

Deep U-tube heat exchanger breakthrough: combining laser and cryogenic gas for geothermal energy exploitation

# Deep U-tube heat exchanger breakthrough: combining laser and cryogenics gas for geothermal energy exploitation



UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA



Wrocław University  
of Science and Technology

Project start date: March 1 2022

Project duration: 36 months

Hop-on extension: July 1 2023

Coordinator in transition from Dr. Eloisa Di Sippio (UNIPD) to Ing. Luc Pockelé (RED Srl)



Geoserv

Prevent  
CO<sub>2</sub>



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# DeepU Project

## Goals

- Developing new **laser drilling technology**
- Extracting energy from **deep (>4 km)** U-shaped closed-loop
- **Reducing the costs** of well drilling
- Making accessible **geothermal energy anywhere**

## Key project figures



## Key project actions

- Drilling technology design and development
- Validation at the lab scale
- Compliance with legal and environmental aspects
- Closed-loop scenario definition
- Cost-effectiveness assessment

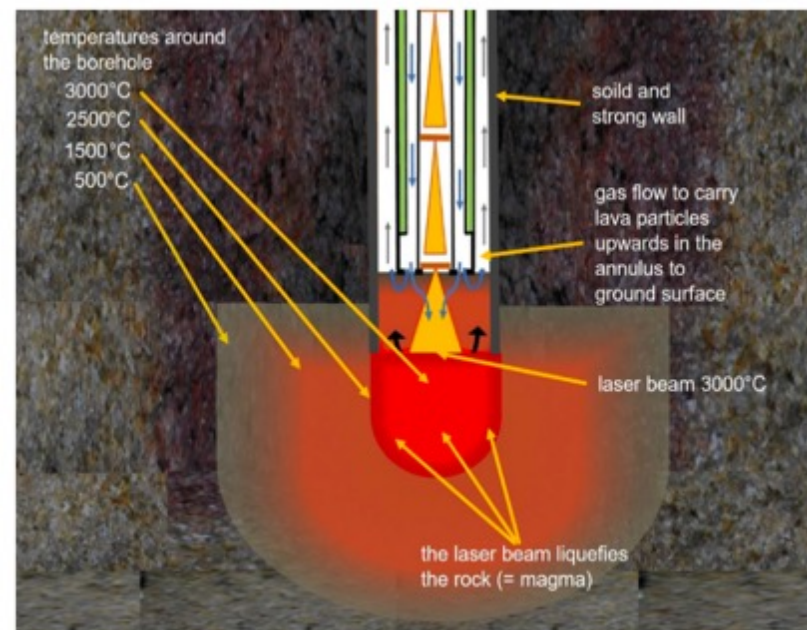
## INNOVATIVE DRILLING TECHNOLOGY

A **laser** propulsion drilling method is combined with **cryogenic gaseous flushing** for cooling the laser drill head.

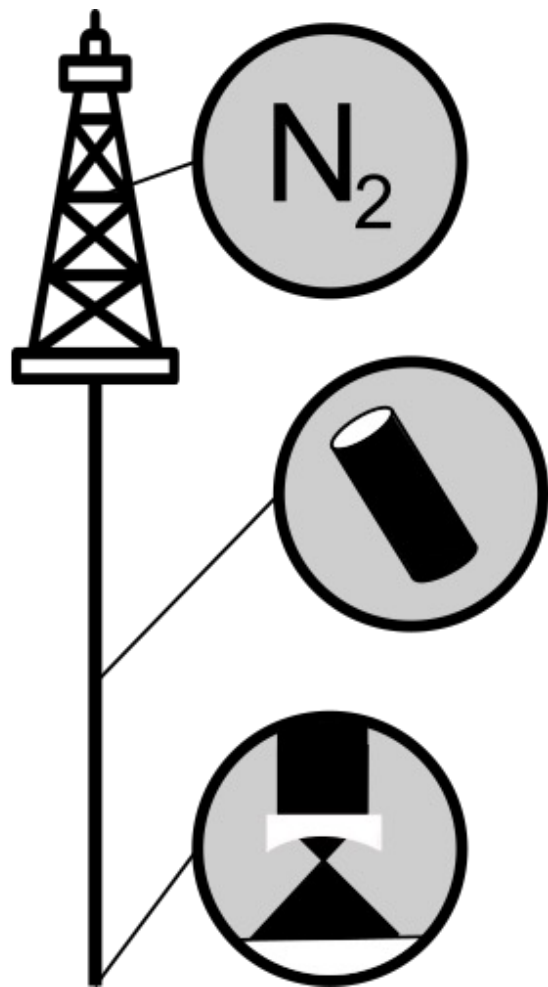
**Improved ROP**  
**Reduced drilling time and cost**

In case a glazed layer is formed on the borehole walls, the obtained systems are physically isolated from the surrounding formations and immediately developed after drilling without requiring further casing activities.

**Reduced time and cost**  
**for setting up the HE**



# Workflow in DeepU Project



7 international teams work on different aspects of DeepU Project, such as:

- Gas flushing medium
- Scaled model of U-tube heat exchanger
- **Petrophysical characterization of drilling process**
- Standards and regulatory integration
- Exploitation planning and IPR management
- Communication
- Management

# Market analysis for a sustainable deployment

The project will analyze and assess:

- The **exploitation potential**
- The economics of the developed **drilling technology**
- The **legislative** aspects and **environmental**
- Health and safety (**EHS**) standards related to the proposed solution.
- The **risks assessment** comparing DeepU technology to conventional deep drilling

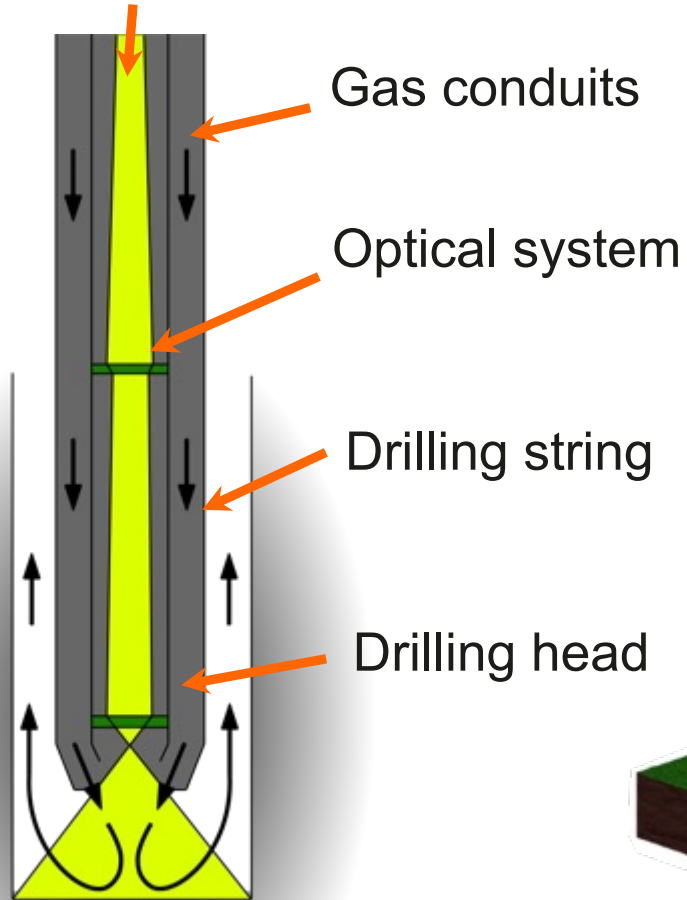




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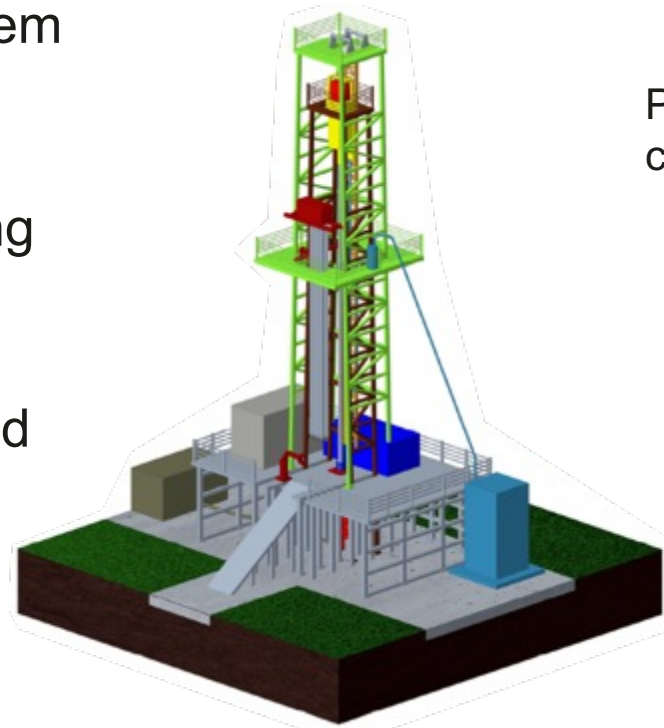
# Cryogenic gas supported laser drilling technology

Laser beam



Bedrock

3D design of the Drilling Tower



Few 3D solutions of the drilling strings

Prototype has been constructed!



Design and 3D printed drilling head

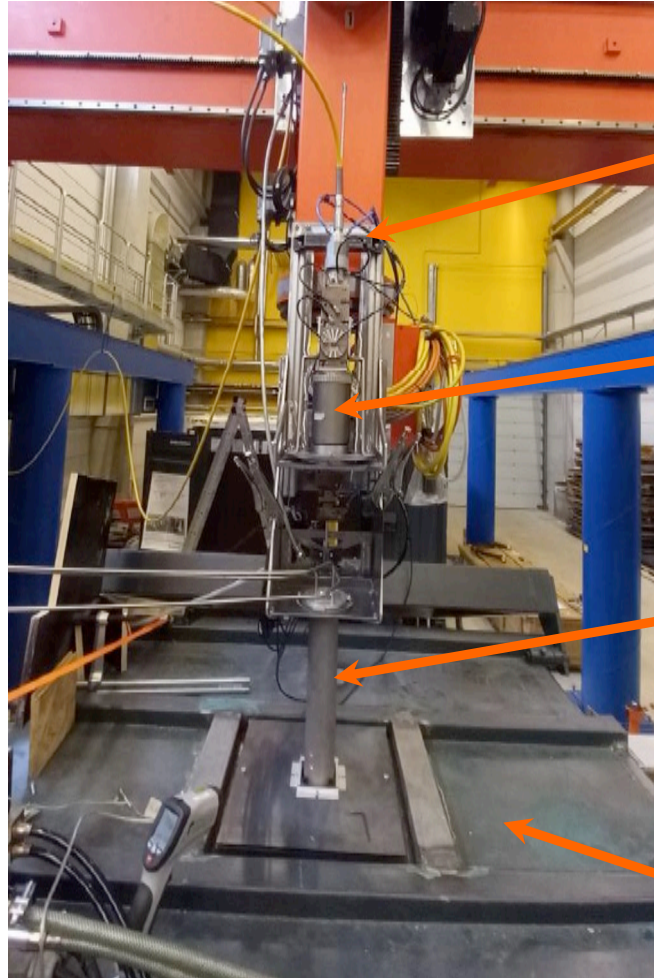


Fully operational and tested!



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## Laser drilling laboratory tests

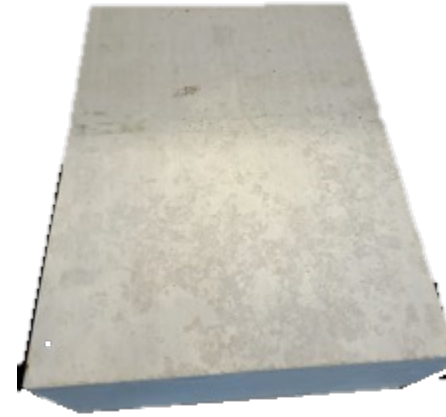


**Robotic arm**

**Optical system**

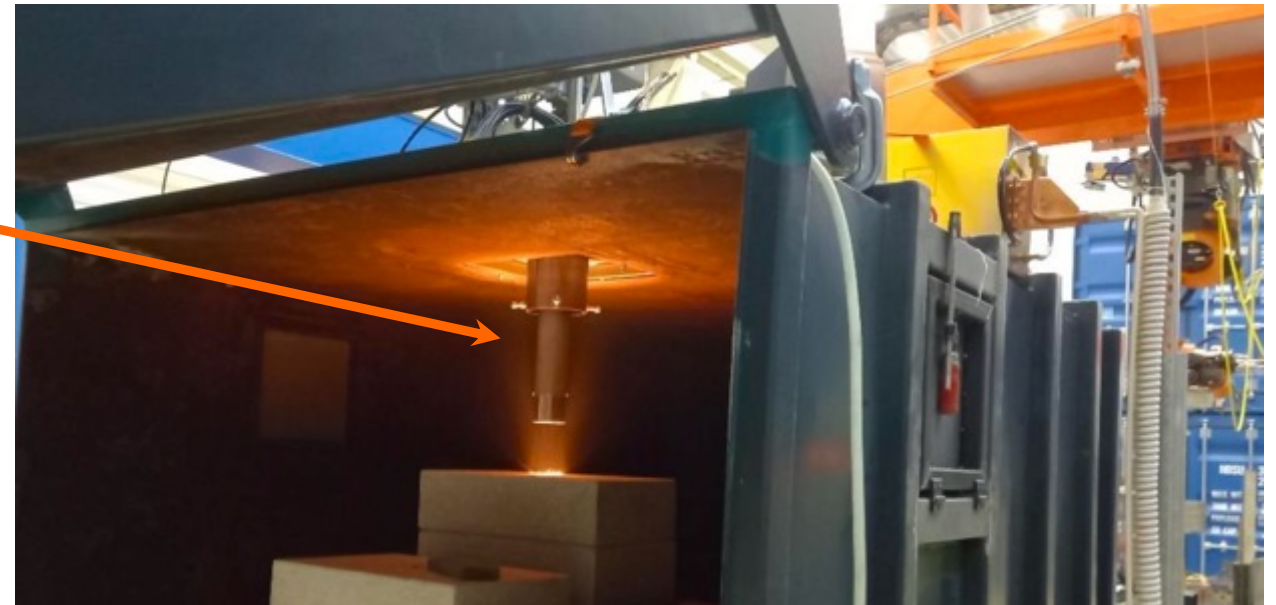
**Drilling string**

**Steel container**



**Rock slabs**

150mm x 300 mm x 500 mm





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# Laser-rock interactions

Laser beam

Laser beam

Laser beam

RFE Exp

Evaporation

Pull-out (Spallation)

Gas assist

Gas assist

5 mm

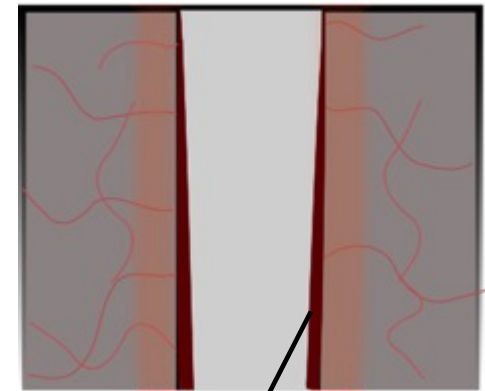
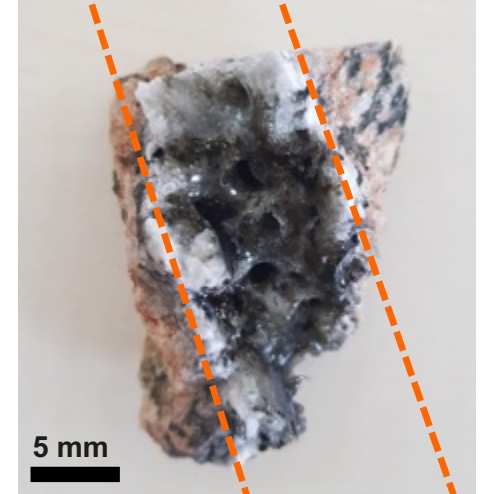
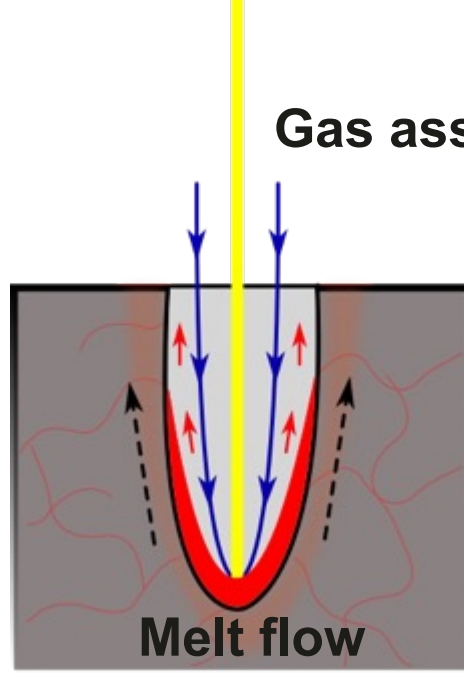
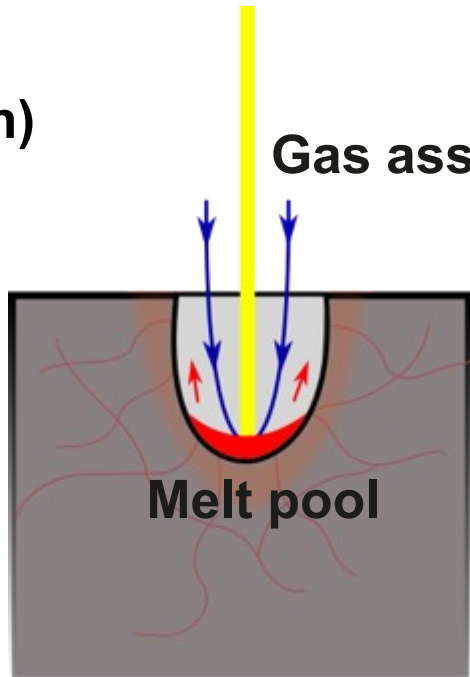
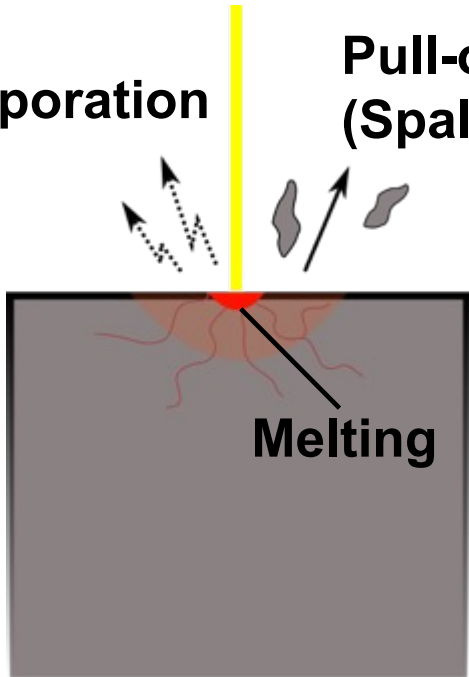
Melting

Melt pool

Melt flow

Verified walls [www.deepu.eu](http://www.deepu.eu)

Based on Li et al. 2015



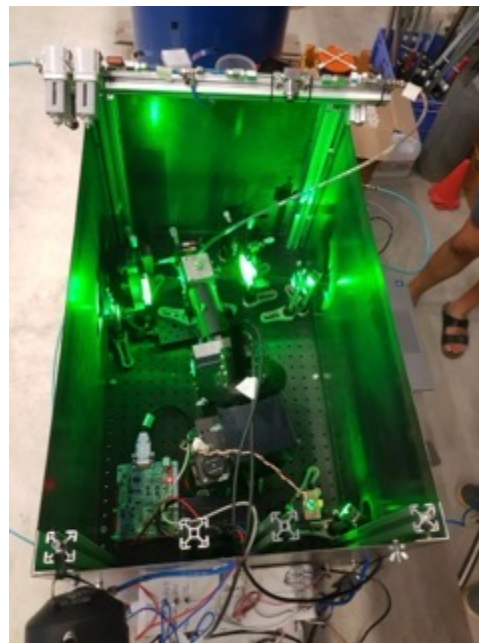
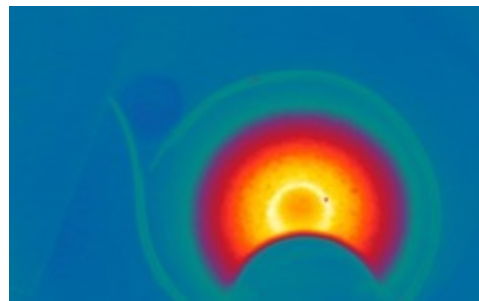




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## Experimental setup

- Fixed position of robotic arm (working distance)
- Drill with and without assistance of room temperature  $N_2$  flux
- New drilling head
- Fixed laser power 30 kW
- Selected lithologies: granite, sandstone, limestone
- Video documentation
- IR video documentation (thermocamera)
- Gas spectrometry

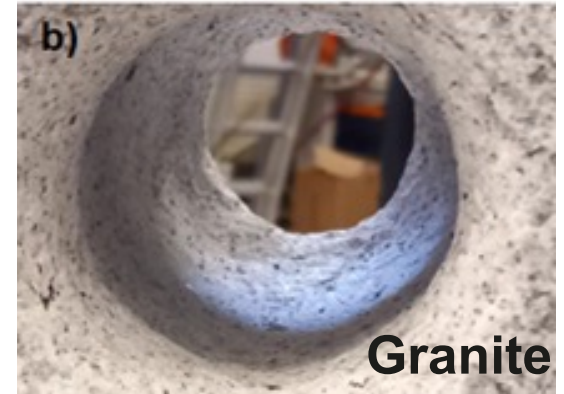




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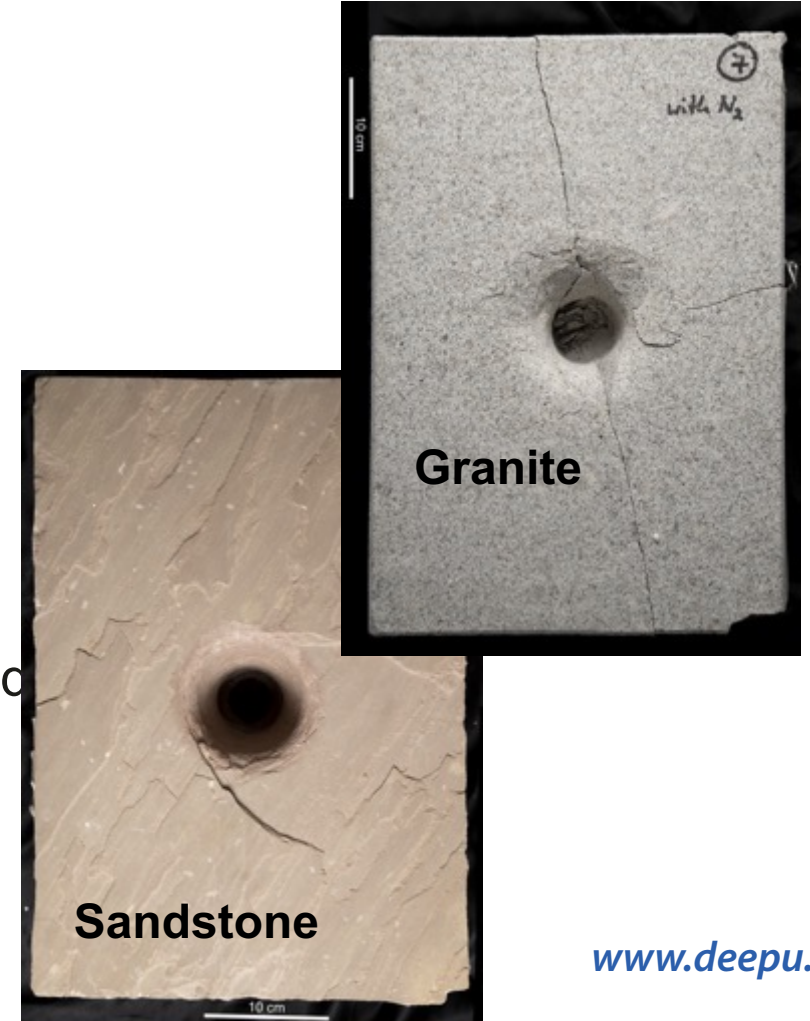
### Results of first test round

- Description of petro-physico-mechanical phenomena; **spallation, melting, evaporation**
- **Formation of the glass** at the bottom of the borehole
- **Successful drills** of selected lithologies
- Diameter of the boreholes up to **18 cm**
- ROP up to **20 m/h**



## Status so far

- **3D Design of drill tower** has been prepared
- Prototype of **drill string is ready** for the tests
- **Drill head** was manufactured, tested and redesigned
- First experimental laser drills **were performed**
- Constant rate of penetration (ROP) **up to 20m**
- All **3 lithologies has been drilled** successfully
- The health and safety standards are being assessed
- The legislative and environmental aspects are being assessed





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# Thank You for Your Attention!

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Check it out! [DeepU.eu](https://www.deepu.eu)

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