



Demonstration of soft stimulation treatments
of geothermal reservoirs

Improving geothermal systems
performance and minimized
environmental impact

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Outline

- Introduction
- Objectives DESTRESS
- Reservoir engineering
 - hydraulic stimulation and induced or triggered seismic events
 - Geldinganes treatment 2019
 - chemical stimulation
 - Soultz treatment 2019 and concept for Mezöbereny treatment 2020
 - thermal stimulation
 - concept for Mezöbereny treatment 2020
- Cost breakdown of the different treatments
- Conclusions

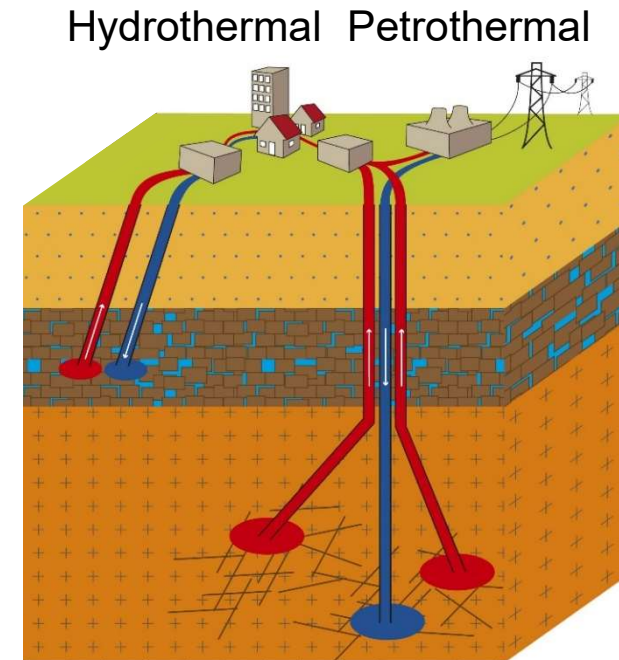
Deep geothermal energy utilization

Challenges:

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

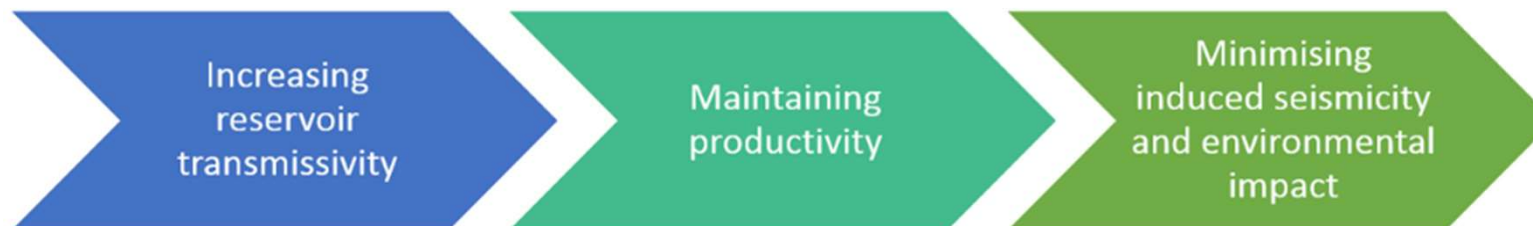
Tasks:

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



Objectives of DESTRESS

- Demonstration of a concept-based approach to develop Enhanced Geothermal Systems (EGS)
- Improvement of the understanding of technological, business and societal opportunities and risks related to geothermal energy by the following:

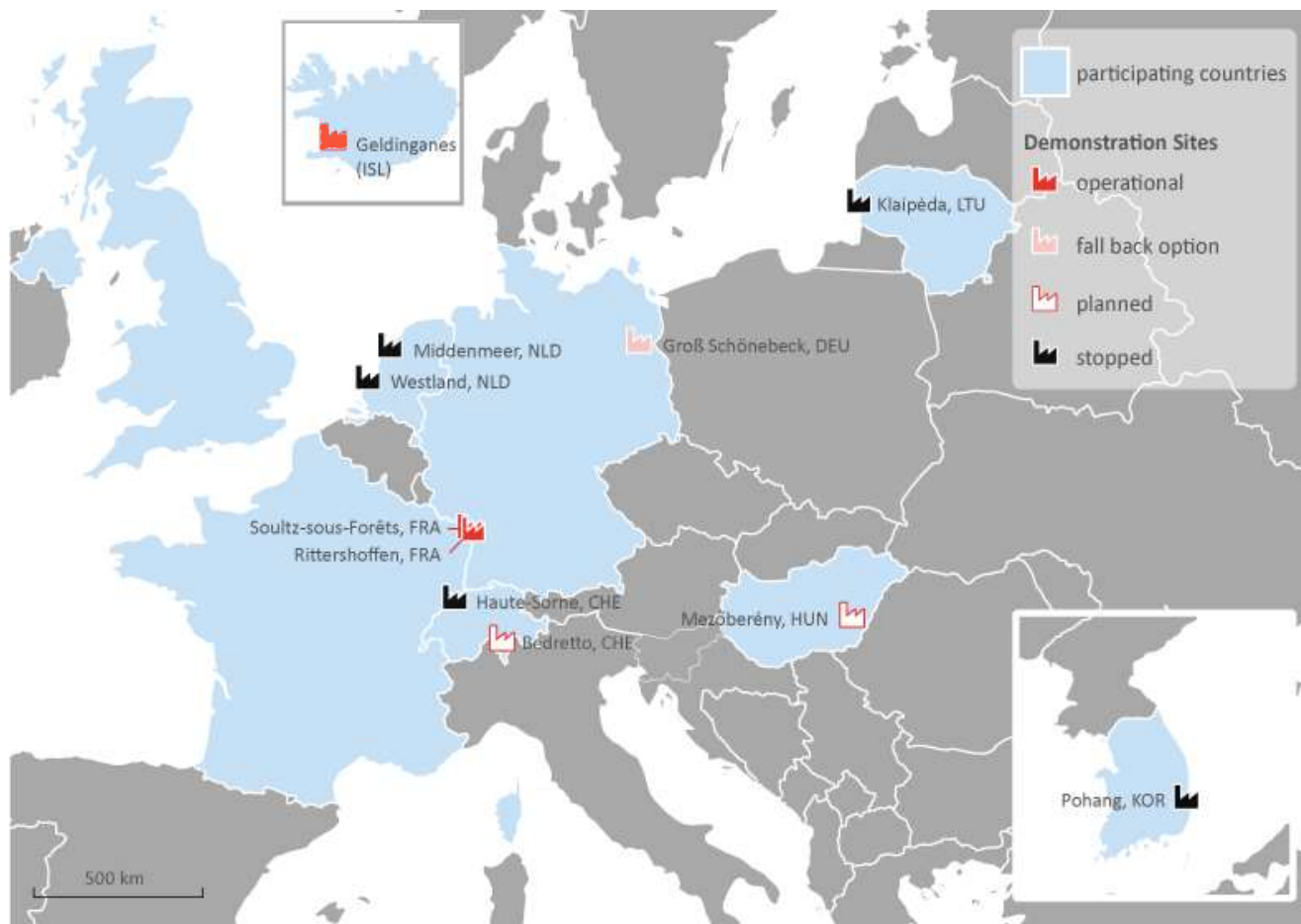


- Workflows for treatments in different geological settings
- Duration of DESTRESS until May 31st 2021

The DESTRESS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691728.

In addition, this is supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number SBF1 Nr. 15.0316-1.

Participating Countries and Demonstration Sites



Foreseen Stimulation Techniques

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

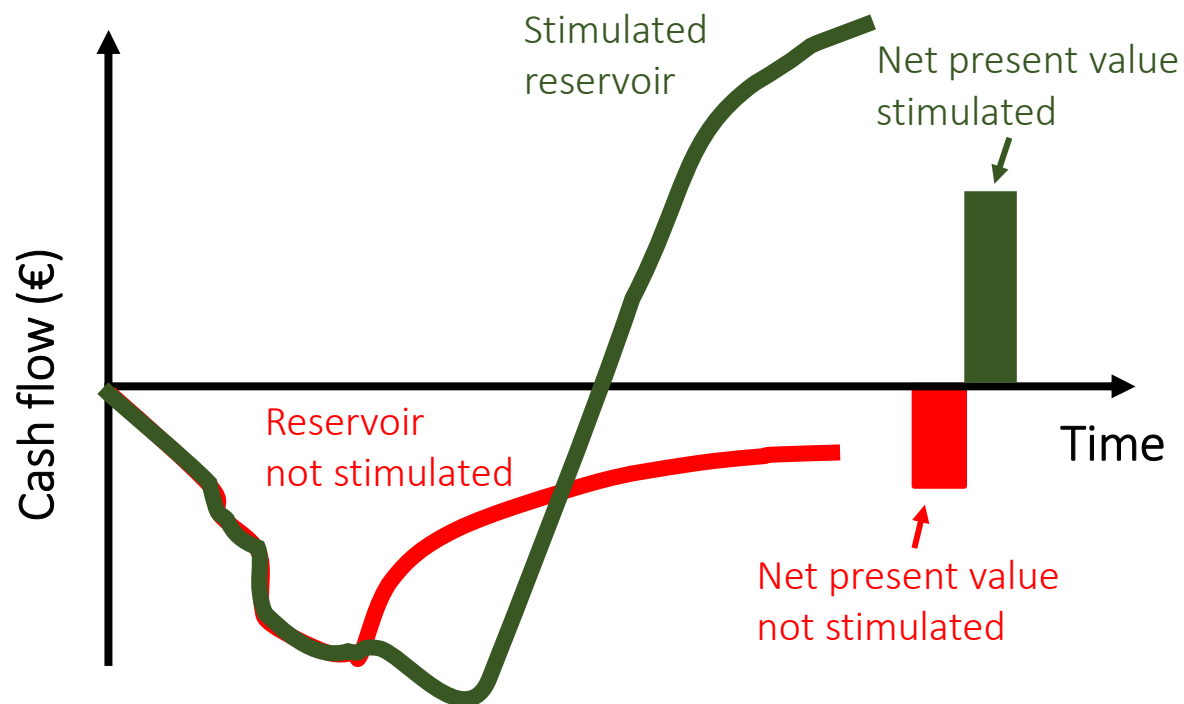
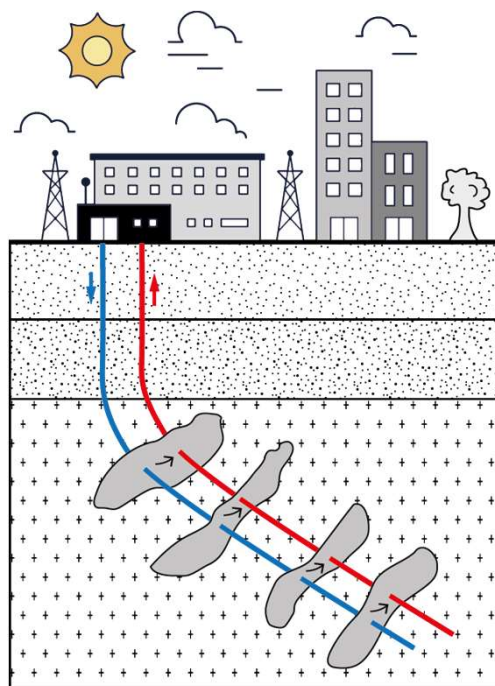


cyclic

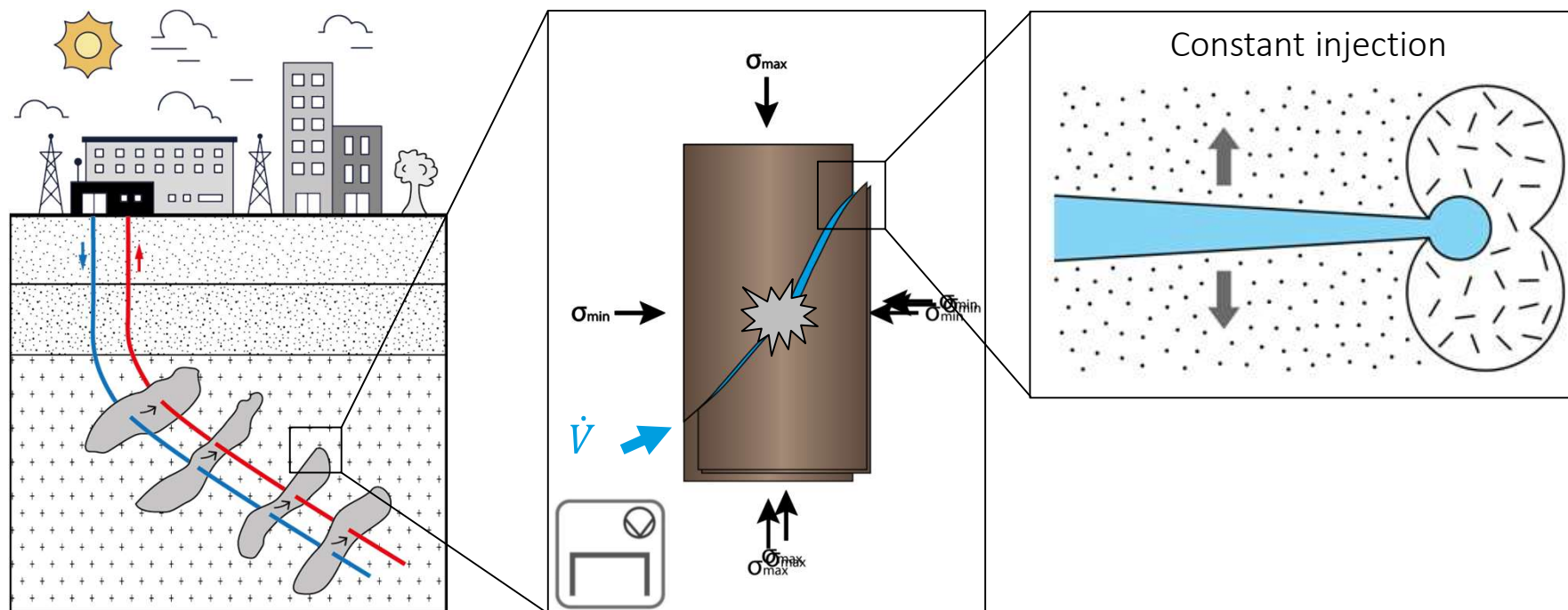


stepwise increase

Economic impact of reservoir stimulation

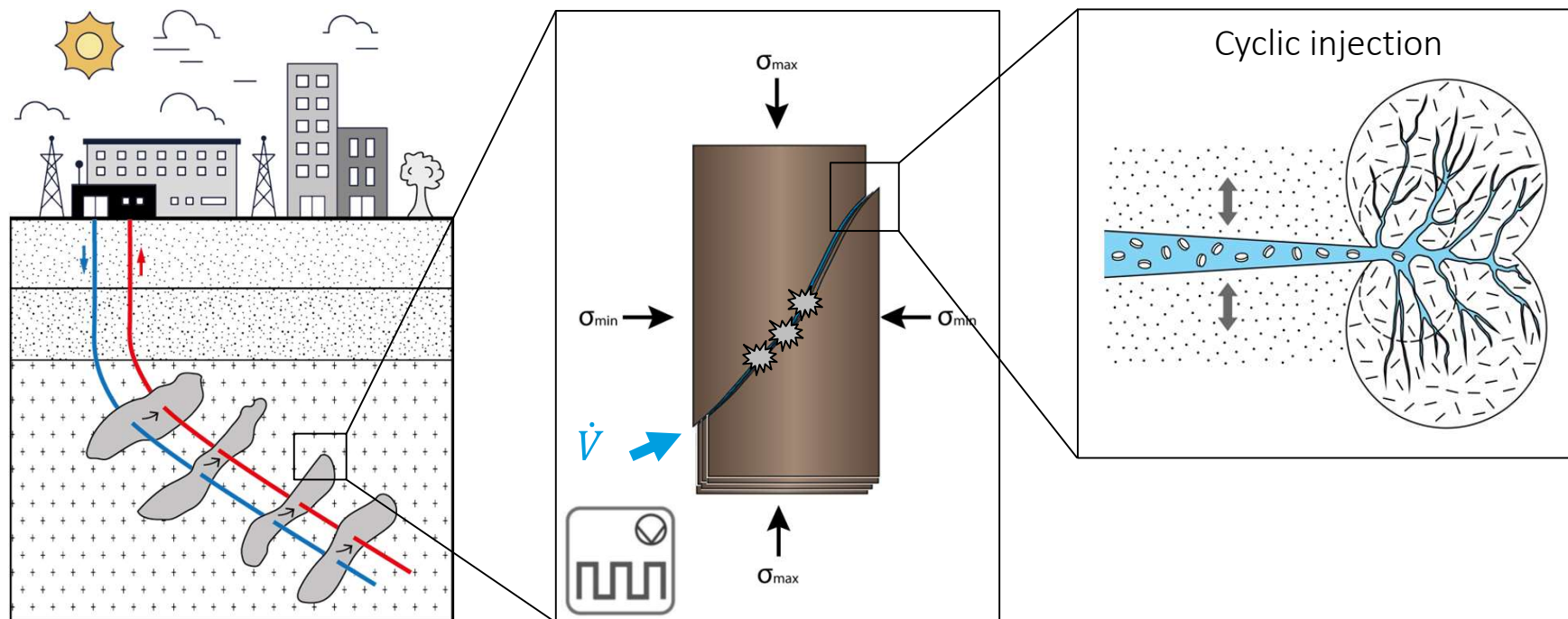


Conventional hydraulic stimulation process



Objective: Validation of „Cyclic Soft Stimulation“ Concept

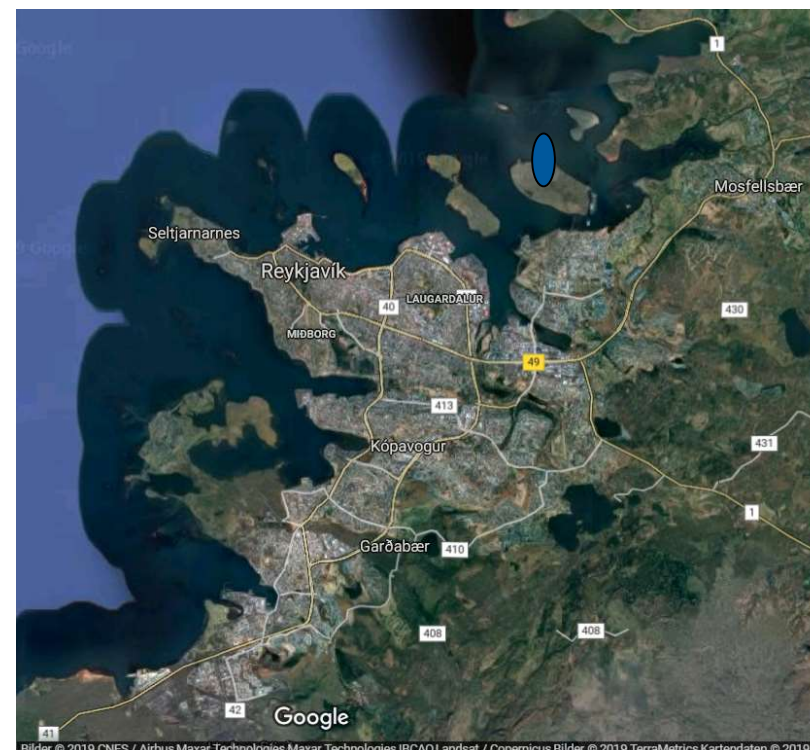
(Hofmann et al. 2018, 2019)



Hydraulische Stimulation zur Deckung des steigenden Wärmebedarfs der Stadt Reykjavik

Hofmann et al.: Presentation Friday 13.11.2020 @ BVG Jahrestagung

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



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



ETH zürich



TNO



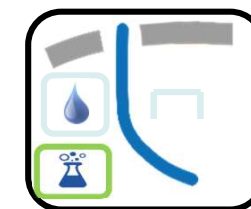
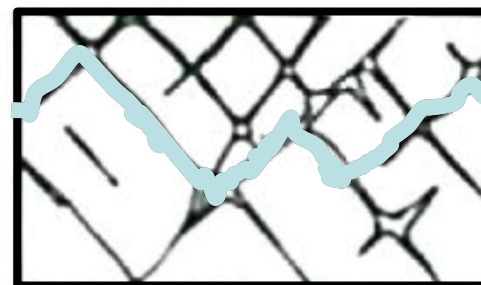
Next steps:

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

Conceptual Chemical Stimulation (I)

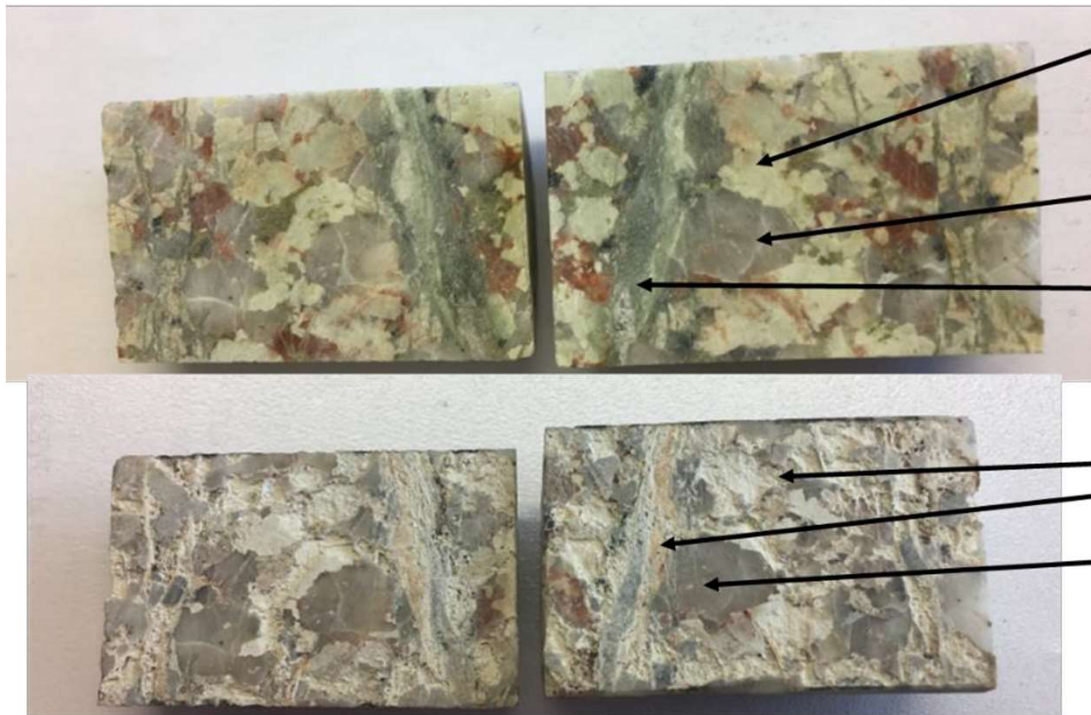
Fractured rocks

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)

<-----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-feldspars are not affected
 Improvement of hydraulic performance after chemical treatment: factor 4 and 30

Lummer & Rauf, EGC 2019

Stimulation methodology : Coiled Tubing



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

Pro ++

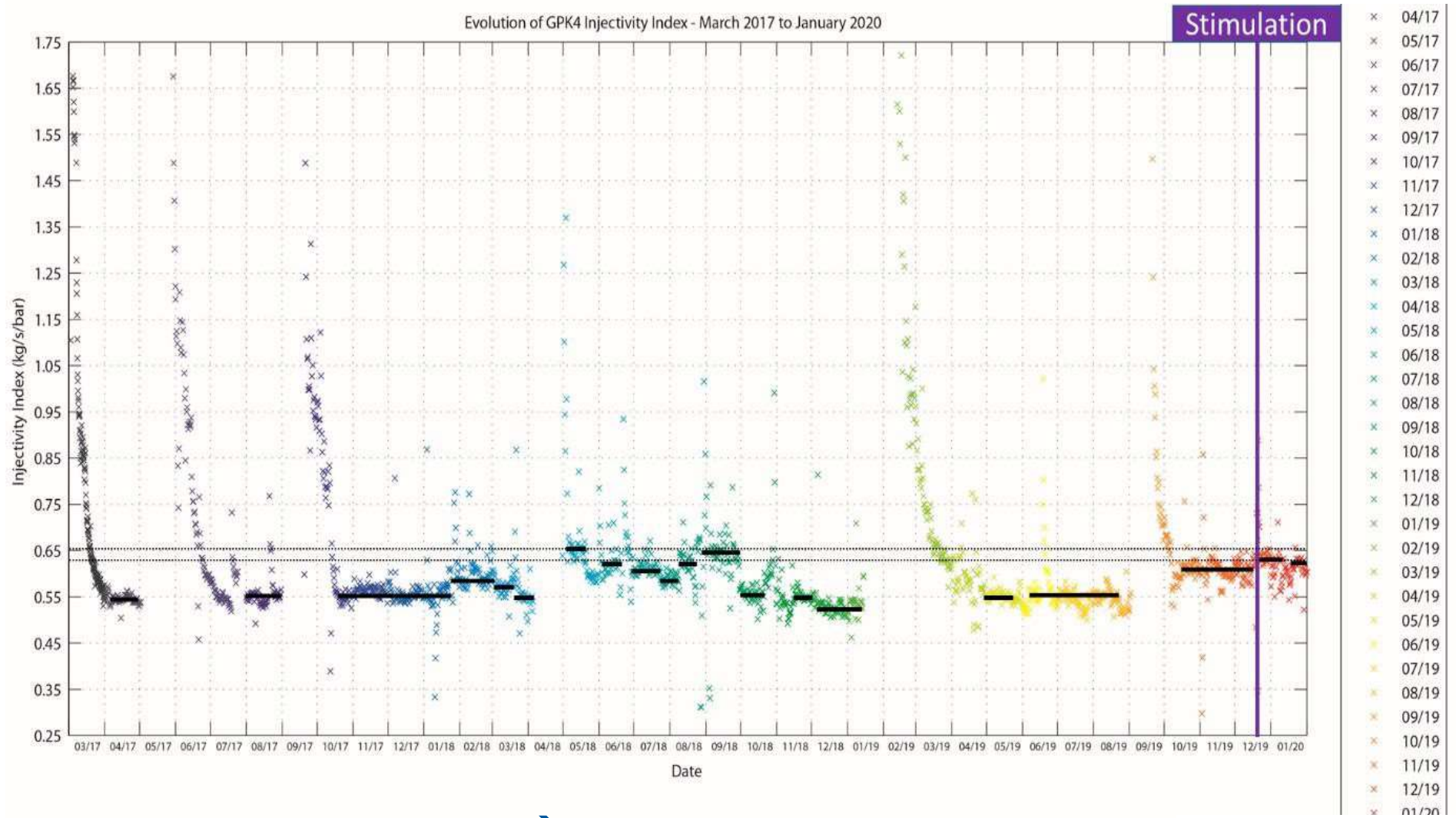
- Protect more than 4 km of the 9"5/8 casing from the acid allow focused injection
- Reduce acid volume in the well in case of injection pump failure

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



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- 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.

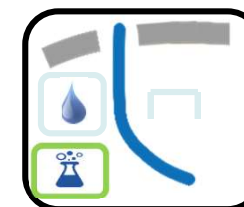
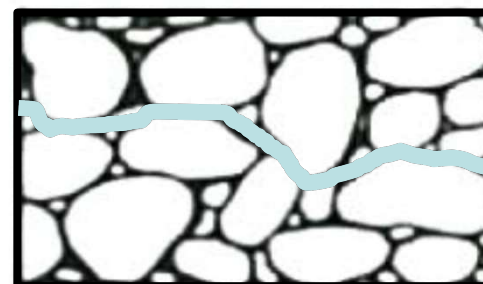
To do:

- 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

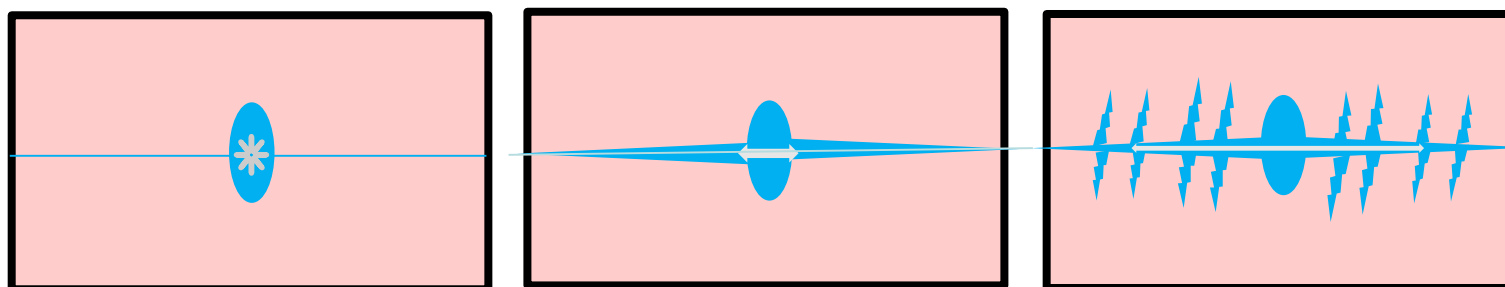
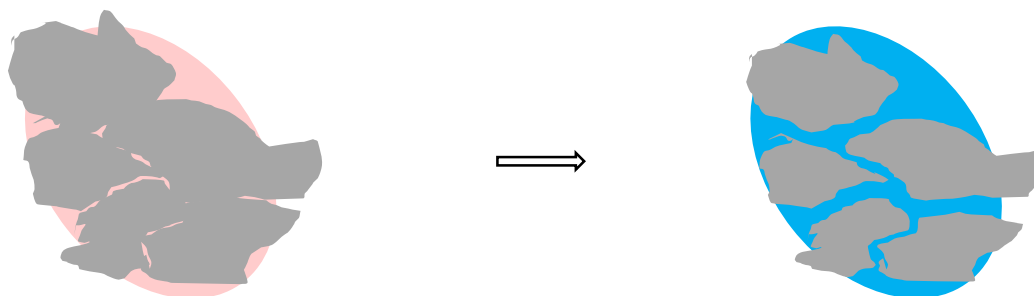
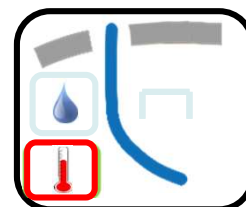
Acidisation to remove obstacles in pores
(e.g. carbonates and fines)
(Mezőberény, Hungary November 2020)



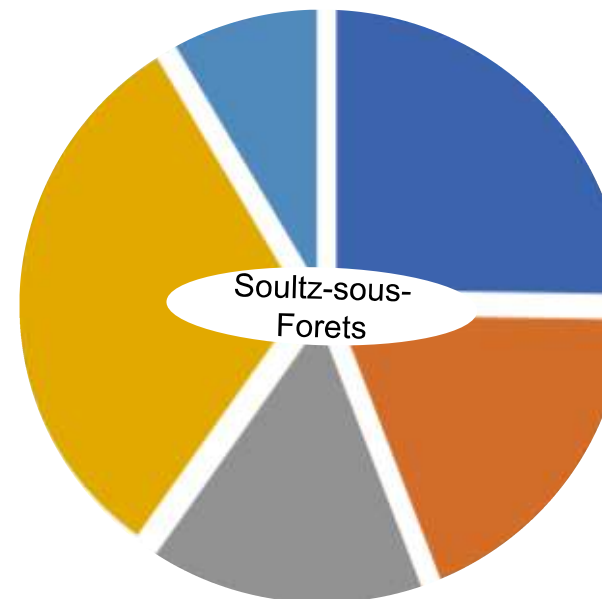
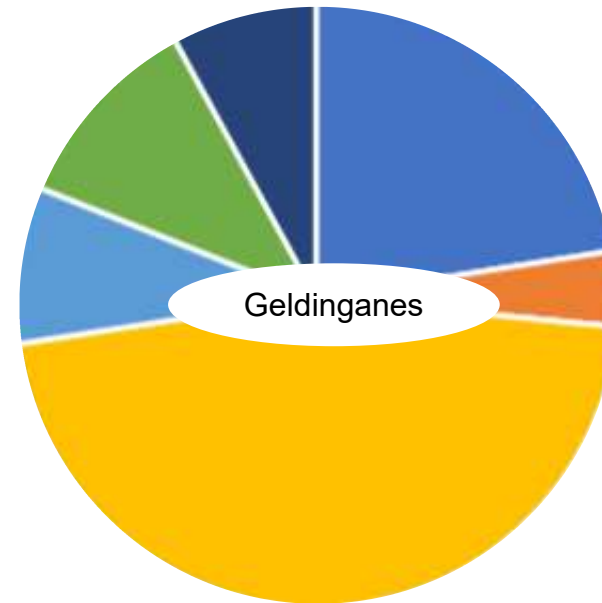
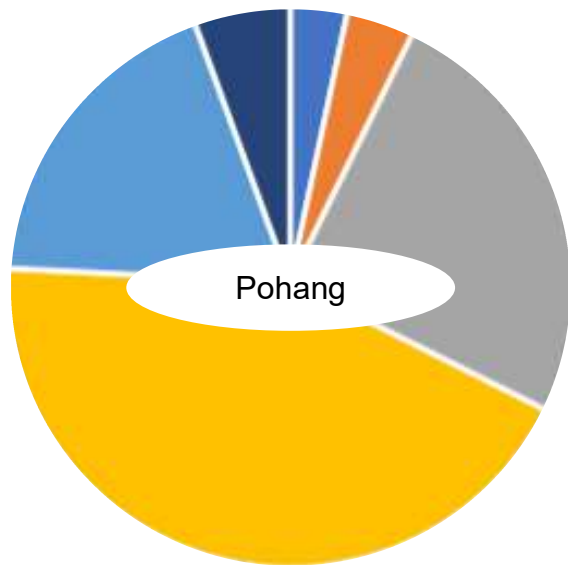
Conceptual Thermal Stimulation

Porous or fractured rocks

Creating fracture due to thermal induced shrinkage (Mezőberény, Hungary November 2020)



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**

Main Results of DESTRESS

- Laboratory experiments referring to soft stimulation, lessons learned implemented in the field experiments in hard and soft rock environment,
- Seismic traffic light system demonstrated and cyclic soft stimulation executed in Pohang (2017) and Geldinganes (2019),
- Pohang: Mw 5.4 EQ! → although the DESTRESS treatment was not responsible, requirements for extended risk assessment for any similar hydraulic stimulation project were lessons learnt
- Mature cyclic stimulation in Geldinganes, Iceland (2019), Challenging borehole breakouts
- Mature chemical stimulation in Soultz, France (2019), Coiled Tubing operation
- Designs and workflows for upcoming stimulation in Mezöbereny, Hungary (2020/21) and Bedretto, Switzerland (2020/21)

Join our online final conference 24 and 25 November 2020

<http://www.destress-h2020.eu/en/stay-informed/news-and-events/final-conference/>