Bedretto Underground Laboratory for Geosciences and Geoenergies

Editorial

Welcome to the first newsletter of the BedrettoLab! We look forward to sharing with you what is happening in the lab and offering you insights into our research. But not only that: you will also be the first to hear about events and other news. Stay tuned!

In this newsletter:

Research at the BedrettoLab

At the BedrettoLab, ETH Zurich currently conducts in close collaboration with national and international partners studies in the following fields of research:

- techniques and procedures for a safe, efficient, and sustainable use of geothermal heat,
- earthquake physics and predictability and
- the development of novel techniques and sensors.

To this aim, we established a unique research infrastructure. It is located 1.5 km below the surface in the middle of the 5.2 km long Bedretto tunnel connecting the Ticino with the Furka railway tunnel.

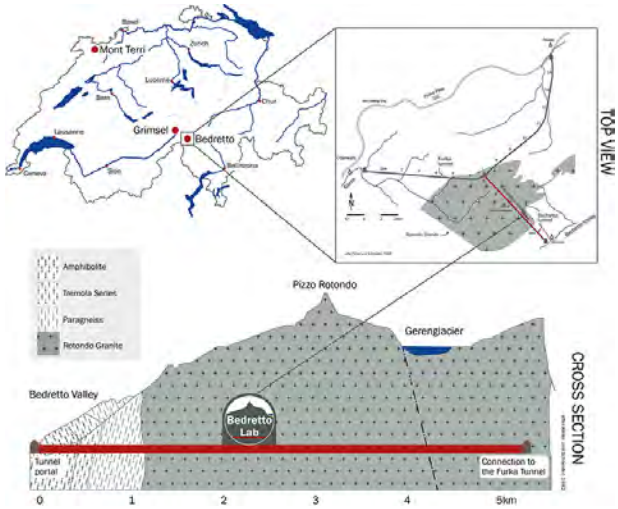

Image: Location of the BedrettoLab. © Swiss Seismological Service at ETH Zurich, 2020.

A glimpse into the deep underground

A research facility as the BedrettoLab is something truly special. Only a handful comparable facilities exist in the world. What makes them so extraordinary and rare?

Researchers already replicated stress and temperature conditions for deep geothermal energy in laboratory tests as realistically as possible. However, these tests take place on a very small scale and therefore their results are not easily transferable to the full scale of a real geothermal power plant. Consequently, to study those processes one ideally has access to the deep underground to conduct in-situ studies. Unfortunately, this is difficult to do, because it is enormously expensive to drill so deep. Using existing underground infrastructures such as tunnels etc., helps to bridge this gap by allowing experiments at an intermediate scale. Thanks to those infrastructures, researchers can access rock masses at great depths and build up a sophisticated characterisation, instrumentation and experimentation

infrastructure.

Research at the BedrettoLab not only focuses on how to build and manage a geothermal reservoir safely and sustainably, but also on the physics of earthquakes. This is not by chance, because when the rock is broken up when building the reservoir, very small earthquakes occur. Therefore, while the researchers generate those small earthquakes under controlled conditions, they measure a variety of earthquake parameters using a dense sensor network. Their goal is to better understand the dynamics of earthquakes and to improve their predictability.

Image: The Rotondo granite at the BedrettoLab. © Werner Siemens Foundation, 2019 (Image: Felix Wey).

Drilling holes into the rock: the Bedretto Reservoir Project

The goal of one of the main projects at the BedrettoLab – the Bedretto Reservoir Project (BRP) – is to mimic a deep geothermal reservoir on a smaller scale. This means that two boreholes should be hydraulically connected (allowing water to flow from one borehole to the other) during a stimulation, and that a series of monitoring boreholes are stuffed with state-of-the-art sensors to detect all signals from the observed rock volume. The infrastructure for this project is also used by other projects.

After completion of the basic infrastructure of the lab in 2018/19, the preparation of this umbrella of boreholes was one of the dominant activities in the BedrettoLab during the last two years. The drilling of the holes in the BedrettoLab took place in three subsequent phases.

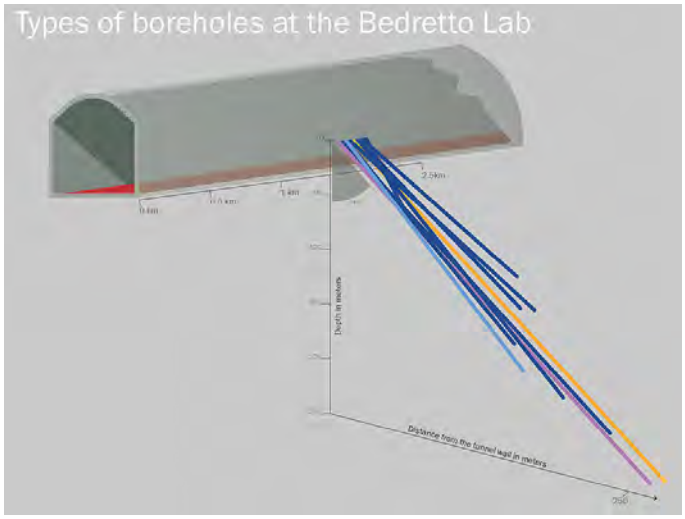

Image: The types of boreholes at the BedrettoLab. **Click on the image to see more details.**
© Swiss Seismological Service at ETH Zurich, 2020.

In the first phase from August to December 2019, our drilling company Züblin drilled three boreholes into the rock by core-drilling to retrieve continuous cores for geological analysis and laboratory testing. These boreholes also served for extensive stress measurements, hydraulic testing and finally a first test stimulation. The goal of the first phase was to characterise the reservoir and to learn how the rock is structured and where we could expect cracks, fissures and water.

Image: Drill cores. © Werner Siemens Foundation, 2019 (Image: Felix Wey).

With this knowledge, we and our research partner Geo-Energie Suisse (GES) started a second drilling phase, where the characterisation boreholes of the first phase were reamed-up to a larger diameter for sensor installation. Additional monitoring boreholes were completed by hammer drilling. Additionally, the two injector/producer boreholes for the engineering of the reservoir were also completed down to a final depth of 350 and 400 metres, respectively.

Image: The custom drill-rig. © Swiss Seismological Service at ETH Zurich, 2021.

Depths and dimensions of the boreholes were stretching the narrow space in the lab to the limits of commercially available drill-rigs. Züblin therefore designed a new modular drill-rig to fit in the small cavern, which leaves flexibility to manoeuvre to the various drilling locations across the lab.

The third phase started with a final working period of Züblin at the end of May 2021. During summer, installations in the remaining monitoring boreholes are now taking place. After setting up all monitoring systems, the reservoir is finally ready for the detailed stimulation phase over several months.

After drilling is completed, only little evidence will remain on the outside from the intense work. Drill cellars will be filled and from the extensive installation, only a few cables sticking out of the boreholes witness the immense work and effort we have spent.

Image: A borehole during the installation of the monitoring system. © Werner Siemens Foundation, 2020 (Image: Felix Wey).

How we collect data at the BedrettoLab: a senior researcher explains

Simply building a lab and drilling boreholes is not enough, somehow our researchers need to collect the data of their experiments. To do this, they

installed a very elaborate monitoring system with many sensors. To learn more about this, we talked to Dr. Anne Obermann, a senior researcher who works at the BedrettoLab and is responsible for the monitoring system.

Editorial: What for have you installed the monitoring system? What do you measure with it?

Dr. Anne Obremann: We installed a multi-parameter monitoring system at the BedrettoLab, which focuses on two areas. Firstly, we have sensors measuring hydromechanical parameters – such as cables for accurate strain and deformation measurements and temperature, acoustic sensing and pore pressure sensors. Secondly, the monitoring system focuses on the seismic monitoring to capture different ranges from nanoseismicity to microseismicity. We have installed those sensors in boreholes and along the tunnel.

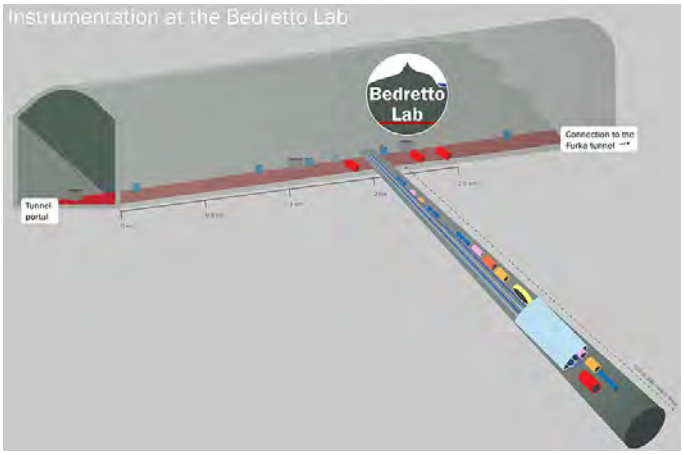

Image: Instrumentation at the BedrettoLab. **Click on the image to see more details.**

What is special about this? What challenges have you encountered?

Unique is the density of the monitoring system and the accumulation of different sensors. We expect to be able to observe effects of the stimulations at unprecedented precision.

One of the main challenges encountered was that there was no ready to be installed equipment on the market that could be installed in around 300 meter long boreholes and that could withstand the hydrostatic pressures. Most of the sensors had to be adapted or developed from scratch.

What are the plans for the future?

In April and May 2021, we could already acquire some first data with our system. Now we are very excited to see the system fully installed and record data in fall this year!

Dr. Anne Obermann

I am a Senior Researcher at the Swiss Seismological Service at ETH (SED), leading the seismology group at the BedrettoLab. Besides my interest for the underground and induced seismicity, my main field of expertise is seismic interferometry.

The installation and use of the multi-packer system: a new approach in deep geothermal energy

Within the Bedretto Reservoir Project (BRP), our research partner Geo-Energie Suisse successfully demonstrated a new zonal isolation stimulation scheme, which could optimise the performance of deep geothermal reservoirs. The zonal isolation was realised by a so-called multi-packer system. Packers are large rubber-wrapped cylinders that are lowered into the borehole. They expand when inflated and fully seal the borehole wall and therefore divide it into several sections. They allow stimulating the different sections separately with exactly the pressure and the amount of water needed. This method aims at enhancing the permeability per section in a controlled way while minimising induced seismicity.

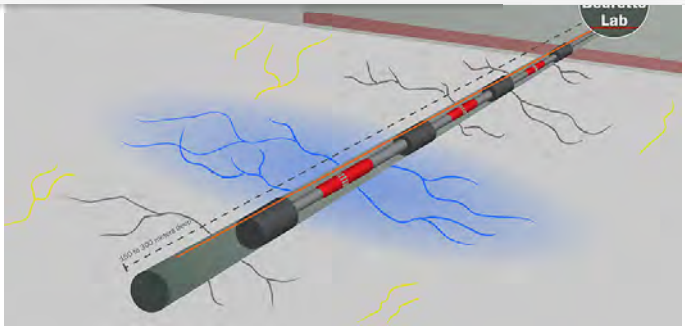

Image: The multi packer system in the BedrettoLab. **Click on the image to see more details.**
© Swiss Seismological Service at ETH Zurich, 2020.

Image: All the multi-packers, ready to be installed in the borehole. © Swiss Seismological Service at ETH Zurich, 2021.

The scientists installed a multi-packer system in one of the stimulation boreholes (ST1). The installation took about ten hard working days. In the 400 metres long borehole, 14 packers were successfully installed in serial. Each packer could be controlled independently. The packers were carefully positioned so that potential fractures and faults (we call them hydraulic conduits) are in between. Each of these packed-off segments was carefully experimented.

The calibration of the multi-packer system took place in spring 2021. The integrity and performance of each packer holds the success of the upcoming stimulation experiment and the future circulation program. As first results show, the use of the multi-packer system was successful and the scientists were able to hydraulically connect two boreholes.

Image: The first packer during installation. © Swiss Seismological Service at ETH Zurich, 2021.

Did you like this first issue of the BedrettoLab newsletter? Is there anything you would like to read more about? We are happy to receive your feedback on bedrettonews@erdw.ethz.ch.

We will publish the next issue in winter 2021.

In the Bedretto Underground Laboratory for Geosciences and Geoenergies, ETH Zurich studies in close collaboration with national and international partners techniques and procedures for a safe, efficient, and sustainable use of geothermal heat and questions related to earthquake physics.
The Bedretto Lab is financed by the Werner Siemens Foundation, ETH Zurich and the Swiss National Science Foundation.