Deep U
This research is funded by the European Union
(EIC, Pathfinder Programme, G.A. 101046937)

Deep U-tube heat exchanger breakthrough: combining laser and cryogenic gas for geothermal energy exploitation – **a perspective of laser-rock interactions**

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Wrocław University of Science and Technology

Institute of Geosciences and Earth Resources
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Deep U-tube heat exchanger breakthrough: combining laser and cryogenic gas for geothermal energy exploitation

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

7
Partner organizations

4
Involved countries

36
Months duration
starting on March 1, 2022

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

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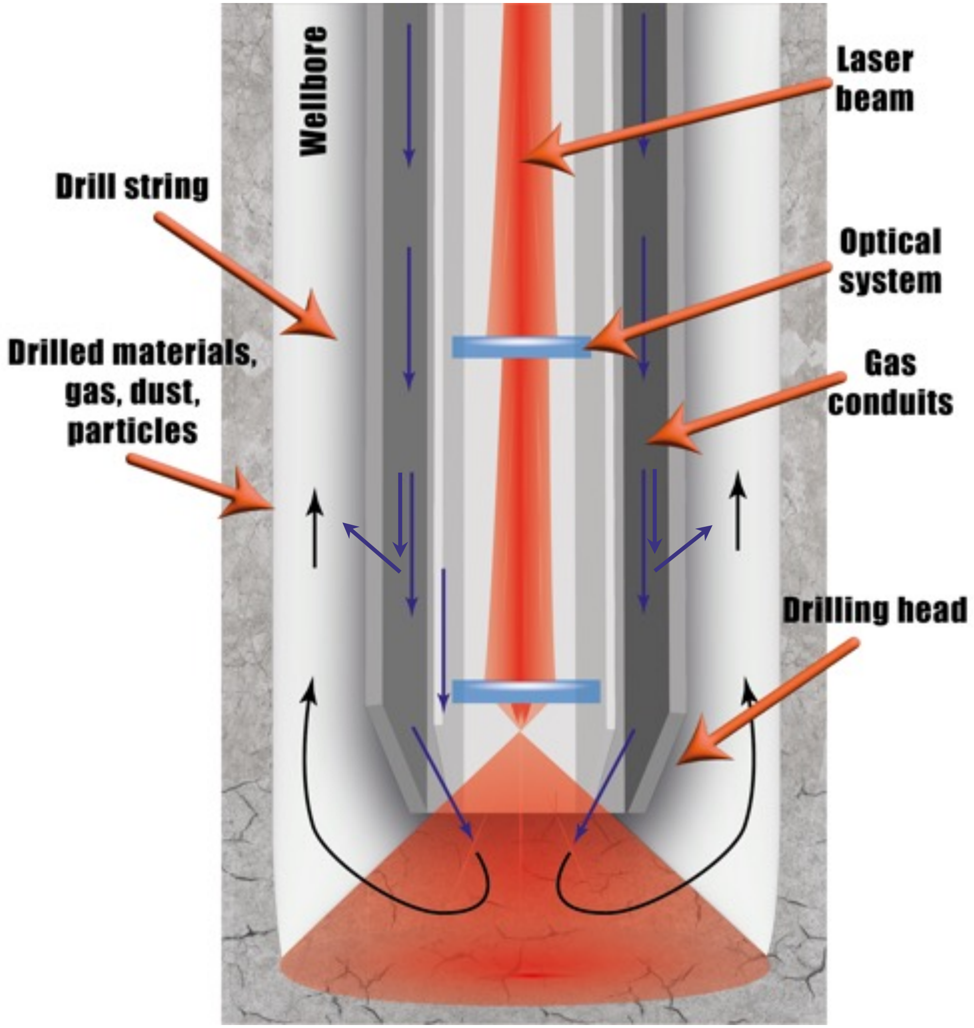
Laser-drilling concept and workflow in the project

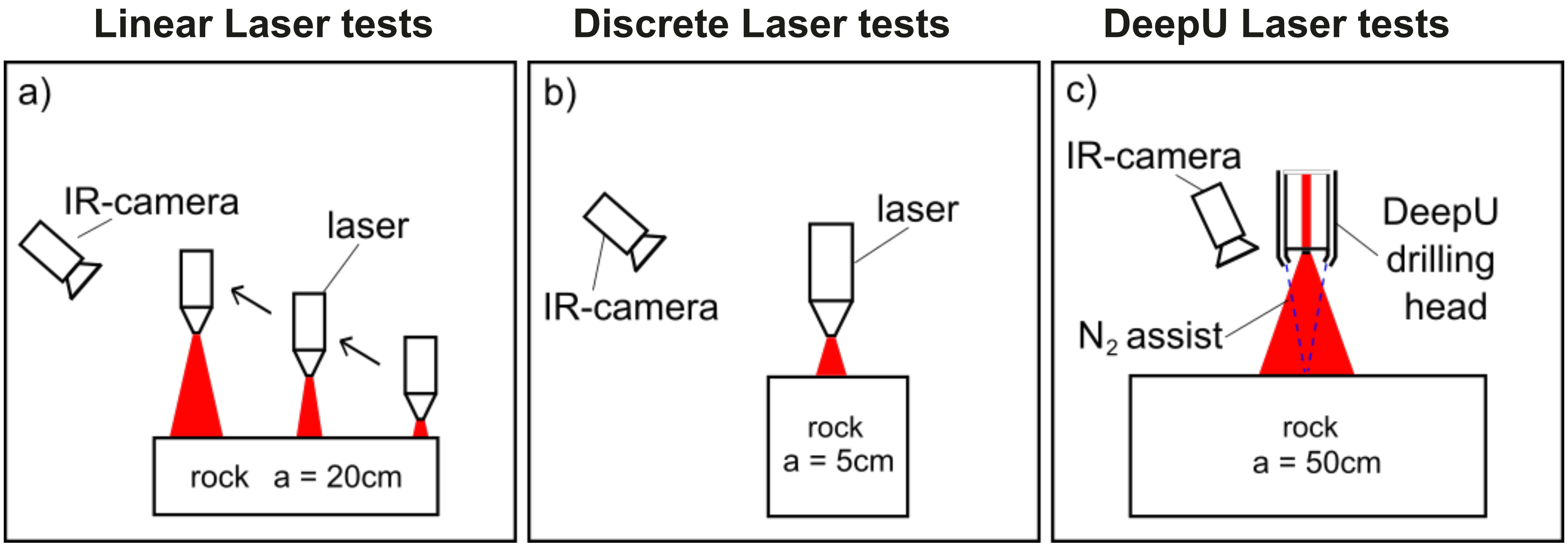


Realized designs:

- Drilling tower
- Drilling string
- Drilling head

Laser-drilling experiments were performed on granite, sandstone and limestone

Experimental setups



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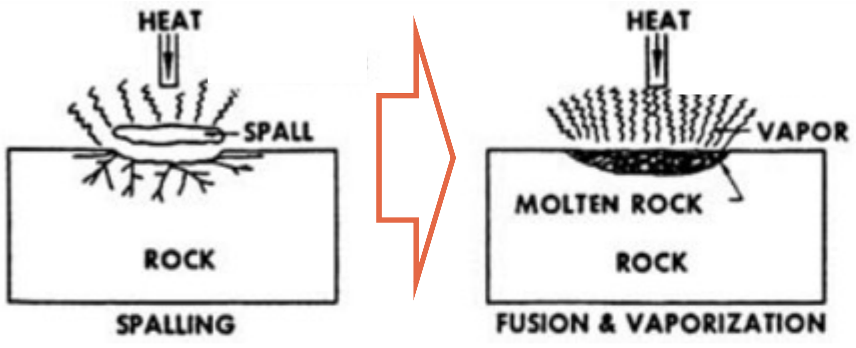
Laser-rock interactions

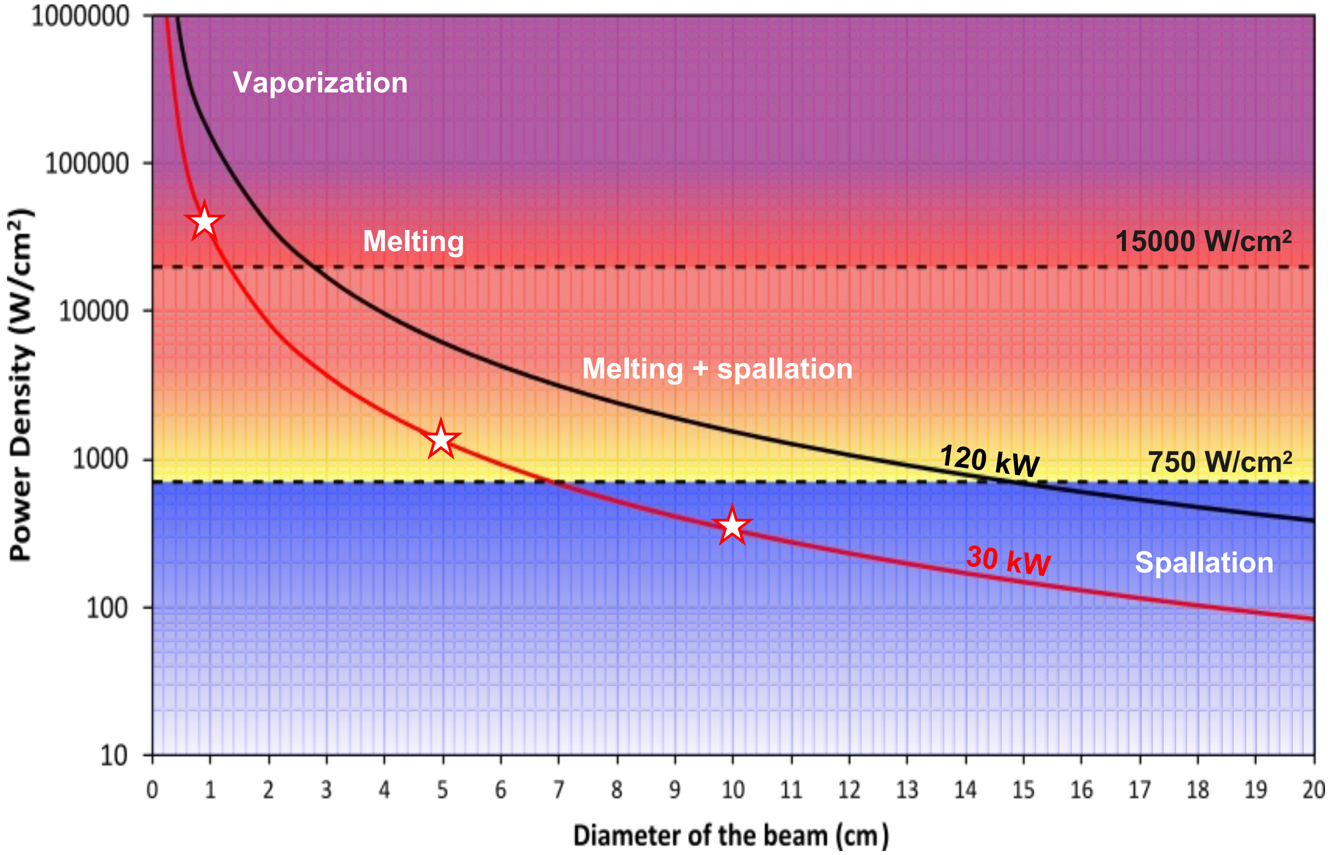
Classification of non contact excavation methods after Mauer 1980



Parameters controlling drilling regime:

- Thermal and physical properties of rock
- Chemical composition of rock
- Irradiation time (s)
- **Power density (W/cm²)**

Laser-rock interactions for granite



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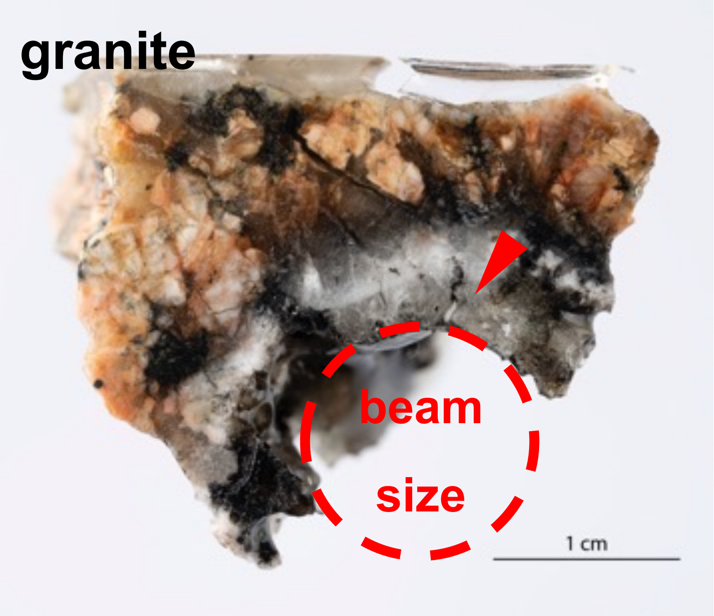
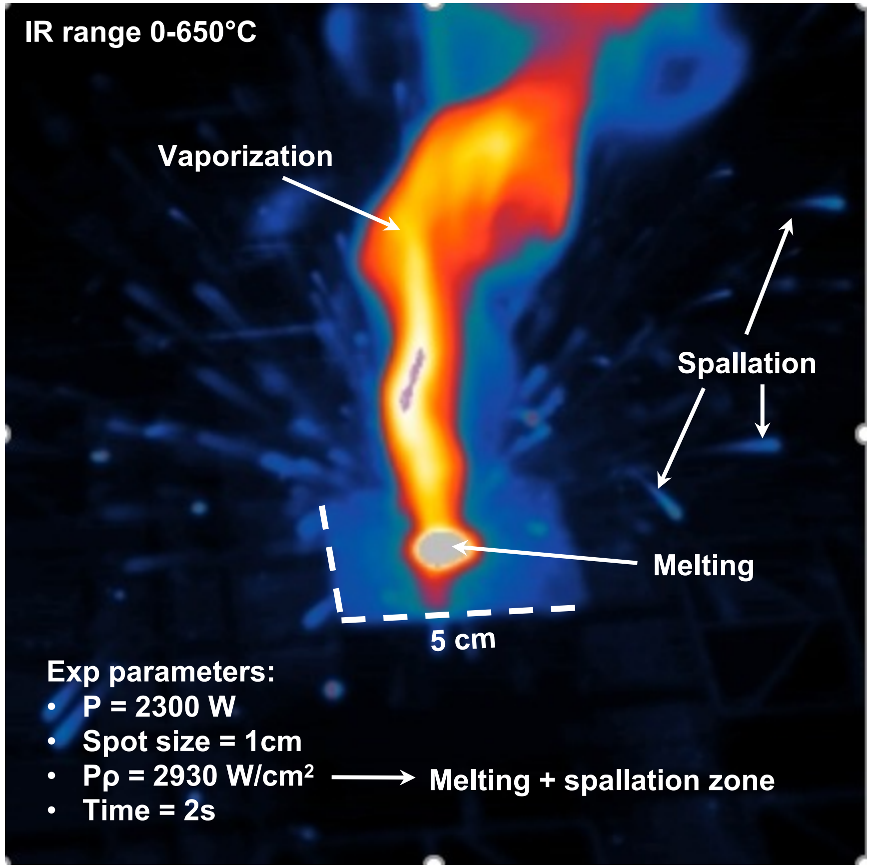
Melting-evaporation laser drilling



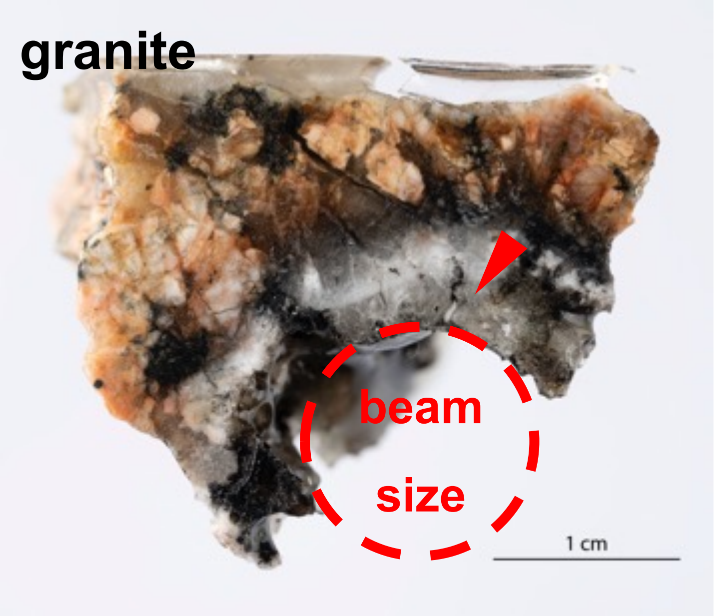
- Small diameter of borehole (<1cm)
- **Vitrified walls**
- Low efficiency of drilling
- High temperature **(>1500°C)**
- Penetration by evaporation

IR image of irradiated granite



Frame 1.32s

Melting-evaporation laser drilling



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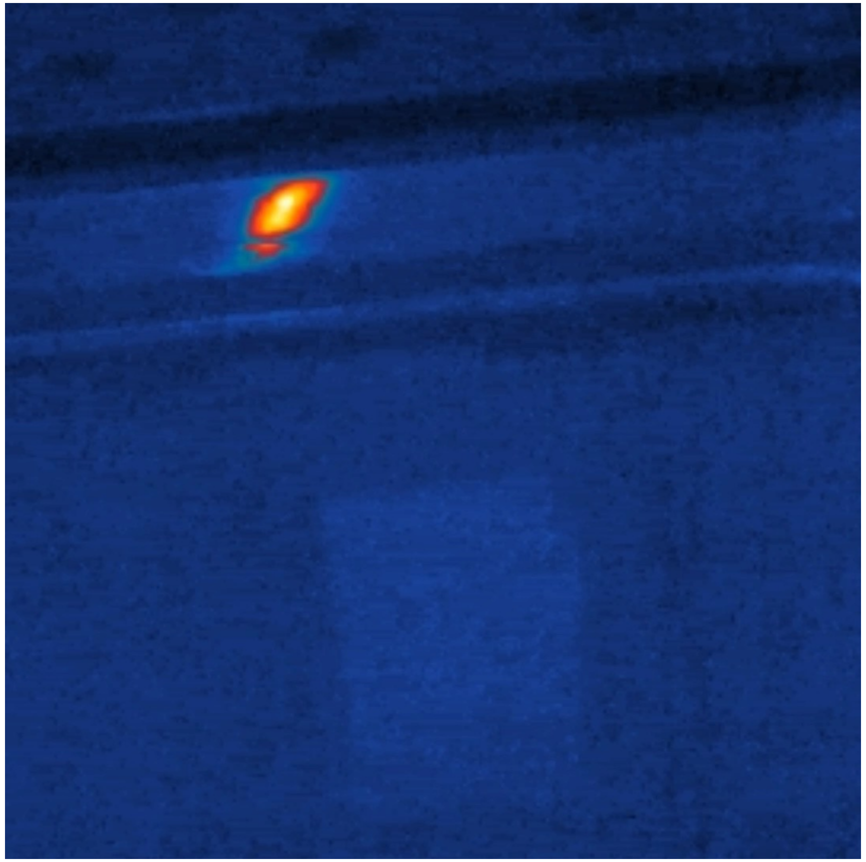

Slow motion 2s

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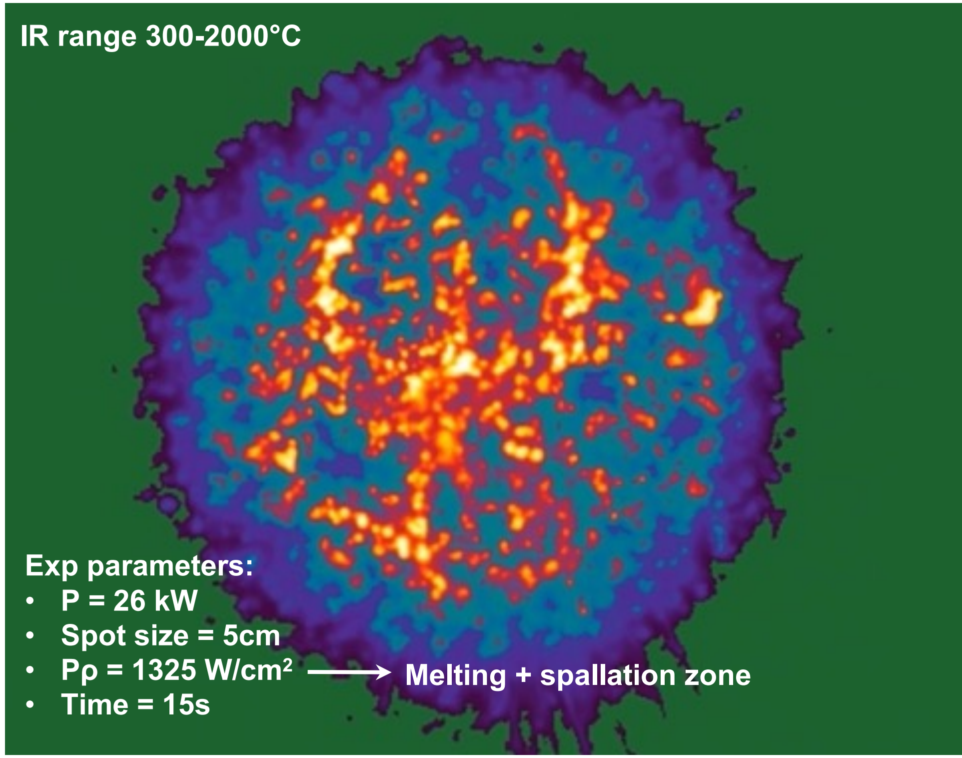
Thermal spallation drilling with N_2 assist

- Large diameter of borehole (>5cm)
- **Purging system necessary (N_2 flux)**
- High efficiency of drilling
- Low temperature **(<700°C)**
- Penetration by spallation



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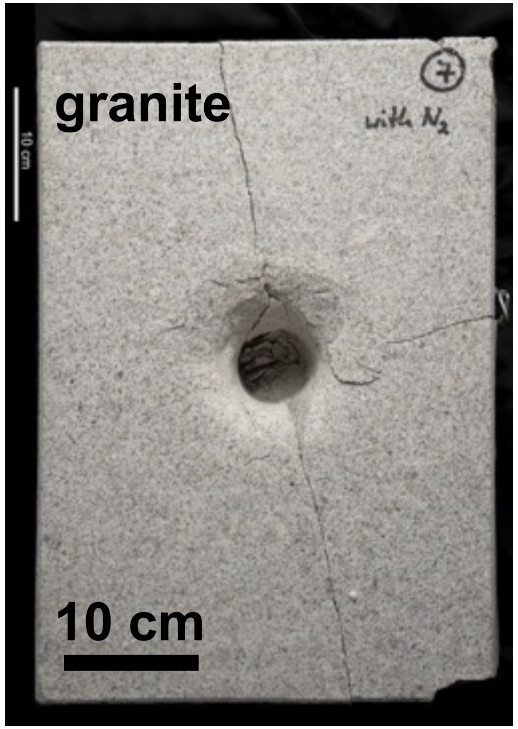
Thermal spallation drilling – DeepU setup



Supported spallation on H_2O saturated rocks

Photogrammetry

Lithology	ROP (m/h)	Specific Energy (kJ/cm³)
granite	4,1 - 15,2	6,35
sandstone	5,9 - 25,2	2,54
limestone	0,4 - 2,0	**8181,82**
saturated limestone	3,9 - 5,1	8,20

melting

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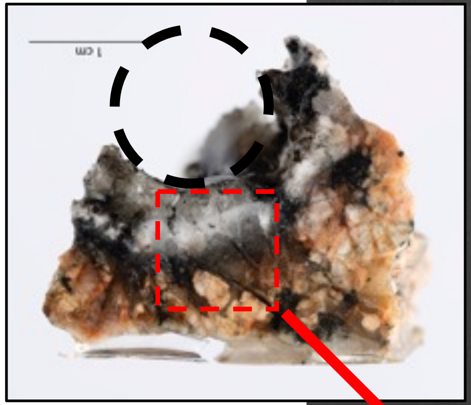
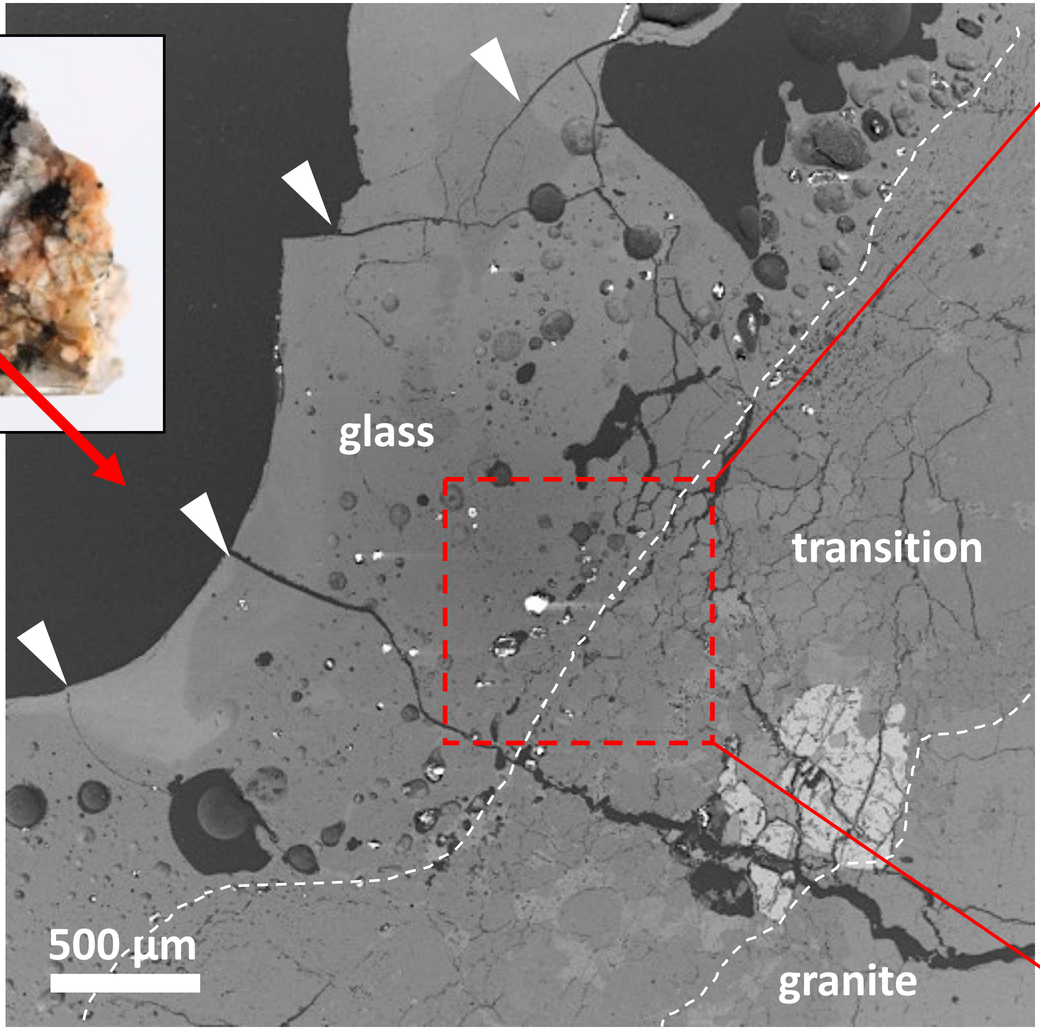
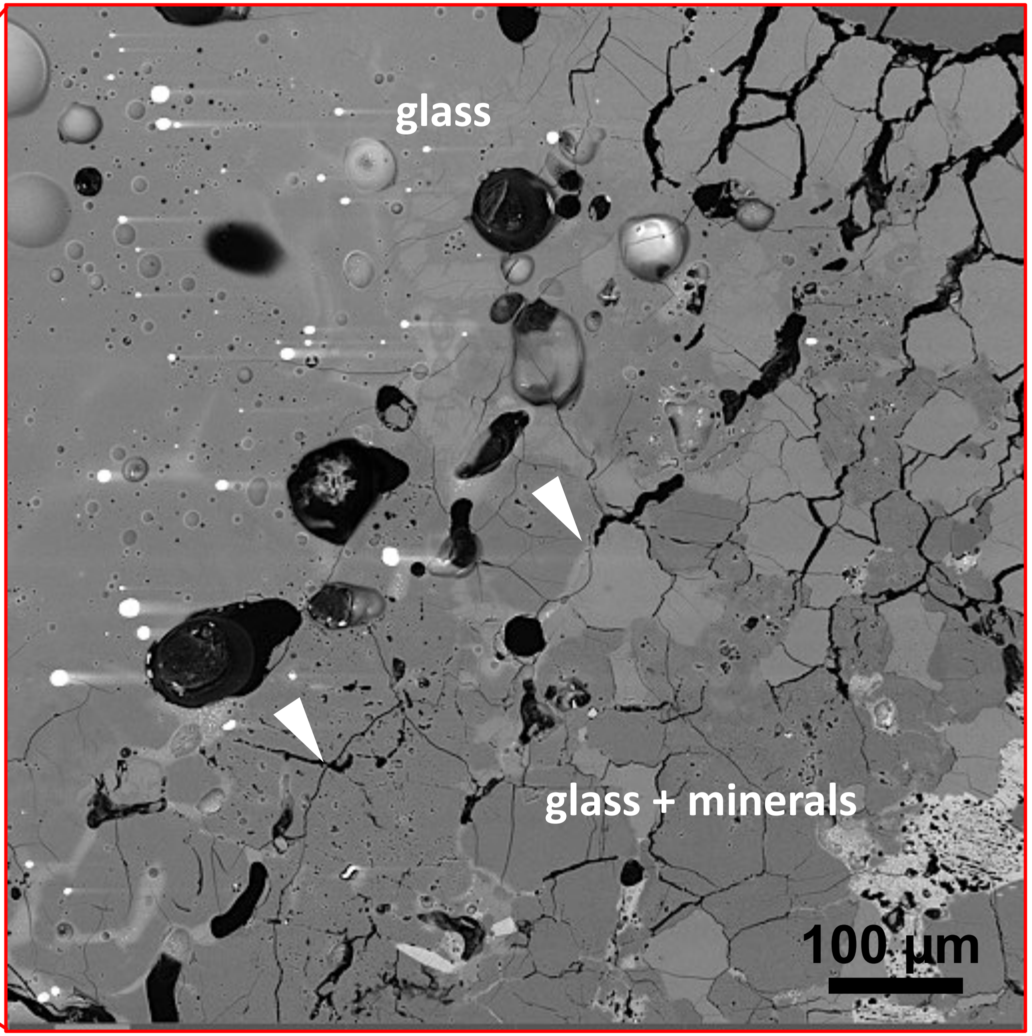
Laser-drilled rocks – melting-evaporation

BSE images of boreholes







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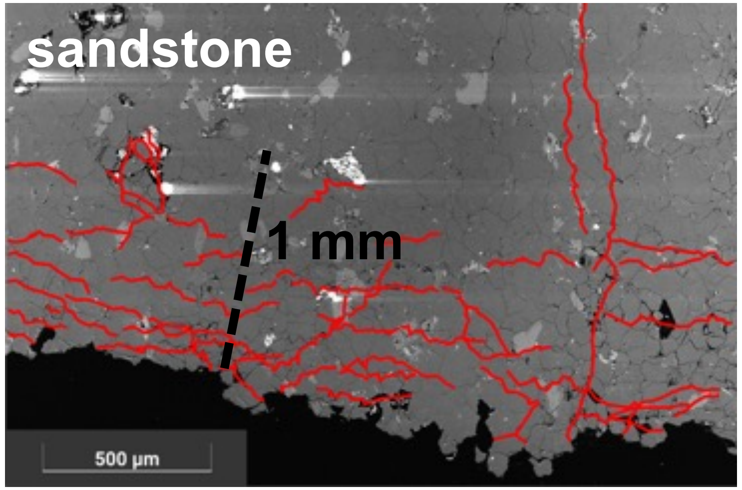
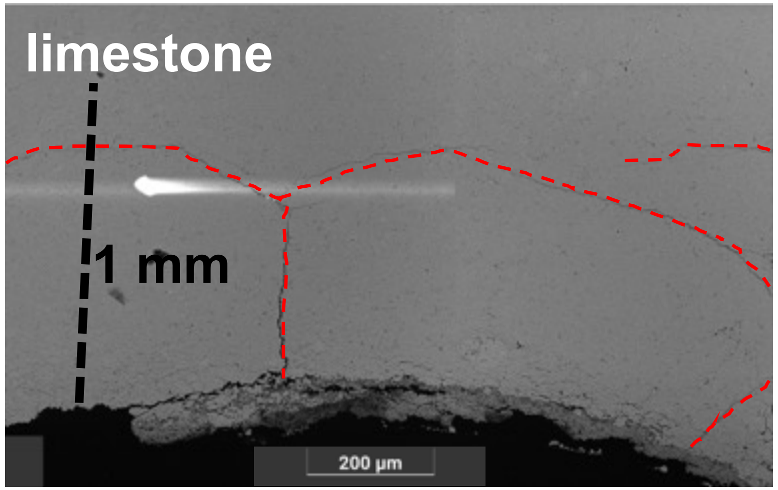
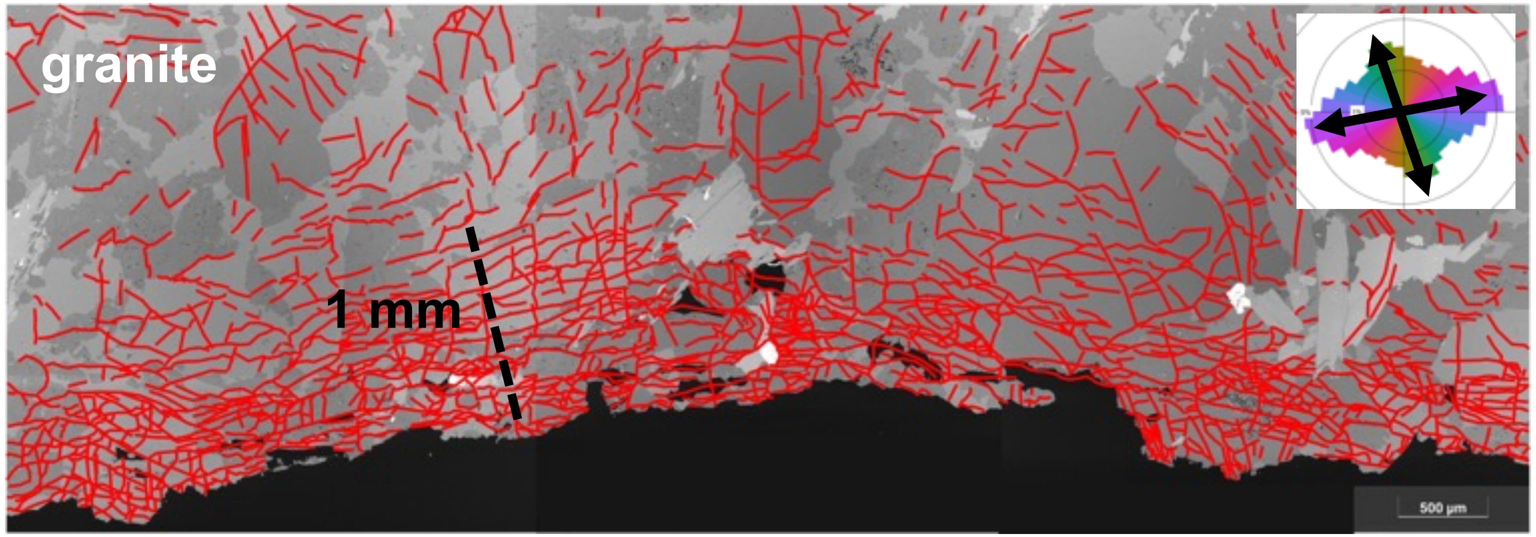
Laser-drilled rocks – thermal spallation

BSE images of boreholes







Thermally spalled rocks are affected up to 1 mm in depth – shearing fractures and tensile fractures

Conclusions

- Melting-evaporation laser drilling is possible but inefficient
- Thermal spallation laser drilling is possible and efficient for wide range of lithologies
- Thermal spallation affects only the surface of the rock, < 1mm
- Vitrified walls of borehole formed in melting process are fractured and permeable

Drilling with laser is possible and the process will be optimized and better understood in next years

Thank You for Your Attention!

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