

Novel Geothermal Drilling for Developing Deep Heat Exchangers: the DeepU Project

Luc Pockelé

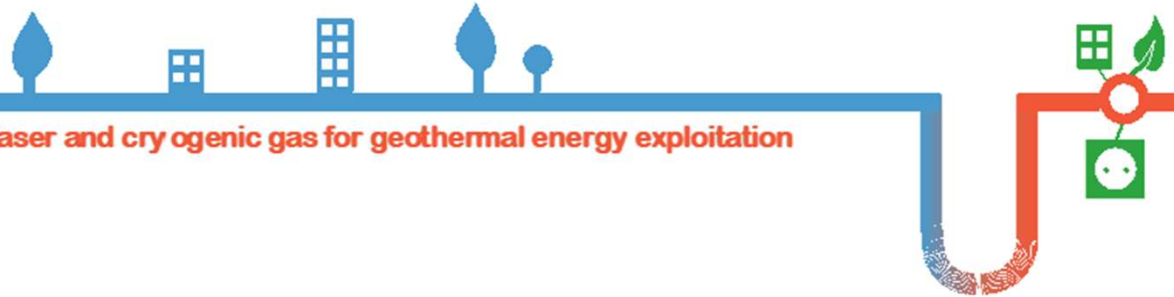


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Deep U-tube heat exchanger breakthrough: combining laser and cryogenic gas for geothermal energy exploitation

Project start date: March 1 2022
Project duration: 44 months

Coordinator
Luc Pockelé (RED Srl)



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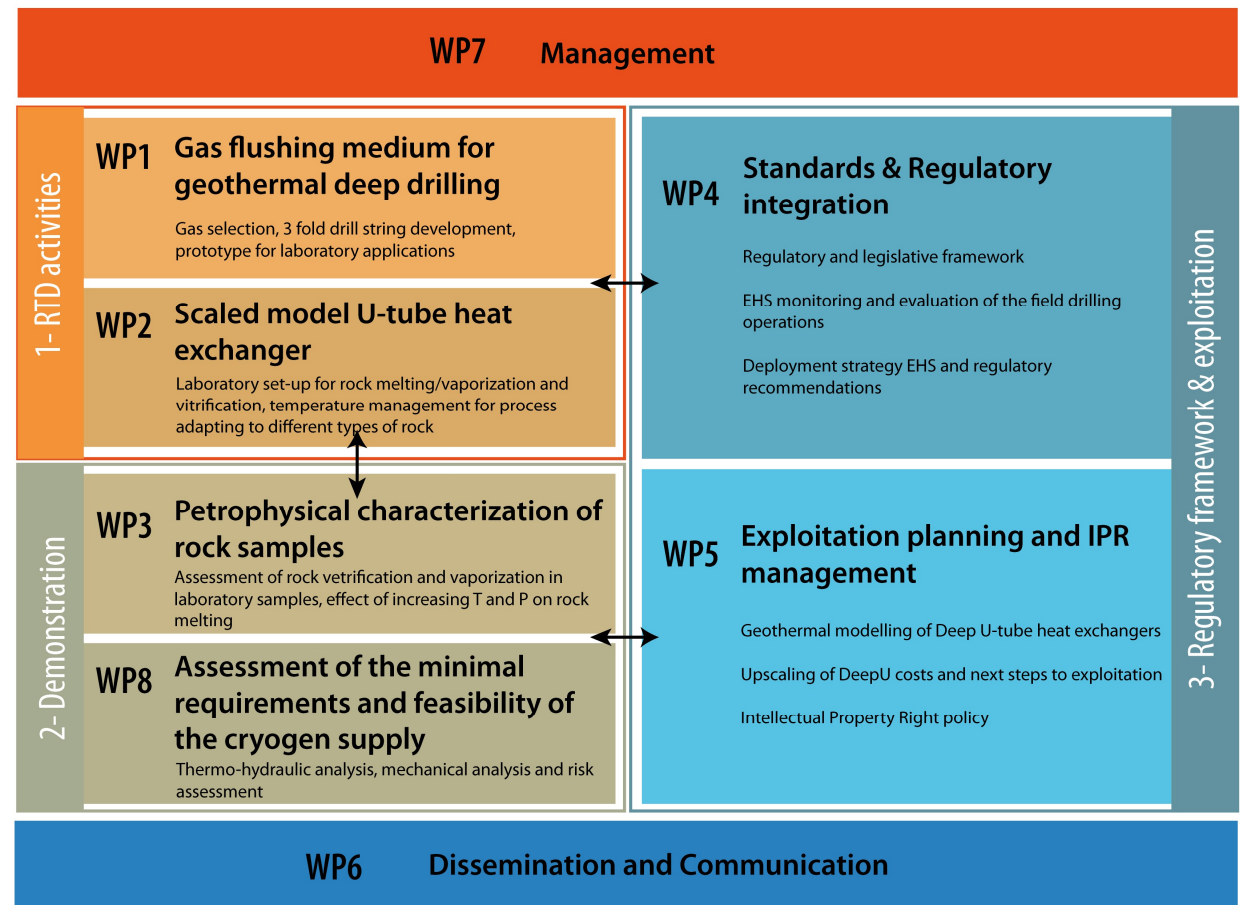
Wrocław University
of Science and Technology

Geoserv

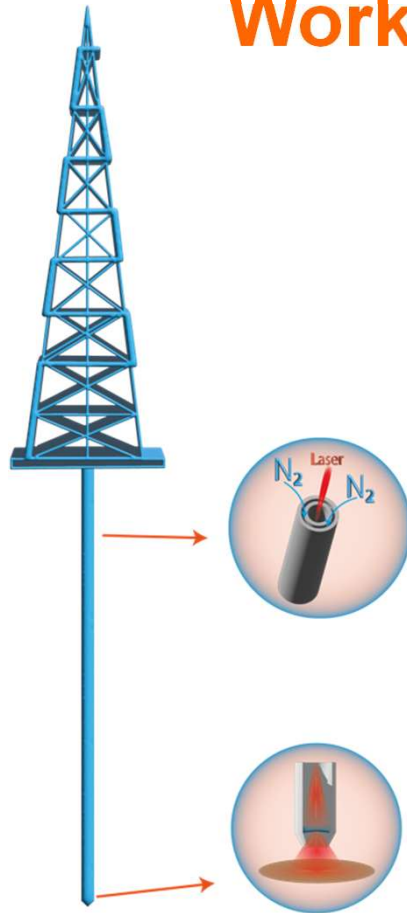


Goals of DeepU project

- Developing a new **laser drilling technology**
- Extracting energy from **deep (>6 km)** U-shaped or other closed-loops
- **Reducing the costs** of well drilling
- Making **geothermal energy** accessible anywhere



Workflow in DeepU Project



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

- Laser driven drill bit
- Gas flushing system and drill string design
- Scaled model of U-tube heat exchanger
- Petrophysical characterization of drilling process
- Standards and regulatory integration
- Exploitation planning and IPR management
- Communication
- Management

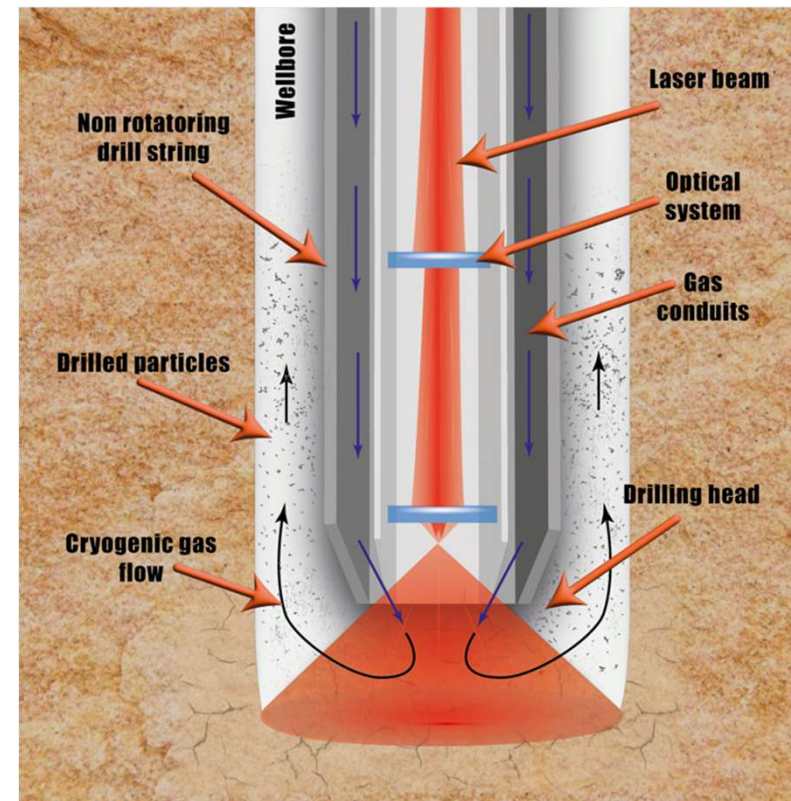
INNOVATIVE DRILLING TECHNOLOGY

A **laser** propulsion drilling method is combined with **cryogenic gaseous flushing** for cooling the laser drill head, borehole walls and bring the cuttings to the surface

Improved ROP
Reduced drilling time and cost

In case 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



Laser drilling laboratory tests



Robotic arm

Optical system

Drilling string

Steel container



Rock slabs

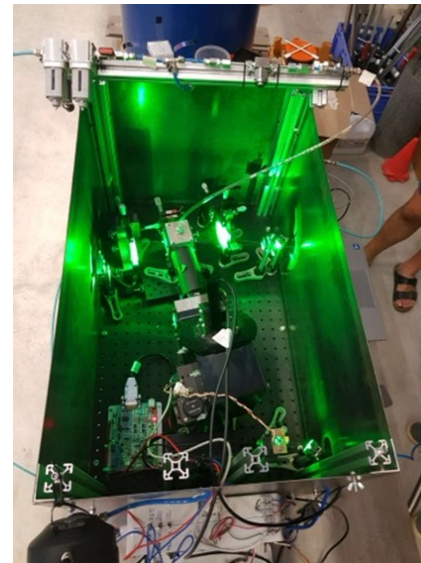
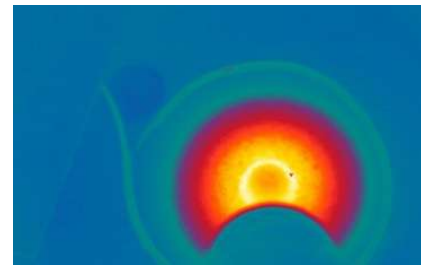
150mm x 300 mm x 500 mm



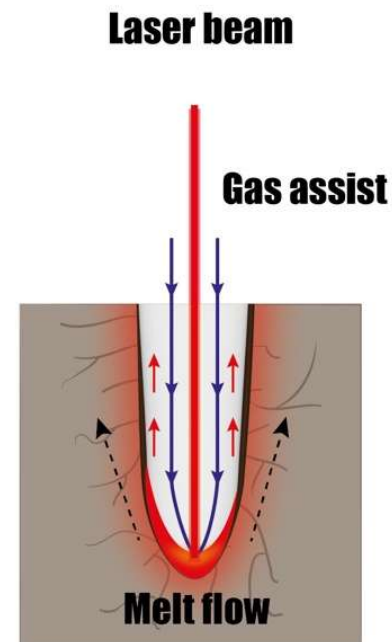
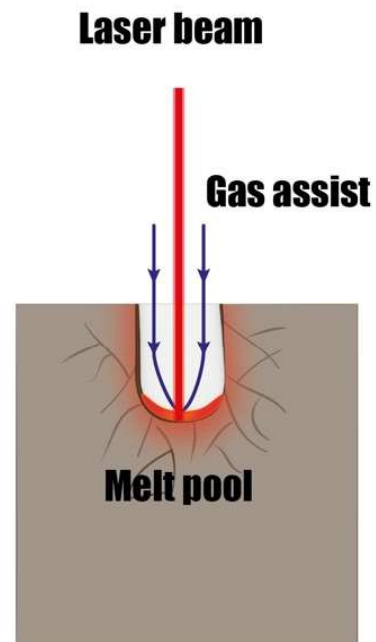
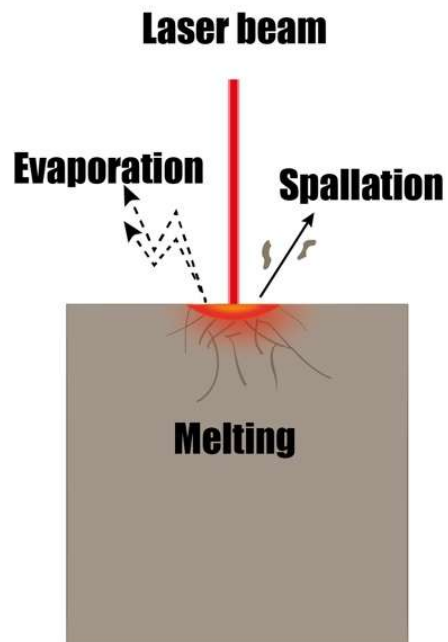


Experimental setup

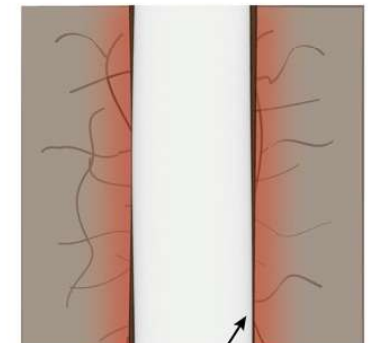
- Fixed position of robotic arm (working distance)
- Drill with and without assistance of room temperature N_2 flux
- Testing drilling heads
- Laser power: 6-30 kW
- Beam diameter: 5-20 cm
- Selected lithologies: granite, sandstone, limestone
- Video documentation
- IR video documentation (thermocamera)
- Gas spectrometry



Laser-rock interactions



RFE Exp

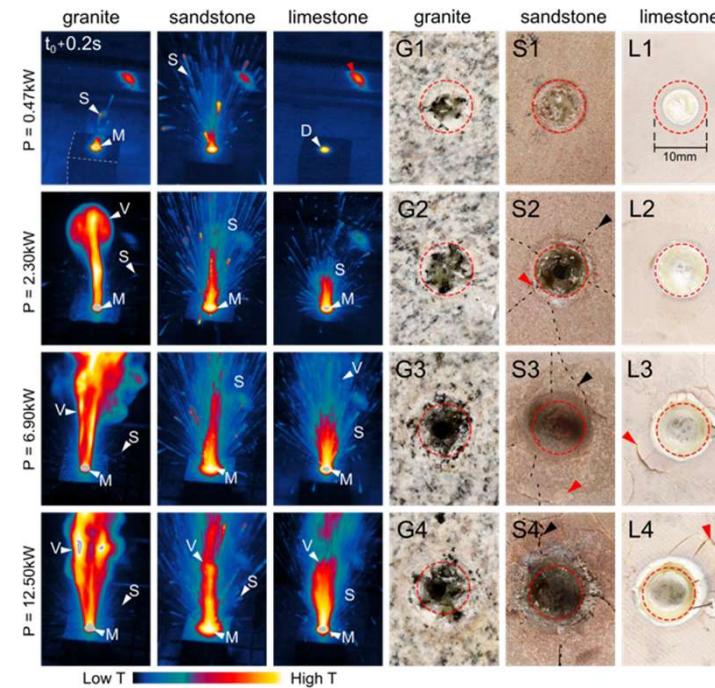
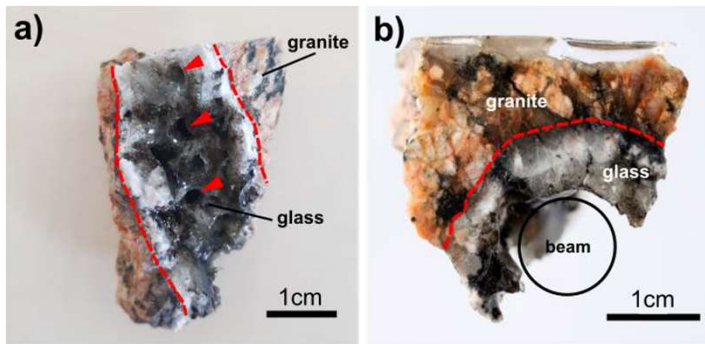


Vitrified walls

Based on Li et al. 2015

Results of the lab tests

- Description of petro-physico-mechanical phenomena; **spallation, melting, evaporation**
- **Formation of glass layer** (1-5 mm)
- **Successful drills** of selected lithologies
- ROP up to **25 m/h**



IR images and
pictures of
crater from drill
head tests



Thermally spalled borehole

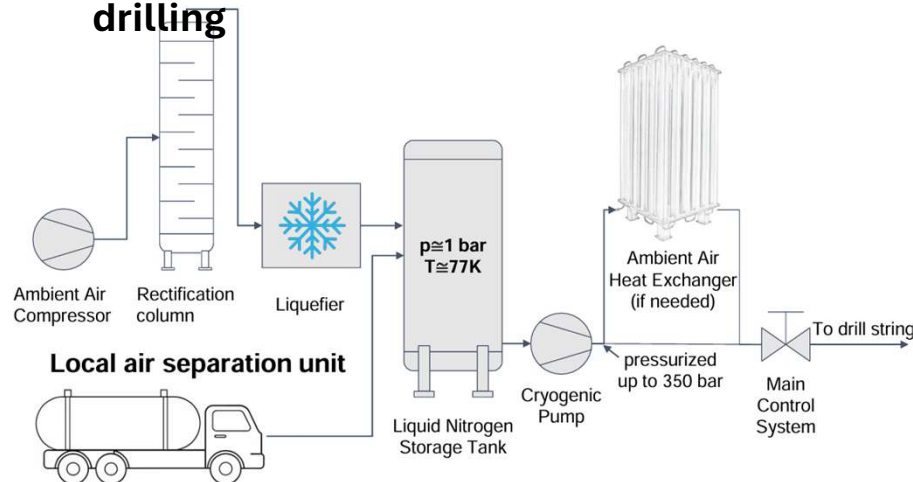
Drilling string and pneumatic transport of cuttings

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





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Costs of drilling operations

Drilling cost estimator:

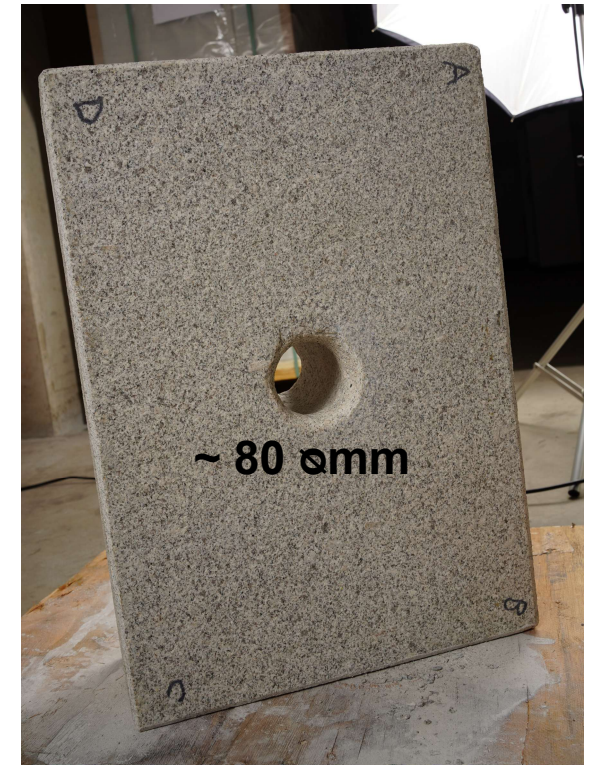
- Spreadsheet based tool to compare State-of-the-Art and DeepU technology drilling costs
- Cost reduction potential in the order of 10 – 15 % without taking vitrification into account and assuming local production or 60 % reduction of supply cost of liquid nitrogen

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 - 20K each in Finland - cheaper at UOOP	SoA	SoA Wellhead equipment	50,000.00 €	1.00	#	50,000.00 €
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						SoA					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		litm		1,487.711		DeepU	DeepU Specific drilling cost		litm		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 validated in laboratory
- **Process simulation model** (drill string, cryogenic gas flow, pneumatic transport) **completed**
- **Pneumatic transport** validated in laboratory

Laser drilled borehole





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Thank You for Your Attention

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Check it out!

www.deepu.eu

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