EMPOWERING
UNDERGROUND
LABORATORIES
NETWORK USAGE

Empowering Underground Laboratories network usage

SITE DESCRIPTION AND DATA OF THE GFZ-Underground LAB

in the Reiche Zeche mine Freiberg

Site services, Characteristics and Data

Dr. Rüdiger Giese, Dr. Katrin Jaksch, Susanne Häberer

February 2, 2022

The project development is part-financed
by the European Union
(European Regional Development Fund)
under the Interreg Baltic Sea Region Programme.

Interreg Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Table of Contents

1 Aim and Introduction

This report provides an overview of the features, properties and services of the GFZ-Underground Lab in the Reiche Zeche mine in Freiberg for external users and site managers.
The aim is to support marketing, project planning/execution, business, and innovation development. General site information, including current use and access to the GFZ-Underground Lab, is followed by information on research, innovation and cooperation possibilities, and the onsite support, including the database. The bedrock geology, hydrogeology, and hydrochemistry data and properties are described in detail.

Contact:

Helmholtz-Centre Potsdam
GFZ German Research Centre for Geosciences

Telegrafenberg
D-14473 Potsdam

+49 (0)331 – 1575

www.3duslab.com

Email: kawi@gfz-potsdam.de, rudi@gfz-potsdam.de

2 Overall description of GFZ-Underground Lab

2.1 Location

2.1.1 Geographical settings

The GFZ-Underground Lab (GFZ-ULab) is located in the Research and Education Mine "Reiche Zeche" in Freiberg (http://tu-freiberg.de/lfbw) which is operated by the Technical University Bergakademie Freiberg. The GFZ-Ulab is situated 150 m below the surface on the first floor of the mine. Figure 1 shows the GFZ-ULab in a perspective view (see also the 3D sketchfab model of the Reiche Zeche https://sketchfab.com/3d-models/flb-freiberg-8b53a8ad9960494b9d571d2b53a75837).

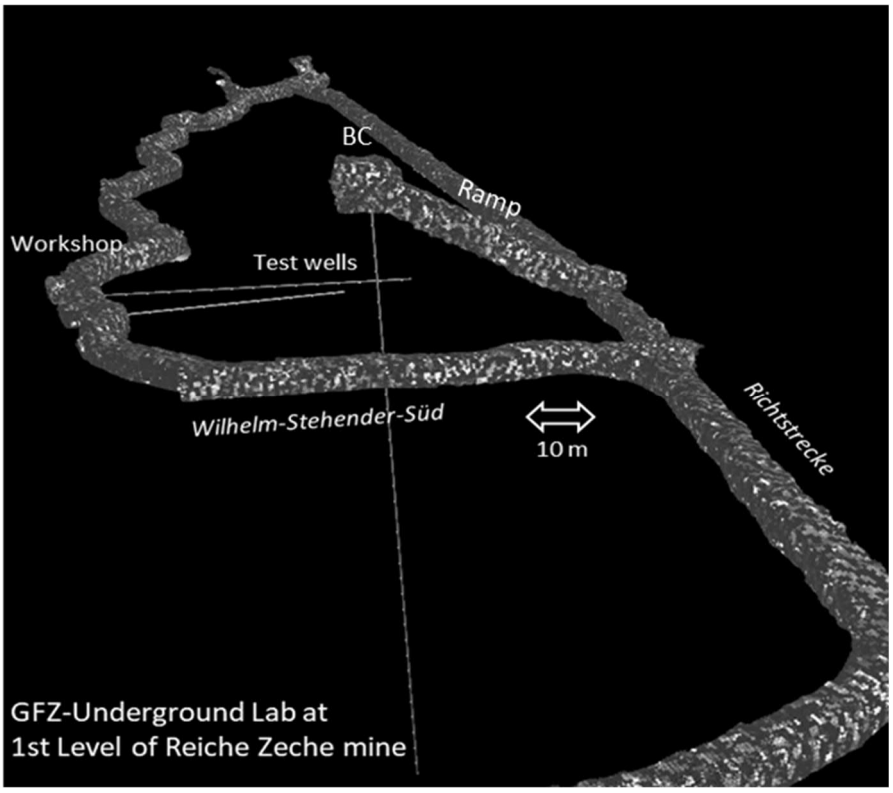

Figure 1: GFZ-Underground on the first level of the Reiche Zeche mine in Freiberg.

2.2 Use and Acces

2.2.1 The original purpose and current use

The development of high-resolution 3D seismic imaging techniques for the structural exploration around tunnels and boreholes is the main objective of the research activities at the GFZ-Underground Lab. Other geophysical or geotechnical tests like borehole magnetic and electric experiments can be performed in the lab as well. Different imaging techniques such as 3-component Kirchhoff-Migration or Fresnel-Volume-Migration are tested and modified with respect to their capability to resolve small-scale structures within rocks. High-resolution surface seismic sources and different seismic receivers for application in underground constructions works have been tested in

the GFZ-ULab. In-house developed and pneumatically-driven impact hammers and magnetostrictive vibrators have been used as sources (Fig. 2).

Figure 2: Pneumatically driven impulse hammer source pre-stressed against the Richtstrecke gallery wall (see Fig 1).

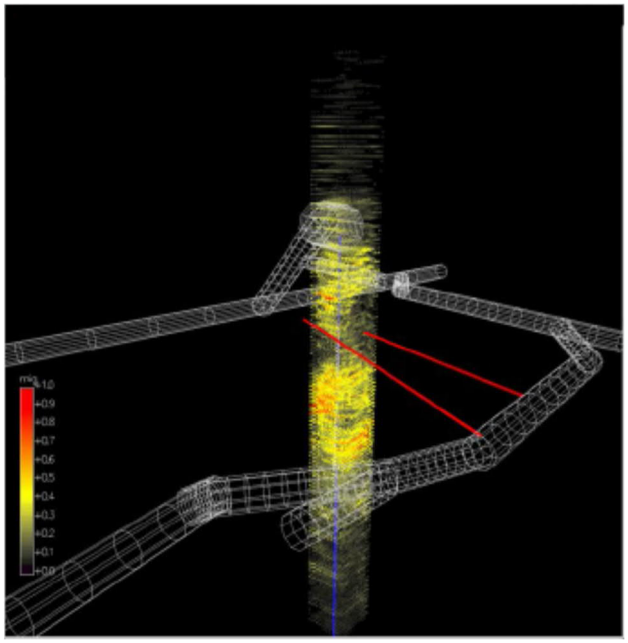

Figure 3: Example of a Fresnel-Volume-Migration for shear waves to image the surrounding area of the vertical borehole. Yellowish and reddish colours mark high reflective areas caused by fracture zones.

2.2.2 Available infrastructure

Test Boreholes:

- Two horizontal open hole boreholes, diameter= 8 ½" (216 mm), length = 30.6 m, length = 20.4 m
- Two horizontal open hole boreholes, diameter= 86 mm, length = 70 m, diameter = 96 mm length = 50 m
- One vertical open hole borehole, diameter = 8 ½" (216 mm), BH3 length = 70 m
- 30 1-m and 2-m deep monitoring boreholes, diameter = 44 mm, distributed along the galleries with 4 m –9 m distance from each other

Available downhole tools and infrastructure onsite

- SPWD - laboratory prototype equipped with four magnetostrictive actuators and four three-component geophones (GS 14L9, 28 Hz) for the application in horizontal dry boreholes
- SPWD - wireline prototype equipped with four magnetostrictive actuators and four three-component geophones for the application in vertical fluid-filled boreholes
- Two pneumatic impulse hammer sources for the application at tunnel surface
- Magnetostrictive actuator sources for the application at tunnel surface
- Seismic borehole receiver tool equipped with four three-component geophone receivers (GS 14L9, 28 Hz) and 1 m spacing for the application in horizontal dry boreholes
- 64 three-component geophone (GS 14L3, 28 Hz) anchors installed in 1 m and 2 m deep steel ropes
- Winch with 100 m cable for downhole tool application in the vertical borehole
- Two carriages equipped with hoisting cranes to transport and apply seismic surface sources on rails installed along with the galleries
- Two compressors
- Workshop including tools for mechanical and electrical services
- Internet connection

2.2.3 Current ownership and organisation

Describe here the managerial structure of the underground facility and the owner/&manager level organisations with whom the uses could be operating. Underground access

Contact:

GFZ-ULab: www.3duslab.com (Research initiatives and collaborations)

– Dr. Rüdiger Giese, Head of 3D-US Lab, Sect. Geomechanics & Scientific Drilling, German Research Center for Geosciences, Potsdam

– Dr. Katrin Jaksch, Coordinator of 3D-US Lab, Sect. Geomechanics & Scientific Drilling, German Research Center for Geosciences, Potsdam

Describe here the extent of the underground facility's access and access protocols to the underground facilities. Especially if elevator, incline/ramp are accessible, what size equipment can be transported.

No protocols; please use the contact data.

2.2.4 Commuting

Describe how to get to the site via public transportation (bus, train, plane) and car. What are the nearest airports, trains stations and bus stops?

The GFZ-ULab in the Reiche Zeche is located in the city of Freiberg, about 40 km from Dresden and Chemnitz. One can get to Reiche Zeche from Dresden by car in about 45 minutes. The train journey from Dresden Hauptbahnhof to Freiberg (Sachs) takes around 40 minutes. Freiberg (Sachs) station is located approximately 3 km from UL (35 minutes on foot). The nearest airports are in Dresden, approx. 50 km from UL, and in Prague (Czech Republic) approx. 140 km (approx. 2 hours by car or 4 hours by train via the central station in Dresden).

2.3 Research, innovation and cooperation possibilities

2.3.1 Innovation and research

Describe the service offering of the underground laboratory. E.g., For innovation and research, we provide access to a unique data and operational underground facility with typical Scandinavian bedrock conditions (crystalline, fractured and water-bearing bedrock crossed by larger and smaller weakness zones). The conditions are very well documented in reports, scientific articles and doctoral theses. Describe on a general or exemplary level the areas of research and innovation conducted at the site.

The GFZ-ULab is a test site for geophysical measurements, single- and cross-hole experiments or tunnel surface to borehole trials. Its combination of galleries and horizontal and vertical boreholes enables the execution of three-dimensional geophysical experiments, e.g. for tool validation and calibration under in-situ rock conditions. This way, it is a complementary test site to other deep crustal lab facilities, which allow tool testing under high-pressure and high-temperature conditions.

2.3.2 National and international cooperation

Describe the existing extent of cooperation both nationally and internationally. If there are any major publicly available projects to mention as an example, that would be good. Additionally, belonging to any organisation, e.g., the European Underground Laboratories Association, would be good to mention as well.

The works and services available in the GFZ-Ulab are coordinated and organised by the Helmholtz Innovation Lab" 3D-Underground Seismics" (3D-US, www.3duslab.com). 3D-US Lab supports companies on projects for exploration ahead and around underground structures, consulting and developing individual customer solutions. 3D-US uses the modular measurement methodology of underground seismic to generate three-dimensional images of underground structures.

The GFZ operating the Underground Lab is a member of the European Underground Laboratories Association.

2.4 Support at the site and available database

2.4.1 Project handling, competencies and quality control

Describe the services and the extent of how the UL can help the users, whether in project management, partnering, or just as a facility and facility service provider, E.g.,

- Rent a facility at the UL for experiments and tests
- Rent equipment
    - 3 component geophones (GS 14L9, 28 Hz) for the application in horizontal dry boreholes

- SPWD - wireline prototype equipped with four magnetostrictive actuators and four three-component geophones for the application in vertical fluid-filled boreholes
- Two pneumatic impulse hammer sources for the application at tunnel surface
- Magnetostrictive actuator sources for the application at tunnel surface
- Seismic borehole receiver tool equipped with four three-component geophone receivers (GS 14L9, 28 Hz) and 1 m spacing for the application in horizontal dry boreholes
- 64 three-component geophone (GS 14L3, 28 Hz) anchors

- Rent onsite operation/monitoring of the activity

The GFZ-ULab boreholes and the infrastructure are available for external scientific (and commercial) utilisation. Due to complex, heavy-duty operations and because of safety regulations, all operations will be conducted under the supervision of GFZ personnel. Tools and instruments of the GFZ as described above can be made available according to needs.

2.4.2 Database

Describe the existence of data sets (surface, geological, geophysical, geochemical, other) for the users to plan and execute their activities.

Various seismic datasets, logs and core scanner data are available from surveys in the GFZ-Underground Lab for further investigations. The seismic tomography data to Krauß et al. (2014) Krauß et al., 2014 are published and available as supplementary datasets Krauß et al. (2013) (Krauß et al., 2013).

Krauß, F., Giese, R., Alexandrakis, C., & Buske, S. (2013). Supplement to: Seismic travel-time and attenuation tomography to characterise the excavation damaged zone and the surrounding rock mass of a newly excavated ramp and chamber. Deutsches GeoForschungsZentrum GFZ. http://dx.doi.org/doi:10.5880/GFZ.sd.2013.001

Krauß, F., Giese, R., Alexandrakis, C., & Buske, S. (2014). Seismic travel-time and attenuation tomography to characterise the excavation damaged zone and the surrounding rock mass of a newly excavated ramp and chamber. International Journal of Rock Mechanics and Mining Sciences, 70, 524–532. http://dx.doi.org/doi:10.1016/j.ijrmms.2014.06.010

3 Site description data and data properties

3.1 Bedrock geological data and properties

3.1.1 Geological data and tectonics

Describe the top-level geological and tectonic data of the underground laboratory.

3.1.2 Major rock type(s)

Describe the major rock type(s) within the underground laboratory.

Freiberger Grey Gneis

3.1.3 Data sources

3.1.3.1 Surface data

Describe the available surface data, e.g., bedrock maps, ground magnetic, resistivity and seismic surveys and where it can be found. (Metadata)

3.1.3.2 Borehole data

Describe the metadata of the borehole data. Describe the metadata of the data sets or, if not applicable, information where the data would be available.

Borehole wall optical scans are available for the two horizontal large-diameter wells. A complete suite of borehole logging data is available for the vertical test well, e.g. acoustic, gamma-ray, electrical logs. Surface scans of the cores can also be made available for users of the GFZ-ULab.

3.1.3.3 Underground data

Describe the extent of the underground data at a general level. Describe the metadata of the data sets or, if not applicable, information where the data would be available.

Various seismic data sets are available with various frequency ranges (10 Hz- 10.000 Hz).

4 Summary

The GFZ-ULab is situated 150 m below surface on the first floor in the education and research mine “Reiche Zeche” of the Technical University of Freiberg. Surrounded by three galleries, the measuring site comprises a block of homogeneous high-grade gneiss of almost 50 m width and 100 m length and ensuring constant environmental conditions. Along the galleries over thirty 3-component one and two meter long geophone anchors with a length of one or two meters are installed with a distant of 4–9 m from each other. Horizontal and vertical boreholes of diameters between 85 mm to 225 mm were drilled into the rock and allows to test borehole geophysical equipment. The site is mainly used to test seismic acquisition systems for exploration and monitoring. Log data and seismic data sets are available to test seismic inversion technics such as tomographic and reflection imaging methods.