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NEWSLETTER #1

May 2023

Come to hear about DeepU

15-17 September 2023 — **World Geothermal Conference,** Beijing, China

19-21 September 2023 — **The Geoscience paradigma: resources, risk and future perspectives,** Potenza, Italy

Welcome to the first issue of the DeepU Project Newsletter

You will read the central concept behind DeepU and its main objectives and goals here. DeepU is a fantastic opportunity for designing and developing disruptive drilling technology to overcome the main obstacles to producing energy from deep closed-loop heat exchangers.

By developing a fast, effective and efficient drilling technology, DeepU will be a powerful engine for distributed geothermal production and economic growth. The main advantages of geothermal energy are decarbonisation, stable, base-load, but also flexible production, and will be affordable everywhere, advancing in the European Green Deal actions toward energy security and the fight against the climate crisis.

We have completed the first year of activities. The project started in March 2022 by meeting and sharing competencies, detailed planning, and adopting a multidisciplinary approach. This first year has seen different analyses for investigating various materials, ideas, and designs. A preparatory year: the project is approaching its focus now, and we will be ready to inform you of the interim and final results.
From now on, we will publish the Newsletter twice a year, and you will find all published issues on our website.

Stay tuned and happy reading!

Eloisa Di Sipio, University of Padua, Italy
DeepU Project Coordinator

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DeepU storyline

Once upon a time, the traditional deep geothermal drilling methods strongly constrained the economic viability of deep underground heat exchangers, as 55% of the total project costs were spent on well drilling and completion.

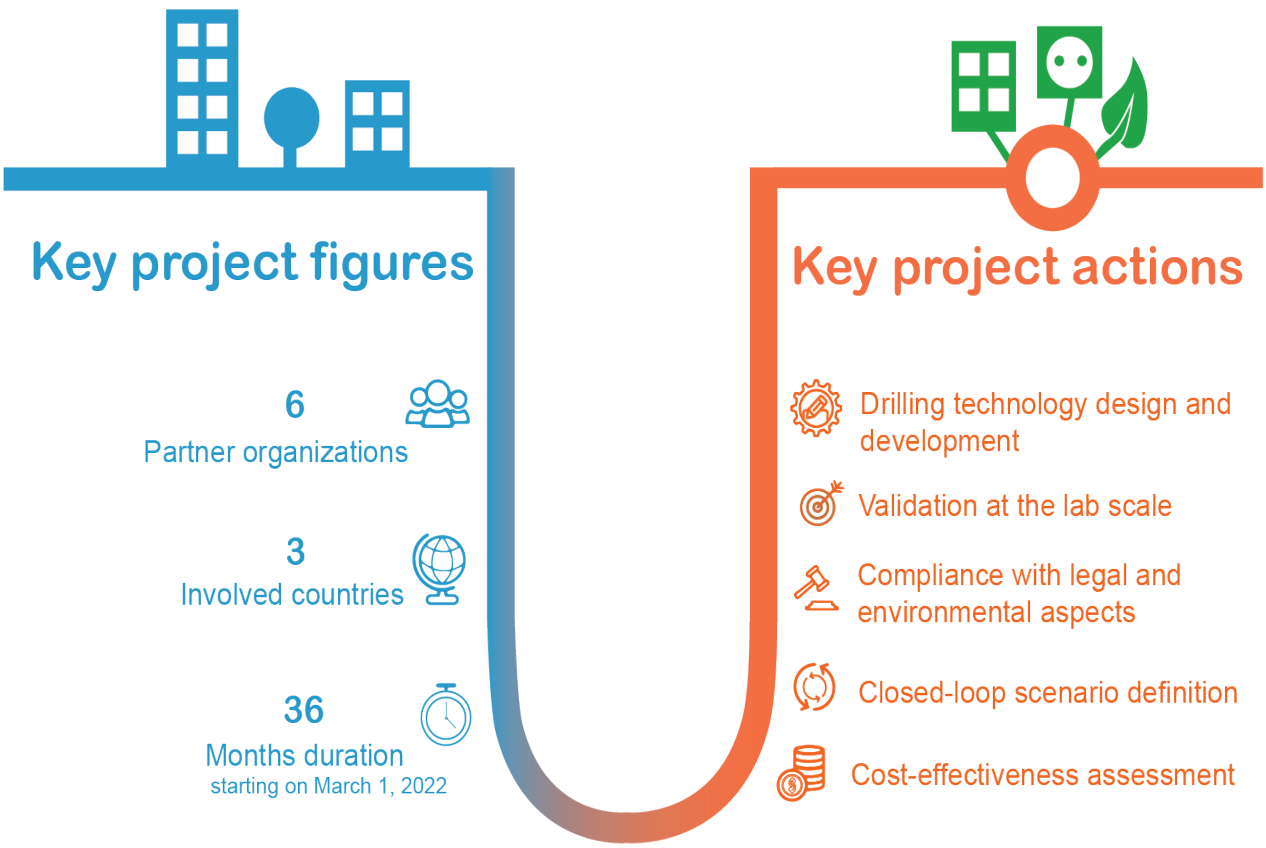
Nowadays, new, ground-breaking technologies are in development to overcome these limitations.

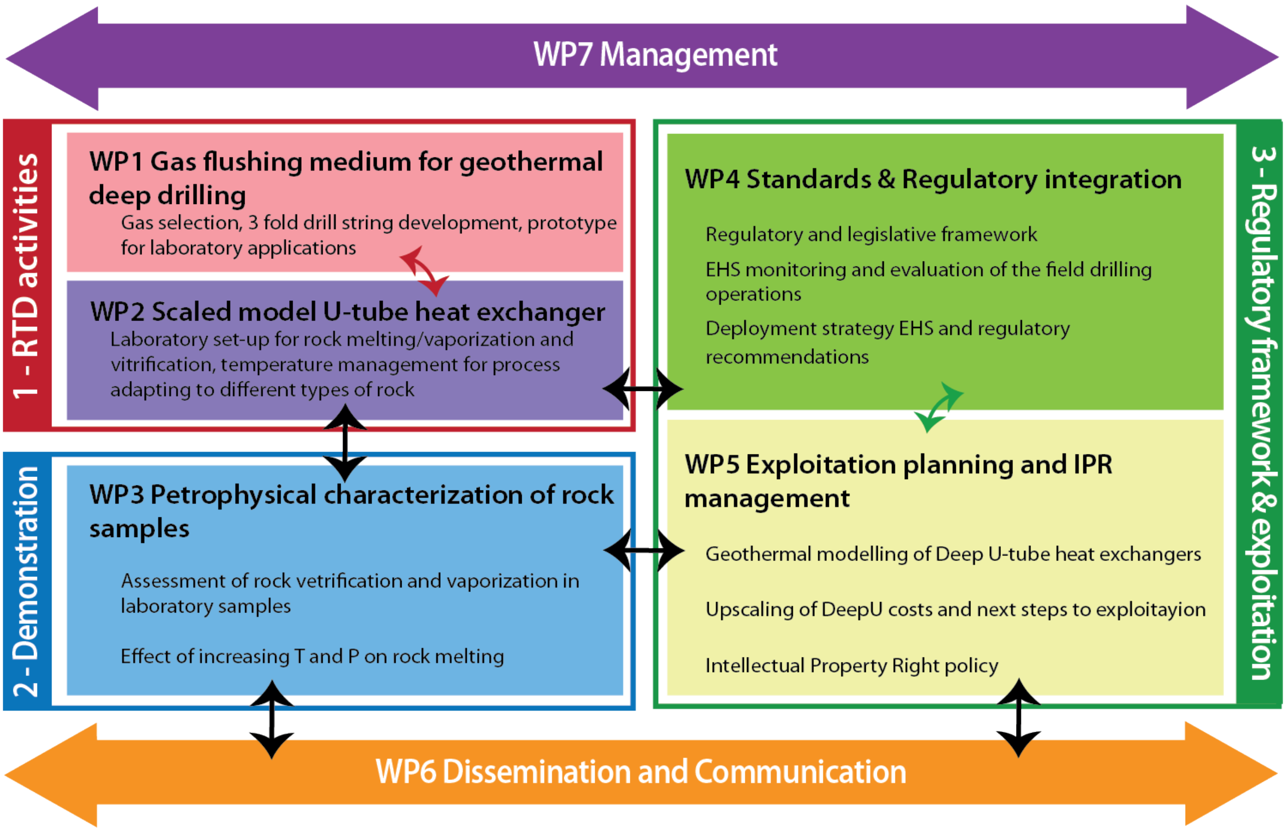
Funded with around 3 million euros by the European Union and European Innovation Council as part of Horizon Europe and launched last year by the University of Padua - in collaboration with Prevent, Fraunhofer IAPT, GeoServ, RED and CNR-IGG - the DeepU project aims to drill efficiently and rapidly, obtaining deep (>4 km) U-shaped geothermal heat exchangers. The project will run until February 2025.

The unique technology developed and tested in a dedicated lab involves a laser propulsion drilling method with cryogenic gaseous flushing for cooling the laser drill head.

As a result, well drilling costs will be reduced due to the higher drilling speed and reduced need for casing since - if vitrification of the borehole walls is achieved - the systems will be physically isolated from the surrounding rocks and ready to be put into production immediately after drilling or with minimal casing activities.

The new technology proposed in DeepU is a game-changer for the geothermal energy sector.





We have divided our work for DeepU into 7 Work Packages (WP), where we explore the road toward the implementation, from the technological development to the demonstration, with a view to the economic and regulatory aspects of the application.

The Research and Technological Development (RTD) activities are for developing the drilling technology prototype (**WP1**) and prepare and carry out laboratory drilling experiments (**WP2**).

To demonstrate the efficacy of the RTD (**WP3**), we will analyse the lithological-thermo-mechanical phenomena affecting different rocks and assess the borehole wall vitrification and integrity.

The laboratory results will be crucial for optimising RTD activities and evaluating the regulatory and exploitation framework.

Intending to achieve regulator acceptance and commercialisation, we are analysing the Health and Safety aspects related to site development, drilling operations and completion, as well as environmental aspects of the DeepU technology uptake (**WP4**).

Using numerical simulations of DeepU systems calibrated by laboratory results, two virtual case studies, in Italy and Ireland, will assist our analysis of the exploitation potential and economics of the developed drilling technology (**WP5**).

Finally, dissemination and Communication (**WP6**) and Management activities (**WP7**) support the entire chain of actions, directing it toward implementation upscaling.

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In the first year, three consortium meetings have been held to discuss all the details for defining the cryogenic gas selection criteria, implementing the new drilling design and examining the thermal effects of the combined action of laser and cryogenic gas on different types of rocks. They were essential for tuning the various activities and contributed to the delivery of ten reports and a Press Release, available on the Project Output page of the website.

We presented the DeepU concepts on some national or international occasions (e.g. at the "Updates on Drilling for Geothermal" Webinar organised by ETIP Geothermal on 21st April 2023: look at our presentation here).

We also took advantage of some main European events (European Geothermal Congress in Berlin, Germany, on October 2022, and at the GeothermExpo in Offenburg, Germany, on February 2023) to distribute our preliminary leaflets and brochures…

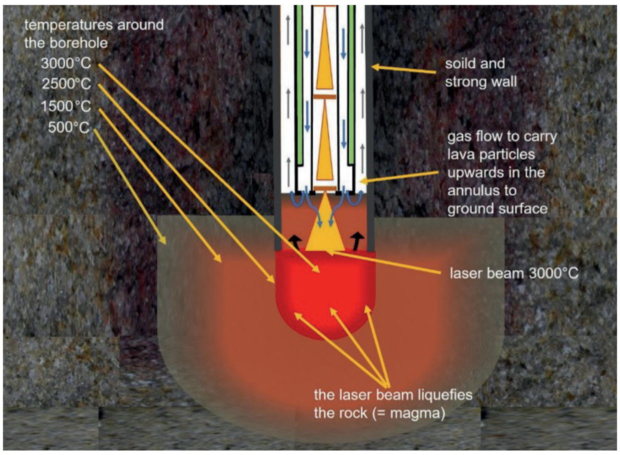
By the way! These leaflets and brochures are available on the project website in three different languages: English, German and Italian: look for them on the project Home Page! We plan to have many more occasions for disseminating the project results in the coming years, and we will provide a list of events on the first page of the Newsletter.

Continue to read: we are so pleased to share the latest developments on DeepU geothermal drilling project.

What is new in DeepU

1. A novel drilling system

The laser drilling process to produce a scaled model of a heat exchanger for deep geothermal energy exploitation involves melting rock with a high-power laser assisted by cryogenic gaseous flushing to cool the laser drill head and carry the melted rock out of the borehole. When the processing head advances through the melted rock, it should create precise and symmetrical holes around the drill string, producing an annular free space through which the melted rock particles can escape and be pushed to the surface with the help of gas.

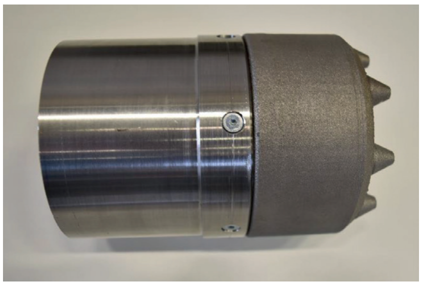


During our first year of DeepU activities, Prevent and Fraunhofer IAPT designed new concepts for the drill string and drilling platform. The novel drill string guides the laser beam through the inner drill string and also transports the cryogenic gas down to the drill head.
The choice of cryogenic gas has been a crucial activity: we need a gas that remains in a liquid state for a very long distance and in a wide range of temperature and pressure conditions to reach the base of the well during drilling. After a series of analyses and tests, Prevent chose the most suitable cryogenic gas based on the required qualities, i.e., availability, low price, and thermodynamic properties.

In the meantime, Fraunhofer IAPT designed a novel lightweight laser and gas processing drill head. The processing head is the final, bottom part of the drill string. Utilising a small area in the centre of the drill string, this unique processing head enables the high-power laser beam to reach the rock melting point at the end of the borehole and directs the gas stream through nozzles onto the melted rock.

We now have our first, 3D-printed prototype! It is made of titanium alloy, which is suitable in terms of mechanical strength and temperature resistance. Indeed, 3D printing technology offers the advantage of rapid prototyping and the simplicity of printing the gas channels directly into the component.
The processing head can also be equipped with diverging lens to expand the laser beam and enlarge the bore diameter.

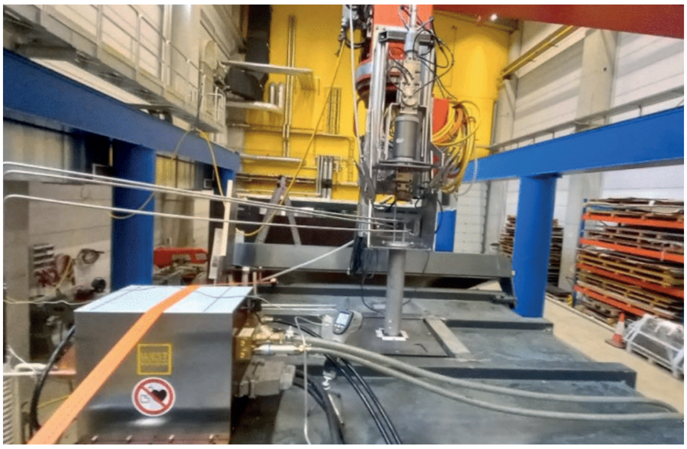
The preliminary drilling results obtained with this innovative drill head have already proved exciting. Read the news in the following article!



2. Drilling tests: how are they working?

First, we set up a laboratory for the experimental development and testing of the new laser drilling method. The facility was designed and provided by Fraunhofer IAPT in Germany. It is equipped with a 30-kW laser system, processing optics specially designed for such a laser, a drill string equipped with our unique 3D printed drill head, and a cryogenic gas feeding system.

Our experiments take place inside a press container acting as a safety enclosure to resist the high pressures and temperature of the experiments. Rock material is piled up inside the press container, which can also be used to compact loose soil formations.



During the drilling process, the drill string is manoeuvred robotically.

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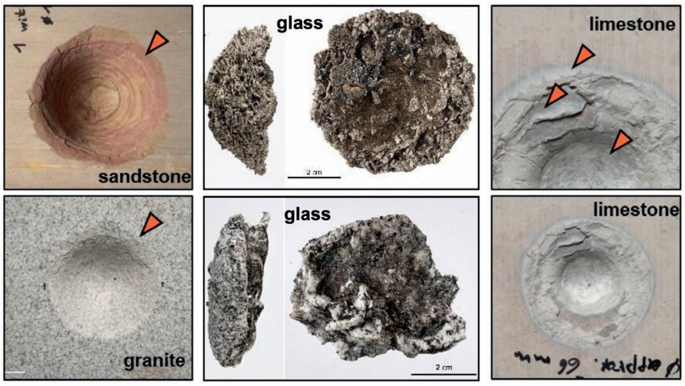
Optics, drill string and drill head, mounted one above the other at the robot, are guided through an opening in the cover plate of the press container where the hosted rock material is drilled. The cryogenic gas is supplied from a tank.

In preliminary drilling tests, using our 3D-printed laser processing head but only the laser beam without the cryogenic gas, we achieved constant rates of penetration upwards of 20m/hr, with relatively low energy inputs and no component wear of the kind that would be associated with mechanical engaging drilling methods. We obtained precise and symmetrical holes in samples representing the hardest rocks to drill at depth, i.e., granite, and the most common geothermal reservoir rocks, i.e., sandstone and limestone.

For the moment, we are analysing the post-drilling rock samples to characterise the impact of the laser beam and cryogenic gas and the vitrification, cracking, and bulging effects. For each lithology, we collected three samples with dimensions of 500 x 350 x 150 mm: one from fresh, unaltered rocks from the quarry and two undergoing the DeepU laser drilling process under variable external conditions (e.g. confining pressure).

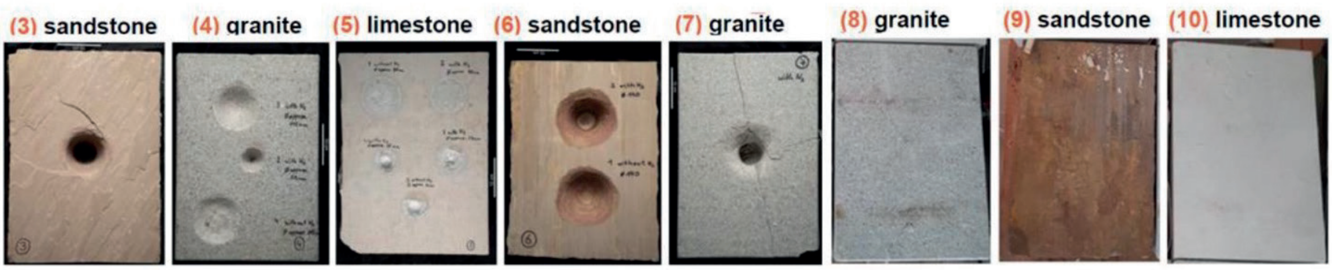
The petrophysical laboratory set up at the University of Padua allows a series of sample analyses by various techniques, including optical microscopy (OM) for petrographic description, Raman spectroscopy for mineral identification, electron microscopy (SEM, EMP) for chemical characterisation, X-ray diffraction (XRD) and X-ray fluorescence (XRF) for mineral phase recognition and chemical analysis of powders, and ultrasound and thermal optical scanner measurements for determining mechanical and thermal parameters of the rocks.



The observations are preliminary but already very intriguing. For example, we observed that an annular thermal alteration is more evident in sandstone and limestone than in granite. Moreover, at the bottom of the boreholes, we found glass entrapping volatiles in granite and spalled flakes in the sandstone, suggesting different melting effects that will be interesting to rule out.

The laboratory experiments will ultimately provide information for optimising the DeepU laser drilling process and for geothermal reservoir characterisation and modelling in virtual case studies in Italy and Ireland. Waiting for the simulation and its findings, the exploitation strategy is already in progress, although qualitative, because the concept behind the drilling process is evident.

However, any technology uptake and commercialisation should achieve regulator acceptance, right? So, let's read how we are already working on this aspect.

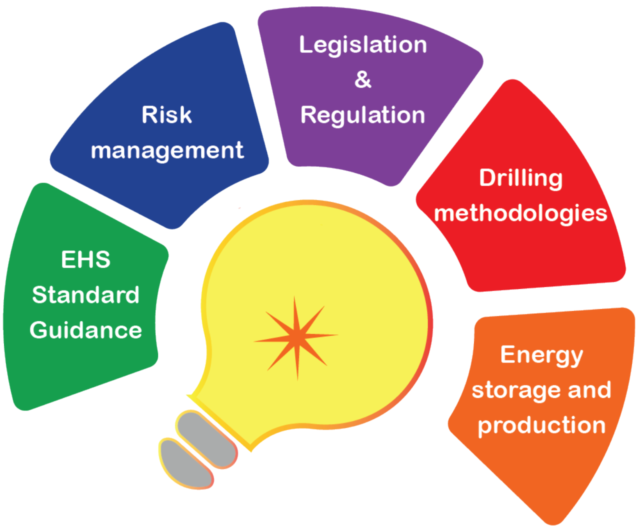


3. A review of the legislative and regulatory framework in Europe for DeepU

What are the current regulatory challenges of DeepU drilling technology, and how to gain compliance with the current deep drilling market? It is a question that we must ask ourselves since the beginning to identify the potential barriers to the development of the DeepU technology, but also the opportunities that such a new drilling method may bring in the context of reduced environmental and health and safety (EHS) conditions associated with the drilling and completion of deep geothermal wells compared to the existing drilling and completion methodologies currently used.

In essence, we want a clear idea of instances where regulatory expectations based on standard processes may require a different approach for DeepU technologies.

With this in mind, we started to review existing legislation and regulations that govern the health and safety of drilling equipment and drill site operations and the utilisation of industrial scale lasers, and the assessment of environmental impact as well as the requirements for mitigation measures applicable in the development of deep drilling projects in Europe.



Admittedly, they differ slightly in terms of national or even regional or municipal implementation. Albeit they are broadly aligned as they derive from common EU Directives.

To integrate the novel technologies into an approved drilling operation, we had to identify the fundamental EHS aspects potentially unique or novel about DeepU from the perspective of a regulator and the requirements and potential consequences of deploying a DeepU system with respect to using existing drilling and completion methodologies. GeoServ, which led this analysis and related review, selected jurisdictions for which identifying the types of governing legislation, nature of the licencing system and application processes for geothermal Projects. Other than Ireland and Italy, our virtual case studies in the DeepU project, France, Germany, and The Netherlands were selected, given the active nature of the geothermal sector in those countries.

A list of recommendations has already been drafted. Some of them are of immediate use for DeepU partners for optimising the technology to mitigate risks through design. Others provide the basis for implementing recommendations to allow the DeepU drilling method to achieve regulator acceptance and commercialisation. Moreover, the review supports undertaking an Environmental Health and Safety risk assessment of the technology with a focus on the virtual case study sites.

The news does not end here: the DeepU team is expanding!

4. New partner on board

Politechnika Wroclawska has recently joined the project and will contribute to assessing the minimal space requirements and technological feasibility of the cryogenic gas supply for the laser drilling system. We look forward to meeting our colleagues and starting the cooperation to speed up the optimisation and set-up of DeepU laser technology.

DeepU is online

Follow us and stay up to date!

Contact us:
info@deepu.eu

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