Thermal Spallation Drilling:
A contactless drilling method to reduce drilling costs and enhance hydraulic stimulation

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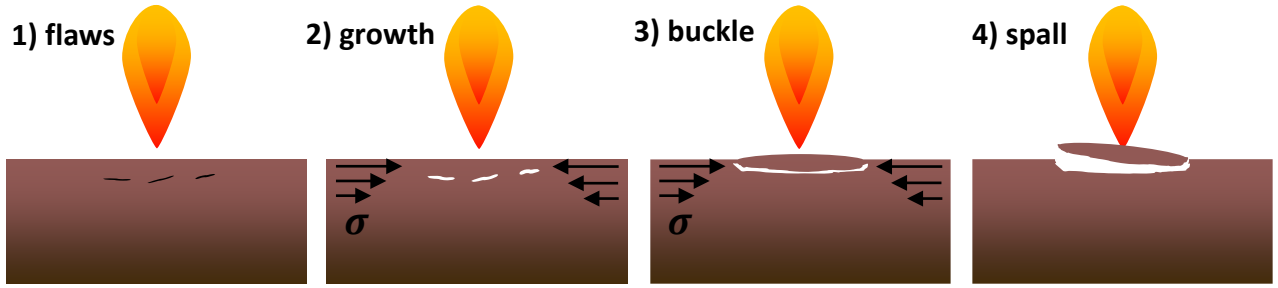
Thermal Spallation Drilling

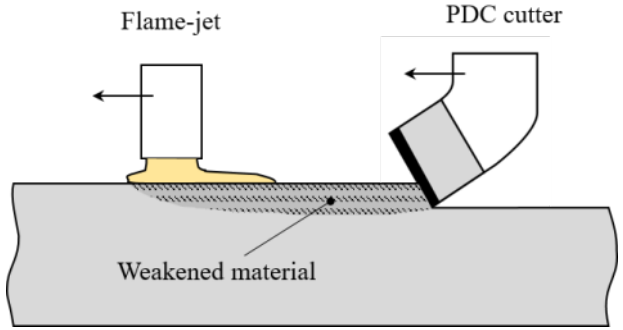
- Local destruction of rock with a flame-jet
- High thermal stresses lead to surface disintegration
- Excellent drilling velocities in hard formations (>10m/h)
- Effective operation under water
- Application fields:
  - Combined thermo-mechanical drilling → reduction of drilling costs
  - Thermal bore hole enlargement → enhanced hydraulic stimulation

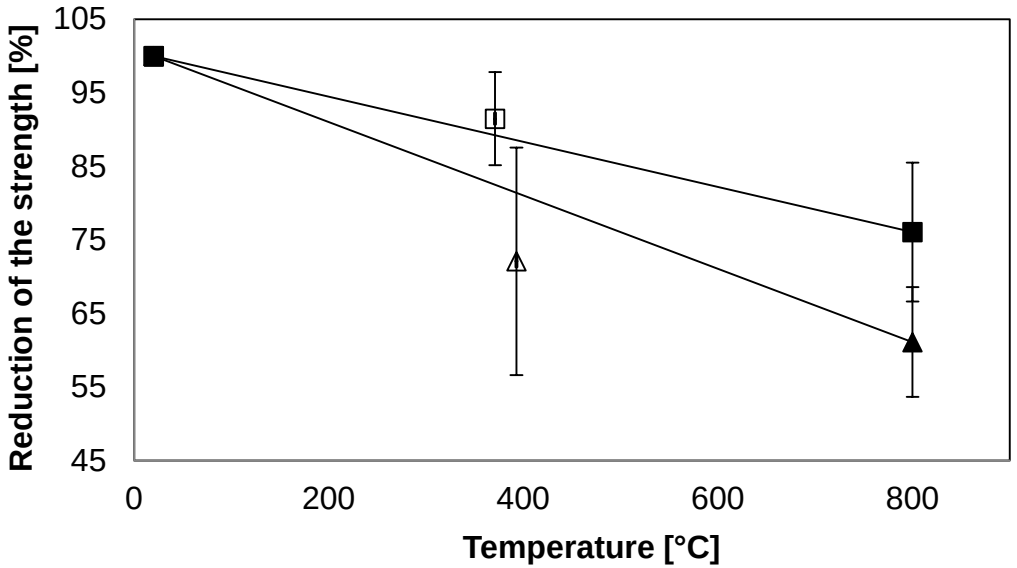


Kant, Rudolf von Rohr (2016), Int. J. of Rock Mech. Min. Sci.
Kant, et al. (2017), European Oil and Gas Magazine 1/2017, Pages 23-25.
Kant, et al. (2017), Journal of Geophysical Research: Solid Earth, 122.

Combined thermo-mechanical drilling

- Combination of spallation & conventional drilling
- Operating modes
  - **Stand-alone spallation drilling (rock spallable)**
    - High rate of penetration
    - Significantly reduced wear rate
  - **Combined thermo-mechanical drilling (rock unspallable)**
    - Thermal assistance weakens rock strength
    - Lower forces on bit
    - Reduces torque, WOB, wear-rate
- Reduction of the drilling costs

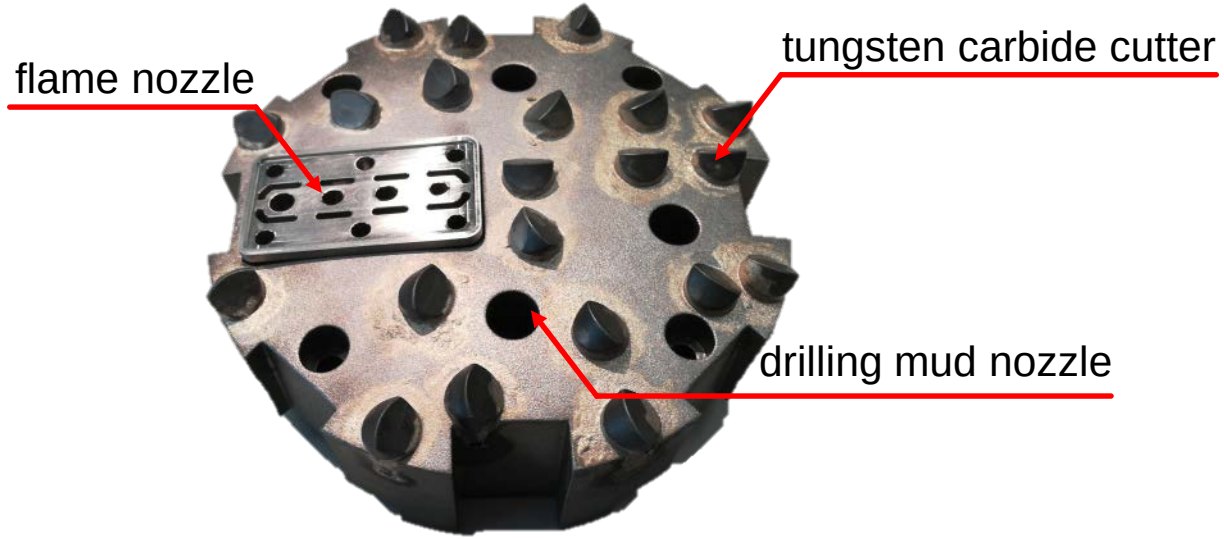




rock type	treatment	temp. [°C]	strength [MPa]
Rorschach sandstone	Initial	20	**63.7**
	■ Oven	800	48.44
	□ Flame	371	56.89
Central Aare granite	Initial	20	105.27
	▲ Oven	800	**64.33**
	△ Flame	400	78.66

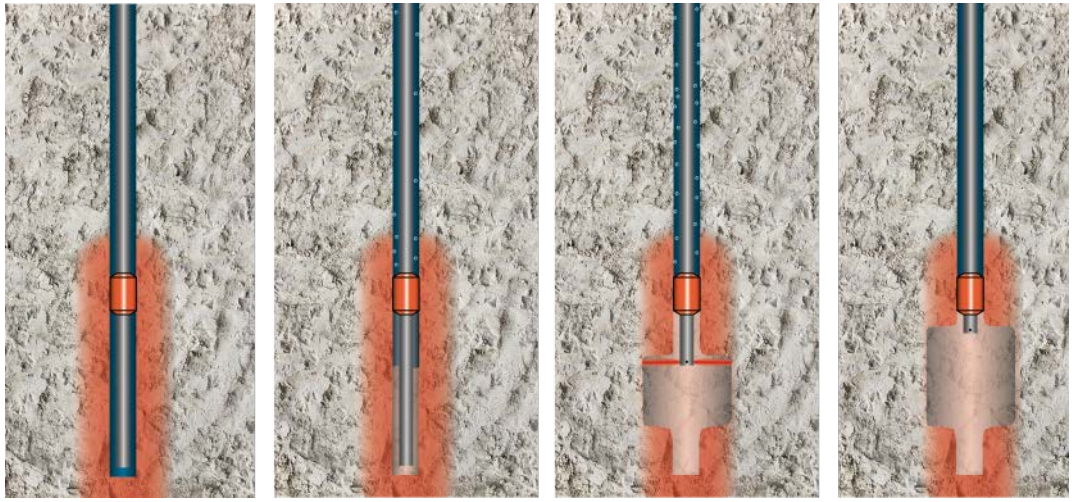
Thermo-mechanical drilling – field test

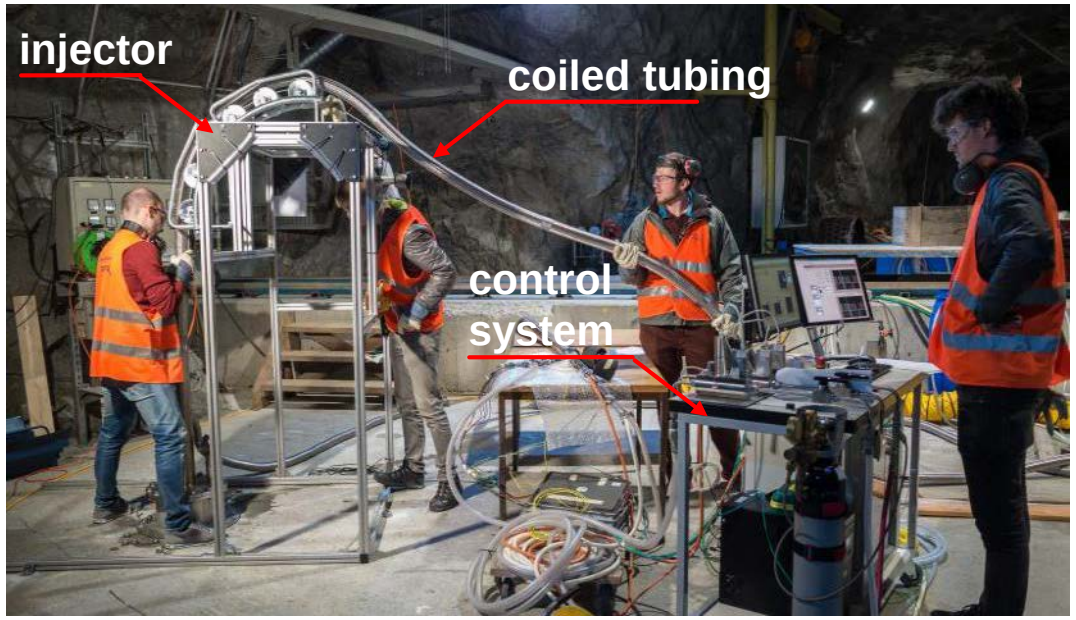
- Partner: Geothermal Center in Bochum (Germany)
  - Drill rig: Bo.Rex, 40 tons, 54 kNm
- Field trial of thermo-mechanical drilling
  - Head size: 6.5 inch
  - 50 kW thermal power (CH_4-O_2)
- First experiment: beginning of 2018



Thermal bore hole enlargement

- Enlargement of the bore hole cross section by using thermal spallation drilling
- Engineered reservoir creation
  - → Enhance hydraulic stimulation progress
  - → Increase the production flow
- Field test of the technology (5/2017)
  - Location: Grimsel Test Site (GTS), Switzerland
  - Water filled 15m deep bore hole
  - Enlargement tool:
    - 70 kW methane-air burner
    - Diameter: 80mm
    - Single circumferential nozzle
    - Supply and control via 25m long coiled tubing

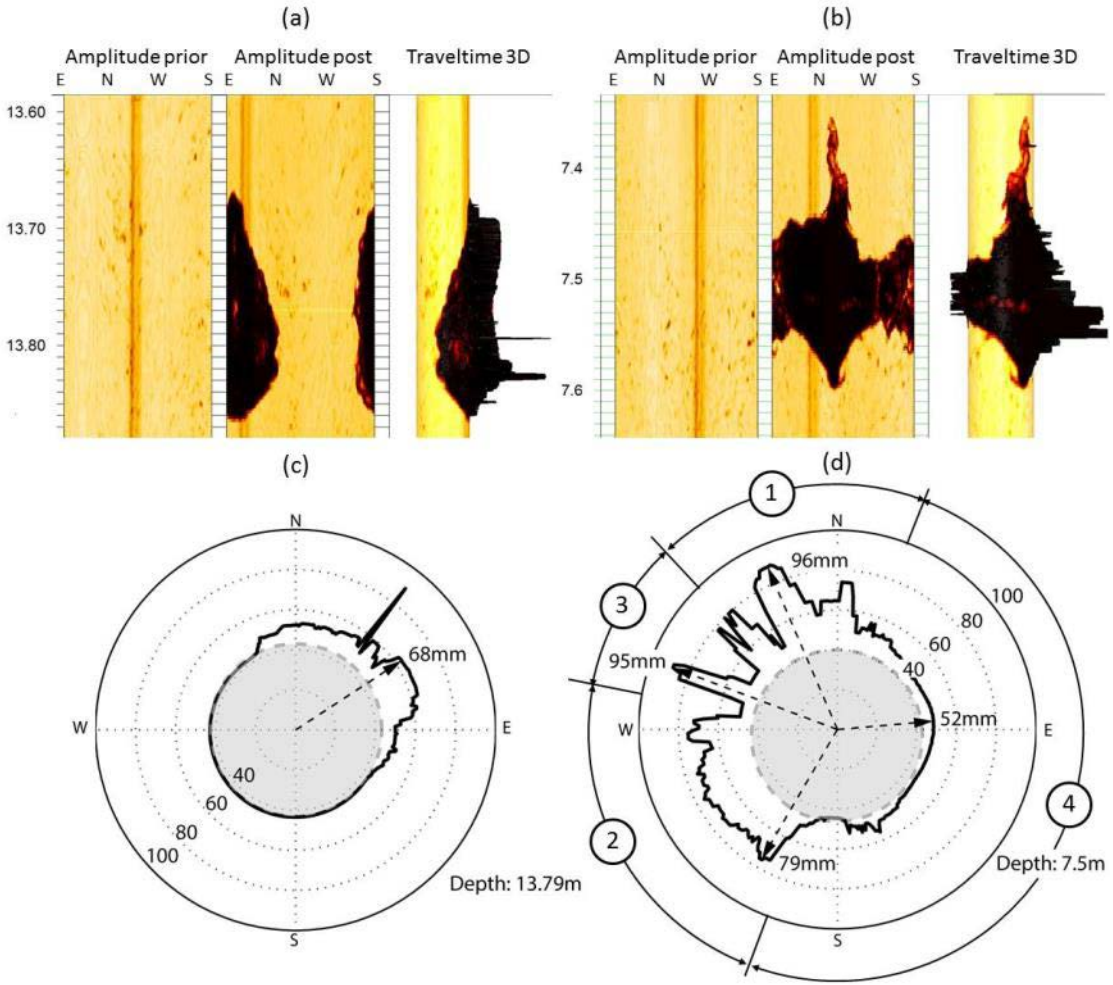


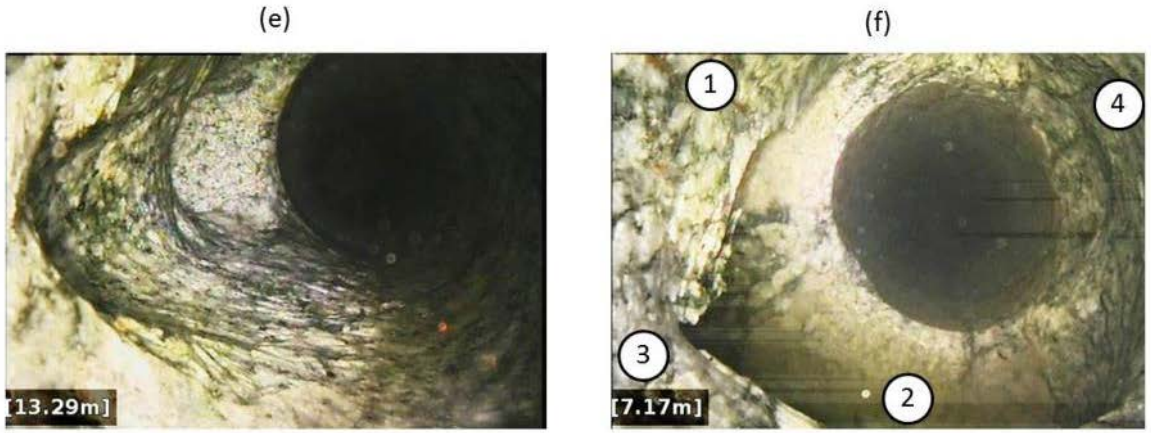


Ph. Rudolf von Rohr, M. Kant et al., E. Rossi, An apparatus for thermal spallation of a borehole, *patent pending.*

Results - bore hole enlargement

- Two bore hole enlargements
  - Depths: 13.5 m and 7.5 m
  - Cross sectional area increase of 200%
  - Radius increase of 200%
- Control direction & location of induced fractures
- Enhanced access to preexisting fractures

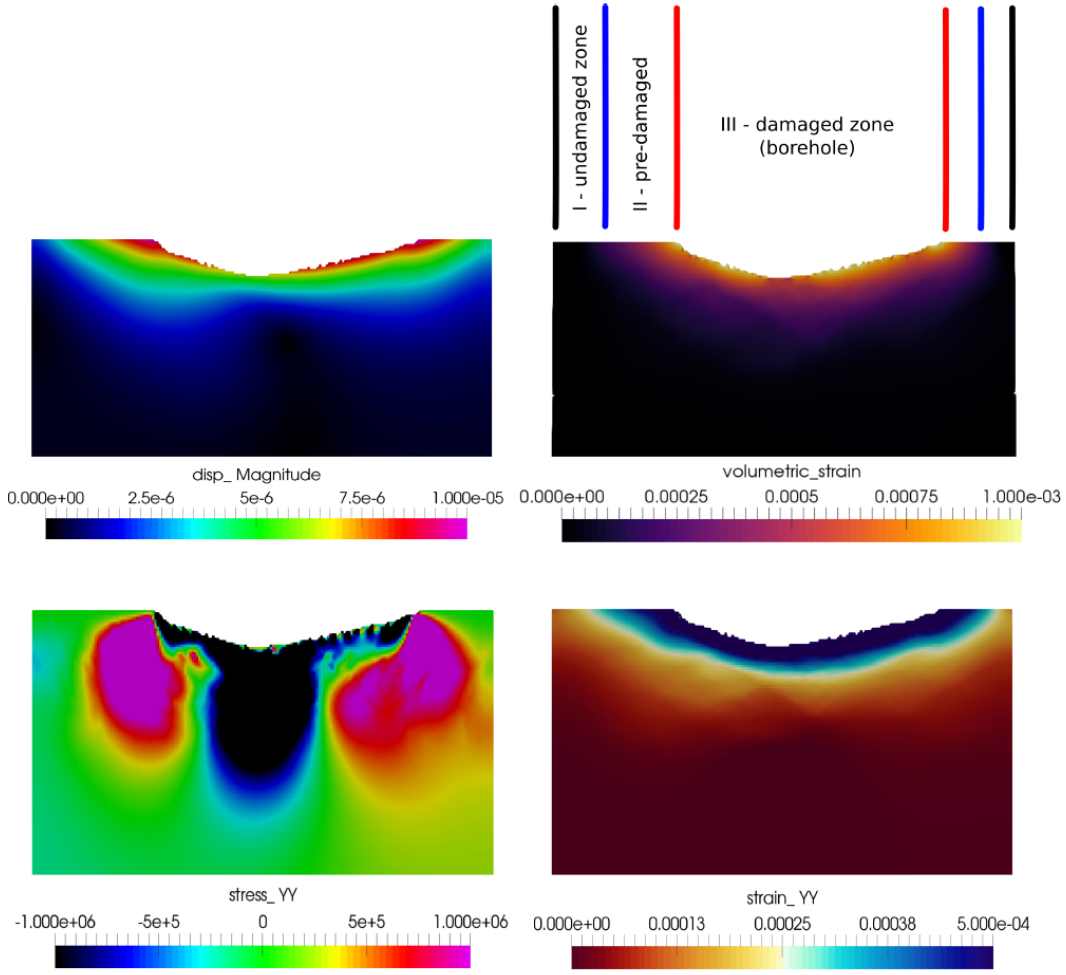




M. Kant, E. Rossi, et al. (2017), *Applied Energy*, under review

Other related research topics

- Numerical and analytical modeling of thermal spallation drilling
  - In cooperation with Martin Saar (ETHZ)
  - Influence of rock properties and inhomogenities
- Life cycle analysis
  - Cost study of thermal spallation drilling
- Heat flux measurement
  - Development of various sensor equipment for p>300 bar & T>1000°C



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Thank you for your attention!

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