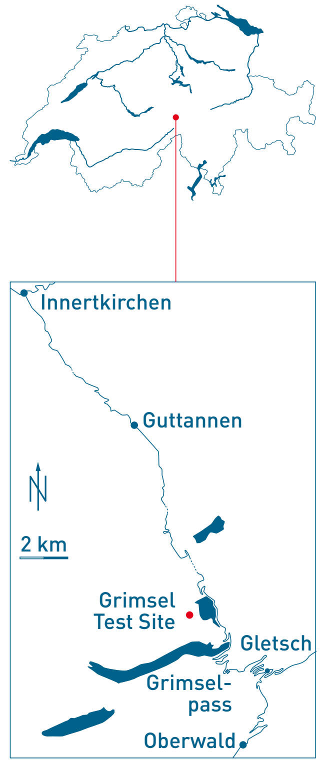
The Grimsel Test Site



450 metres beneath the Juchlistock
The Grimsel Test Site is located at an altitude of 1730 metres above sea-level in the granitic formations of the Aar Massif. It is reached via the access tunnel of the Oberhasli AG hydro-power plant (KWO). The total length of the laboratory tunnels is around one kilometre; the tunnel network was excavated in 1983 using a full-face boring machine and blasting techniques and was extended in 1995 and 1998.

Geology
Some 300 million years ago, magmas solidified to form granitic rocks in the Grimsel area. New molten masses flowed into fissures of the cooling rock and formed dyke rocks (lamprophyres). During the alpine orogeny, which affected the Grimsel area around 40 million years ago, the rocks of the Aar Massif were passed over by the northwards-moving alpine nappes and subsided by around 12 kilometres. The rocks were then overprinted under high temperature and pressure conditions and shear zones and fracture systems were formed. Uplift (0.5 to 0.8 mm/a) and erosion processes, which are still continuing today, brought the rocks of the Aar Massif to the surface once more. The mineral fractures for which the Grimsel area is famous formed around 16 million years ago.

Not a laboratory in the conventional sense
Deep in the rock, the range of geological conditions found in the laboratory (fractured/water-bearing and homogeneous/tight areas) present ideal boundary conditions for investigating the functioning of both the geological and engineered barriers of deep repositories. Projects that look at the disposal concepts on a large scale are also an important aspect of the work at the Test Site. A radiation controlled zone allows radionuclides to be used under monitored conditions, giving a direct insight into the transport of radioactive substances in the rock.

Internationally recognised research centre
Today, around 25 partner organisations, as well as universities, research institutes and consulting companies from various countries, are involved in the projects at the Test Site. The European Union and the Swiss State Secretariat for Education and Research provide financial support to several experiments. The work at the Test Site makes an important contribution to maintaining knowledge on the long term and to transferring know-how to future generations.

Visit us
From June to October, Nagra offers groups the opportunity to experience free guided tours of the Grimsel Test Site.

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Grimsel Test Site

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July 2010
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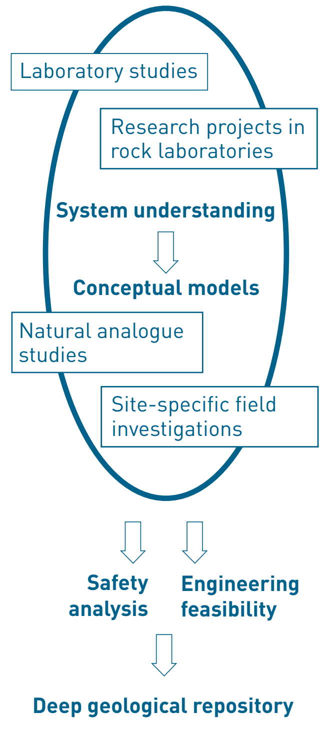
grimsel test site

research on safe geological disposal of radioactive waste

nagra

Deep geological disposal

Building blocks of a waste management programme

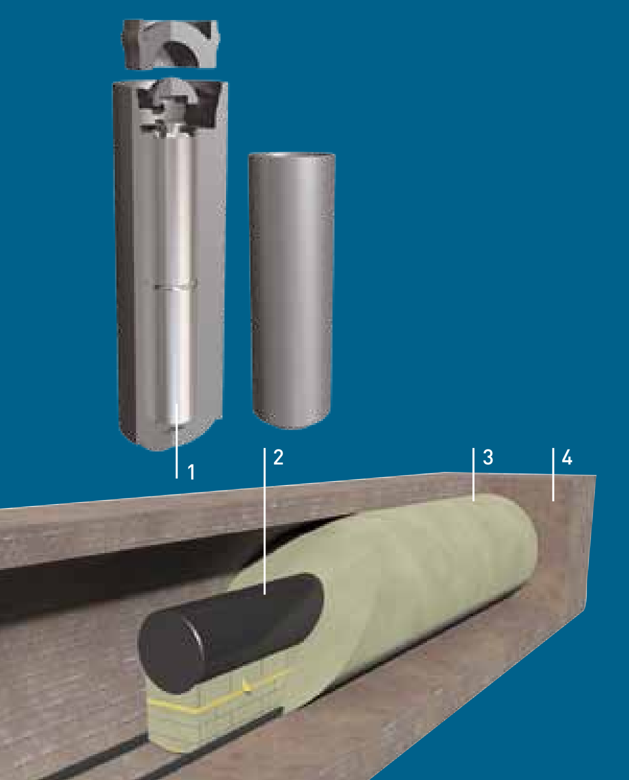


Taking responsibility
Our generation is producing radioactive waste and it is our duty to manage this waste in a way that is both responsible and sustainable. The waste producers have entrusted Nagra with implementing this important task.

The way to deep disposal
In Switzerland, deep geological disposal is required by law for all types of radioactive waste. Experts worldwide are in agreement that this strategy represents a safe long-term management solution. Field investigations for determining the suitability of potential disposal sites are an important component of a waste management programme. The field work is complemented by laboratory studies, investigations of relevant natural processes (natural analogues) and research projects in underground rock laboratories; these provide a better understanding of the safety of geological repositories, the properties of suitable host rock formations and the functioning of the engineered safety barriers.
The two rock laboratories in Switzerland – the Grimsel Test Site (Canton Bern) and the Mont Terri Rock Laboratory (Canton Jura) – are important research centres, both for the Swiss national programme and for international collaboration.

Contribution of the rock laboratories
Rock laboratories make a key contribution to answering the questions raised by safety analyses and to confirming the feasibility of deep disposal of radioactive waste from an engineering viewpoint. The focus of research activities includes:

- Geological and hydrogeological characterisation of rock formations that are potentially suitable for deep disposal.
- Properties and long-term behaviour of the components of the engineered safety barriers.
- Transport and retention of radionuclides in the engineered barrier system and the surrounding geosphere.
- Verification of the data and models used in safety analysis.
- Technologies for tunnel excavation and waste emplacement.
- Providing information to the public, politicians and the authorities.
- International collaboration and exchange of know-how.



In the research spotlight
Properties and functions of the safety barriers and the feasibility of constructing and emplacing engineered barrier systems for deep geological repositories.

Practical application
The safety barrier system for a deep geological repository for high-level waste consists of:

Engineered barriers
1 Glass matrix (containing the radioactive waste)
2 Steel container
3 Clay backfill (bentonite)
These engineered barriers delay the release and transport of radioactive substances into the surrounding rock.

Geological barrier
4 Rock

More than 25 years of research at the Grimsel Test Site

Focus of research to date
The research activities over the last two decades have focused mainly on the following:

- Developing techniques for site investigations. One example is the remote sensing of rock formations using seismic tomography.
- Testing technologies for repository construction and evaluating their impact on the functioning of the geological barrier. Examples include investigating the excavation disturbed zone in the rock caused by tunnel construction and borehole sealing systems.
- Developing and testing the engineered barrier system. Besides demonstrating disposal concepts on a large scale, projects have looked at the long-term evolution of the barriers in terms of saturation, heating and gas migration.
- Testing of the models and databases used in safety analysis. This includes investigations of the transport and retardation of radioactive substances in the rock or the effects of colloids and highly alkaline solutions on the transport of radionuclides.

The future
Many repository projects will be implemented in the 21st century and the investigations in a rock laboratory prepare the way for this step. When planning projects, the feasibility and operational safety of deep disposal are in the foreground. The aim of the investigations in the rock laboratory is to look at the behaviour of disposal systems over periods of decades under repository-relevant conditions, to optimise technical procedures and to document their safety. The following objectives have been set for the coming years:

- Performing experiments that demonstrate and verify the functions of the engineered and geological barriers of a deep repository. This involves recreating the conditions that prevail in repositories over many years to allow slowly occurring coupled processes to be better quantified.
- Development of new technologies for the emplacement of radioactive waste (e.g. remote handling and monitoring techniques).
- Education and training of technical experts and students.

Focus of current research and main projects

1 – Processes and long-term behaviour of the engineered barriers

FEBEXe (Full-scale HLW Engineered Barriers Experiment – extension) 1:1 demonstration of the emplacement concept for high-level waste

FORGE (Fate of Repository Gases) Gas migration in the engineered barriers (bentonite/sand)

GAST (Gas-Permeable Seal Test) Gas-permeable tunnel sealing (planning phase)

2 – Radionuclide transport: interactions between waste, engineered and geological barriers

CFM (Colloid Formation and Migration) Formation and transport of colloids and their influence on radionuclide mobility

LCS (Long-term Cement Studies) Long-term interactions between cement solutions, porewaters and the rock

3 – Characterisation of the geological barrier

LTD (Long-term Diffusion) Long-term diffusion of radionuclides

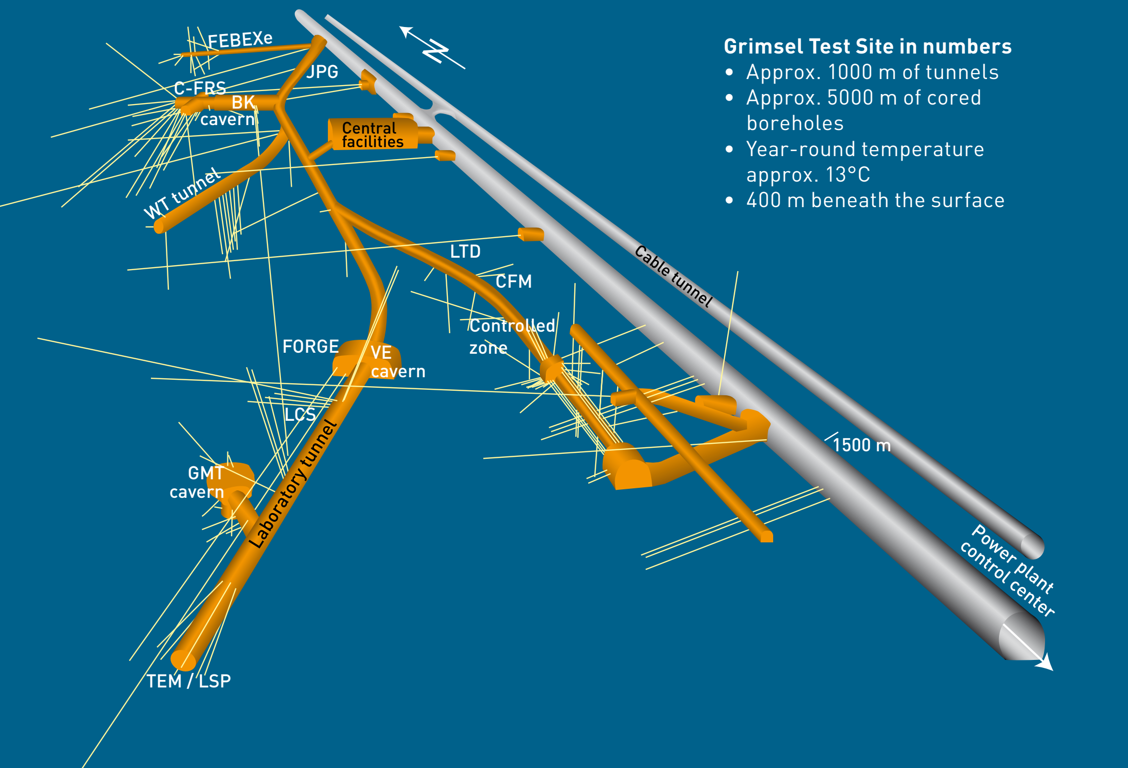
C-FRS (CRIEPI Fractured Rock Studies) Hydrogeological and geological characterisation of tectonic fracture structures

4 – Technical and operational aspects of repository construction

LSP (Low-pH Shotcrete Plug) Use of low-pH cements

TEM (Test and Evaluation of Monitoring Techniques) Testing monitoring techniques

JGP (JAEA Grouting Project) Cement injection under high formation pressures



Tunnel system at the Grimsel Test Site. Yellow lines: boreholes.

GAST:
Location not yet decided.

Grimsel Test Site in numbers

- Approx. 1000 m of tunnels
- Approx. 5000 m of cored boreholes
- Year-round temperature approx. 13°C
- 400 m beneath the surface

What questions are being addressed by the work at Grimsel today?

What effect does the heat emitted by high-level waste have on the tunnel backfill and the surrounding rock?
The FEBEXe project is looking at the emplacement concept for high-level waste on a 1:1 scale. The heat generated by radioactive decay and the weight of the waste container are simulated by an electric heater embedded in bentonite blocks. The aim of the experiment is to predict the effectiveness of the engineered barrier functions under the influence of heat and to demonstrate their engineering feasibility.

What happens to gas produced in a waste emplacement tunnel?
The planned GAST project is a large-scale sealing experiment. In a backfilled repository, gases are produced by the corrosion of metals and the degradation of organic materials. How can a gas-permeable tunnel sealing system be constructed without compromising the hydraulic tightness of the system? The focus of the experiment is on investigating saturation behaviour and gas transport through the backfill material. Engineering feasibility is also considered.

How are radioactive materials retained in the rock and what influences their mobility?
Most waste disposal concepts plan to use cementitious materials which, together with groundwater, form high-pH solutions. The flow properties and the retention capacity of the rock for radioactive substances can be altered by these highly alkaline waters.
The LCS project is looking at the interaction between the rock and such highly alkaline waters.
The LTD project is investigating the diffusion of radionuclides from fractures into the rock matrix, where they are partly retained.
The CFM project addresses the question of the influence of colloids in the vicinity of fractures and shear zones on the transport (mobility) of radionuclides. Complex in situ experiments are carried out under realistic boundary conditions to investigate the migration behaviour of radionuclides and colloids.

Radionuclides
Each chemical element has stable and spontaneously decaying (= radioactive) isotopes. Radioactive isotopes are also called radionuclides.

Diffusion
The passive balancing of the concentration of gaseous or dissolved substances between areas of higher and lower concentration is termed diffusion.

Colloids
Microparticles of organic or inorganic origin (e.g. fine clay particles) that are microscopically dispersed in a medium such as water.

Current research
For more information on the current research projects at the Grimsel Test Site, visit the English-language website www.grimsel.com. An overview can be found at www.nagra.ch.