# Alternative Drilling Technologies

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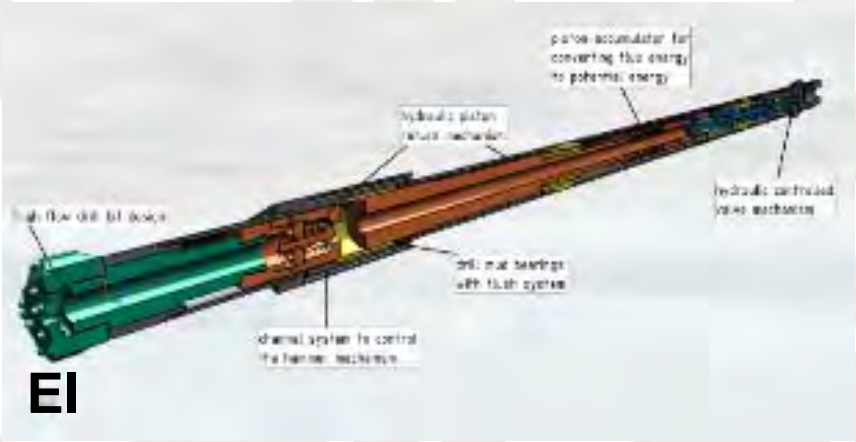
Bundesministerium für Wirtschaft und Energie

# Drilling R&D at GZB



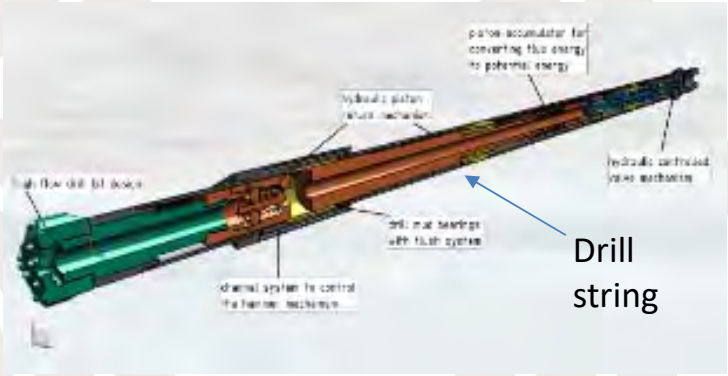
- Hydraulic DTH hammer drilling
- HP jetting
- Thermal drilling methods : Laser, Spallation, El drilling, Plasma
- Borehole simulator → reservoir conditions

- MOUSE system to control and log drilling operations : QA + QC

- Work with oil field drilling engineers and contractors

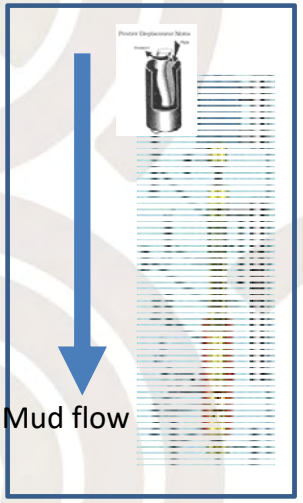
# Hydraulic DTH mud hammers : 2 basic systems

- **Closed loop system ("external" tool)**
  → percussion section is being powered via hydraulic or electric energy being generated downhole by mud generator
  → tool may be added to any BHA with enough flow (e.g. TU Freiberg is working on a similar design)

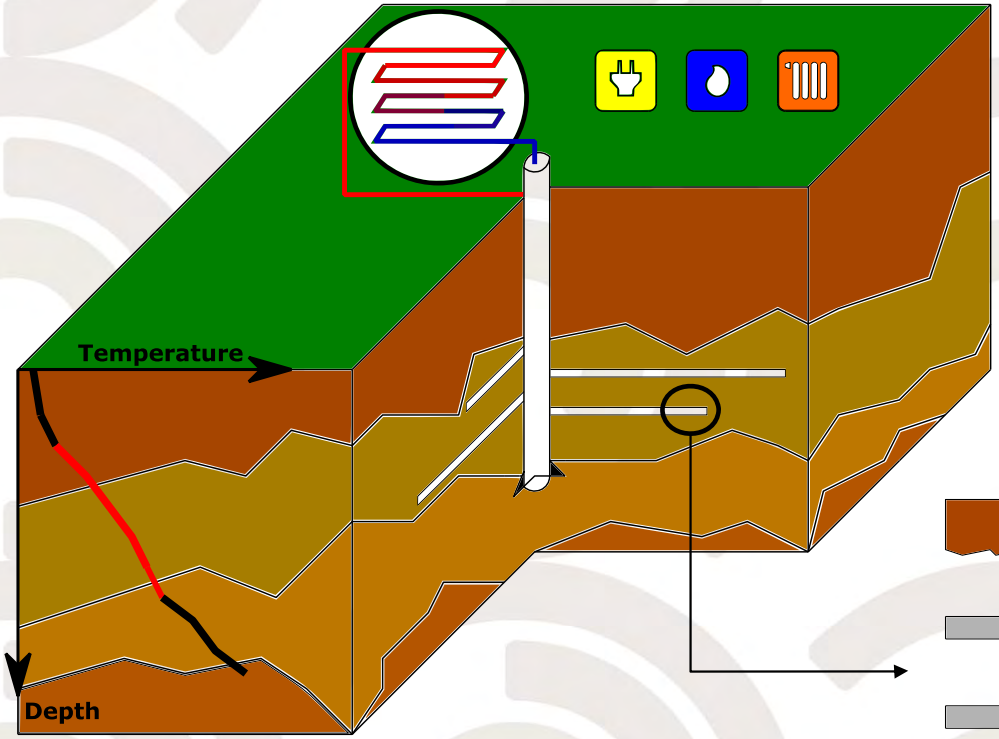



- **Flow through, internal system** → e.g. Wassara in Sweden, Hanjin South Korea, all other developments in the past 30 + years → available

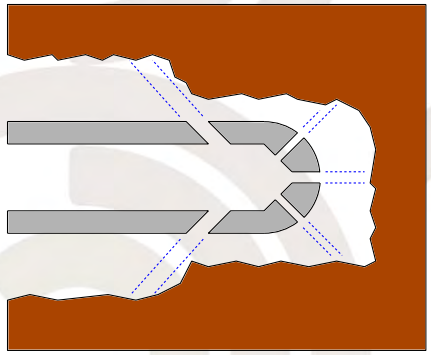

Drill
string

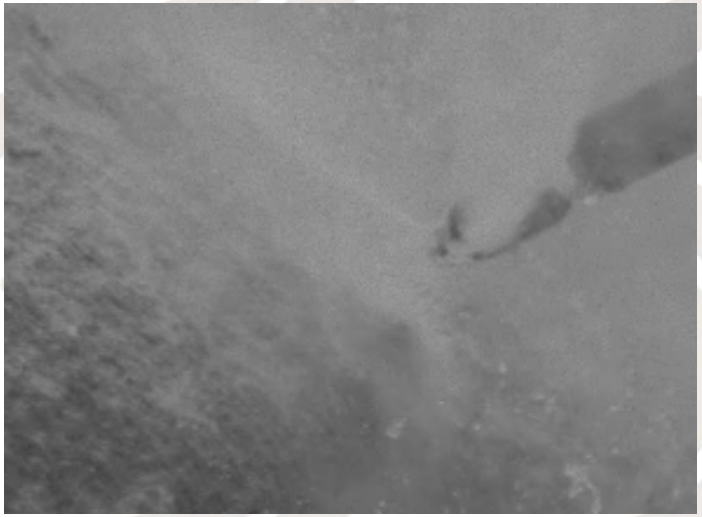


# Radial Jet Drilling Technology




Geothermal Reservoir





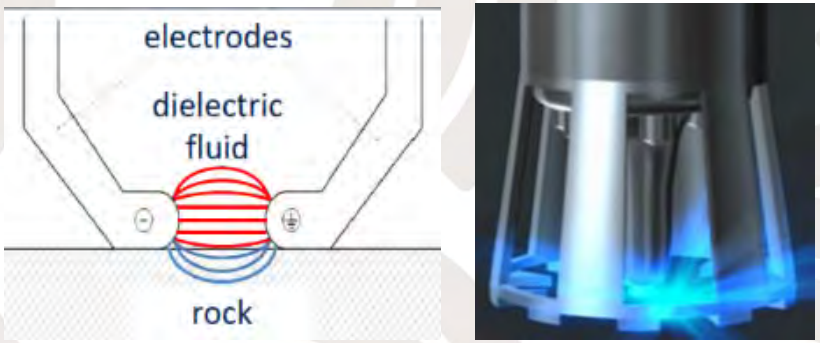
Jetting nozzle with forward and backward oriented nozzles

# Current thermal Drilling technologies under investigation

- **Hydrothermal Spallation process**
- (Potter Drilling, Inc. & ETH Zurich)
- High temperature fluid-jet → generates heat →
- intense thermal stress → Spallation (Augustine, 2009; Von Rohr, Rothenfluh, & Schuler, 2015; Potter, 2011)

**Hydrothermal Spallation** (Potter, 2011).

- **Electro Impulse Technology**
- (Technische Universität Dresden and Baker Hughes INTEQ GmbH)
- Electrical voltage impulse → passing pulse through rock → volume of rock breaks(Voigt & Anders, 2016)



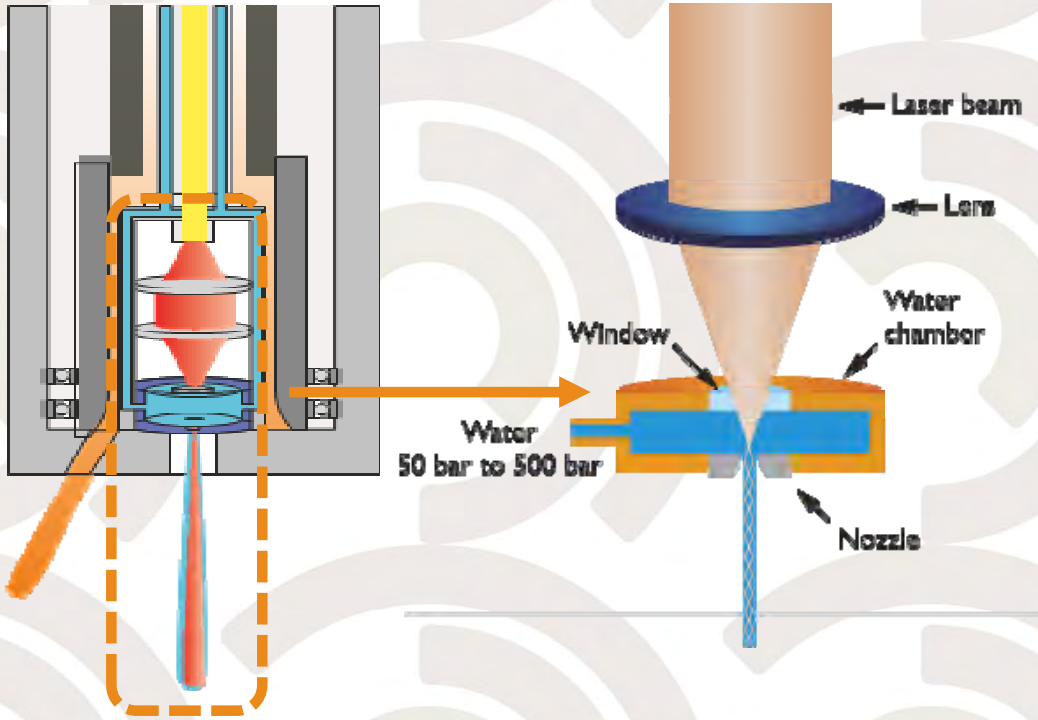

**Electro Impulse Technology** (Voigt & Anders, 2016)

# **Thermal Drilling** : innovative way to break hard rock
## LASER JET drilling @ GZB

**LaserJet Drilling**

Laser + Water jet + Mechanical assistance

Novel drilling method for deep hard rocks




**Mechanically Assisted LaserJet and Drill head concept.**
modified after (Wagner et al., 2009;Fraunhofer IPT)

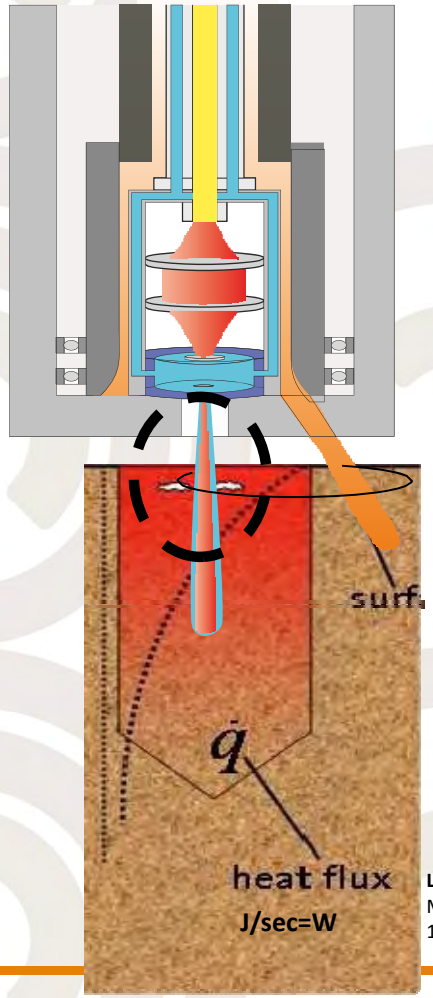
**Water guided LaserJet**

**Transportation of additional energy to the bit**

Spallation + softening of rock

Mechanical assistance → rock destruction

# Thermal spallation drilling with LaserJet




**Laser spallation process principle**. Modified after (Preston & White, 1934;Fraunhofer IPT)

A water jet guided Laser transports the thermal energy

↓

Excessive, rapid thermal energy

↓

Thermal stresses

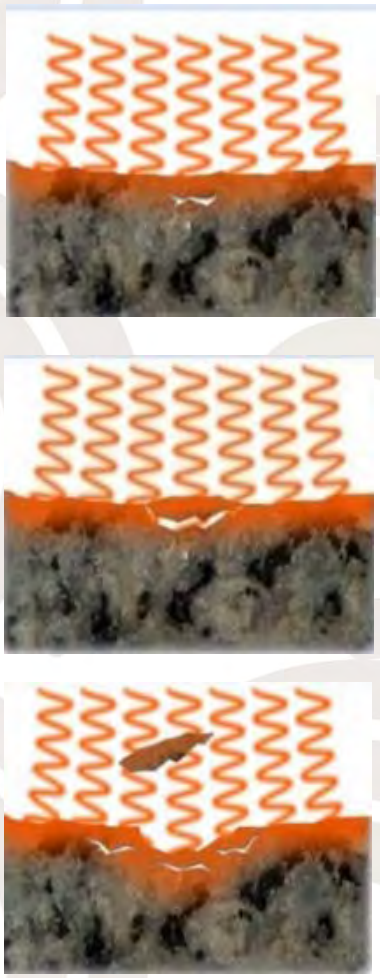
↓

Rock weakening +

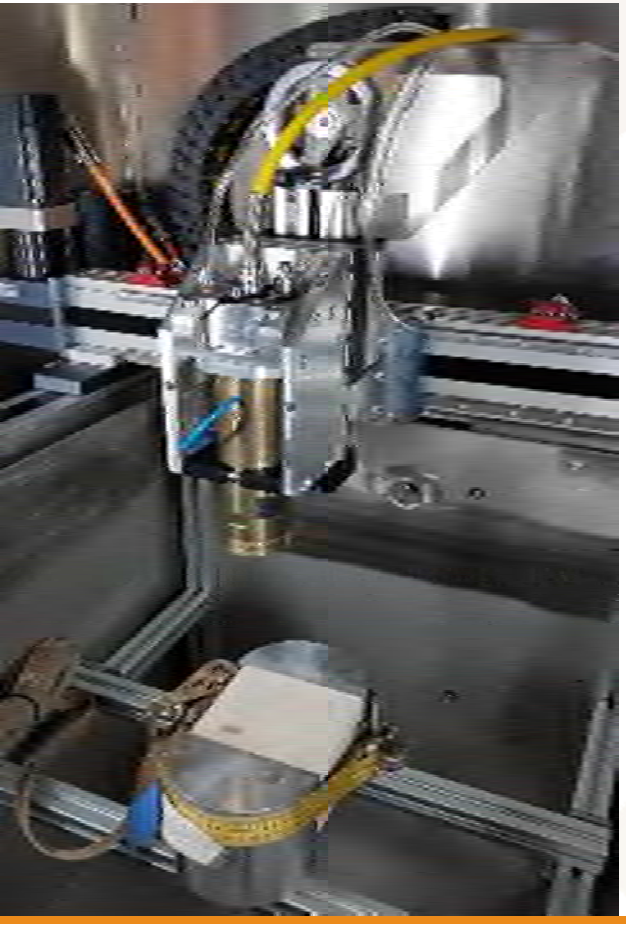
Thermal Spallation

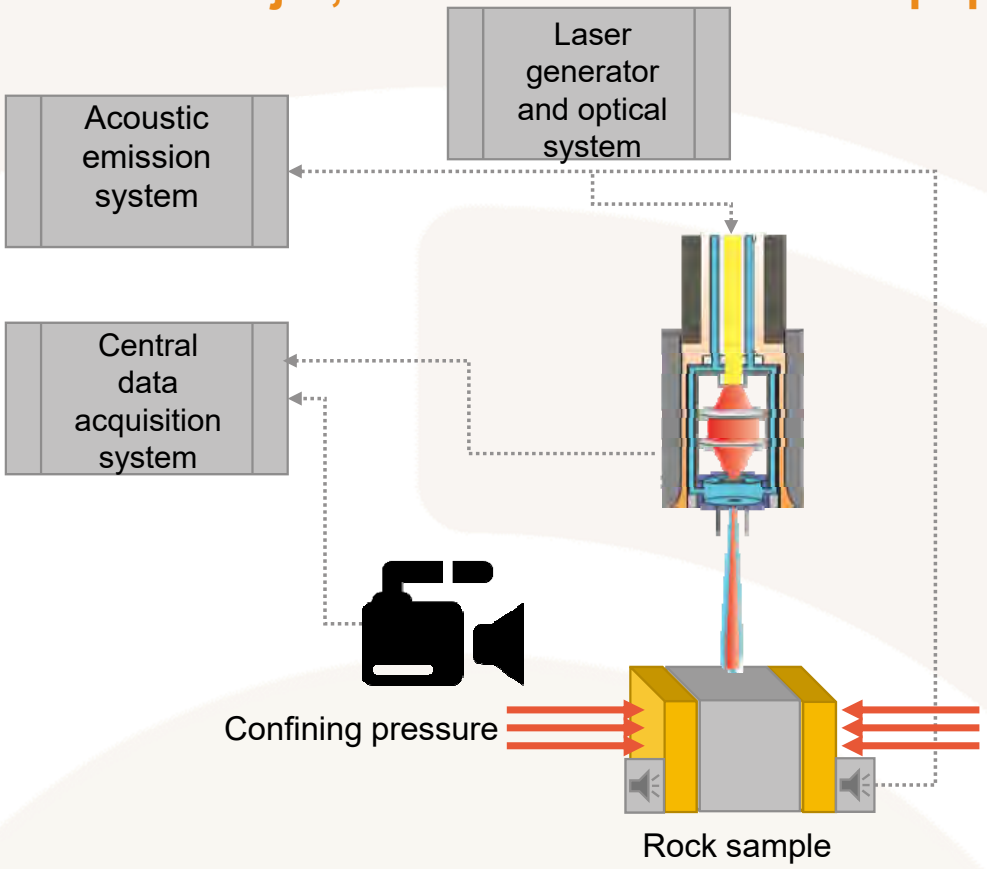
↓

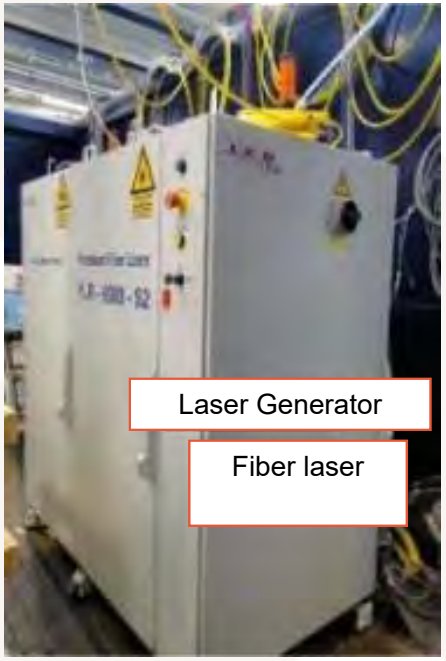
mechanical assistance complete rock destruction



# Rock disintegration : drilling via LASER technology combined with monitoring, logging, characterization and analysis of water jet, rock destruction and equipment





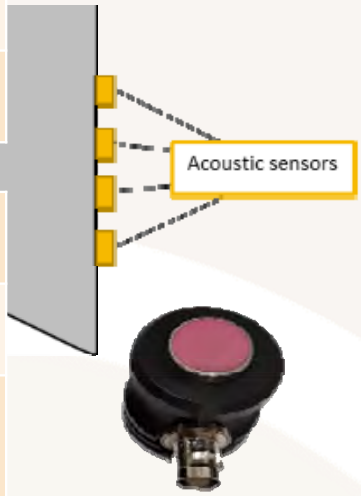



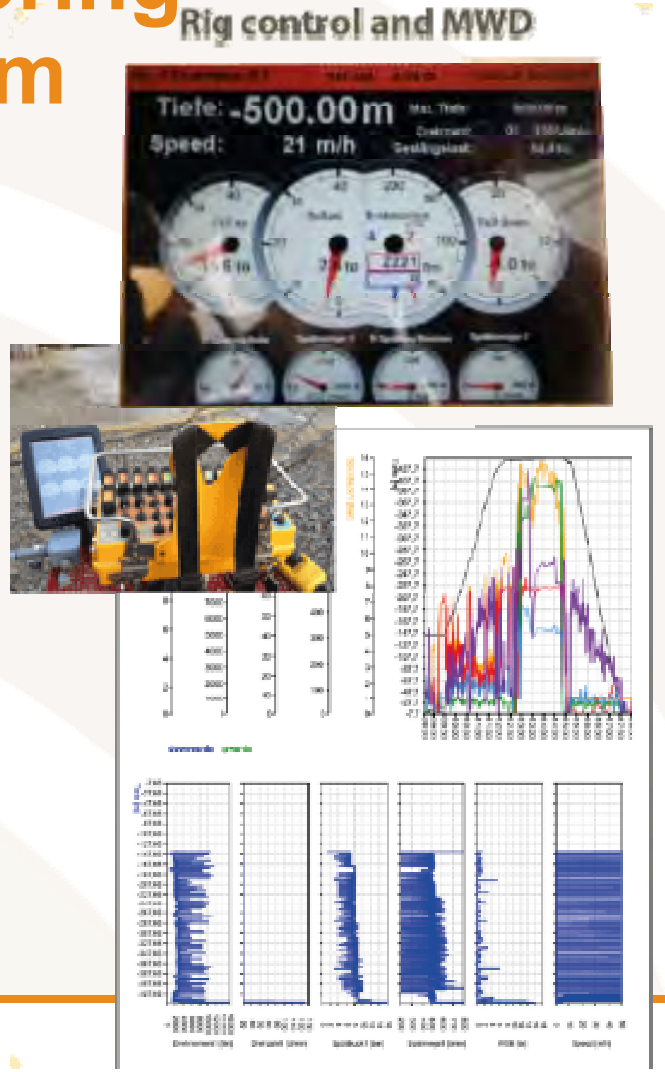

**Laser generator and optical system**
(Fraunhofer IPT)

## determine required drilling parameters

# Rock behavior while spalling : monitoring via acoustics and drill rig MWD system

| | | |
|---|---|---|
| **Aim 1 ( Dynamic Modulus)** | Big cracks detection | Small cracks propagation |
| **Resolution** | Low | High |
| **Frequency Range** | Low Freq. → < 10 kHz (50 kHz) | High Freq. → < 150 kHz |
| **Aim 2 (Drilling effect)** | Crack occurrence | Crack localization |
| **Sensors (No. / Pos.)** | 1 / any | ~ 6 / all around |
| **Observation** | Real-time | Post processing (Seismic traveltime tomographic inversion) |

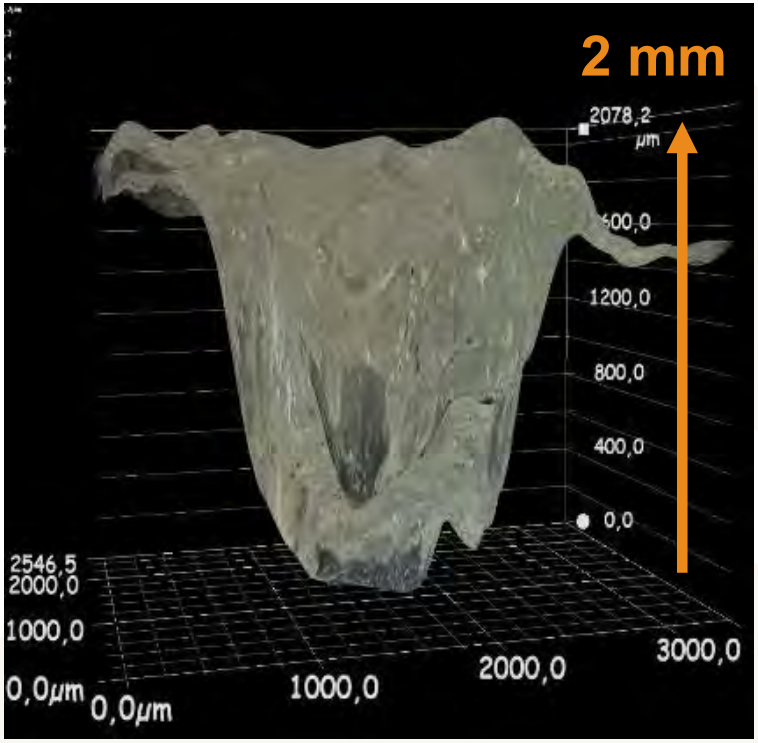


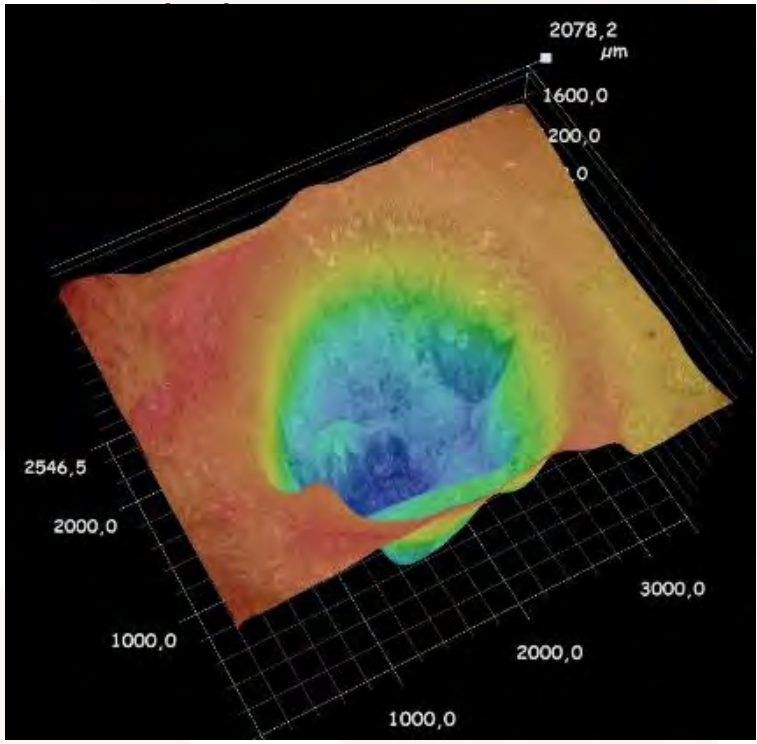
# Drilled Holes → spallation analysis + measurement → preparation for new MWD

**Lazed samples**

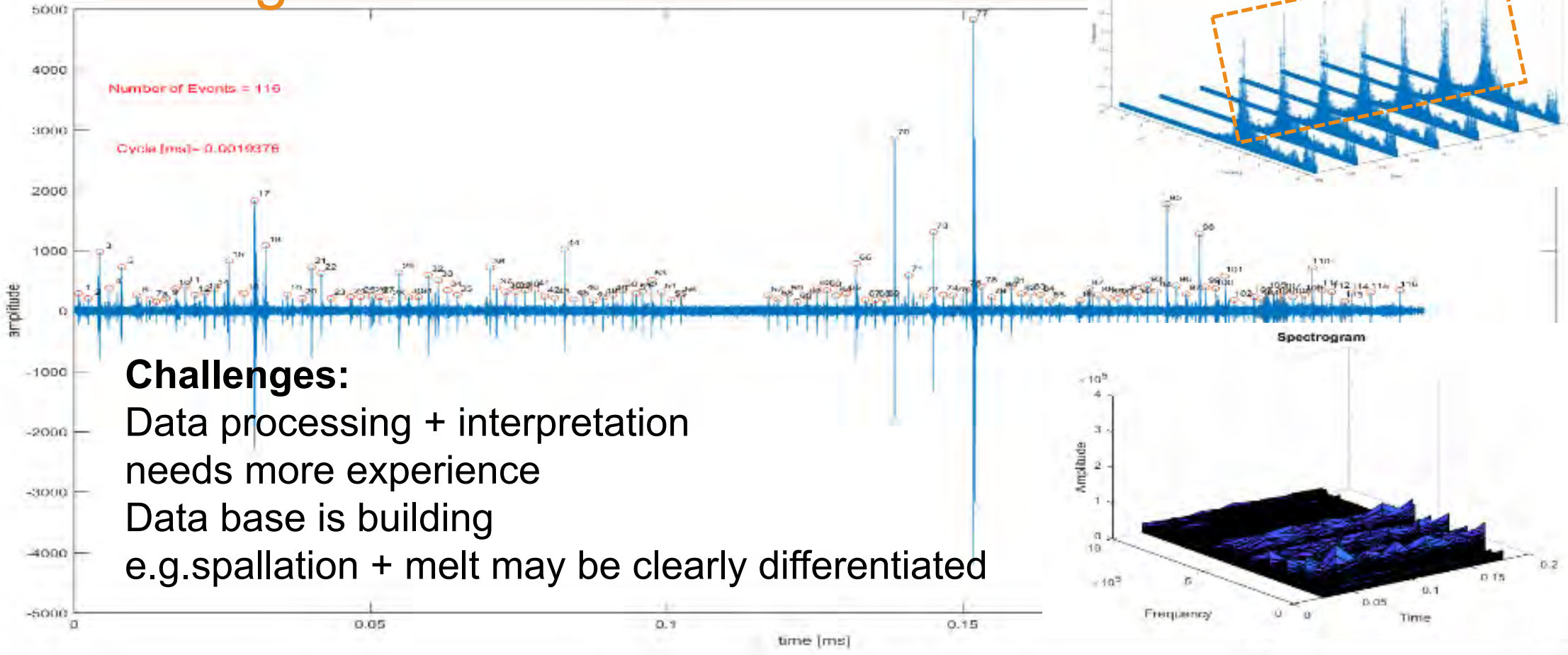
**3D side view**




**Top view 3 D and hole quality**



# new **MWD system** for contact-free drilling monitoring + control of rock destruction




**Challenges:**
Data processing + interpretation
needs more experience
Data base is building
e.g.spallation + melt may be clearly differentiated

# Full scale drill tests @ GZB with mobile rig :

## "**bring the geology to the GZB drill rig + test site**"

## →subsurface installation of rocks + instrumentation

### Various investigated methods for sample preparation

Rock sample Cementing using a metal frame

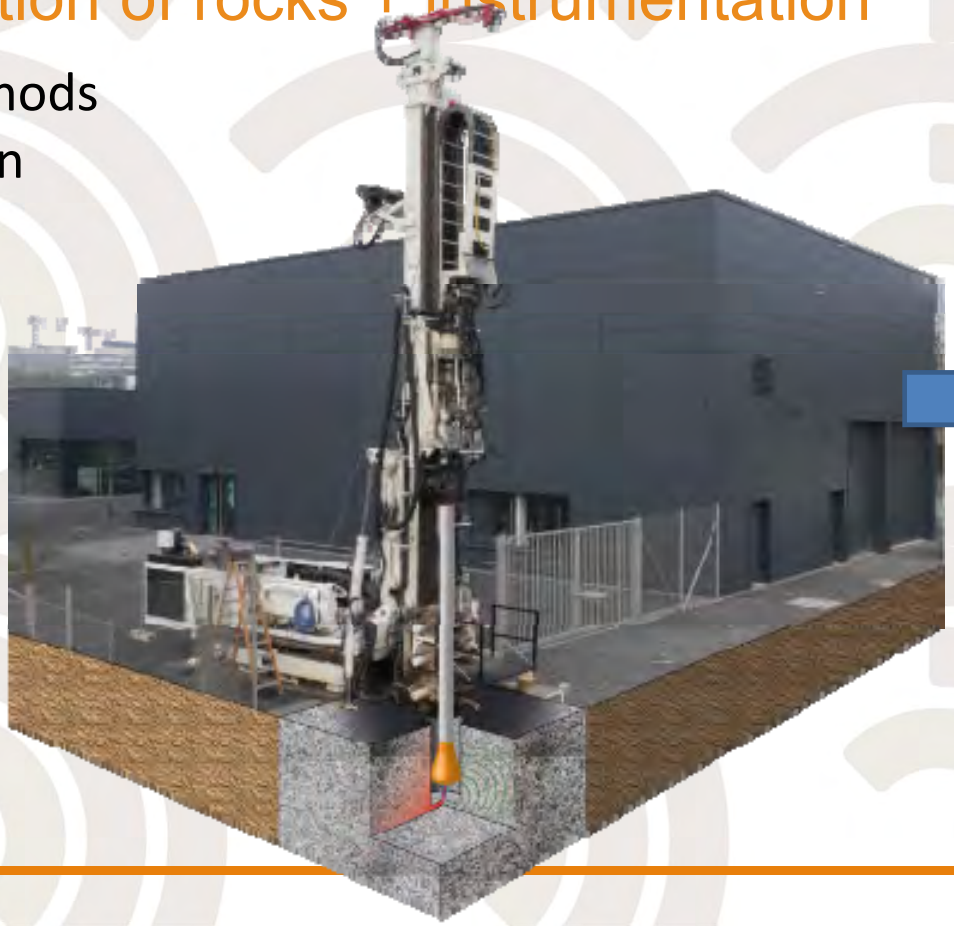
Reinforced cement

Curing the cement

Removing the metal frame

Measurement system installation

Sample in manhole placement



### Inspection and analysis

Using a crane for :

Rock handling

Rock lifting

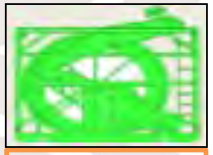
Rock recovery after the test → Crane

Removing the cement

**Inspection and analysis of the drilled sample and borehole wall**

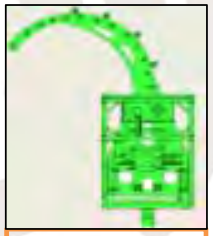
# Coiled Tubing rig : easy to integrate fiberoptic cable and Laser energy

1



Injector Head

2

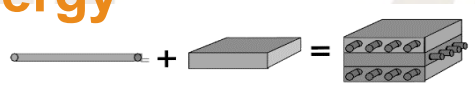


Tubing Reel Assembly


- Testing platform :
- Endless, continuous coil
- Investigate, develop and test new drilling methods.

- Compatible with novel drilling technologies:
- Jetting technologies,
- Thermal drilling (e.g. Laser assisted, Plasma)

- Good spoolability and low WOB → Improved trajectory control → Suitable for directional / horizontal drilling



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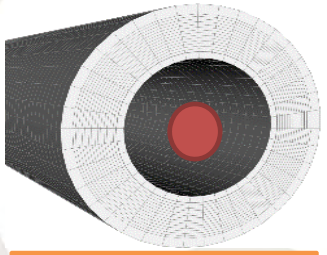


Advanced composite coil

- Higher mechanical strength
- Reduced total weight
- Enhanced mechanical, chemical and fatigue resistance properties → longer service life
- higher temperatures possible, depending on coil material + design

# Complete **MATCH.**BOGS system assembly when in full operation

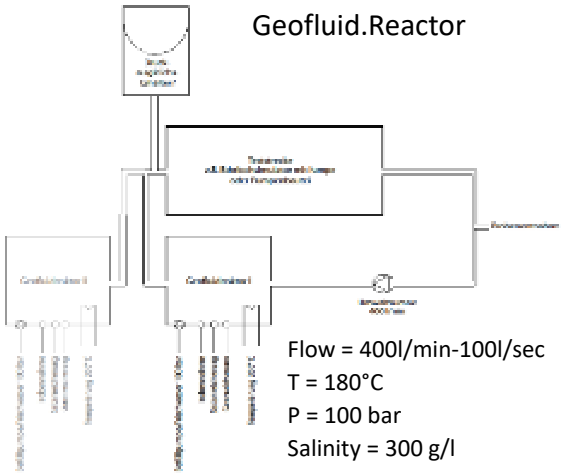
**Flow loop**
**Downhole**
**Well flow**

Downhole-Testing-Device

D = 1500 m  D = 200 m

**Fluid.BOGS**
**Reservoir fluids**

Geofluid.Reactor

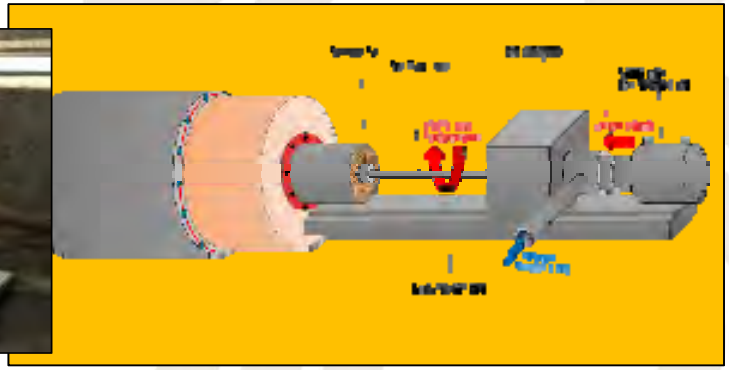


Flow = 400l/min-100l/sec
T = 180°C
P = 100 bar
Salinity = 300 g/l

**i.BOGS**
**Reservoir**

L = 4m / 3m
B = 42 cm
T = -10°C to 180°C
P = 125 MPa / 1.250 bar

**Drill.BOGS**
**Drill rig**

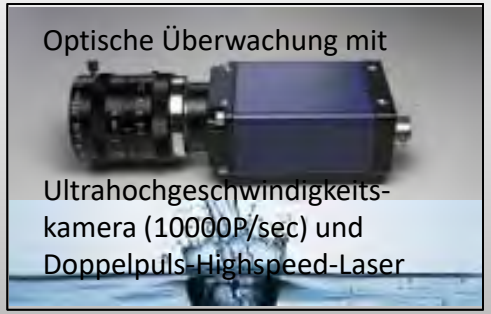


Blow Out Preventer
LPipe = 3m
Torque = 10.000 Nm
Push = 80 kN on rock / 1.250 bar pore pressure

Machine monitoring + control while drilling

**Innovative MWD system**

Acoustic unit i.BOGS



Optische Überwachung mit

Ultrahochgeschwindigkeits-kamera (10000P/sec) und Doppelpuls-Highspeed-Laser

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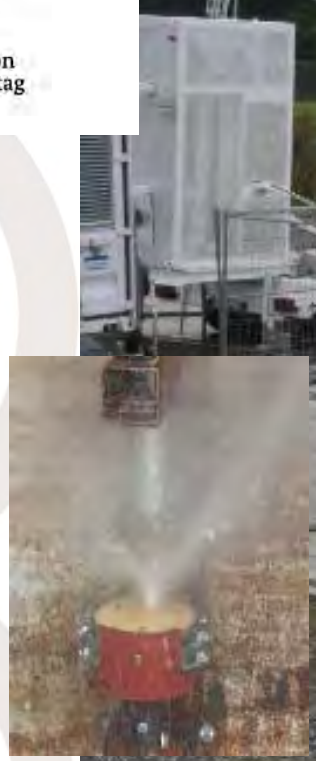
# Thank you for your attention

## Do you have any questions ?



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