGS)
- Reservoir characterisation
- Reservoir engineering
  - hydraulic stimulation and induced or triggered seismic events
    - Geldinganes treatment 2019
  - chemical stimulation
    - Soultz treatment 2019 and concept for Mezöbereny treatment 2021
  - thermal stimulation
    - concept for Mezöbereny treatment 2021
  - Cost breakdown of the different treatments
- Reservoir exploitation
- Conclusions

DESTRESS

Demonstration of soft stimulation treatments of geothermal reservoirs

Introduction

market,

recovery of geothermal heat,

why Engineered Geothermal Systems,

targeted stakeholder groups,

society-economy-technology,

objectives EGS

Energy transition requires a change in heat supply

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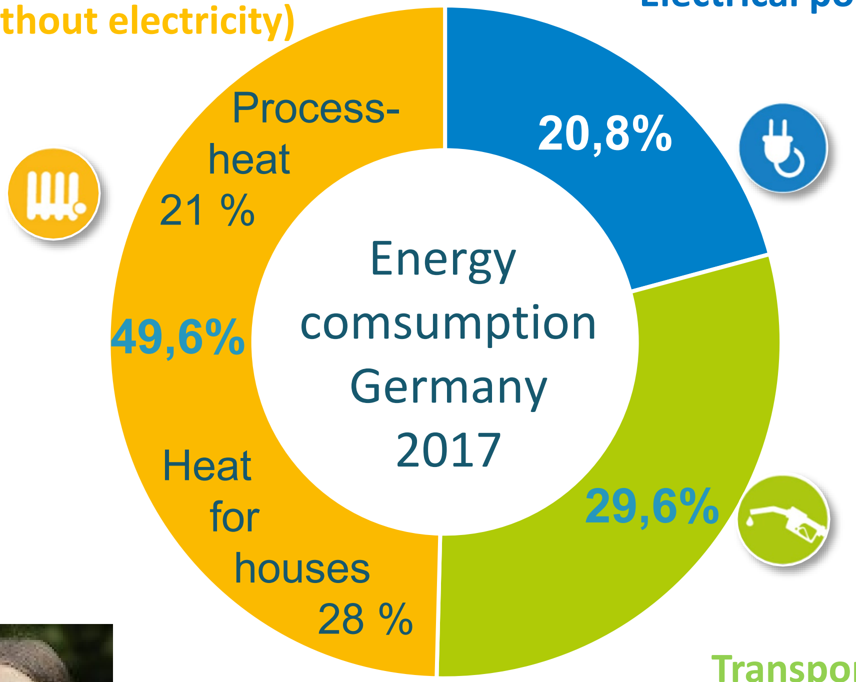
Grand challenges:

- Climate change
- Energiewende

Heat market ~ 2x market for electricity
↓
today ~14% from renewable ressources

Geothermal – the sleeping giant

- Huge potential of deep geothermal
- Low CO2-emissions
- Local base load energy source



→ with geothermal domestic added values

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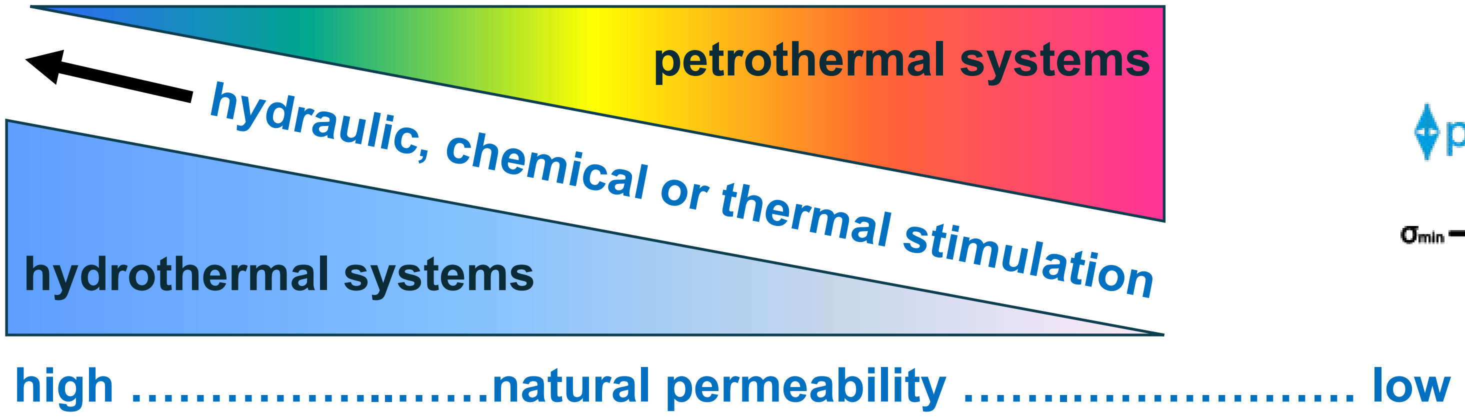
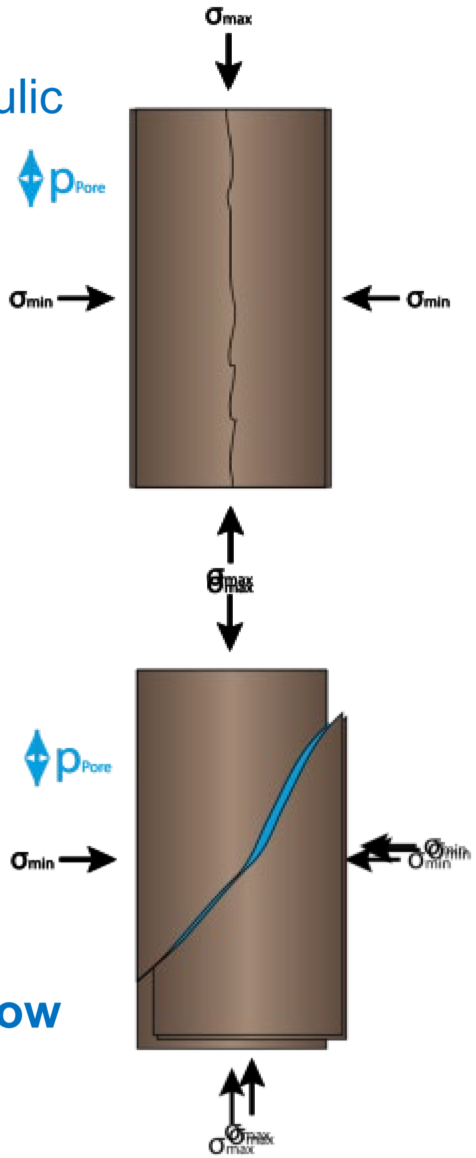
Enhanced geothermal systems (EGS)

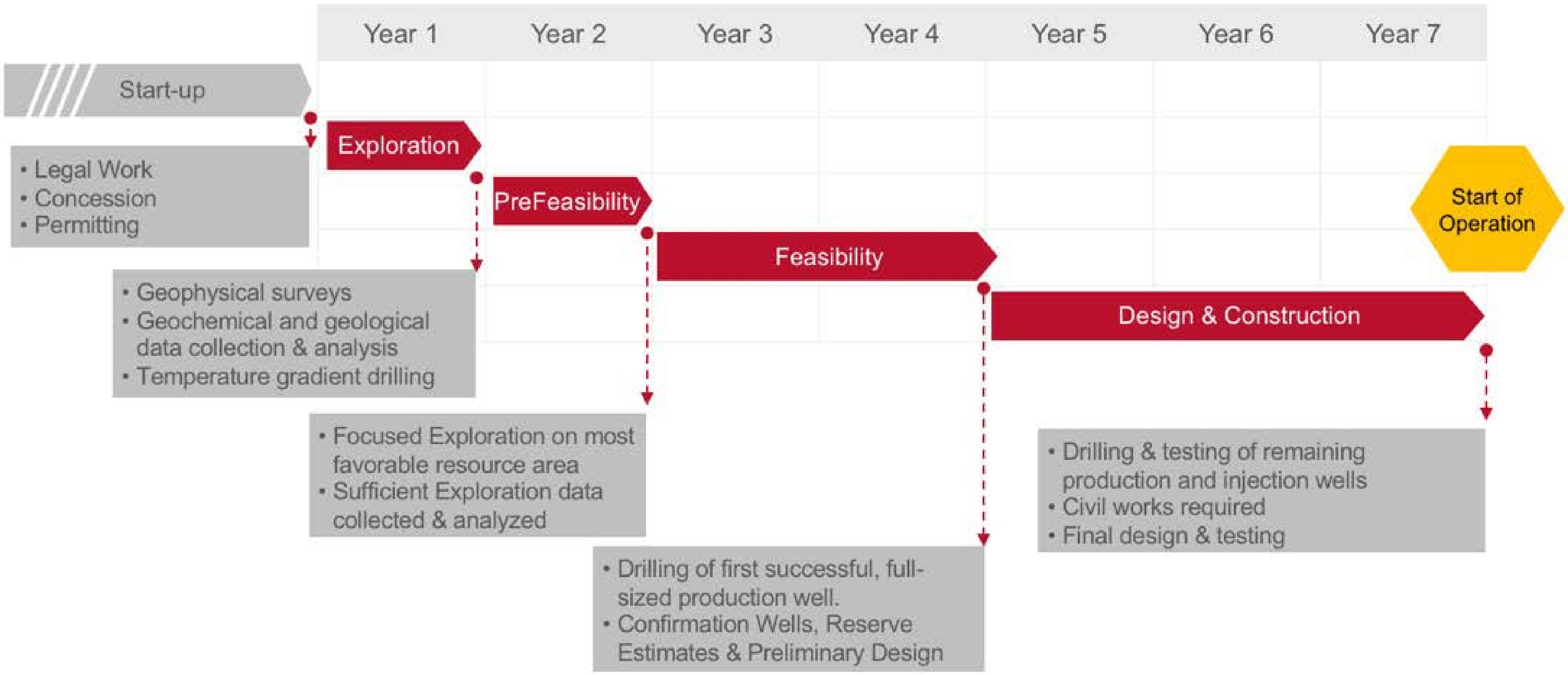
- The EGS concept includes artificial improvement of the hydraulic performance of a reservoir with the goal to use it for an economical provision of heat or electric energy
- The enhancement challenge is based on several non-conventional methods for exploring, developing and exploiting geothermal resources that are not economically viable by conventional methods
- Enhanced vs Engineered





Targeted Stakeholder Groups

Geothermal Project Timeline

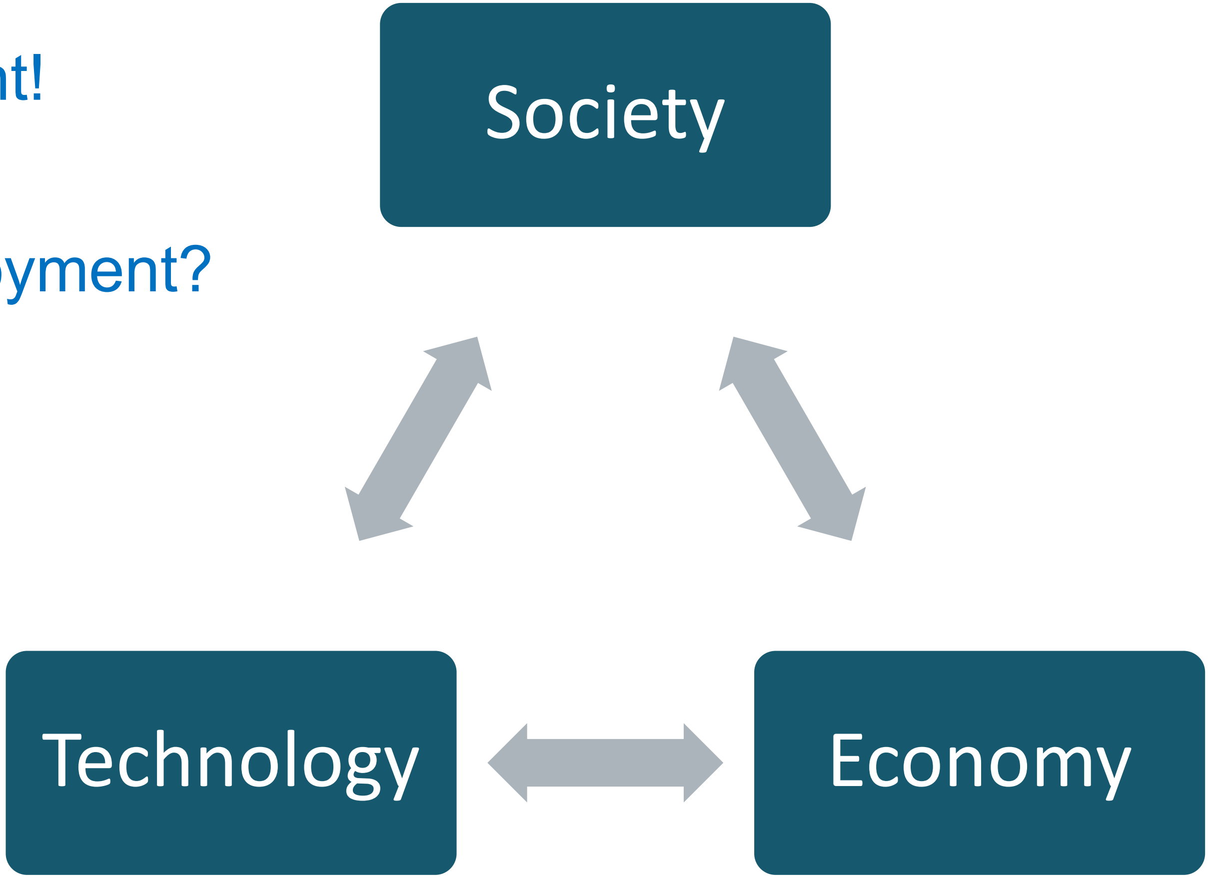


Richter 2018

Why is the development so slow?

Identify bottlenecks of deployment!

How can we accelerate the deployment?



Society

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Acceptance

- Public debate on a sufficient level
- Fake news concerning fracking and geothermal etc.
- Benefits for the society not transparent

Acceptability

- Provide options to mitigate unwished environmental effects
- Make the value chain visible
- Participation

Mining authorities

- Approval procedures
- Permitting

Public debate

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Economy

Acteurs

- Demand and supply
- Domestic energy providers
- Those, who are responsible for safe energy provision
- Those, who want to earn money

Services

- Contribution to the developing chain (exploration, drilling,…)
- Reliable mitigation strategies for unwished environmental effects
- Risk assessment and risk management

Incentives

- Feed in tariff
- Campaigns for market penetration

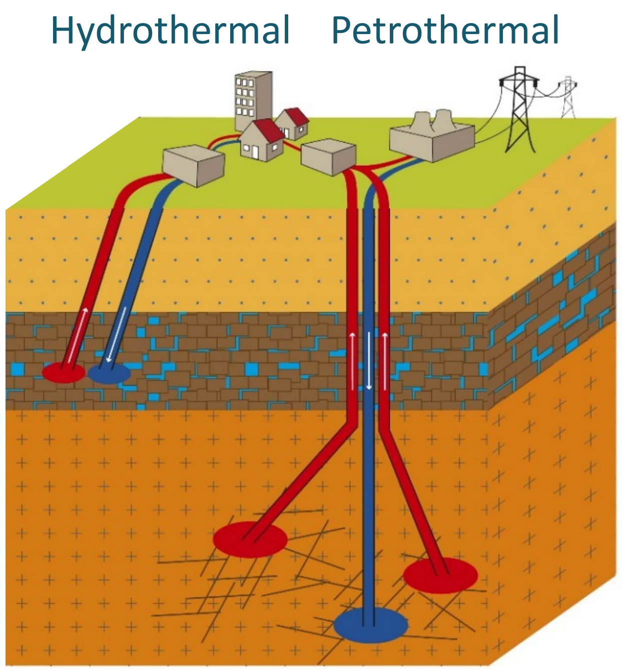
Value chain

Safe supply & safe for the environment

Deep geothermal energy utilization

Challenges:
- Easily exploitable reservoirs limited (hydrothermal systems)
- Most rocks require engineering (petrothermal systems)

Tasks:
- Increase productivity (economics) → Stimulation
- Reduce seismicity (environmental impact) → Soft stimulation



Reservoir Characterisation

Exploration Goals: Imaging and characterization of geothermal fields and reservoirs

Methods:

- Structural (field) geology
- Seismics
- Seismology
- Magnetotellurics
- Other Geophysics, Temperature, Geochemistry …

Results:

- Geometry and structure
- Stress field
- Lithology, fracture characterization
- Alteration, fault zone characterization
- Reservoir boundaries & active faults

Importance:

Controls on geothermal activity and sustainability!

Methods

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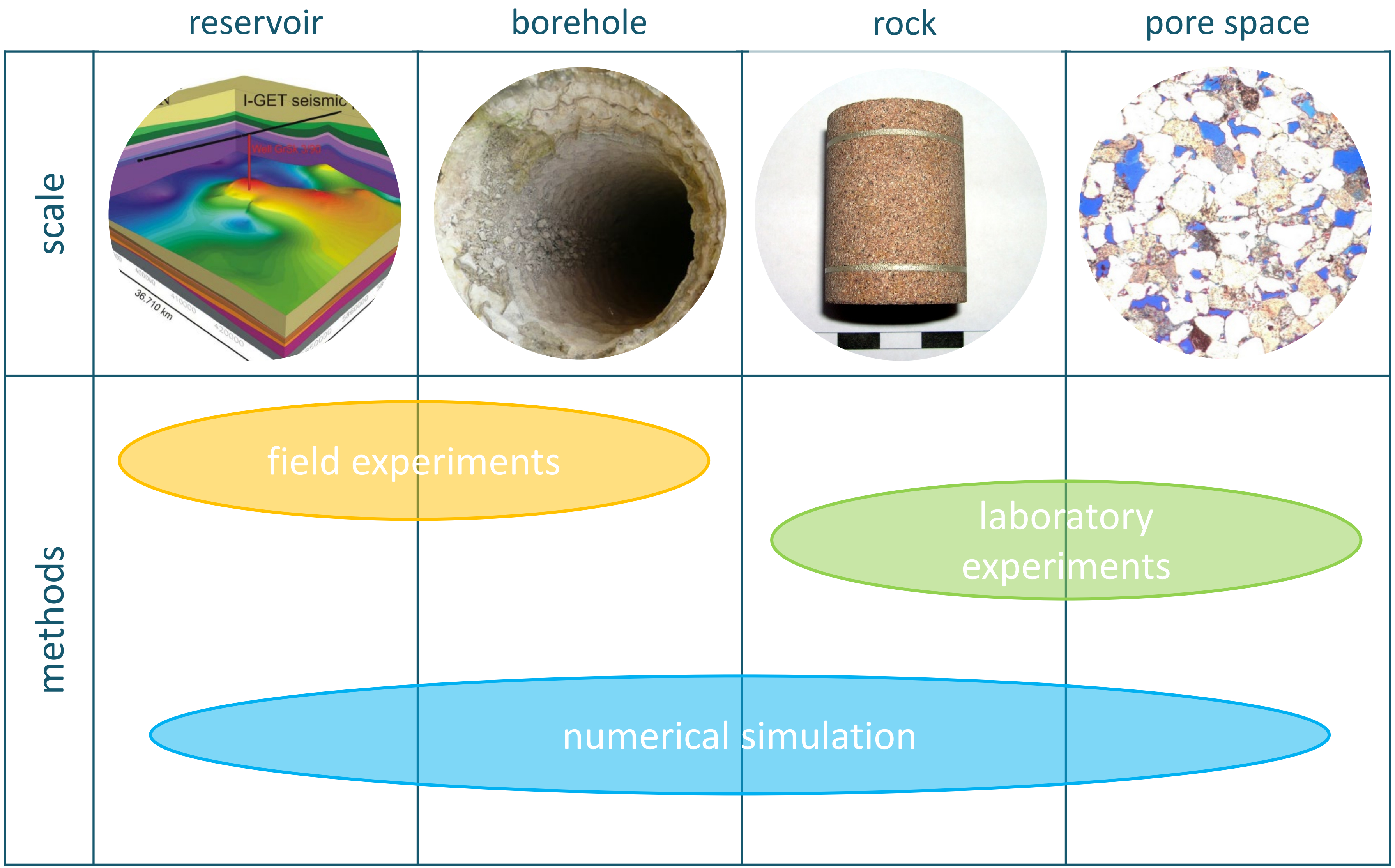

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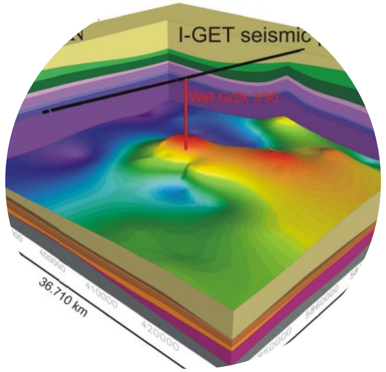
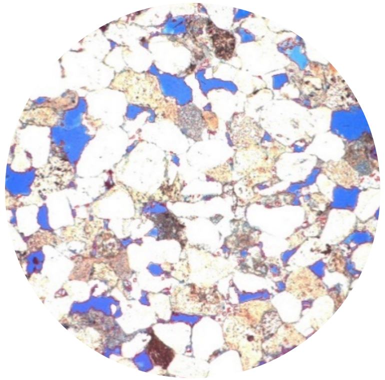
Topics

	reservoir	borehole	rock	pore space
scale				

topic

- reservoir access
- parameter correlation
- stimulations treatment
- process monitoring, analyses & understanding

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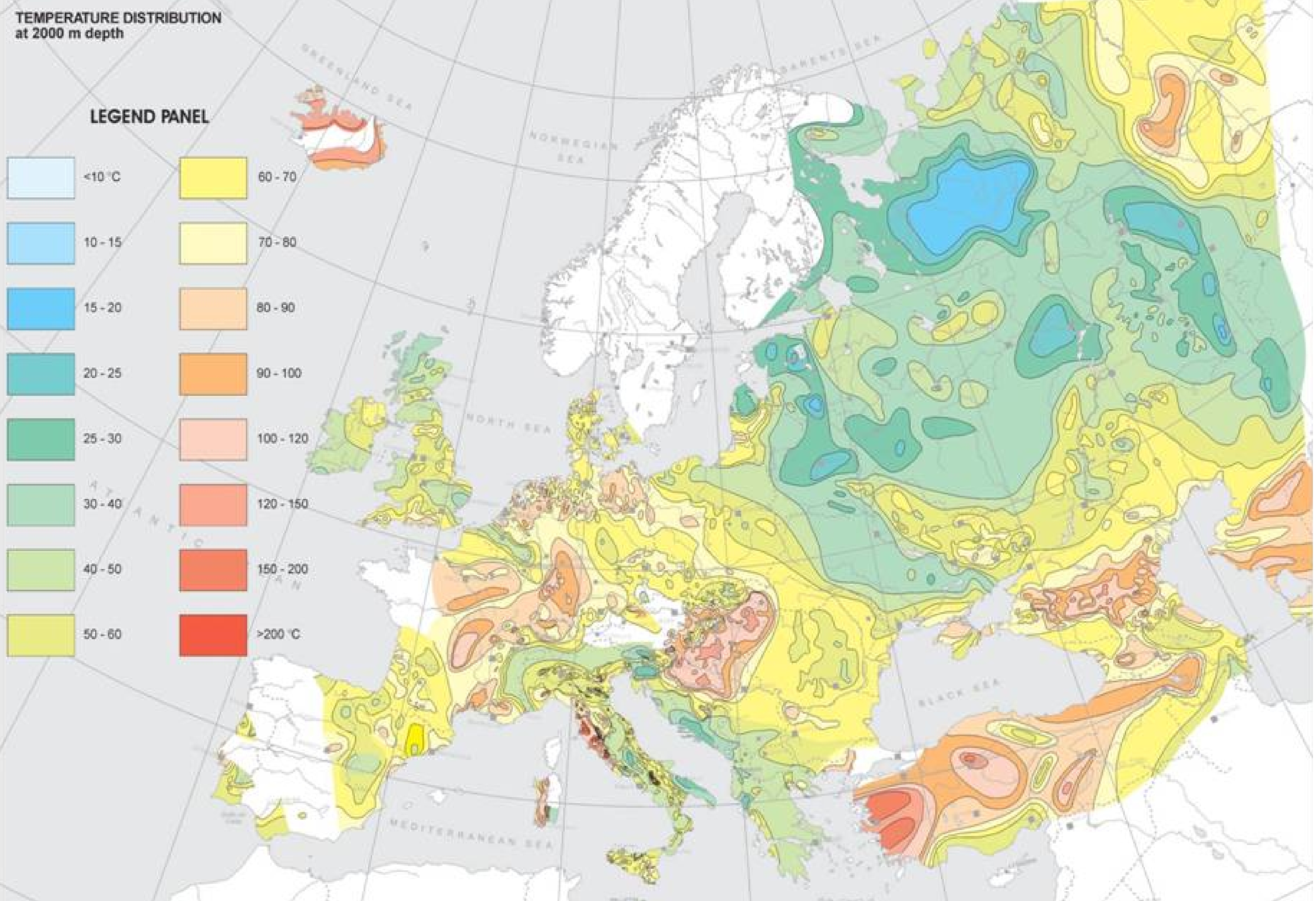

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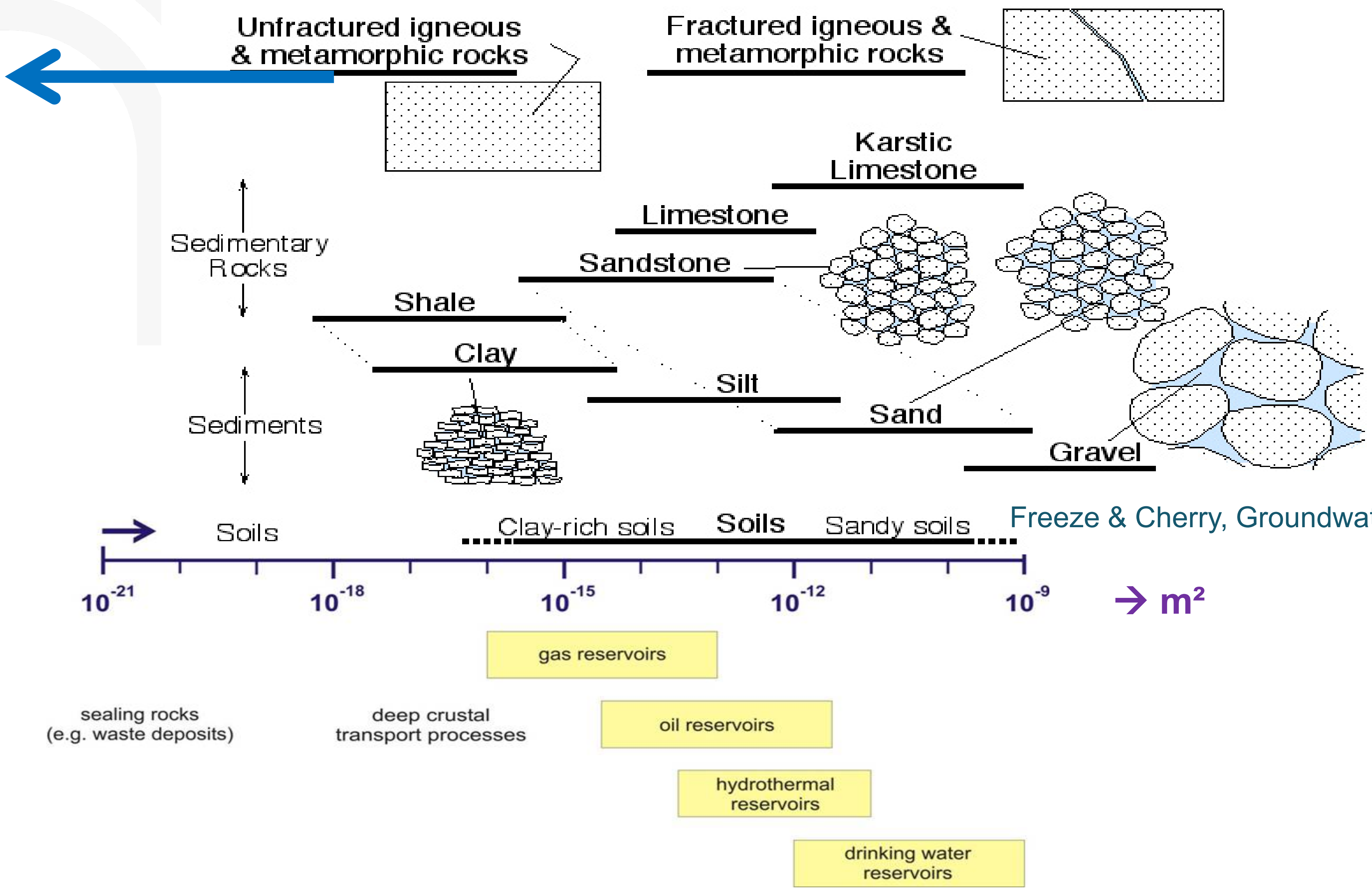
Hurter & Schellschmidt 2003

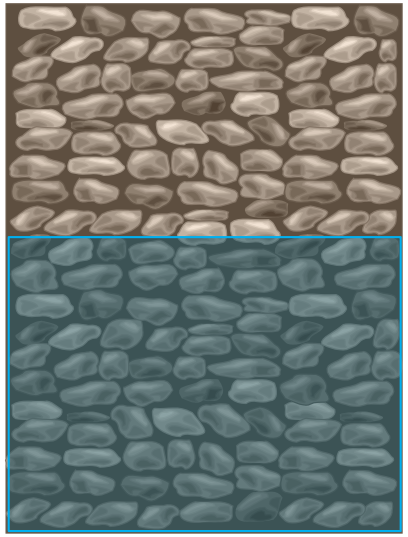
Permeability of rocks



Freeze & Cherry, Groundwater

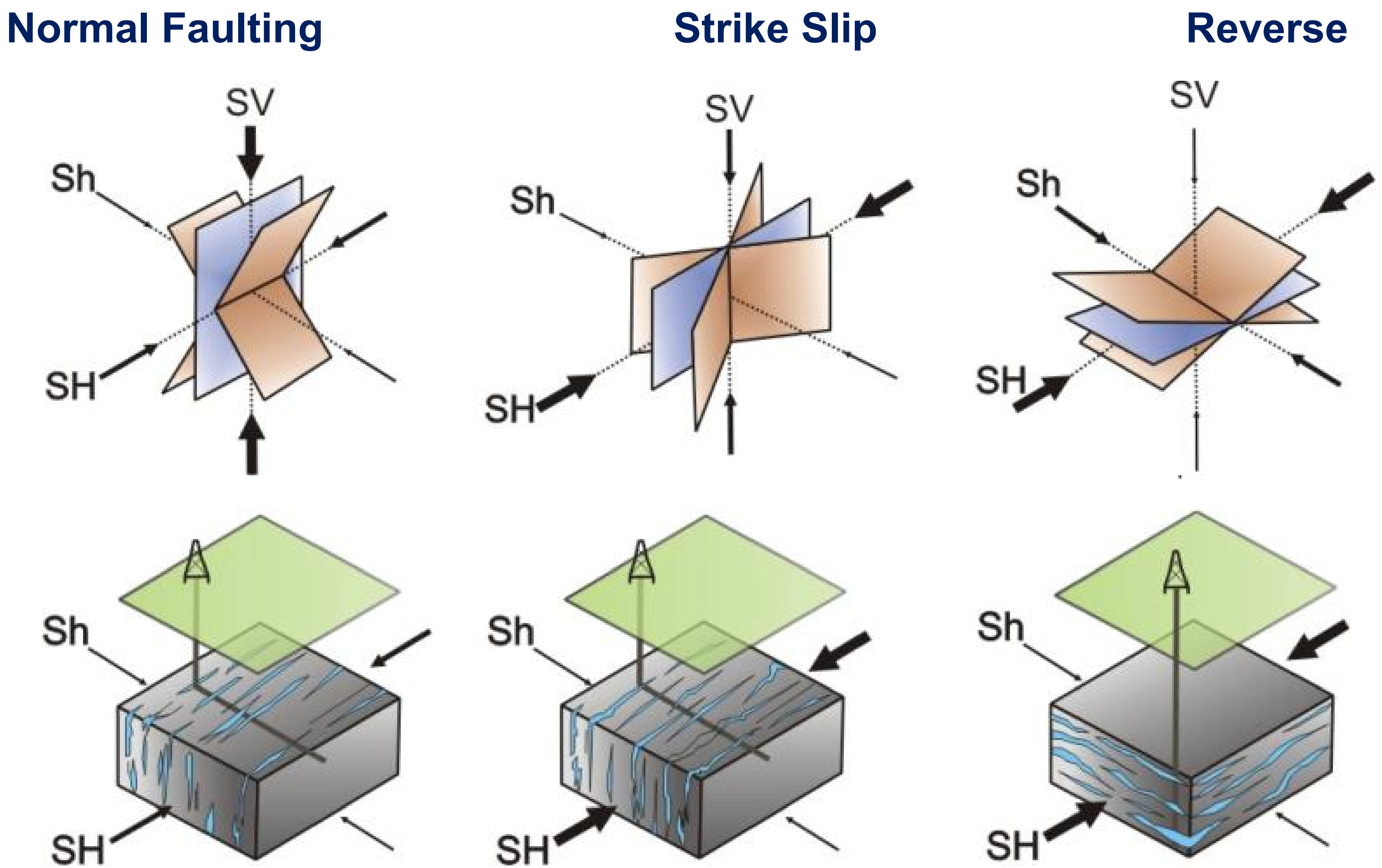
Definition of the Geothermal Fluid

- multi phase substance (gas + liquid)
- high temperature
- transported in the pores or fractures of a geological formation (= reservoir)



Regenspurg, 2013

Stress regimes and their impact to frac orientation



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Most stable well path orientations in various stress regimes

Normal

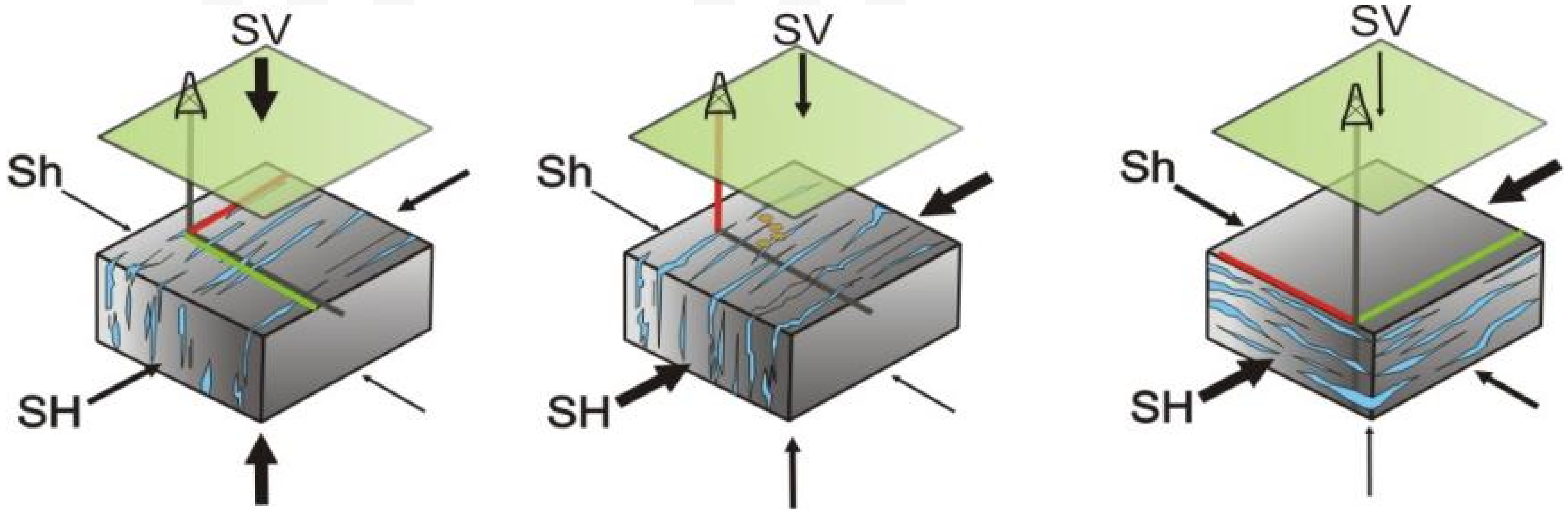
SV>SH>Sh

Strike slip

SH>SV>Sh

Reverse

SH>Sh>SV



Stability of well direction:

- Most stable (green line)
- Least stable (red line)
- Zero stress anisotropy (green ellipse with red outline)

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Reservoir engineering

Results of the DESTRESS-project

Foreseen stimulation techniques

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Demonstration of soft stimulation treatments of geothermal reservoirs

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Borehole configuration

doublet | single well | sw with one fracture | sw with laterals | sw with multistage fractures

Treatments

hydraulic injections | chemical injections | thermal injections

Pumping

continuous | cyclic | stepwise increase

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Economic impact of reservoir stimulation

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Demonstration of soft stimulation treatments of geothermal reservoirs

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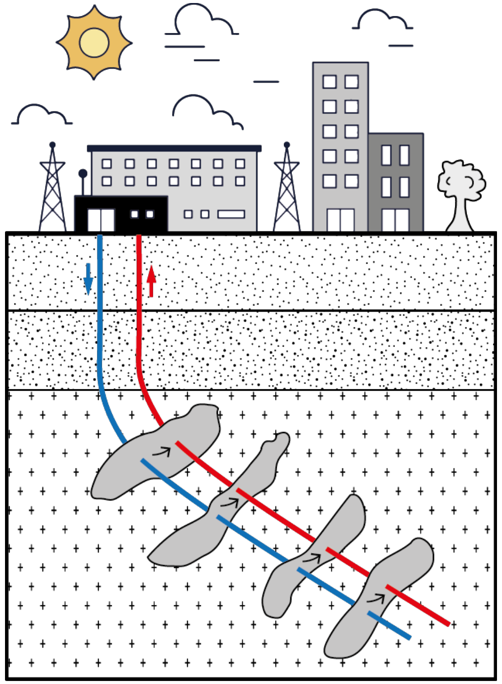

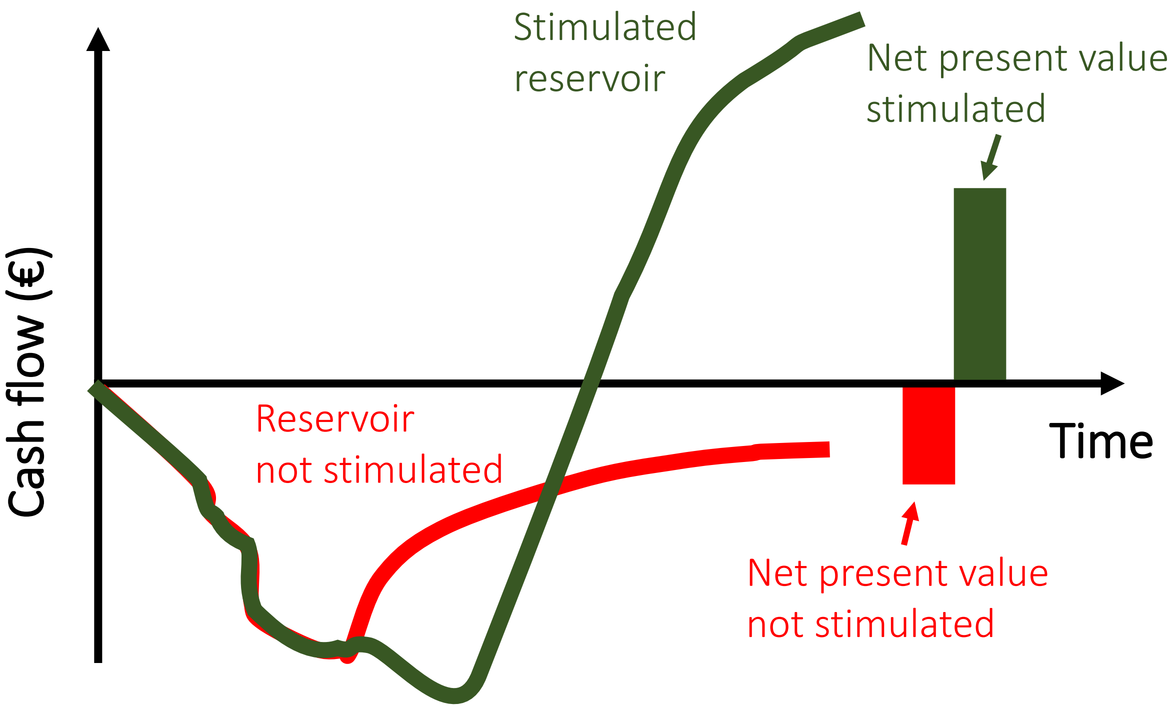

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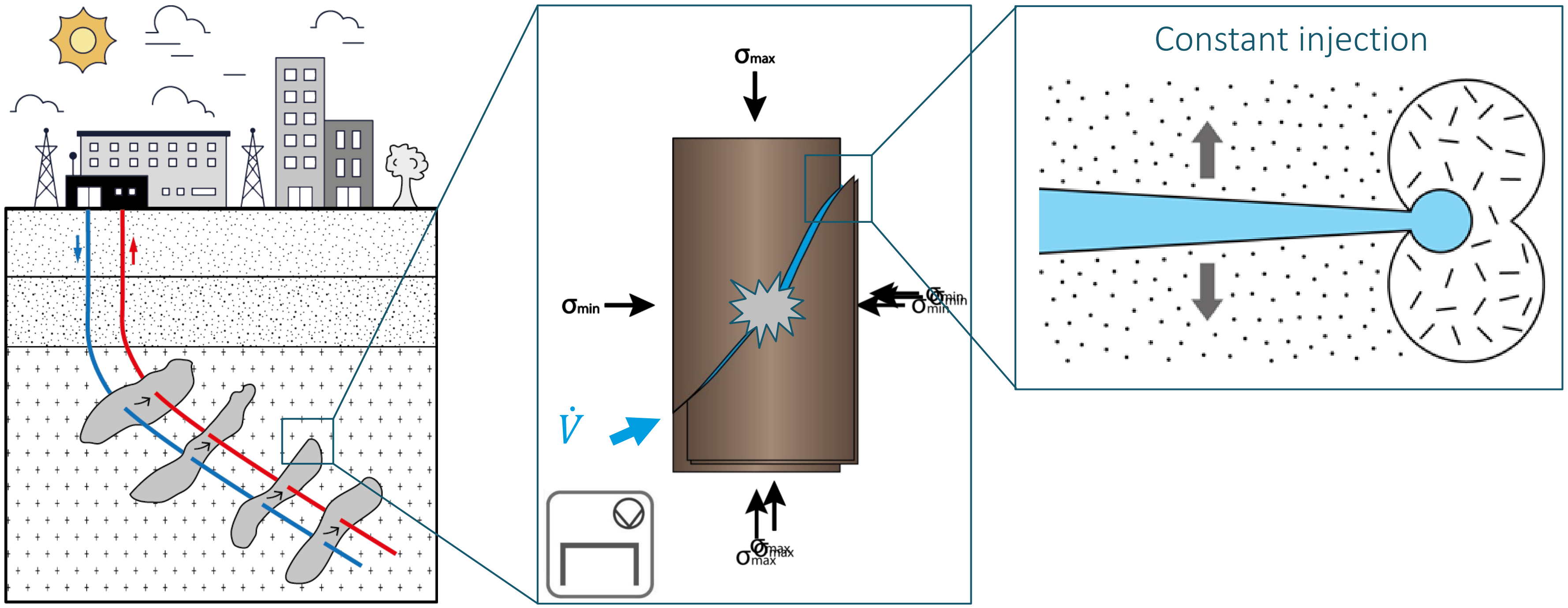
Conventional hydraulic stimulation process



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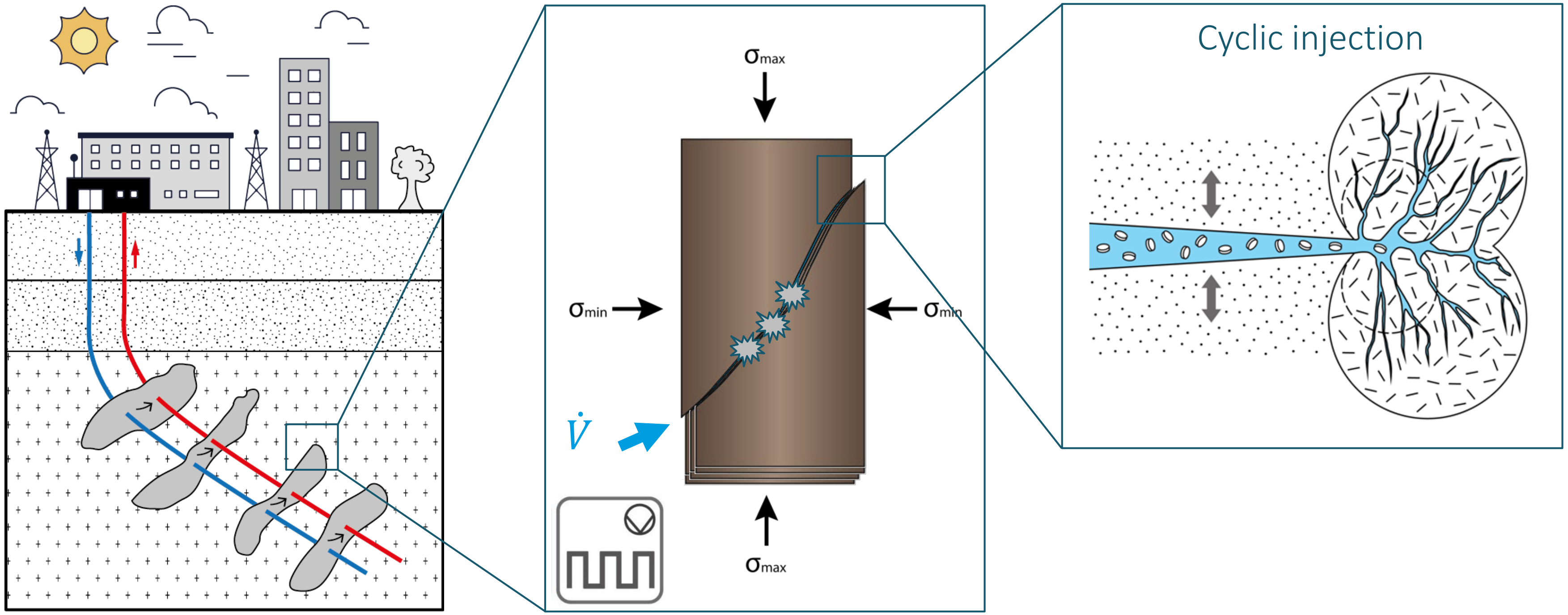
Objective: Validation of „Cyclic Soft Stimulation“ Concept

(Hofmann et al. 2018, 2019)



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Field experiment in Reykjavik, Iceland
7 October – 1 November 2019

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Partners & contractors:

GFZ Helmholtz Centre Potsdam
ICELAND DRILLING
Veðurstofa Íslands
ETH zürich
ÍSOR
TNO
OR Reykjavík Energy

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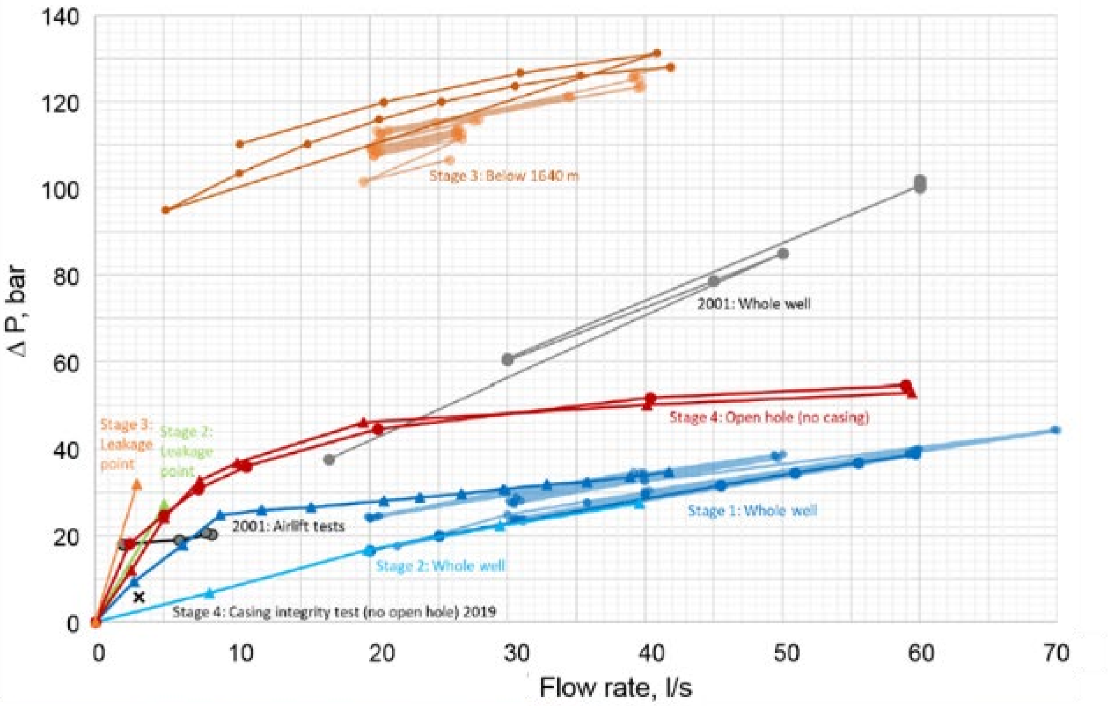

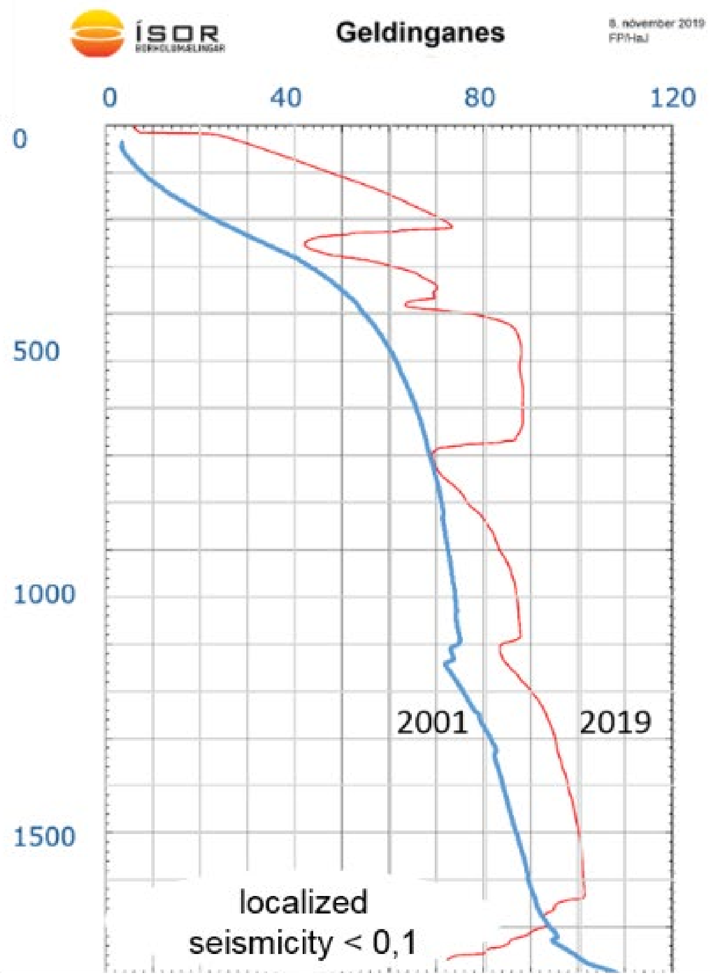

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Lessons learnt Geldinganes:

- a multi-stage stimulation attempt with a straddle packer assembly
- Increased injectivity by a factor of ~3 to 1.25 l/s/bar , low seismicity
- demonstrated treatment is a new developing option for geothermal heat supply in Reykjavik

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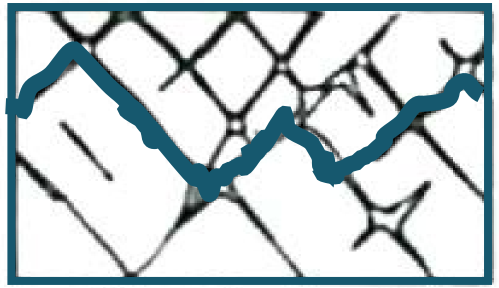
Next steps:

more to come (mature multi-stage stimulation → Bedretto)

Conceptual Chemical Stimulation (I)

Fractured rocks

Acidisation to weaken strength of particles (e.g. barite) in contractions (Soultz, France December 2019)



Soultz GPK4 stimulation methodology

Acid selection for Calcite and Quartz dissolution (lab testing)

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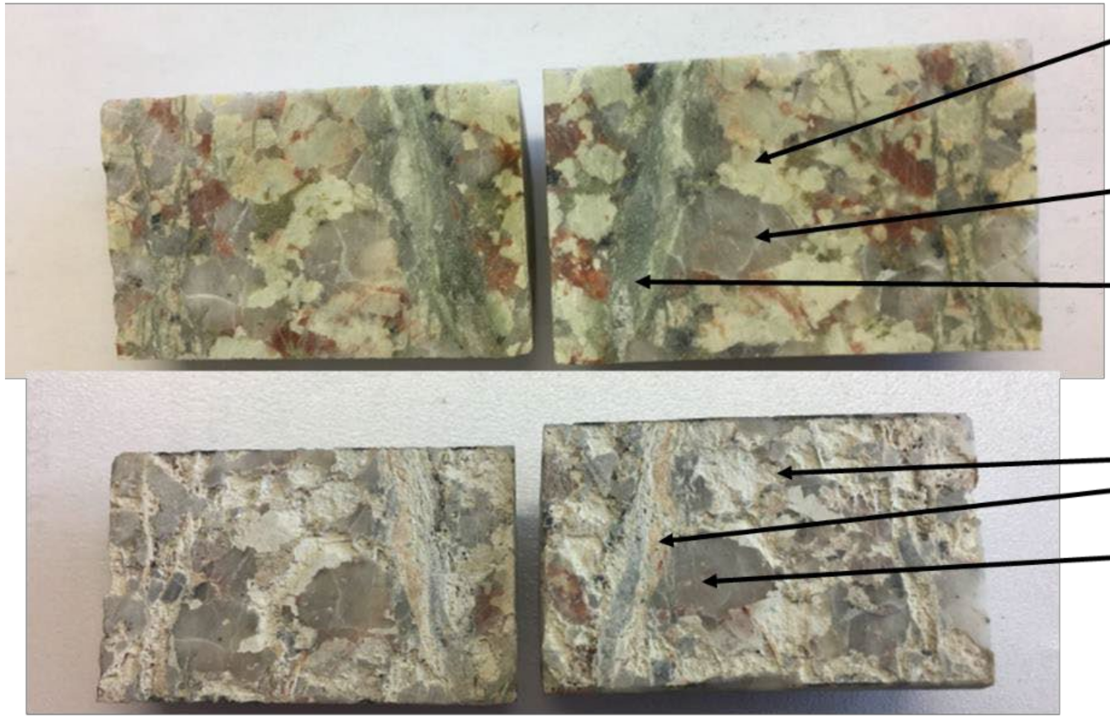
<---------DZ--------->QZV<-DZ><DZ---->QZV<----------DZ--------->



Secondary illite (clay bearing K) located in the damage zone (DZ) around the quartz vein (QZV)
Sample @1674m

Relics of primary K-feldspar, partly transformed into illite

Secondary quartz sealing veins

Strong dissolutions of illite and secondary quartz vein

K-feldpars are not affected

Improvement of hydraulic performance after chemical treatment: factor 4 and 30

Lummer & Rauf, EGC 2019

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esg és géothermie

Stimulation methodology : Coiled Tubing

Injection of acid in front of the targets with a coiled tubing

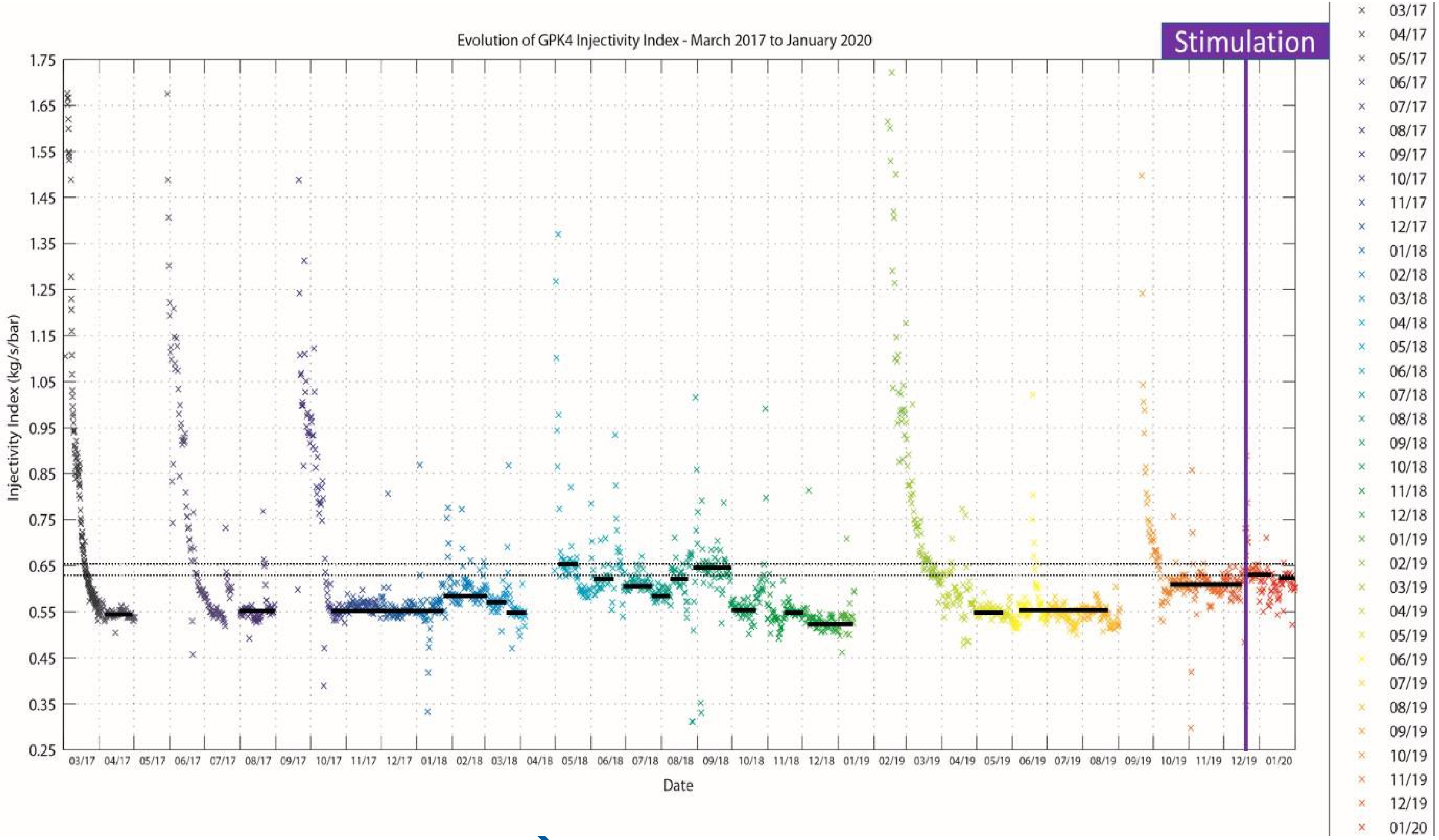
Pro ++

- Protect more than 4 km of the 9''5/8 casing from the acid allow focused injection
- Reduce acid volume in the well in case of injection pump failure

Con --

- Risk of Coiled tubing stuck or Lost In Hole
- Operation more expensive than well-head injection

Stimulation effect



→poor

Lessons learnt from the Soultz experiment 2019

- Treatment itself was a mature operation
- No change of seismicity during and after

Why improvement poor?

- Past operations have probably already improved the near wellbore permeability of the well
- A positive effect of the acid treatment may be compensated by other effects such as fracture collapse, fine transport or precipitations at the wrong locations.

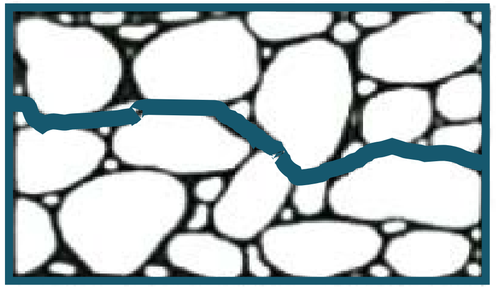
To do:

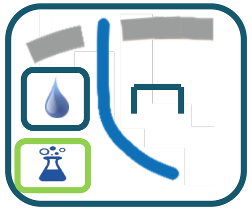
- Laboratory investigations are helpful but not sufficient to clear in advance the performance of the treatment.
- More information required prior to the decisions for the treatment such as additional logging (PLT, casing integrity log) to determine suitable flow zones.

Conceptual Chemical Stimulation (II)

Porous rocks

Acidisation to remove obstacles in pores (e.g. carbonates and fines) (Mezöberény, Hungary 2021)

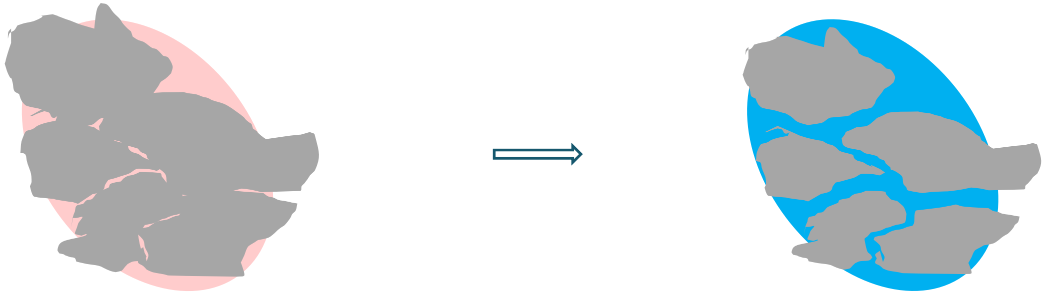


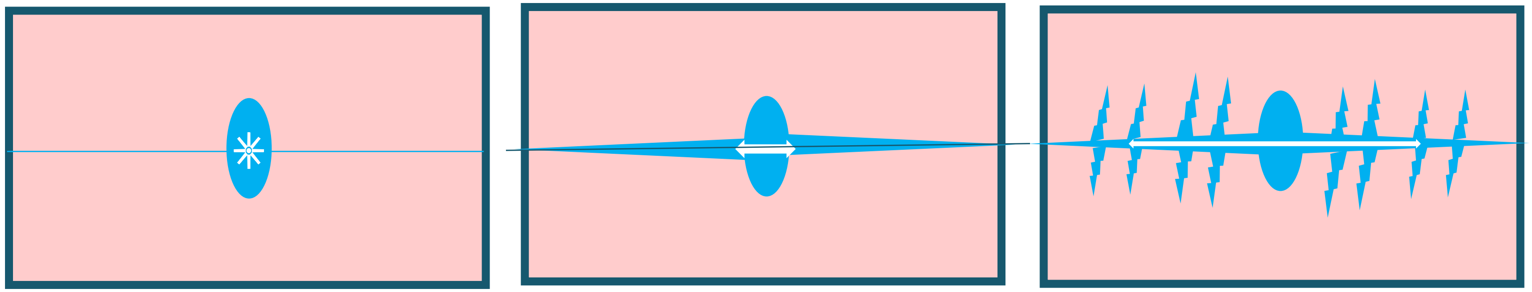


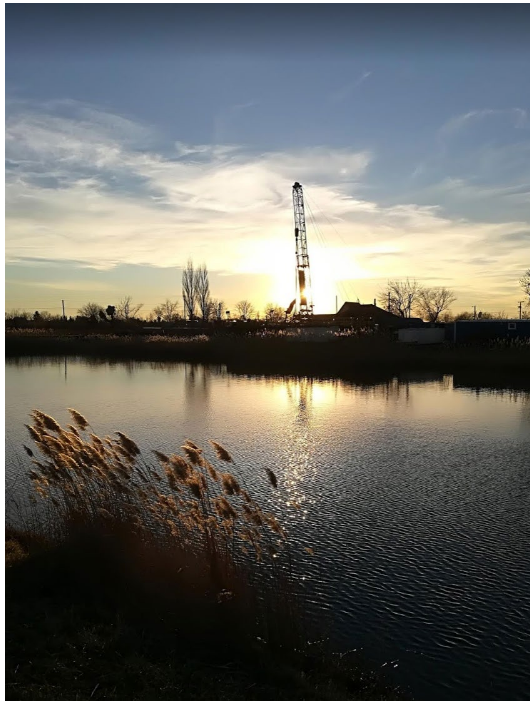
Conceptual Thermal Stimulation

Porous or fractured rocks

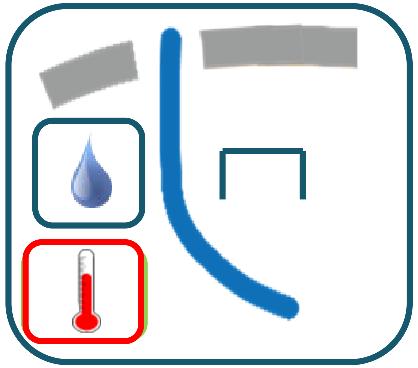
Creating fracture due to thermal induced shrinkage (Mezöberény, Hungary early 2021)

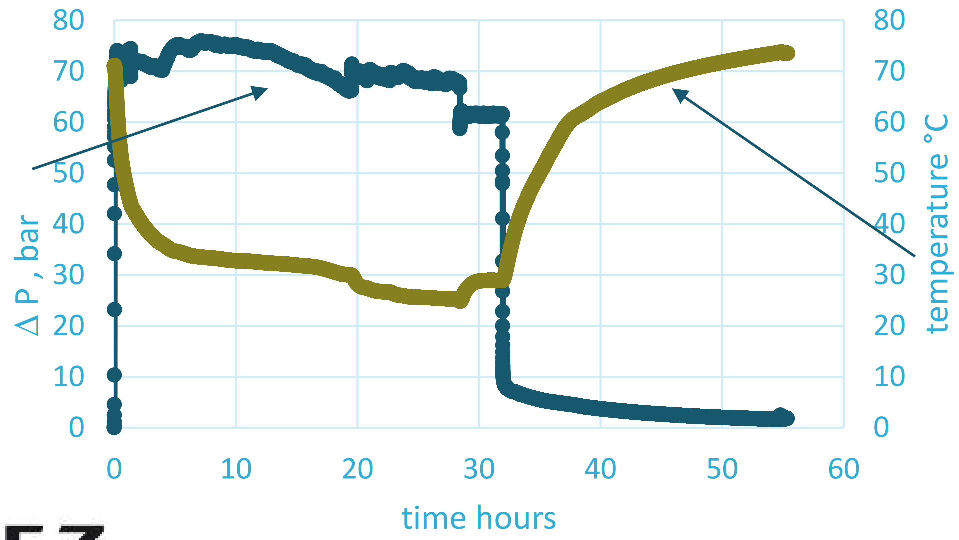


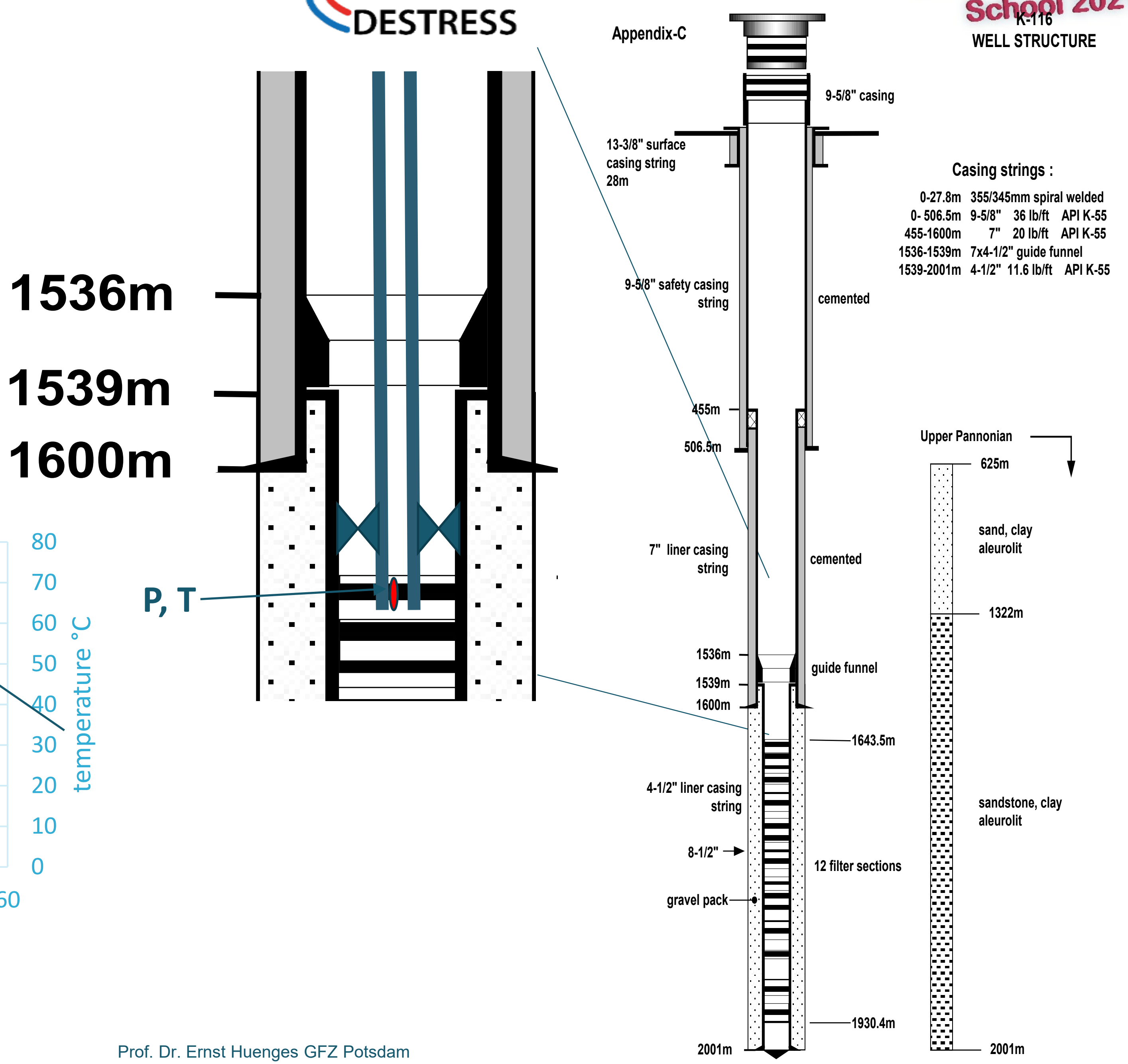




Mezöberény, Hungary







Mezöberény, Hungary,
Thermal stimulation Feb 2021

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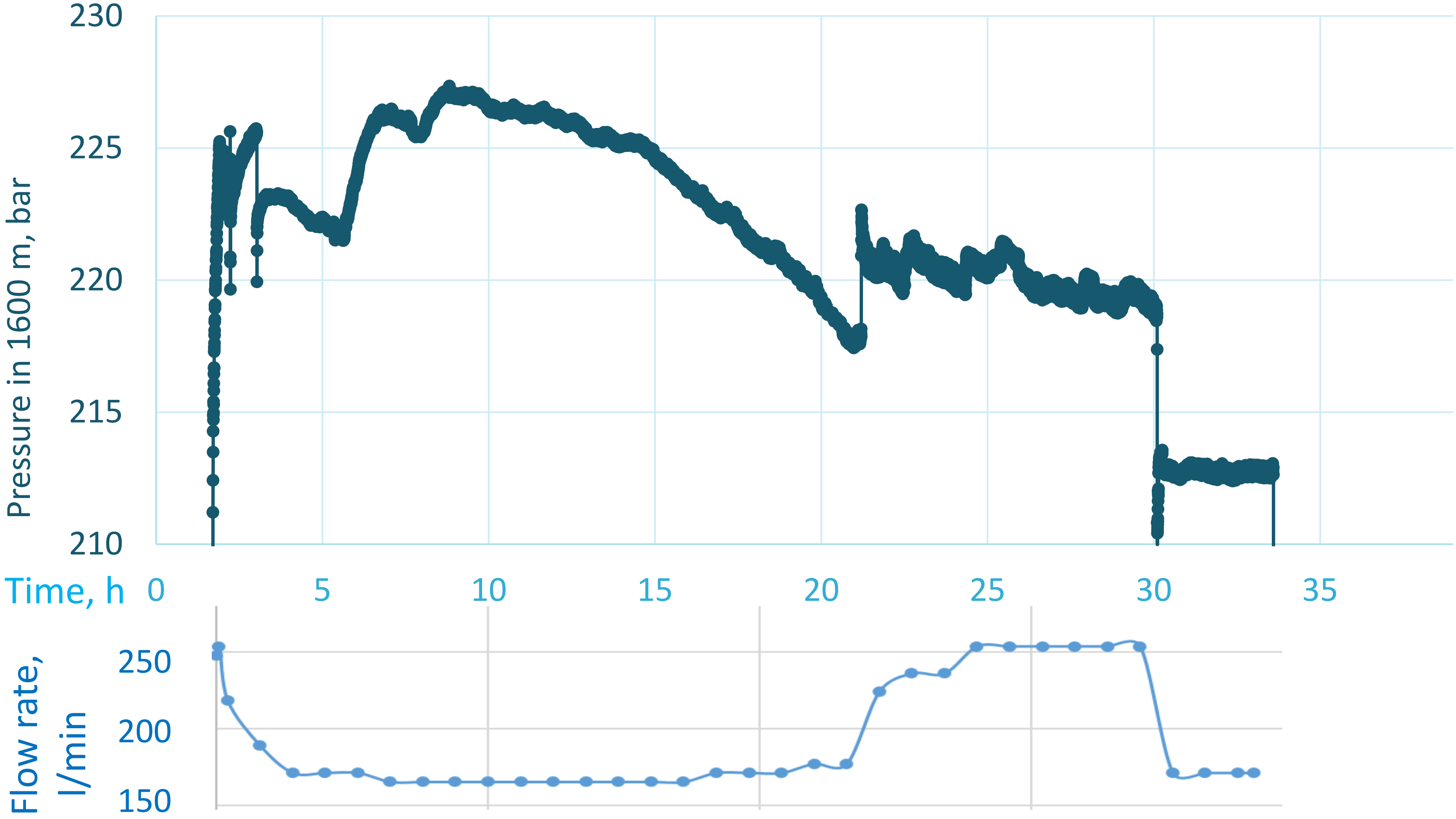

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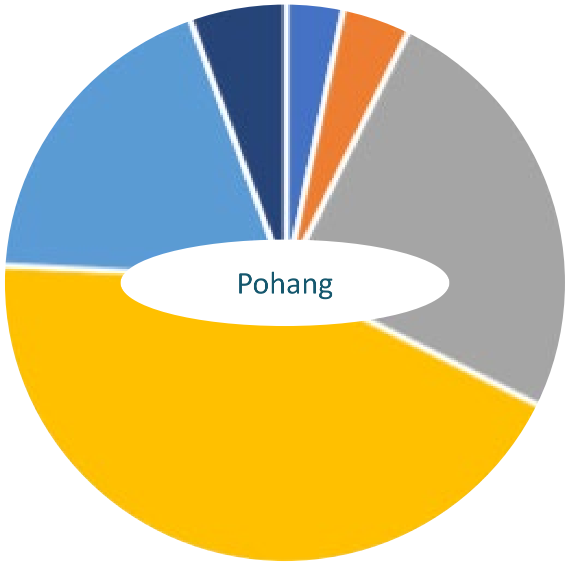
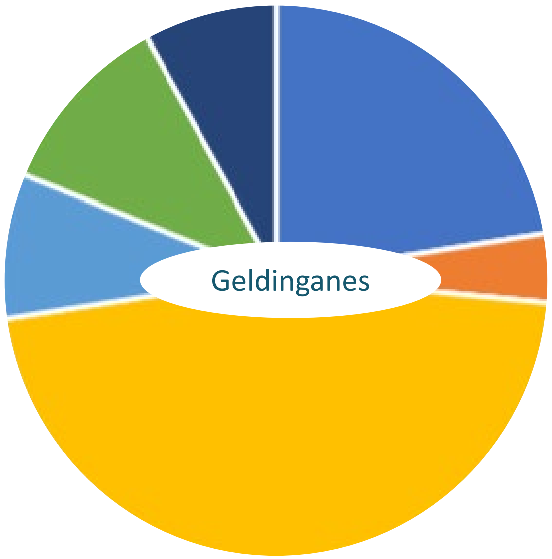
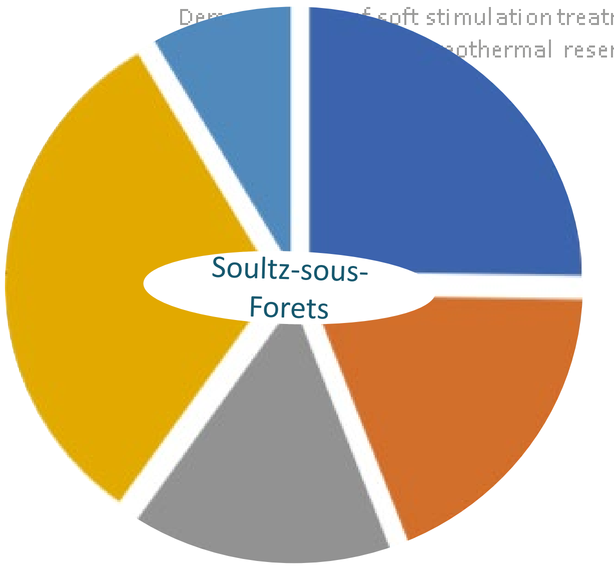
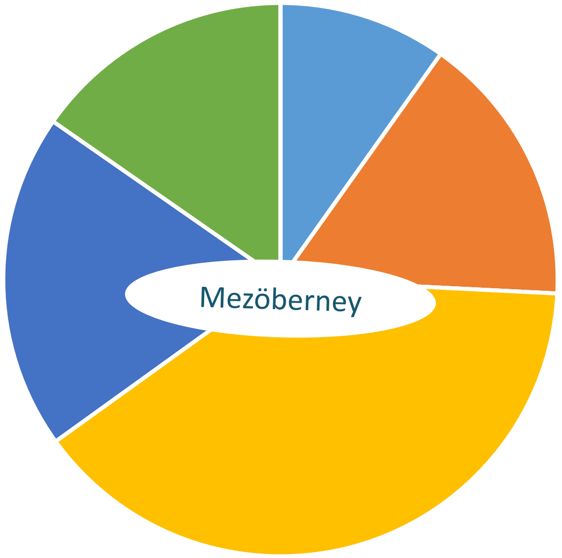
Costs Breakdown of DESTRESS treatments





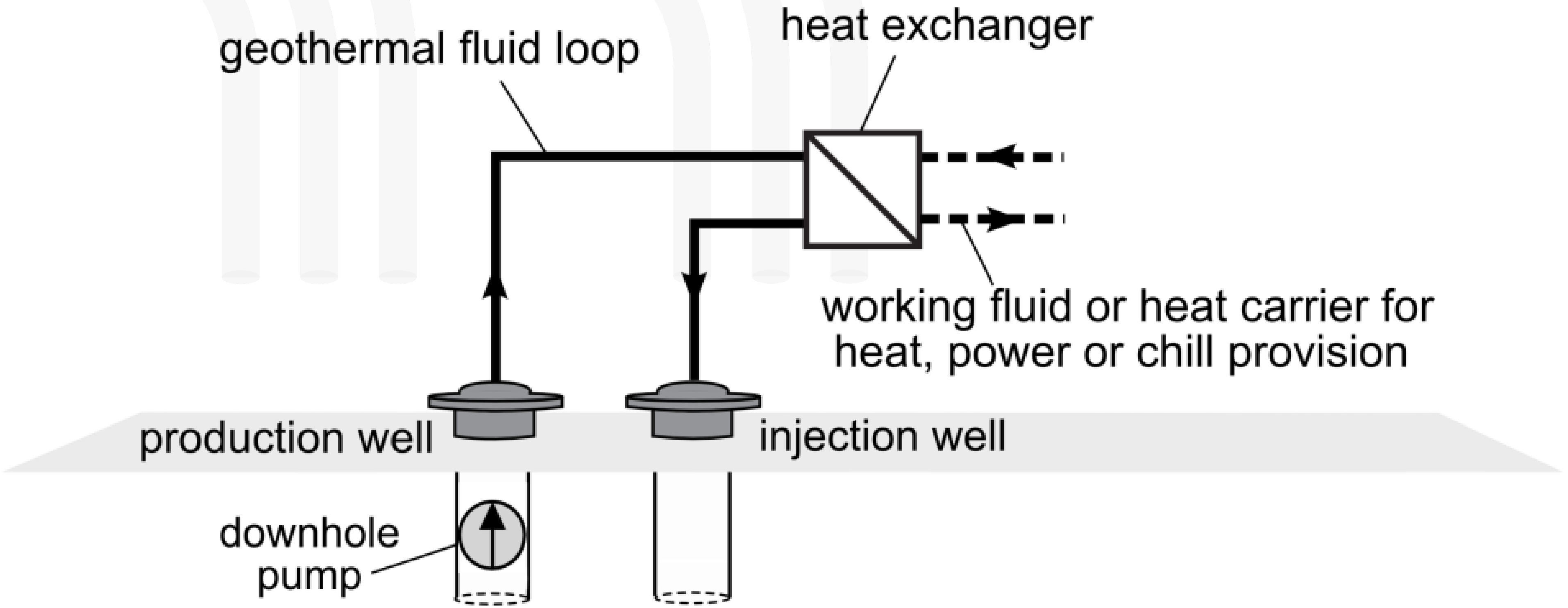


Mob/Demob Rig resp. Coiled Tubing
Chemical Fluids
Cleaning/Waste management
Stimulation Treatment (incl. crews)
Supervision/Planning
Logging/Wellsite preparation
Monitoring



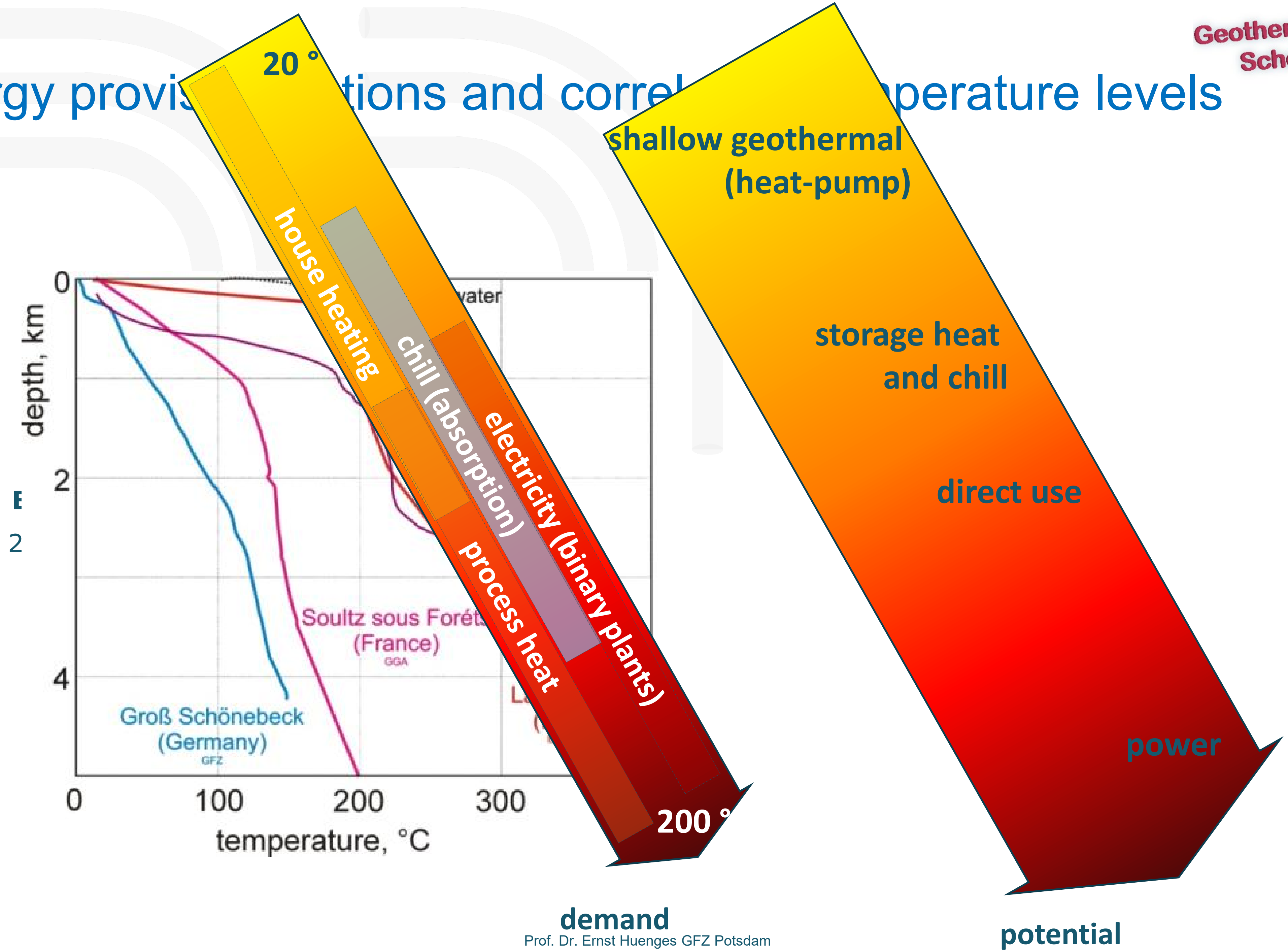
Reservoir exploitation

Thermal water loop



Saadat et al. 2010

Energy provis… tions and correl… perature levels



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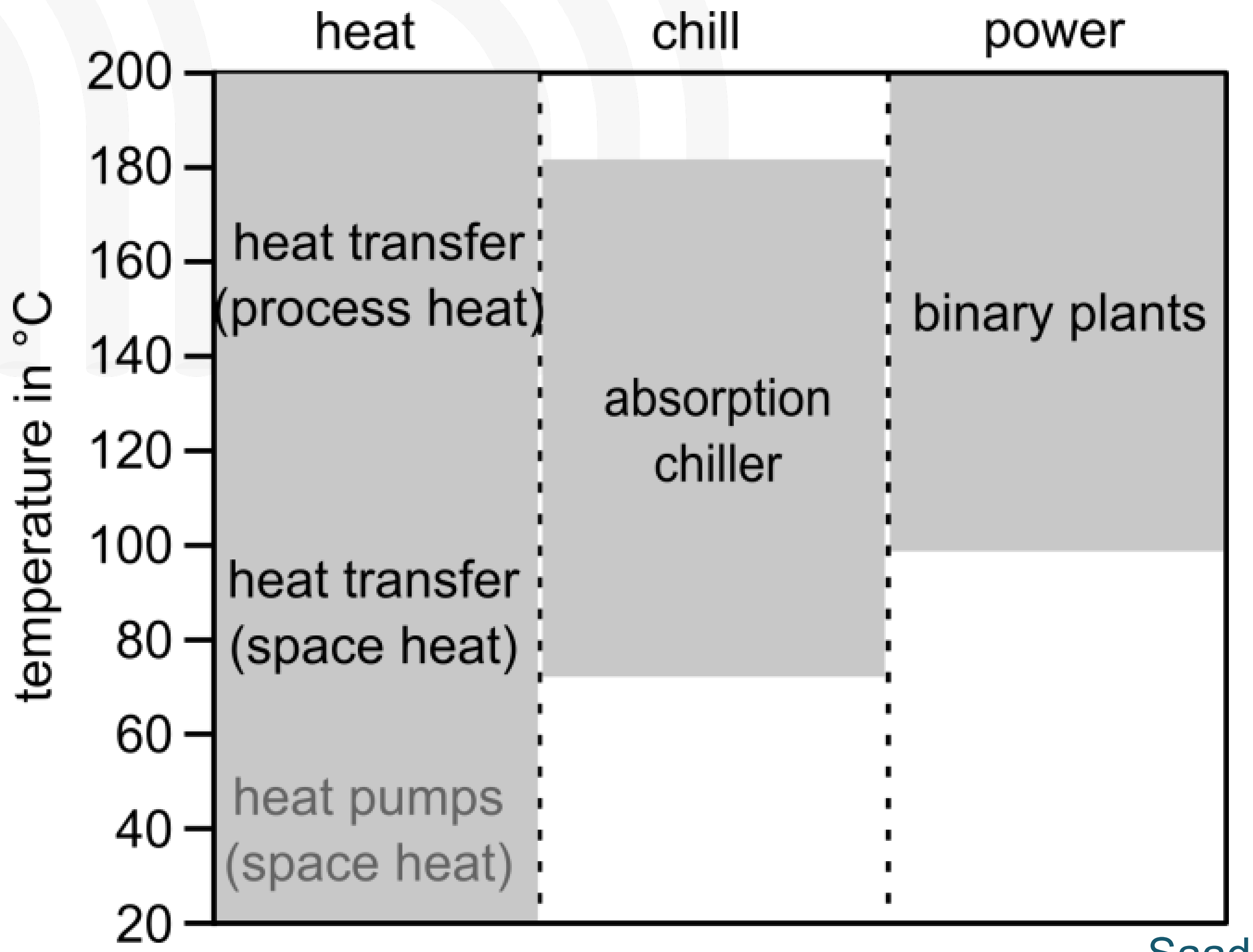
Energy provision options and correlating temperature levels



Saadat et al. 2010

Conclusions

EGS is a solution for renewable heat supply

Reservoir characterisation with special focus on geomechanics

Soft stimulation treatments with mitigation of environmental issues

Temperature defines the market segment in which geothermal energy should be provided

Contact details

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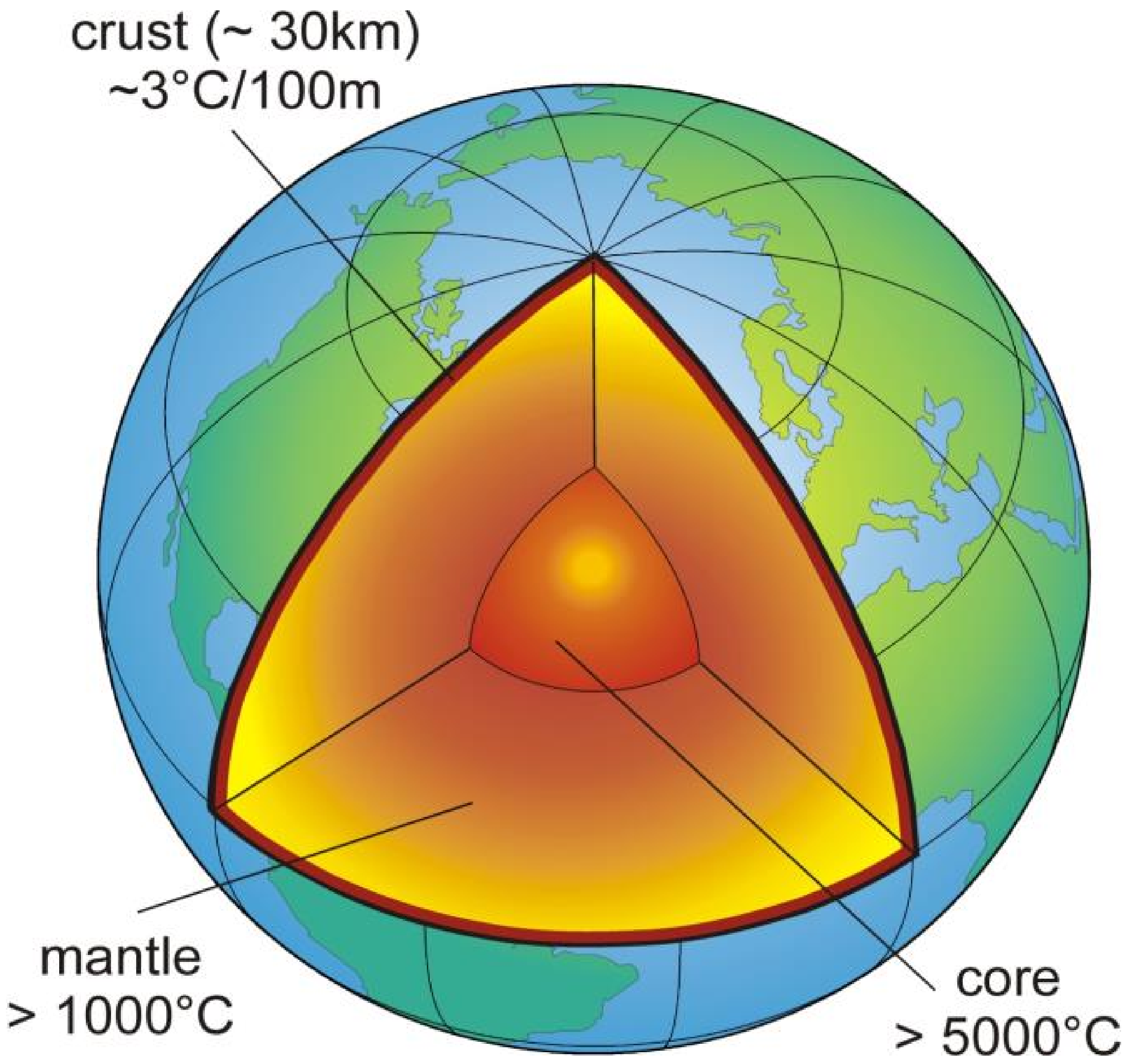

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Thank you very much for your attention

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