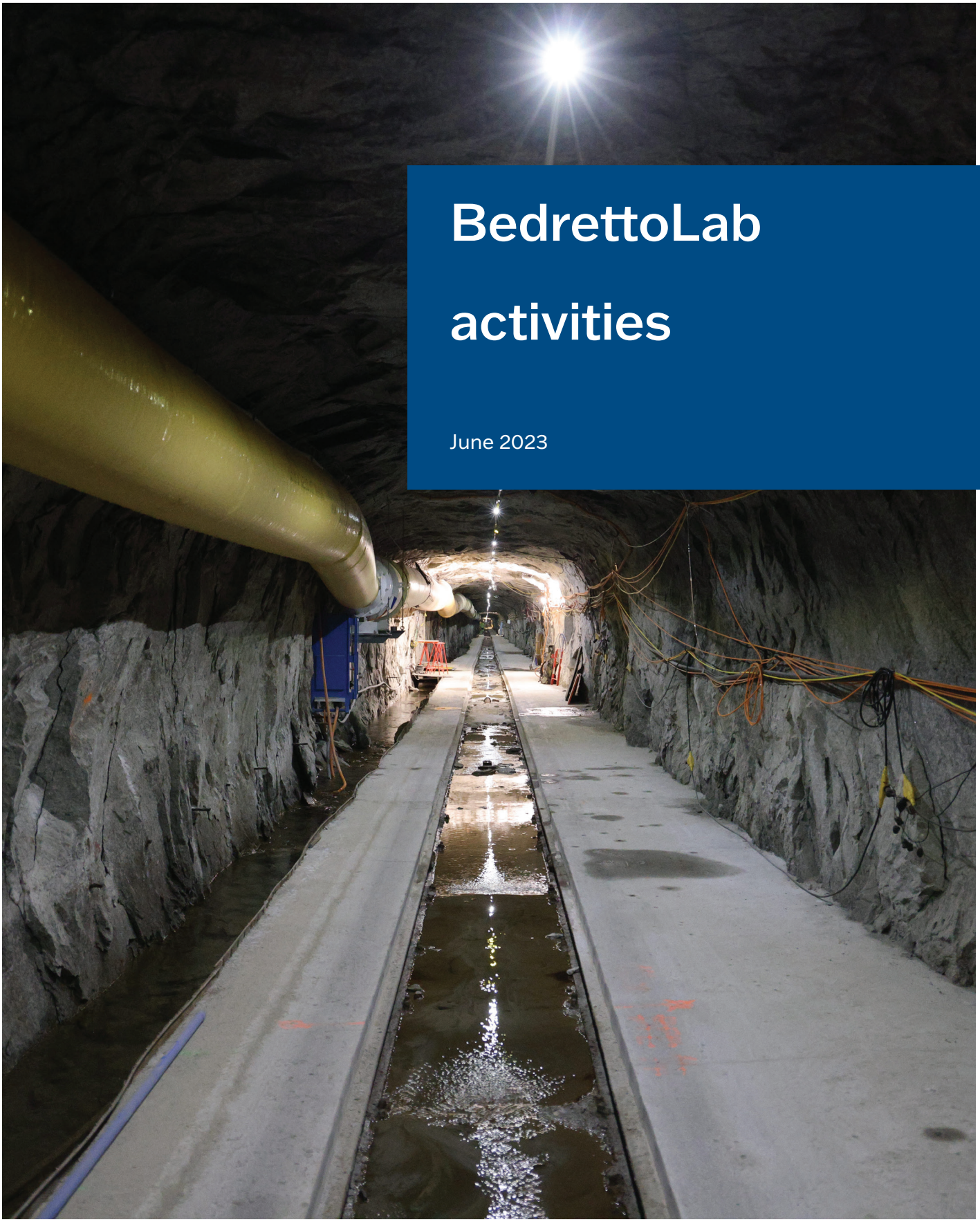
ETH zürich

Bedretto Lab



BedrettoLab activities

June 2023

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Introduction

Another year has passed at the Bedretto Underground Laboratory for Geosciences and Geoenergies. With this newsletter we would like to inform about our various activities since July 2022.

We will cover the whole bandwidth of activities performed by our team of students, researchers, technicians and administrative staff members.

This newsletter is accompanied by the first BedrettoLab Science Report, which summarises the scientific activities in the BedrettoLab.

The Bedretto tunnel is a playground not only for researchers but also for artists. Together with PhD student Lena Bakker, artist Monica Ursina Jäger explores the aesthetics of fungi and biofilms living in the Bedretto tunnel.

Administration

Following the Oversight Committee meeting in 2022, the structure of the BedrettoLab has been modified.

In May 2023, new members from the Department of Earth Sciences joined the BedrettoLab Board of Directors :

- A. Prof. Jordan Aaron
- Prof. Whitney Behr
- A. Prof. Cara Magnabosco
- Prof. Johan Robertsson
- Prof. Martin Saar

We've welcomed the new members to the Board of Directors with an extended Board meeting on May 11th 2023. The full Board will meet twice a year to discuss strategic questions. The autumn meeting will be held in combination with the meeting of the Oversight Committee.

ExeCom: The ExeCom has been added to the BedrettoLab organisation for daily operations and consists of :

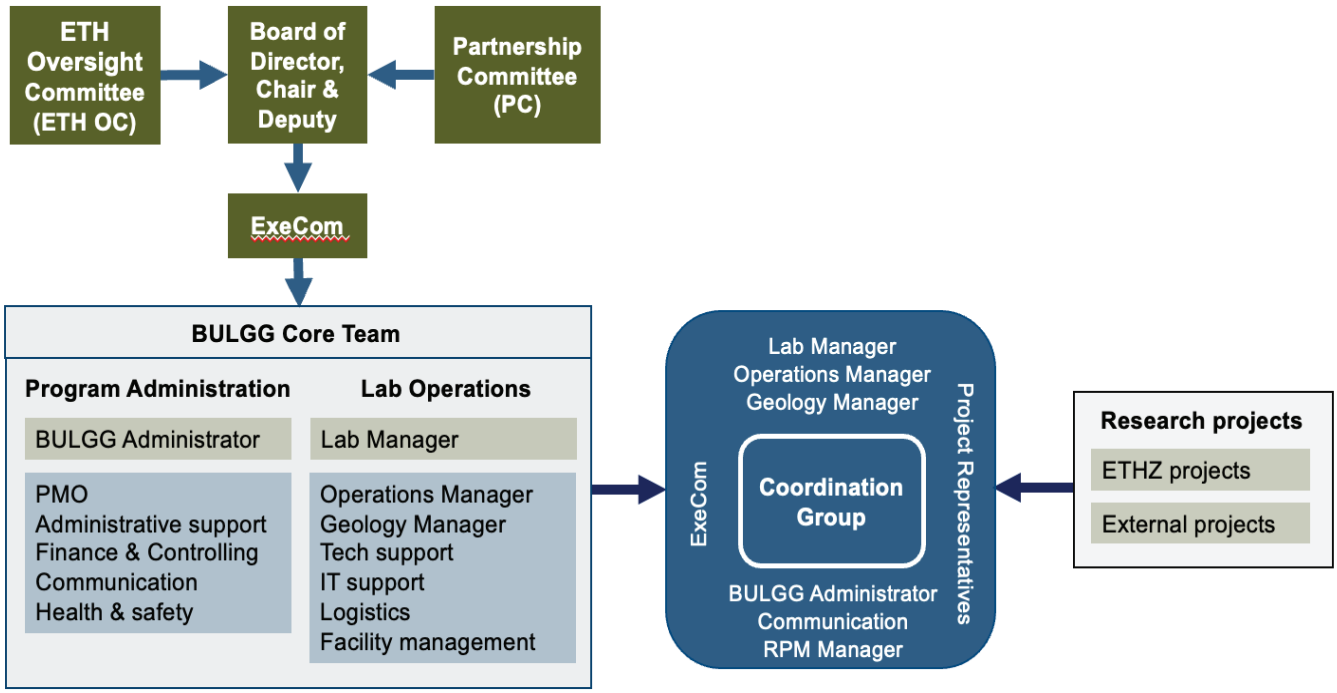
- Prof. Domenico Giardini (chair)
- Prof. Stefan Wiemer
- Prof. Hansruedi Maurer

Partnership Committee: The International Advisory Board has been renamed to Partnership Committee. There are ongoing discussions with several partners with whom we are establishing Memorandum of Understandings.

Oversight Committee: On October 6th 2022, the Oversight Committee met in Bedretto for its annual meeting. Andreas Hofmann, Director of ETHZ Facility Services, replaced Simon Wepfer. They decided that a scientific review of the BedrettoLab should take place in mid-2023. The next OC meeting will take place in Zurich in autum 2023.

Mattherhorn Gotthard Infrastruktur (MGI)

In February 2023, a third amendment to the contract with Matterhorn Gotthard Infrastructure was signed. This amendment sets out the conditions for the road pavement of the tunnel to 5,250 m, the availability of a fibre-optic connection for internet and access to electricity for the illumination of the tunnel which MGI provides at no cost. The 2023 annual review meeting with MGI is scheduled for September 14th 2023 in Bedretto.



Infrastructure

Tunnel road extension

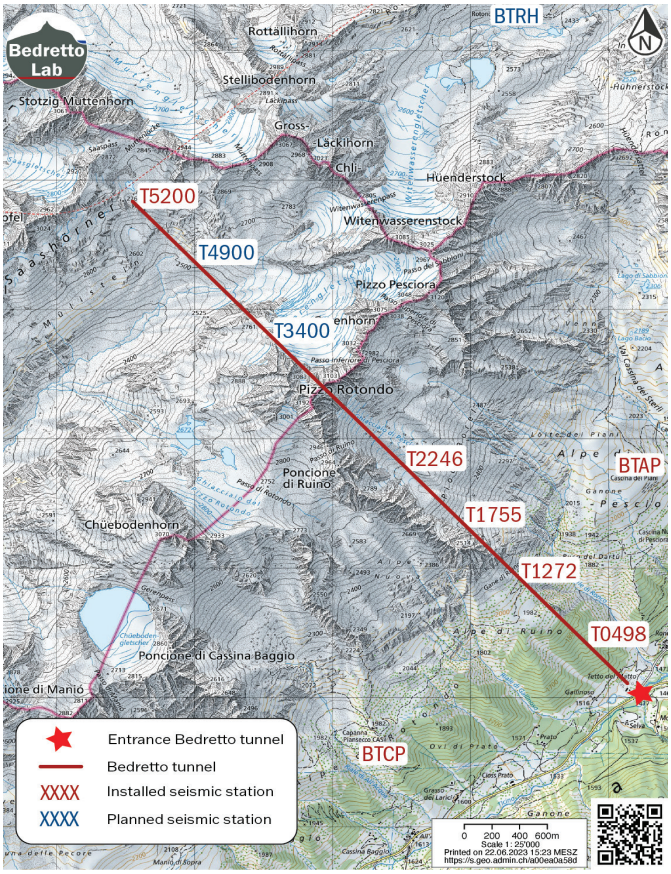
Over the last year the tunnel extension kept the operations team busy. As planned, the road was paved up to 3,300 m. For safety reasons, it was then decided to extend the two-lane road through the entire tunnel which is 5,250 meters long. This section of the tunnel was also equipped with LED lighting to provide a safer second exit from the tunnel. A redundant internet connection was installed during this extension in collaboration with MGI.

During this phase, a second and third cavern were paved to improve logistics in the tunnel.

The tunnel extension was funded by the Werner Siemens Foundation.

Barrack Bedretto tunnel (BRB)

With the change of ownership, the site at the entrance to the Bedretto Laboratory will become a landfill for the construction of the Gotthard Tunnel. With these changes, the current Barrack will have to be moved. The municipality of Bedretto will build a new Barrack, which will be rented by ETH Zurich as an external infrastructure for the BedrettoLab. With the construction of the new Barrack, a new access road will be built.



Initial plans from architects have been received. In July 2023 final discussions between ETH Immobilien and the Bedretto municipality will take place. Construction is scheduled to start in mid-2024.

BedrettoLab Bus stop

With the change of timetable 2022, the BedrettoLab has now its own bus stop, called “Bivio per Ronco (Bedretto)”, located directly at the quarry in front of the tunnel entrance. This has made the journey easier for BedrettoLab researchers and staff.

Operational vehicles

Since June 2022, we have purchased an additional electric vehicle (Loki) to support the FEAR side tunnel construction site, as well as 4 electric bikes specially developed with Kyburz for the conditions in the tunnel.

Seismic Background Monitoring Network

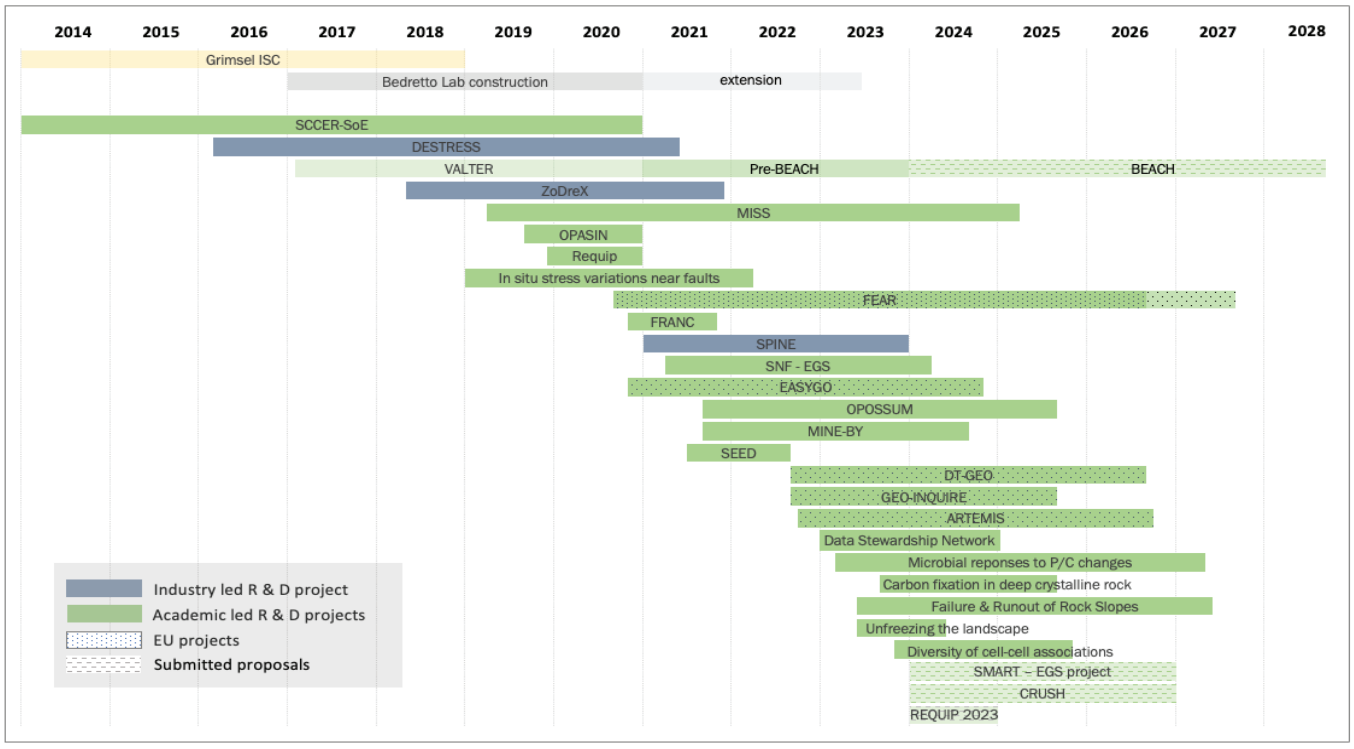
When we started working in the tunnel, we needed to install a monitoring network to distinguish between natural sesimic events and those induced by our experiments. We installed stations in the mountain area as well as inside the tunnel. All stations are connected to the Swiss Seismological Service’s (SED) acquisition system.

With this improved monitoring network, we can detect previously unknown, very small seismic events in the Bedretto Valley, for which the regular SED network is not dense enough. The higher sensitivity network facilitates the scientific study of such quakes, and it is a crucial element of our safety and alerting system.

IT

In the autumn of 2022, a second data storage of one petabyte was purchased and installed at the IT-center at ETH to accommodate the large amount of data acquired by the BedrettoLab.

R & D Projects



In 2023 the following projects with an involvement in the BedrettoLab have been approved:

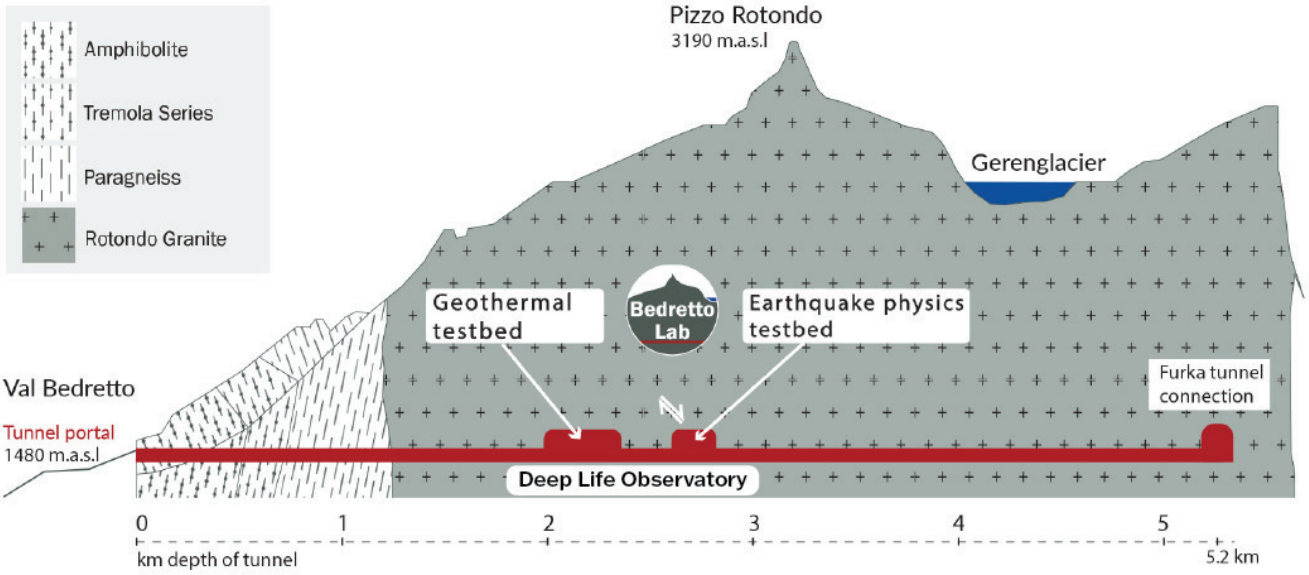
- Understanding the Mechanisms that Drive Catastrophic Failure and Runout of Rock Slopes" (A. Jordan; SNF)
- Microbial responses to rapid physical-chemical changes in the continental subsurface (C. Magnabosco; SNF)
- Carbon fixation in deep crystalline rock: contribution and key microorganisms (C. Magnabosco; ETH Grant)
- Unfreezing the Landscape (M. Ursina Jäger; Pro Helvetia)
- Investigations into the diversity of cell-cell associations and non-standard life using metagenomics and cryogenic electron microscopy (C. Magnabosco; ETH Centre for Origin and Prevalence of Life)

The BedrettoLab is also part of the Pilot group of Data Stewards which has been established at ETH Zürich through the Swissuniversities programme on Open Research Data.

The following proposals have been submitted and are awaiting approval:

- Bedretto Energy Storage and Circulation of Geothermal Energy BEACH (M. Brehme; BFE)
- An Earthquake On-Fault Observatory at the Bedretto Underground Laboratory (M.A. Meier; SNF Requip)
- Cataclastic reactions in the subsurface and on early Earth (C. Magnabosco; SNF)
- Data Management Concept for Underground Laboratories – DAMOCLES (M. Hertrich; ORD Track A – Explore)

The BedrettoLab testbeds



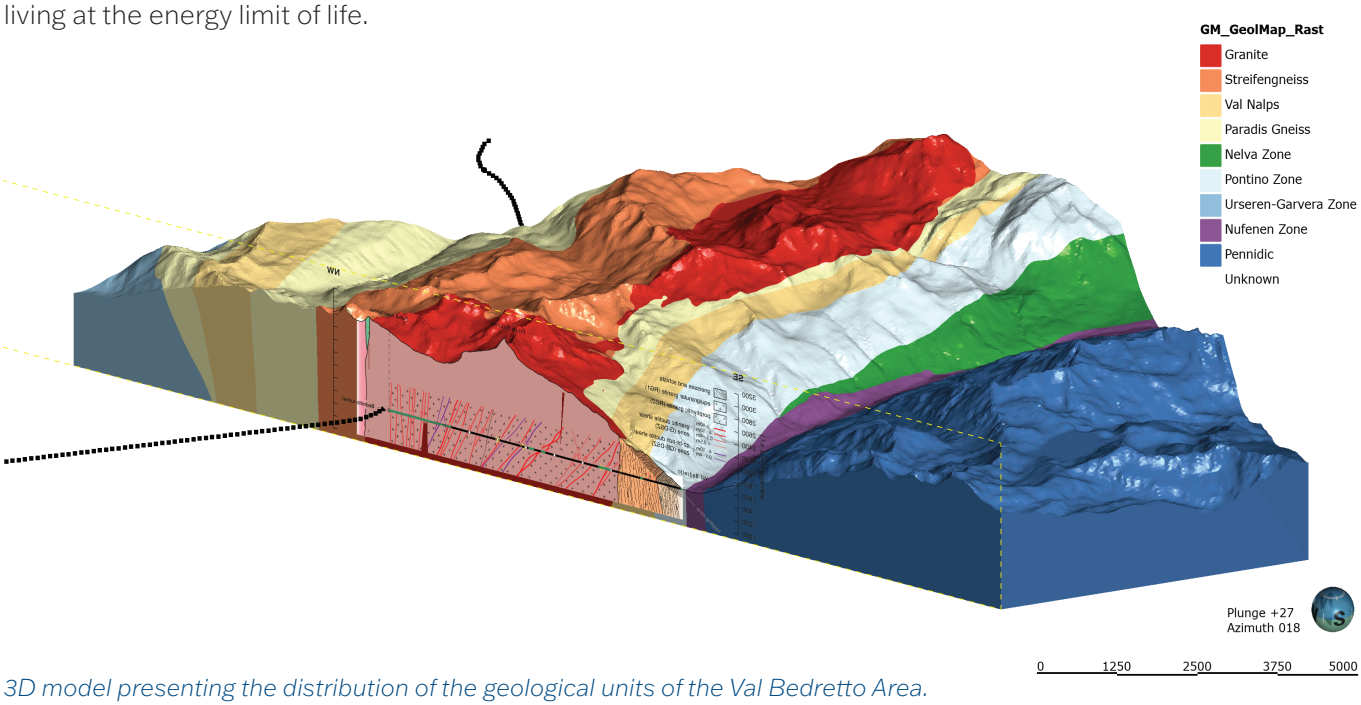
Geothermal testbed, focusing on the development of large-scale deep reservoirs for water circulation, storage and extraction of geothermal energy.

Earthquake Physics testbed, focusing on the fundamental understanding of earthquake physics.

DELOS (Deep Life Observatory) to study organisms living at the energy limit of life.

Geological Mapping of the Rotondo granite

Extensive field work by the BedrettoLab geologists have produced a geological map linking the faults observed in the BedrettoLab to the surface.



3D model presenting the distribution of the geological units of the Val Bedretto Area.

The model is sliced parallel to the Bedretto tunnel, showing in the cross section the tunnel into the Rotondo granite and some of the fault zones that can be traced from the surface to the tunnel.

The dotted curve represents the trace of the Furka base tunnel.

Earthquake Physics testbed

FEAR side tunnel

For the ERC Synergy project FEAR, we will excavate a side tunnel to the Bedretto tunnel. As the estimated cost for the construction of the side tunnel was over 2 M CHF, a public tender was required to select the construction company. In February 2023, 5 bids were received. After careful evaluation, the company Consorzio Cristallina (c/o Ennio Ferrari) was selected to carry out the construction of the FEAR side tunnel with a maximum length of 120 m.

The construction permit has been applied for with the Canton of Ticino and we are confident that it will be approved before the planned start of construction in mid-August 2023. The FEAR side tunnel will be completed by April 2025.

Construction of the FEAR side tunnel will begin with the logistics niche, followed by a 3-month pause during which boreholes will be drilled for the PRE-CODE MineBy project and the first FEAR experiment.

Bedretto on-fault observatory

With the submitted SNF Requip proposal “An Earthquake on-fault observatory at the Bedretto Underground Laboratory”, the BedrettoLab moves from near fault observatories to on-fault observatories. The MC fault within the Earthquake Physics testbed will be the first on-fault observatory of its kind.

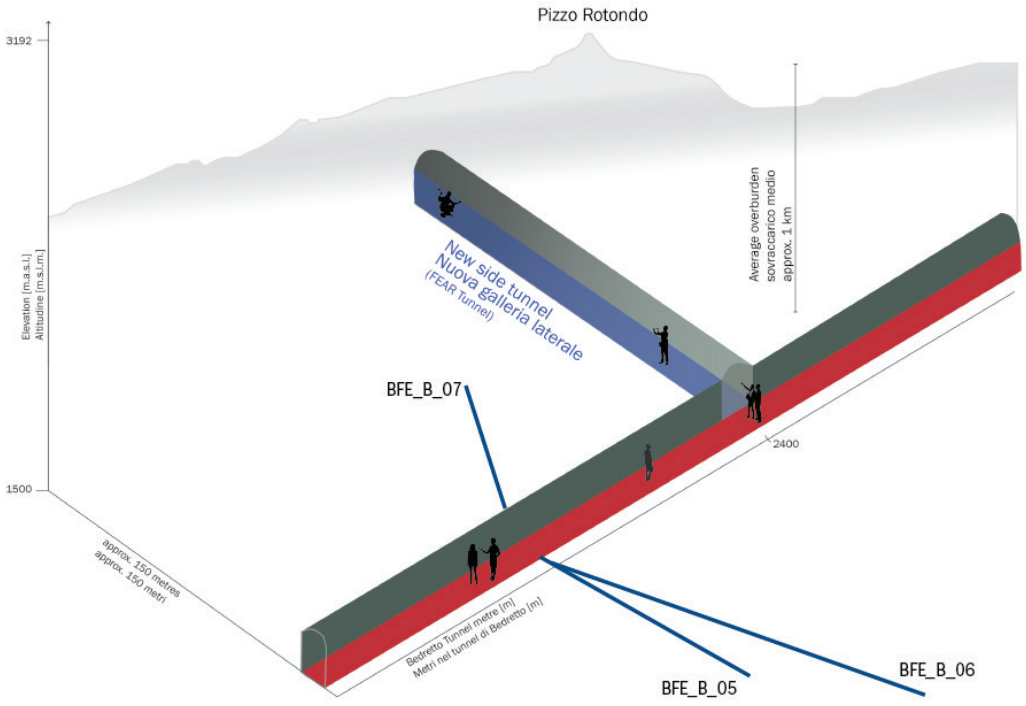
Monitoring boreholes

In September 2022, boreholes BFE_A_05, 06 and 07 were completed by fretus AG. These are three boreholes traversing the MC fault zone of the Earthquake Physics testbed. Their main purpose is the characterication of the MC fault zone which was realised in a first step by using a stress profile with the SIMFIP probe (SPINE project, see below). It will further be characterised with the FEAR experiment 1.

In January 2023, eight short boreholes between 8 and 10 m were drilled by the company Mhoch3 in the Earthquake Physics testbed for micro-seismicity monitoring with tetrahedral 3D mini-arrays of acoustic emission sensors.

SPINE

In December 2022, the BedrettoLab hosted the Lawrence Berkeley National Laboratory (LBNL), the coordinators of the Geothermica SPINE project, to measure the stress profile in borehole BFE_A_05 in the Earthquake Physics testbed using a SIMFIP (Step-Rate Injection Method for Fracture In-Situ Properties). In July 2023, the LBNL partners will return to the BedrettoLab to install a DORSA (Downhole Robotic Stress Analysis) tool to measure borehole displacements in six degrees of freedom.



Schematic of the future FEAR side tunnel (blue), perpendicular to the Bedretto tunnel (red). BFE_B_05,06 and 07 represent the drilled monitoring boreholes for projects FEAR and SPINE)

Geothermal testbed

VALTER

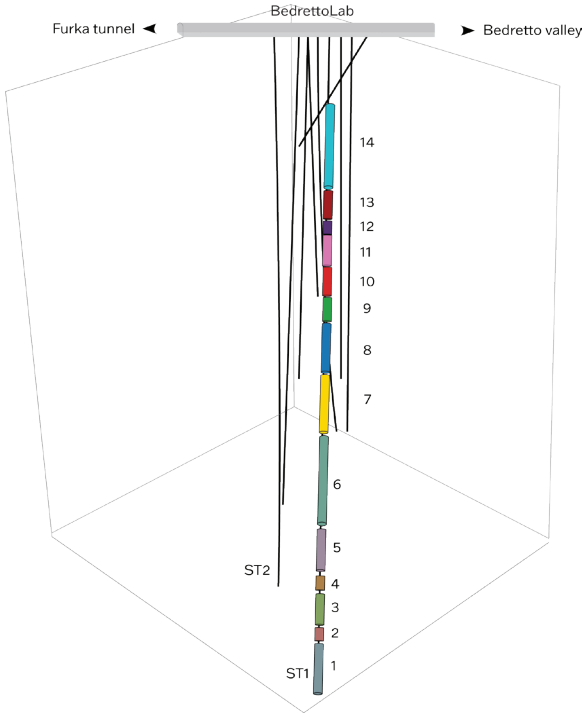
In early 2023, the second phase of the VALTER stimulations took place in the Geothermal testbed, allowing the fractured VALTER reservoir to be visualised for the first time. With a calibrated reservoir now available, the next step will be to conduct the first storage and energy exchange tests for an alternative storage solution in the Swiss basement.

In this context, the journal article about the multi-component network in the Geothermal testbed has benn published in March 2023 (Plenkers et al.)

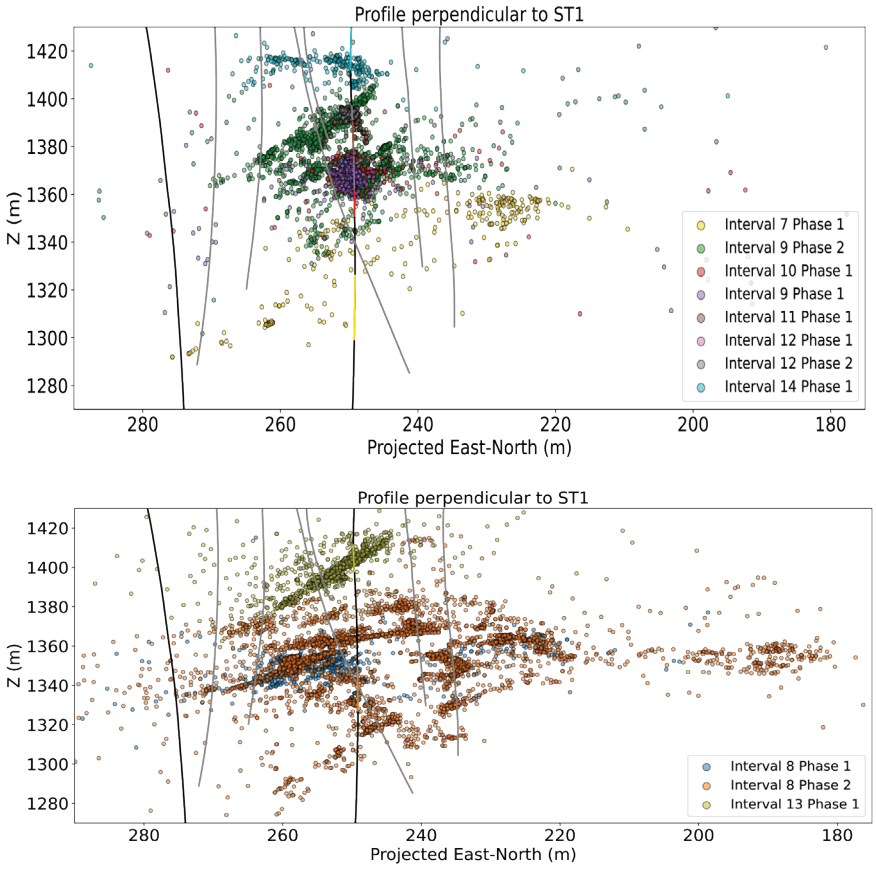
BEACH

Project “Bedretto Energy Storage and Circulation of Geothermal Energy (BEACH)” aims to establish a fully monitored and controlled geothermal reservoir at the BedrettoLab and operate it over 4 years with a seasonal cycle of energy storage and retrieval.

The proposal is in the final stages of negotiation with the SFOE and should start in late 2023.



Top: Boreholes in the Geothermal testbed and intervals in the 399 meter long ST1 stimulation borehole.



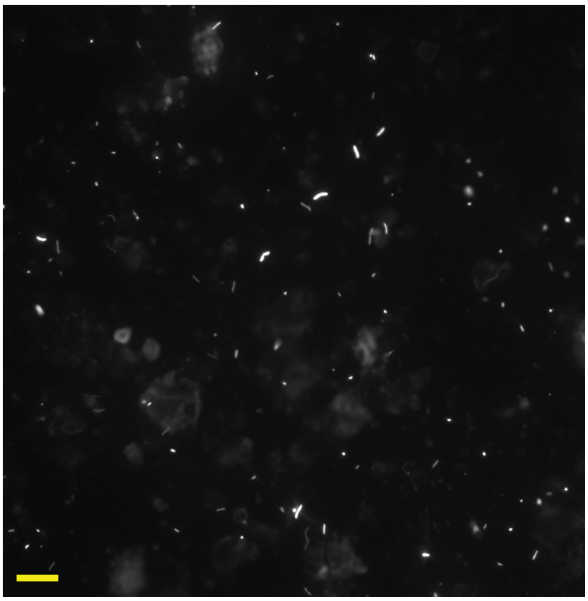
Left: Seismic events recorded during hydraulic stimulation experiments in intervals 7 to 14 of the stimulation borehole ST1. The seismic event points are colored depending on the stimulation interval. The black lines represent the stimulation and monitoring boreholes

Deep Life Observatory

The Deep Life Observatory (DELOS) of the Bedretto-Lab was established in 2021 to study organisms living at the energy limit of life.

As part of DELOS, dedicated field instruments and borehole infrastructure have been deployed throughout the tunnel, either in the Geothermal testbed or in unexplored areas, to support a variety of projects such as:

- tunnel-wide characterisation of tunnel and surface biogeochemistry
- in-situ experiments to study changes in microbial biomass during hydraulic stimulation
- microbial community evolution experiments with fluids from the BedrettoLab,
- characterisation of the 'microbial dark matter' inhabiting the Bedretto Rotondo granite.



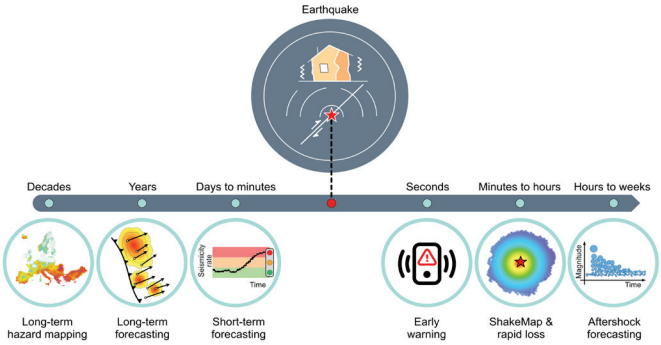
When a drop of water from the BedrettoLab is viewed under the microscope, it looks a little bit like the night sky. Millions of microorganisms, viruses and particles can be found in 1 L of BedrettoLab water. Scale bar in yellow = 10 µm.

Other projects

DT-GEO & Digital Twins

The MC fault in the Earthquake Physics testbed has been identified for near fault monitoring and modeling in the framework of the Digital Twin Earthquakes in the EU Project “Digitial Twin-GEOphysical extremes” (https://dtgeo.eu).

This digital twin will enter the EU flagship initiative “Destination Earth” (DestinE) at the end of 2023 and we are planning a digital twin for the whole Bedretto-Lab volume.



Dal Zilio et al, 2023 (in press)

SaMiEx

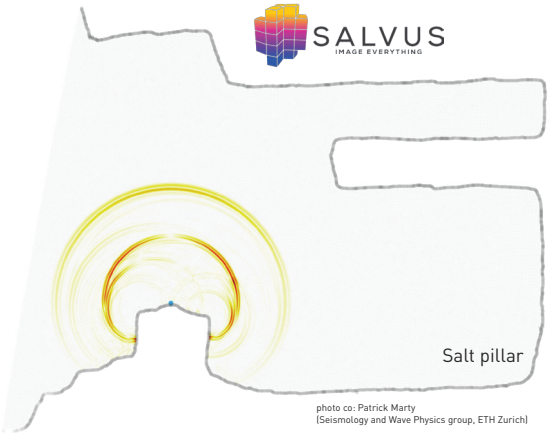
As part of the EU Synergy Project FEAR, seismic sensor calibration experiments have been carried out in the Merkers salt mine in Germany. The sensors will later be installed in boreholes for the FEAR experiments to measure picoseismicity.

Geo-INQUIRE

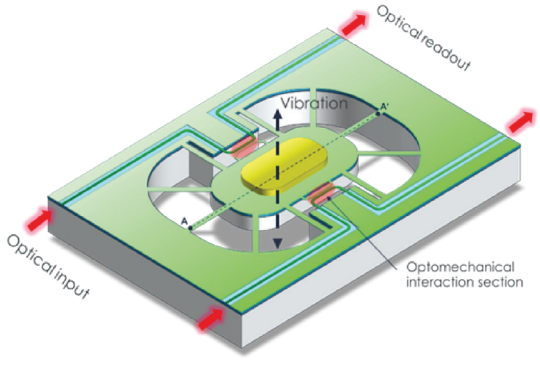
In the framework of EU Project Geo-INQUIRE (www.geo-inquire.eu) the BedrettoLab will provide physical and virtual access to the infrastructure and data to the scientific community

ArtEmis

ArtEmis will develop an intelligent sensor system that monitors radon, temperature, acidity and other observables in groundwater in real time. The pioneering sensor design will ensure affordability, resilience and low power consumption, optimising life cycle management. The project aims to produce 100-200 sensors, some of which will be installed in the BedrettoLab.



Synthetic wavefield using the SALVUS model for a point source on the salt pillar surface. Models will be used to absolutely calibrate the acoustic emission sensors – the same sensors that will be used for the FEAR experiments in the Earthquake Physics testbed



Schematic of the OPOSSUM sensor design.

OPOSSUM

Within project “Ultra-sensitive photonics accelerometers for next generation seismic sensor networks (OPOSSUM)”, in collaboration with the Centre Suisse d’Electronique et de Microtechnique (CSEM), the Bedretto team is working on developing a new sensor to measure high frequency acceleration.

At the heart of the sensor lies a gold-plated proof mass. The displacement of this proof mass is measured by light inferometry at the optomechanical interaction section.

In the next step the sensor will be placed in a vacuum sealed package and characterized in the laboratory.

Events & Visits

A selection of events and visits over the last year.

Mangia & Cammina

On August 7th 2022, the BedrettoLab took part in Mangia & Cammina, an event taking place in the Bedretto valley and organized by the local association Pro Bedretto.

Mangia & Cammina 2023 will take place August 13th and the BedrettoLab will be participating once again.

FEAR Annual Meeting 2023

In March, the 3rd FEAR annual meeting took place in Rome with the participation of over 50 partners and members.

WSS family Visit

In March, the Werner Siemens Family visited the BedrettoLab and had a nice meal organized by Bekir Yüce in the Barrack.

Earth Science Department Visit and Open House 2023

On June 2nd 2023, the BedrettoLab hosted collaborators of the Earth Science Department of ETH Zürich. About 90 employees from the department visited the BedrettoLab on a sunny day.

On June 3rd 2023, the BedrettoLab opened its doors to the public. Approximately 100 people from Ticino and the German-speaking Switzerland, as well as friends and family from team members, visited the BedrettoLab.

ETH Board visit

On July 13th 2023, the Board of ETH will be visiting the BedrettoLab during their yearly retreat.

Outreach

Bedretto Lab

Il Gazzettino di Bedretto

Numero 2 (Agosto 2022)

Cari residenti di Bedretto, cari lettori,

Benvenuti alla seconda edizione del Gazzettino BedrettoLab!

È passato più di mezz'anno dalla nostra prima edizione e sono successe molte cose nel laboratorio.

Gli esperimenti del grande "Bedretto Reservoir Project" stanno procedendo bene. Mentre alcuni sono stati impegnati in esperimenti e analisi, altri hanno ampliato il laboratorio e cementificato, scavato e pianificato.

In questa edizione potrete conoscere alcune persone che stanno contribuendo al BedrettoLab.

Vi auguriamo una buona lettura,

Il team BedrettoLab

Un laboratorio unico di fisica dei terremoti nel BedrettoLab

Oltre alle intense attività di ricerca in corso nel BedrettoLab, da novembre 2021 la galleria è anche un cantiere aperto. È infatti in corso un ampliamento del laboratorio per aggiungere un secondo ambiente sperimentale e dunque si stanno applicando rivestimenti, posando pavimentazioni, installando impianti elettrici e sistemi di ventilazione. Uno dei principali progetti di ricerca futuri che beneficeranno di tale ampliamento è denominato FEAR (Fault Activation and Earthquake Rupture).

L'idea centrale di FEAR è comprendere come si scatenano e si arrestano i terremoti modificando lo stress sulle faglie e usando iniezioni di acqua per provocare piccoli terremoti non dannosi, fino a 1 grado di magnitudo. Una fitta rete di strumentazione consentirà di avere una visione ravvicinata dei processi in atto nella faglia prima, durante e dopo la rottura sismica. Le scoperte ottenute grazie a FEAR miglioreranno la comprensione della fisica delle rotture sismiche, contribuiranno a spostare sempre più in avanti i limiti della prevedibilità dei terremoti e faranno progredire lo stato dell'arte nell'uso sicuro della geoenergia. La galleria di Bedretto offre una base perfetta per gli esperimenti di FEAR.

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Il Gazzettino

Il Gazzettino di Bedretto adresses the population of the Bedretto Valley and region. It has been published in August 2022 (2nd issue) and April 2023 (3rd issue).

BedrettoLab in the Media

The BedrettoLab is often visited by the media. Here is a selection of articles published during the year:

- In diesem Bunker über der Goldküste lagern jetzt Steine statt Patronen (Tages-Anzeiger, 31.03.2023)
- Ancient underground water could unlock secrets of alien life (Space.com, 09.11.2022)
- Lithium-Hype am Rhein: Chance oder Risiko? (SWR Wissen, odysso, 12.10.2022)
- Lassù dove i terremoti fanno meno paura (Corriere del Ticino, 29.08.2022)
- Looking for the origins of life deep underground (swissinfo.ch, 21.08.2022)
- Life deep inside the Earth (swissinfo.ch, 10.08.2022)

Education

During the last year, the BedrettoLab hosted:

- the joint-Master Case Studies where the students visited the Swiss Underground Rock Laboratories Grimsel, Mont Terri and BedrettoLab.
- the borehole geophysics lecture

The following MsC students have finalized their master's degree with projects involving the BedrettoLab:

- Maria Blanch: Analysis of anisotropic wave propagation of S-waves in the Rotondo Granite using seismic crosshole measurements.
- Deborah Stadler: In situ stress profiling along Bedretto boreholes via integrated geomechanical approaches
- Claire Epinay: Investigating anisotropic seismic velocities of the Rotondo granite in intact and fractured sections by crosshole seismic surveys
- Fenna Houtsma: Geological model selection for the Bedretto lab using gravity and magnetic observations

Personnel

Since summer 2022, two new PhD students have joined the Bedretto team:

- Lu Tian is studying how to monitor and backproject microseismic events.
- Danyang Jiang is using numerical modeling combined with field measurements to understand the physical origins of seismicity.

In 2023, a total of 25.6 FTE are active in the BedrettoLab. 8.5 FTE are senior scientists, 7 PhDs, 9.8 FTE for the general BedrettoLab operation including administration, IT, technical staff, and communication.

With the planned increase in activities, the BedrettoLab will recruit additional technical staff and a data manager.

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