

DeepU



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

# Deep laser drilling for heat exchangers: the DeepU project concept and results

Project start date: March 1 2022

Project duration: 44 months

Hop-on extension: July 1 2023

Coordinator Ing. **Luc Pockelé** (RED Srl)

[luc.pockele@red-srl.com](mailto:luc.pockele@red-srl.com)



UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA



Geoserv

Prevent  
CO<sub>2</sub>



Wrocław University  
of Science and Technology

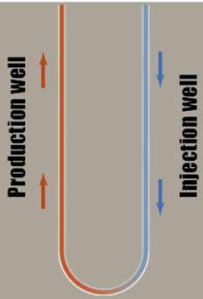




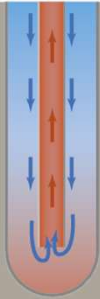
Deep U-tube heat exchanger breakthrough: combining laser and cryogenic gas for geothermal energy exploitation

# Deep closed loops

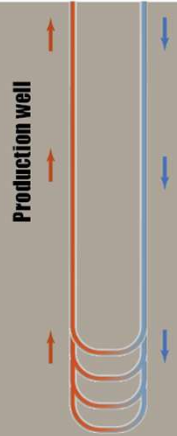
**U-tube or Double Legged design**



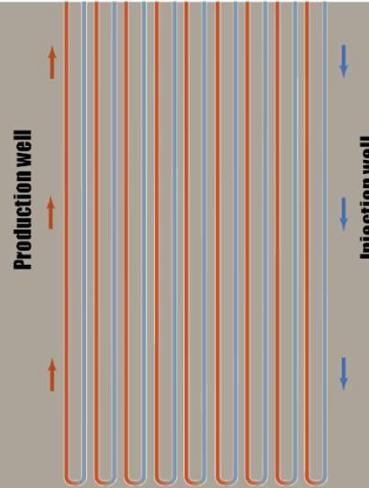
**Coaxial tube design**



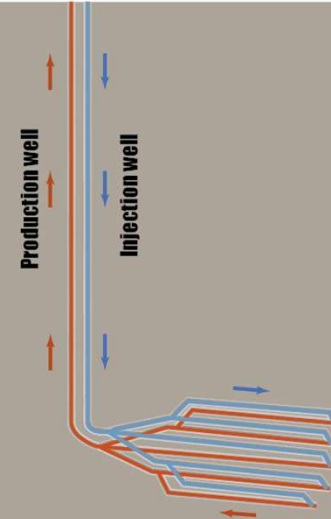
**Helical (Spiral) design**



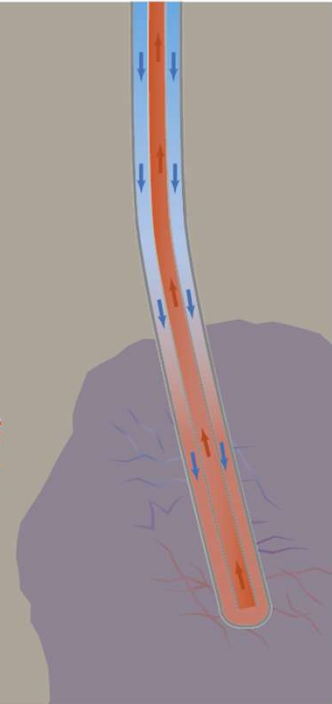
**Multi-legged designs (Borehole arrays)**



**Horizontal loop – Radiator design**

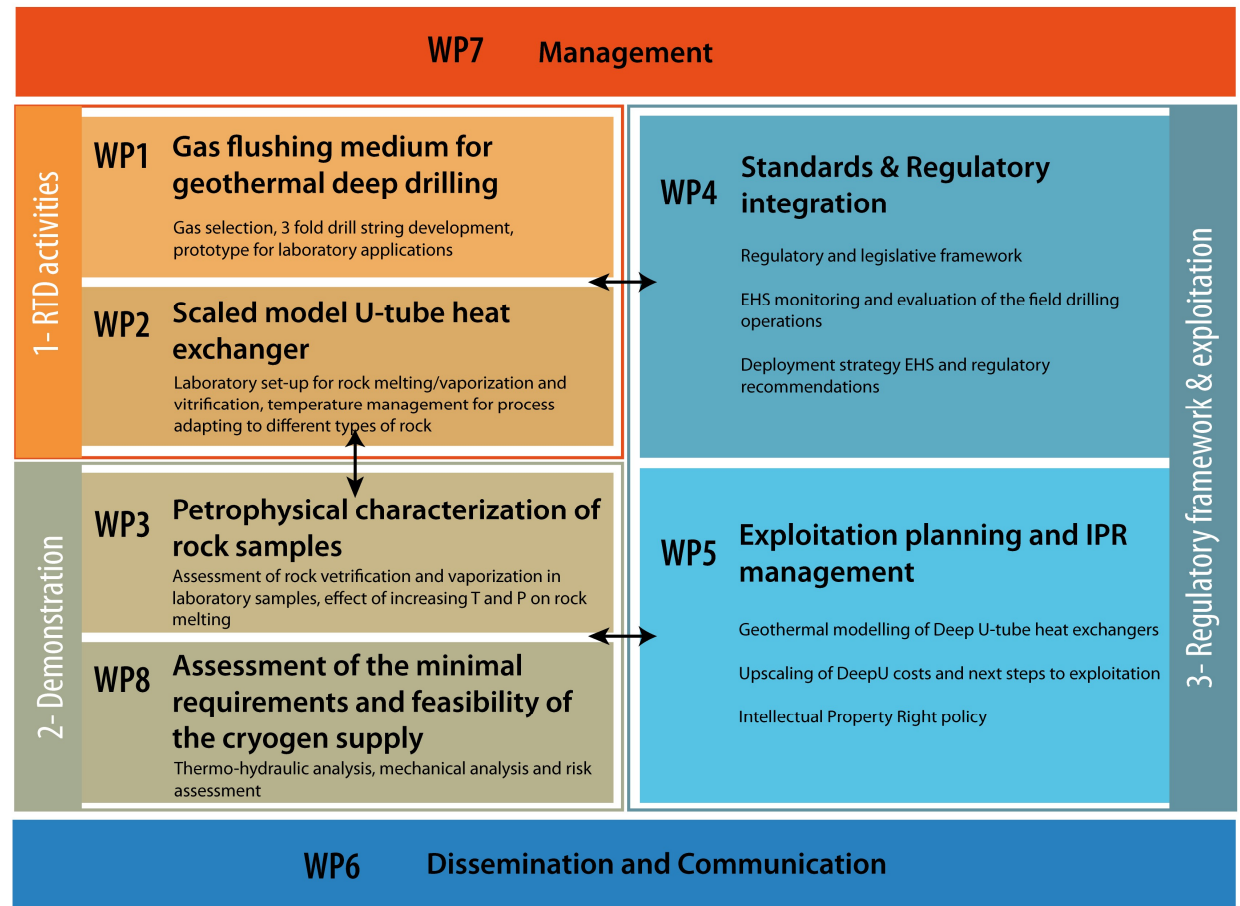


**Fracture based geometries (EGS)**



# Goals of DeepU project

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



# A new innovative drilling technology

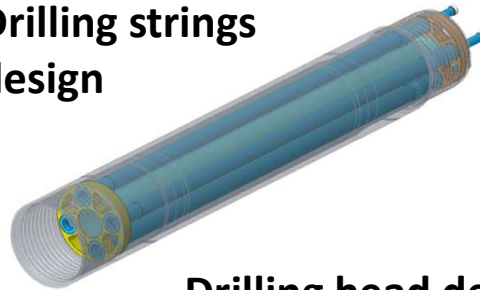
A laser propulsion drilling head is combined with **cryogenic gas flushing**, cooling the laser drill head, borehole walls and transport the cuttings

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

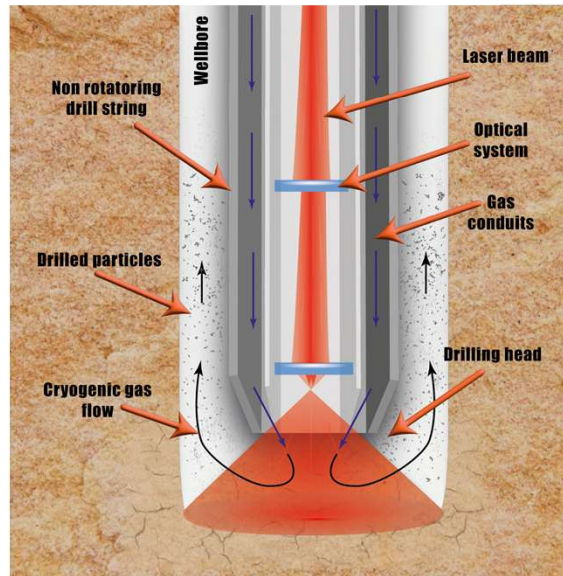
If a glazed layer is formed on the borehole walls, the borehole is physically isolated from the surrounding formations without requiring further casing activities.

**Reduced time and casing cost**

**Drilling strings design**



**Drilling head design**



**Laser Drilling Laboratory Tests**

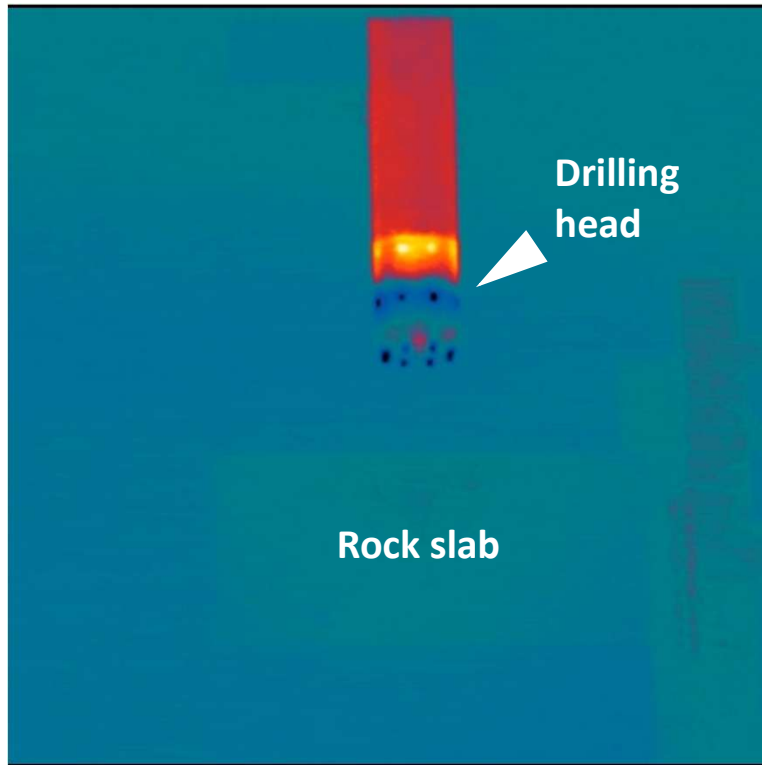


**For more information about laser drilling technique see the next presentation:**

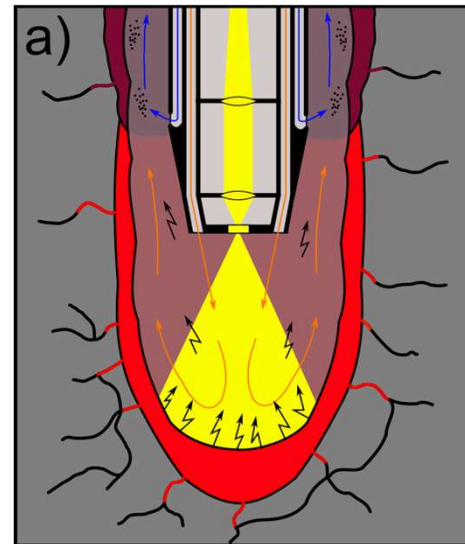
**16:40** Advancements in the development of novel laser drilling technology for geothermal energy exploitation (DeepU)

# Laser drilling experiments

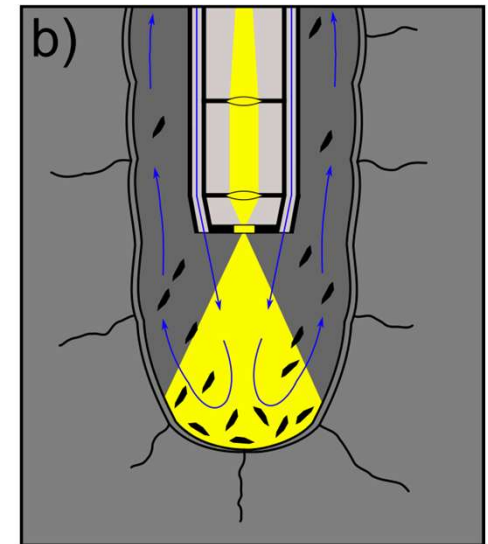
IR video of laser drilling test



Two laser rock removal concepts developed by DeepU



Melting-vaporization drilling



Thermal spallation drilling

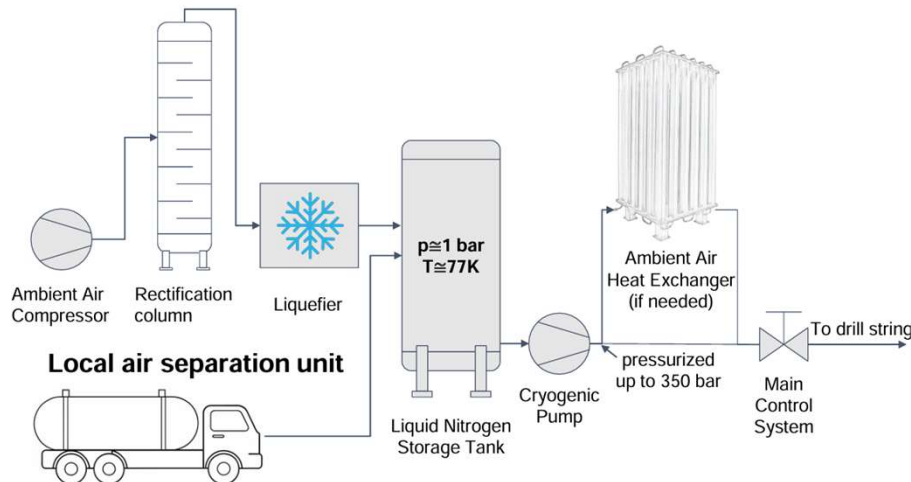
# Drilling string and pneumatic transport of drills

## Pneumatic Transport Tests with Cryogenic Gas In Laboratory

### Cryogenic gas flow experiments:

- Cryogen flow analysis modelling
- System construction options for cryogen transport
- Assessment of minimal mechanical requirements for the cryogenic system
- Verification, validation and analysis of one prototype drill string

### Cryogenic supply for geothermal drilling





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

# Costs of drilling operations

## Drilling cost estimator:

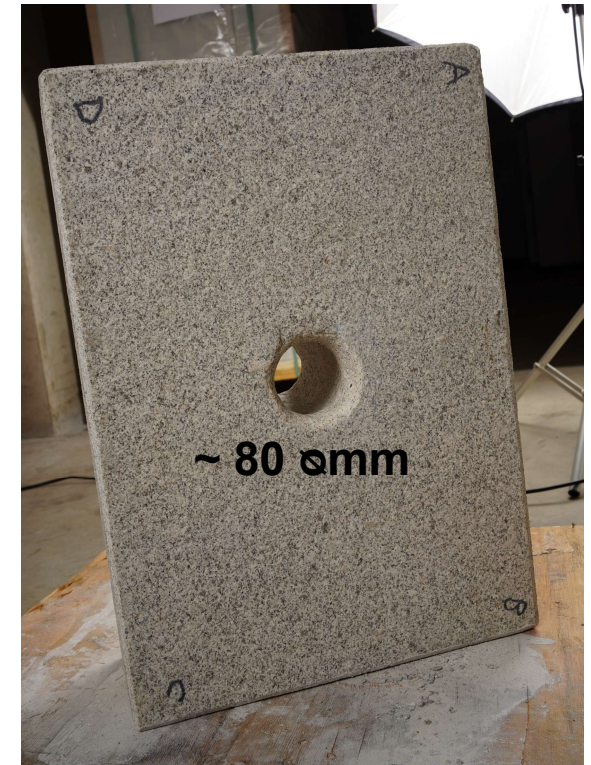
- Spreadsheet based tool to compare State-of-the-Art and DeepU technology drilling costs
- Cost reduction potential in the order of 10 – 15 % without taking vitrification into account and assuming local production or 60 % reduction of supply cost of liquid nitrogen

COMPLETION		Completion PH		Completion Sub-total-days		SoA			Days	€		DeepU		Vertical	Days	€			
COMPLETION Phase-Sub-total		Completion PH		Phase-Sub-total		SoA				1,790,000.00 €		DeepU				1,790,000.00 €			
COMPLETION Single-Sub-total		Completion PH		Single-Sub-total		SoA	number of branches	Vertical	2.00	895,000.00 €		SoA	number of branches	Vertical	2.00	895,000.00 €			
Wireline logging Suite	I	Completion PH	Completion	Service	Day rate	SoA	SoA Wireline logging Suite	75,000.00 €	3.00	Days	225,000.00 €	Based on SLB's Logging Costs - 3 site visits, 5 Sonde Runs	SoA	SoA Wireline logging Suite	75,000.00 €	3.00	Days	225,000.00 €	
Pump Testing	I	Completion PH	Completion	Service	From table	SoA	SoA Pump Testing	300,000.00 €	1.00	Set	300,000.00 €	(allow 10 days to rig time)	SoA	SoA Pump Testing	300,000.00 €	1.00	Set	300,000.00 €	
Stimulation	I	Completion PH	Completion	Service	From table	SoA	SoA Stimulation	300,000.00 €	1.00	Set	300,000.00 €	(allow 10 days to rig time)	SoA	SoA Stimulation	300,000.00 €	1.00	Set	300,000.00 €	
Wellhead equipment	I	Completion PH	Completion	Material	From table	SoA	SoA Wellhead equipment	50,000.00 €	1.00	#	50,000.00 €	Two wells - 28K each in Finland - cheaper at UDCP	SoA	SoA Wellhead equipment	50,000.00 €	1.00	#	50,000.00 €	Verify if a customized wellhead is necessary
Rig Skid from completed Well to new Well	I	Completion PH	Site preparation	Service	From table	SoA	SoA Rig Skid from completed Well to new Well	20,000.00 €	1.00	Days	20,000.00 €		SoA	SoA Rig Skid from completed Well to new Well	20,000.00 €	1.00	Days	20,000.00 €	
GRAND TOTAL										80,206,737.97 €						70,997,684.02 €			
Contingency						SoA			15.00 %	12,031,010.70 €		DeepU		15.00 %	10,649,652.60 €				
Total Drilling Operations with Contingency						DeepU				92,237,748.67 €		DeepU				81,647,336.63 €			
Specific drilling cost						SoA	SoA Specific drilling cost		1/m	1,487.711		DeepU	DeepU Specific drilling cost		1/m	1,316.891			

## Achievements

- **Feasibility** of laser drilling with cryogenic gas **demonstrated** in laboratory
- **Understanding reached** on **interactions laser/rock** in function of rock type and applied power
- Design of **drill head** completed and **proven** in laboratory
- **Mechanical design of drill string completed** and being tested/validated in laboratory
- **Process simulation model** (drill string, cryogenic gas flow, pneumatic transport) **completed** and pneumatic transport under validation in laboratory

Laser drilled borehole



DeepU



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

Thank You for Your attention!

Contact: [luc.pockele@red-srl.com](mailto:luc.pockele@red-srl.com)



UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA



*This research is funded by the European Union (G.A. 101046937). However, the views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.*

Geoserv

Prevent  
CO<sub>2</sub>



Wrocław University  
of Science and Technology

