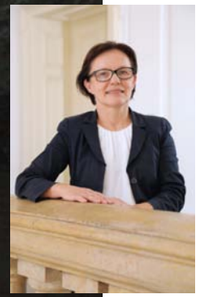
MONTAN UNIVERSITÄT LEOBEN

ZaB ZENTRUM am BERG



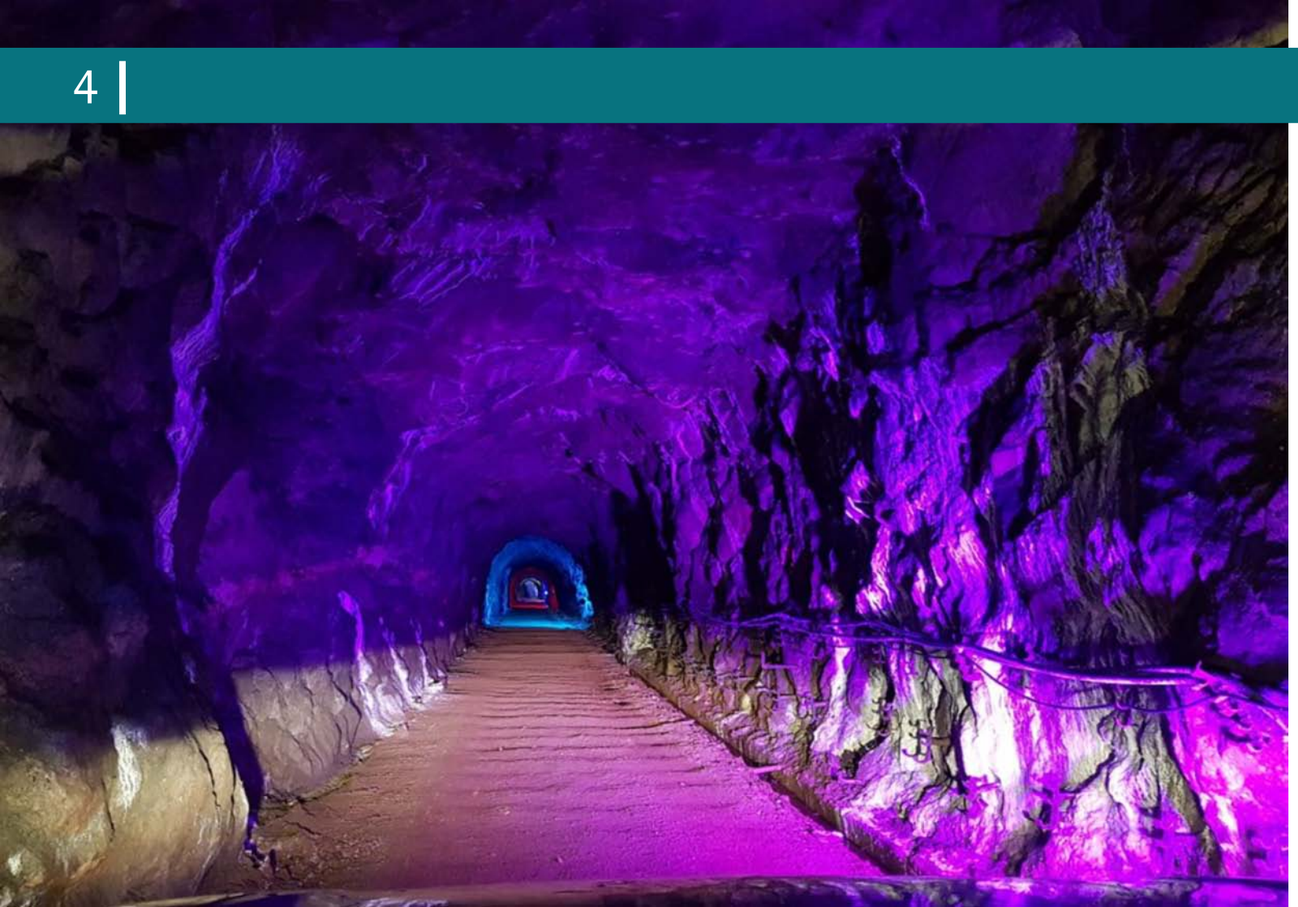
Research on highest level

Within the research and development community ZaB - Zentrum am Berg is a further unique selling point of Montanuniversitaet Leoben. The research@ZaB enables research at the highest level not just on all challanges related to tunnel and underground construction, such as further development of existing and the generation of new underground tunneling methods, but also special research questions from all kinds of industries. It enables the use and testing of new materials and equipment as well as the use of alternative tunnel ventilation systems. There are also completely new perspectives for safety technology, including the extinguishing systems integrated in the tunnel. Within the scope of a large-scale EU-project, possibilities for underground energy storage are also explored at Zentrum am Berg. As a consequence, Montanuniversitaet also provides a sustainable political impulse for Upper Styria and especially for the region of Eisenerz.

Thanks to the funding bodies of the federal government, namely BMWFW and BMVIT as well as the federal state of Styria, it was possible to establish this unique research infrastructure.

Univ.Prof. Dipl.Ing. Dr.techn. Dr.h.c.
Wilfried Eichlseder
Rector of Montanuniversitaet Leoben

Dr. Martha Mühlburger
Vicerector of Montanuniversitaett Leoben



ZaB-Zentrum am Berg

With the project "Research@ZaB - Zentrum am Berg", an underground facility for research, development, education and training purposes is established, which on the one hand should meet the requirements of public institutions, but at the same time represents a development factory for the responsible universities as well as for private companies.

The underground facility includes two parallel road tunnels and two parallel railway tunnels as well as a test tunnel, which will enable research, development, training and education under real underground conditions on a 1:1 scale.

Welcome to ZaB – Zentrum am Berg

Univ.Prof. Dipl.Ing. Dr.mont.
Robert Galler
Head of Department ZaB-Zentrum am Berg

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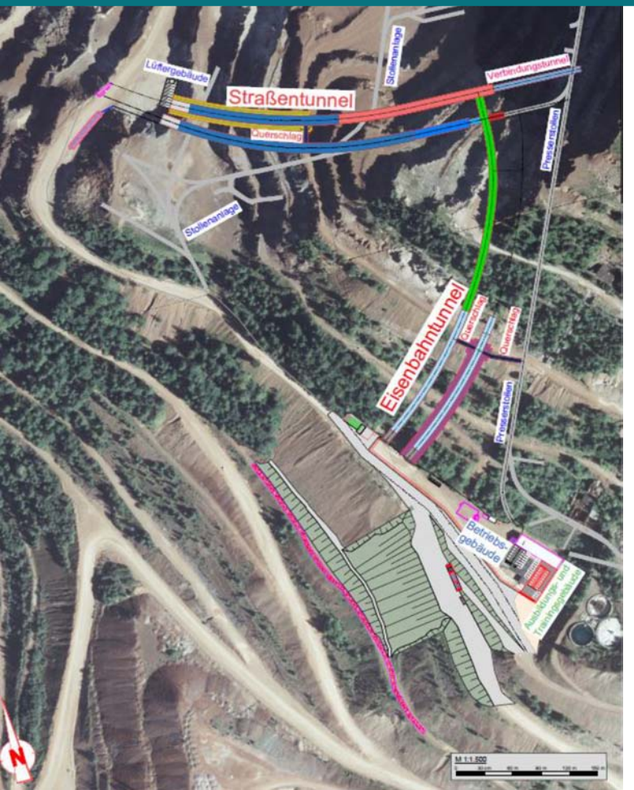


CENTRE OF EXCELLENCE FOR

- SCIENCE
- INDUSTRY
- EMERGENCY ORGANIZATIONS

With ZaB-Zentrum am Berg Montanuniversitaet Leoben operates a unique neutral and independent research infrastructure for the construction and operation of underground facilities.

The facility consists of an extensive tunnel system and enables research and development on a 1:1 scale as well as training and education under real conditions.

1. EXCELLENT RESEARCH AND DEVELOPMENT

of international research institutions, students and companies on research topics related to the safety, construction and operation of underground facilities such as tunnels, underground railways, mining facilities, power plants or deep drilling rigs from the oil and geothermal industry.

2. EDUCATION AND TRAINING

- of emergency organizations under realistic tunnel and operational conditions,
- of operational strategies and testing of evacuation scenarios,
- of tests with automatic fire fighting systems,
- of operational and maintenance personnel on topics such as safety in construction and operation of underground facilities, optimized handling of maintenance procedures or material and equipment optimization.

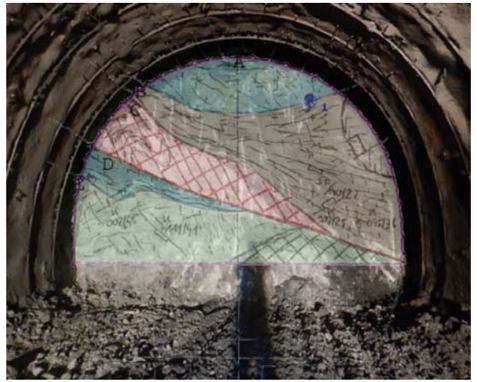
3. TRAINING OF USERS OF THE ROAD- AND RAILWAY INFRASTRUCTURE

4. SEMINAR CENTER

for international networking for science and economy

THREE PORTAL LOCATIONS
FIVE TUNNEL TUBES

The underground facility includes two parallel road tunnels and two parallel railway tunnels as well as a test tunnel. The tunnels can be reached via three entry portals. At the end a total of five tunnels are available for research and test purposes.



ROAD TUNNEL

The tunnels are designed and fully equipped according to the directive for tunnel crosssections (RVS 09.01.22). The width of the lanes of the road tunnels are defined for directional traffic and a projected speed of 100 km/h. The clearance height of the traffic area above the roadway is 4.70 m. Conventional ventilation systems (longitudinal and transverse ventilation) are used, which allow investigations in case of very high fire loads (e.g. truck fire).

The road tunnels are also equipped with an extinguishing water pipe, emergency call and fire-fighting niches and wall hydrants. Escape route warning lights, escape route orientation lights and escape route orientation signs indicate the emergency escape route.

RAILWAY TUNNEL

For the railway tunnels the clearance profile LPR 1 was fixed. This enables investigations using double-deck wagons. The walkway has a clearance height of 2.25 m and a width of 1.20 m. Instead of using slab tracks, a ballasted track was chosen; the dimension of the ballasted track construction is in line with the slab track construction.

- INTERNATIONAL RESEARCH PROJECTS
- RESEARCH ON A 1:1-SCALE
- REALISTIC UNDERGROUND CONDITIONS

The unique tunnel system of ZaB-Zentrum am Berg offers realistic underground conditions for questions from broad areas of research, development and testing on a 1:1-scale, e.g. in the fields of:

- Geotechnical monitoring
- Numerical simulations in geotechnics and tunnelling
- Safety research, safety technologies, ventilation, tests of fire detection and fire protection equipment, risk management
- Rescuing conditions
- Thermo- and aerodynamic questions
- Long-term stability and durability of materials
- Refurbishment of underground structures
- Effects of climate change: mudflows, rockfall, landslides and forecasting technologies
- Innovative and low-vibration excavation methods
- Technical equipment such as control systems, door systems (leakage requirements vs. pollution) or electro technical equipment in railway tunnels

The fully equipped road-, railway- and test tunnels allow a variety of training possibilities and experimental procedures for emergency, operational and maintenance personnel. The intention is to make a decisive contribution to increasing the safety of users of underground facilities. Training courses will also be used to train service and maintenance personnel and provide practical training for relevant professions.

- Testing of evacuation scenarios using a wide range of protection- and control devices, signaling techniques, etc.
- Tests with automated fire-fighting systems
- Training for very high fire loads (e.g. truck fire)
- Effects of different operating scenarios for plant and operating technicians, optimized handling of maintenance procedures Education of relevant professions

- **TRAINING OF OPERATING AND SERVICE PERSONNEL**
- **TRAINING FOR EMERGENCY PERSONNEL**
- **TRAINING OF ROAD AND RAILWAY INFRASTRUCTURE USERS**

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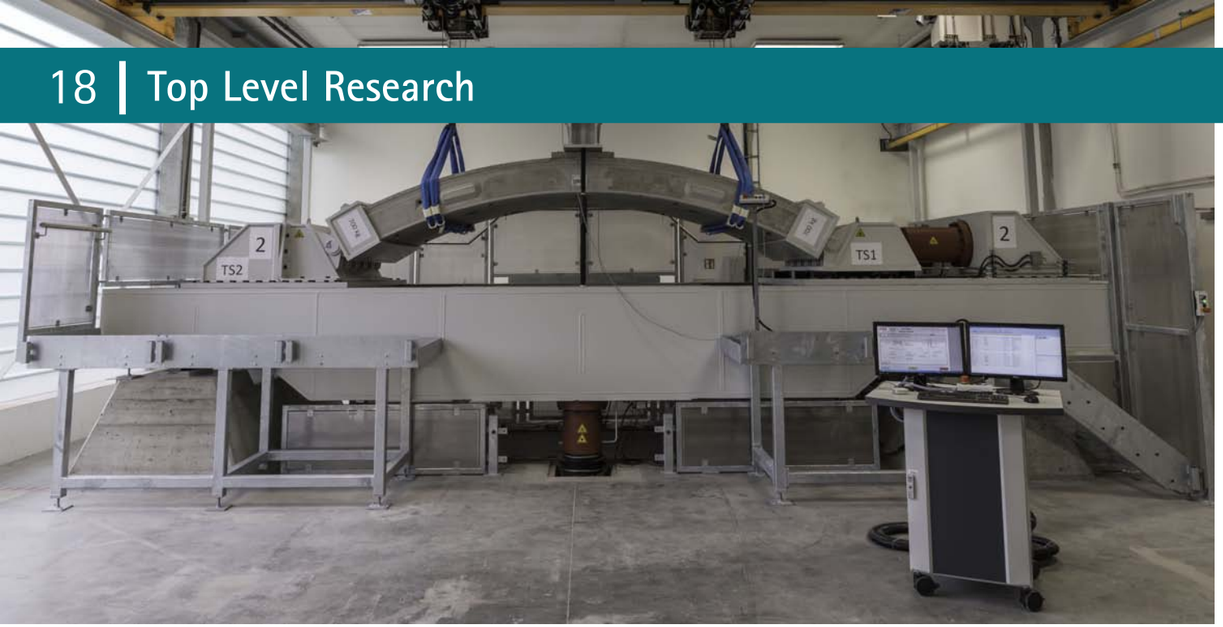
Digital transformation in tunnel construction

Digitalization as a key to making conventional tunnel construction "smart". Research groups at the chair work with the latest technologies on innovative and sustainable solutions tomorrow. The digital transformation of the new Austrian tunneling method (NÖT) is being advanced on an interdisciplinary basis. The Zentrum am Berg serves as a research facility for evaluating these new methods and testing the latest technologies. Point cloud data are generated using laser scanning processes and processed into an image using algorithms from artificial intelligence. This enables object recognition similar to a conventional photo. In this way, objects can not only be identified, but also provided with metadata. The vision is to store every component in the tunnel, no matter how small, with its respective history. This information can be queried at any time with a simple mouse click or with the blink of an eye through data glasses. In order to implement the vision, we at the chair also work with young, creative start-up companies from all over Austria.

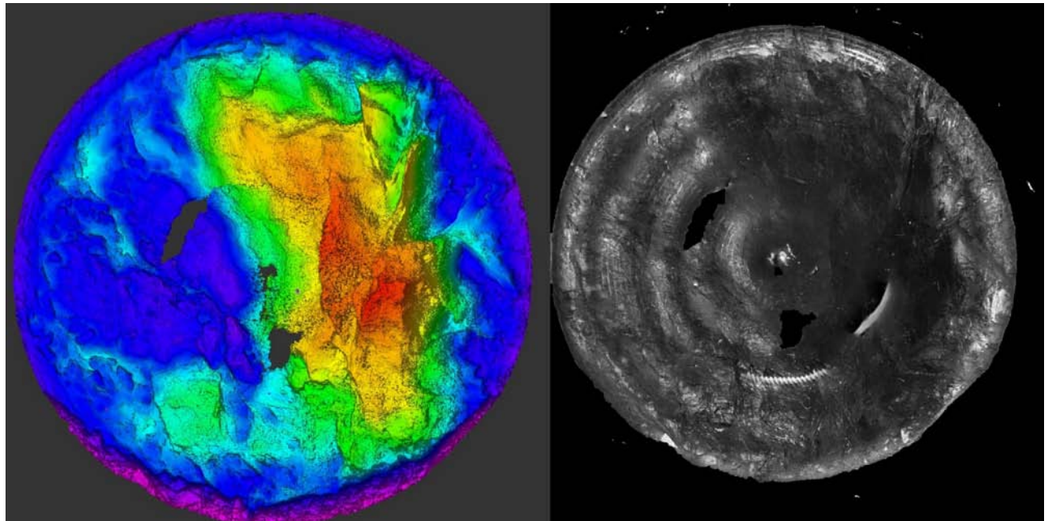


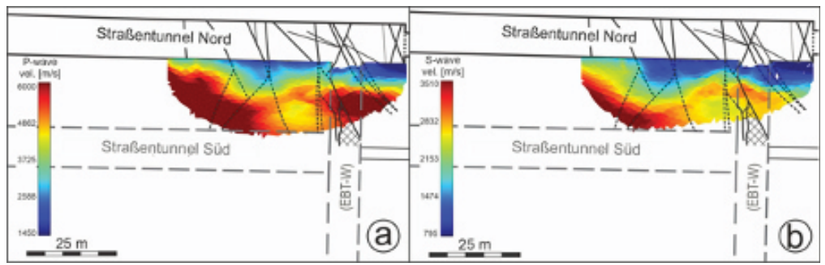
Lining Segment Test Facility

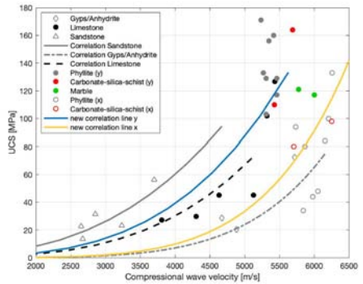
For the verification of the load-bearing and deformation behavior of construction site-compliant segments under precisely defined load conditions, a test facility for biaxial tests was developed and implemented in cooperation with ÖBB-Infrastruktur AG. Furthermore, a camera-based system for the detection of cracks was developed at the Chair of Subsurface Engineering. A 3D finite element model of the segments examined was created using the Abaqus finite element package and the numerical simulation was validated on the basis of the test data.

Tunnel Boring Machine (TBM) Excavation

The development status of the engineering geological documentation of the excavation face is an ongoing challenge due to the few openings in the cutting head. The restricted view in particular has so far significantly limited the informative value of the geologist's engineering geological mapping. A multi-camera system has now been developed to meet the requirements of the largest possible excavation face, which, thanks to its positioning in the disc boxes, is flexible with regard to the number of possible cameras, light in design and also easy to assemble.







Geophysics in tunneling

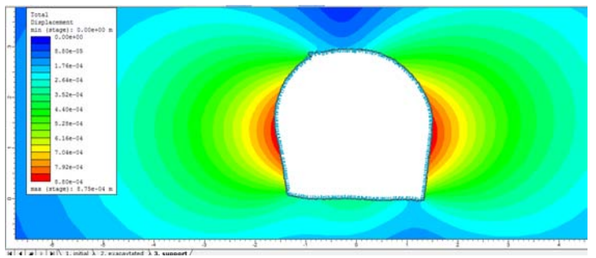
Geophysics is playing an increasingly important role in exploration ahead of the excavation face in the form of electromagnetic as well as seismic refraction and reflection measurements. These measurements are aimed at geological faults and structures up to 150 meters ahead of the face, which can delay or even bring the tunneling to a standstill due to difficult-to-estimate geotechnical parameters and the associated water in flow. The correlation of these seismic measurement signals with geotechnical parameters such as elastic modulus, shear modulus, bulk modulus or density of the rock is carried out by determining the wave velocities (P and S waves). The evaluation of these geophysical measurements can be carried out, but is still affected by limitations and ambiguities with regard to resolution, prediction accuracy or mathematical evaluation of the pilot signal. Advance exploration in the near-field range of up to 20 meters is still completely unclear and requires efficient, high-quality basic research, which ongoing projects are aimed at. This approach of correlating geomechanical and geophysical parameters is also pursued in the laboratory.

TBM Disc Force Monitoring

The increasing optimization of the cutting processes for the successful and economical handling of current large, TBM tunnel construction projects increasingly requires monitoring of the cutting tools. Research work at the Montanuniversitaet led to the development of cutting force measurement systems for full-face machines equipped with discs. These continuously provide measurements of the forces acting on the disc cutters. Only when the loads experienced are known can factors for the service life and material fatigue of cutting tools be determined and wear predictions developed further. The measured disc forces are also used to characterize the rock.

Geomechanical Modelling

The ZaB provides a perfect facility for examining long-term performance of subsurface excavations with combined monitoring and geomechanical numerical modelling (image at right) of deformation of old mining galleries. The new excavations also provide the opportunity to examine the impact of new excavations on adjacent old galleries through observation of support integrity, deformation monitoring and numerical modelling. The results from these studies can inform best practice for ensuring the longevity of subsurface infrastructure.



The Zentrum am Berg offers students the opportunity to be taught directly in the field under 1: 1 conditions: Among other things, the trainees learn how to apply shotcrete and take samples.

Students have the opportunity to operate construction vehicles, experience safety training on site, and be involved in research projects.

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Furthermore, training courses for practitioners and the interested population are carried out. The offer ranges from training courses in the specialist field of shotcrete to drilling and blasting technology to special issues in geotechnical engineering. Users of the railway and road infrastructure can complete theoretical and practical training on questions of tunnel safety.

This unique center is also designed for exercises by fire and mine rescue teams. A fully equipped building with showers and training rooms is also available for this.

Thanks to the winding tunnel and gallery system, the facility offers a top-class underground exercise route. Mobile smoke generators, gas-fired fire dummies and fully functional tunnel equipment allow realistic training.

In addition, the fully equipped black and white area including a respiratory protection workshop meets the most modern standards and rounds off the portfolio of the entire system. With the highest safety standards, the Zentrum am Berg offers a unique training opportunity to best prepare the emergency services for an emergency.

Zentrum am Berg serves as an event infrastructure and international hub for researchers, students, emergency organizations, industry, as well as operators and users of road- and railway infrastructures. The aim is to initiate excellent international and interdisciplinary cooperation in the field of underground research.

- NETWORK FOR SCIENCE AND INDUSTRY
- TECHNOLOGY CONGRESSES, EXHIBITIONS AND CONVENTIONS
- TRAINING AND EDUCATION

INFRASTRUCTURE

- 2 road and 2 railway tunnels
- Test tunnels, laboratories, blasting chamber
- Training- and seminar center
- Realistic conditions on a 1:1-scale

RESEARCH AND DEVELOPMENT

- Initiation and implementation of cooperative research projects
- Interface to scientific staff and researchers

SERVICES

- Installation and disassembly of experimental arrangements
- Support of trials and tests
- Maintenance and repair services

KNOWLEDGE TRANSFER

- Networking for industry and science
- Dissemination via congresses, conferences, seminars
- Platform for continuous knowledge transfer
- Continuing education and training
- Training and special education

The Erzberg with its Zentrum am Berg is also used for major international events, such as one of the toughest motorcycle races in the world:
the Erzbergrodeo!

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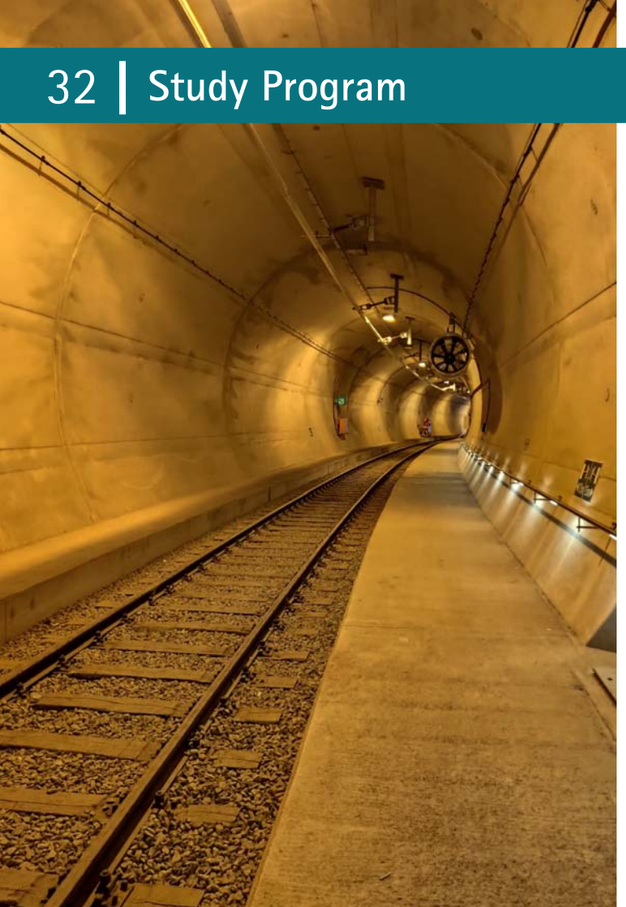
With its tunnels and galleries as well as the attached training center, which also includes a black-and-white and canteen area, the Zentrum am Berg offers a training center for all emergency organizations and operating organizations.

Mining and Tunneling with Specialization in Geotechnics and Tunnelling imparts knowledge in the fields of geotechnical investigation analytical and numerical calculations for the design of underground structures and the selection of the right construction method. This includes issues arising from cost calculation and construction management as well as contracts and tunnel safety. ZaB - Zentrum am Berg provides all students the possibility to work in a 1:1-research-lab.

Bachelor Programm - Mineral Resources Engineering(Semester 1-7)

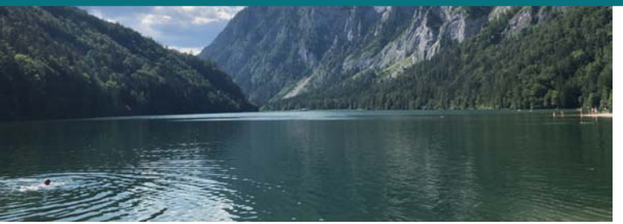
- Introduction to the Study Program
- Mathematics I & II
- Statistics
- Chemistry I-A, I-B & II
- Physics I-A, I-B & II
- Mechanics I-A
- Introduction into Mineral Resources Engineering including mining, tunneling and construction materials
- Fundamentals in Geology
- Physical Chemistry I
- Methods of Chemical Analysis
- Machine Drawing
- Electrical Engineering I
- Elements in mechanical engineering I-A & I-B
- Engineering Project in machine elements
- Computer Applications and Programming
- Prinicples of Soil and Rock Mechanics
- Design Models and Structural Design
- Introduction to Mineralogy and Petrology
- Mineralogy
- General Business Administration I & II
- Basics of Open Pit and underground Mining I & II & III
- Basics in Mineral Processing
- Surveying
- Processes and Plants in the Minerals Industry
- Building Materials I
- Binders I
- Introduction to Ceramics
- Tunneling Methods
- Health and Mine Safety Regulations and Management
- Mining Law
- Organisation in Mineral Resources Engineering
- Heat Engineering
- Seminar to the Bachelor Thesis
- Mandatory Practice

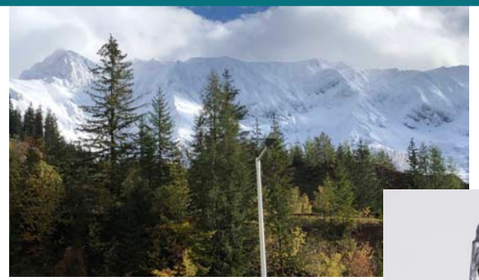


Master Programm (Semester 8-11) - Mining and Tunneling
Focus: Geotechnics and Tunnelling

- Selected topics of Soil Mechanics
- Geophysical Exploration in Tunneling
- Rock Mechanics and Rock Engineering
- Geotechnical Laboratory
- Geotechnical Survey
- Finite Elements
- Selected Aspects of Engineering Surveying in Mining and Tunneling
- Computer based calculationsin the field of Subsurface Engineering
- Geotechnical Monitoring and Instrumentation

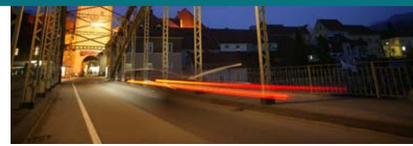
- Fundamentals of Geothermics
- Numerical Modelling in Geotechnics
- Construction Contracts
- Conventional Underground Construction Models
- Specialized Construction Methods in Rock and Soil
- TBM Tunneling
- Project Planning and Construction of Underground Structures
- Design of Underground Structures
- Practical Exercises and Training in the field of Geotechnics and Tunnelling
- Maintenance of Underground Infrastructure Projects
- Construction Operations
- Cost Calculation and Construction Managment
- Safety Underground
- Excursion
- Seminar Masters thesis





www.hochsteiermark.at - www.eisenerz.at - www.leoben.at

Here, in the heart of Styria, in the ERZBERG LAND region, is your world for very personal adventure. Be role models for little explorers in big experiences. Follow in the footsteps of Aquarius deep underground in the mystical tunnel system of the "Erzberg Adventure". True explorers do not stroll in the future, but find the rich treasures in the present - like by far the most dazzling color world of the water at Leopoldsteinersee, the winner of the Styrian seat selection.



The old town and modern flair play together perfectly in Leoben. In 2005, parts of the Dominican monastery that are protected as a monument were integrated very stylishly and modernly into the most modern shopping center in Upper Styria! The interplay between city and nature works like nowhere else! Many of the festivals have a long tradition and they are often part of mining customs.

100 years of eventful history have left many traces in the second largest city in Styria, which is also known as the "gateway to the Styrian iron road". In no other city is there such an ingenious interplay between omnipresent history and innovative modernity as in Leoben.

Research- and development center
Training- and education center
Department ZaB – Zentrum am Berg
Head:
Univ.-Prof. Dipl.-Ing. Dr.mont. Robert Galler

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