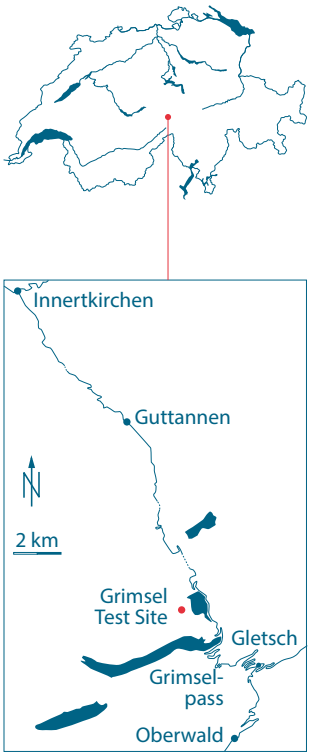
grimsel test site

research on safe geological disposal of radioactive waste

nagra we care

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 hydropower plant (KWO). The total length of the laboratory tunnels is around one kilometre; the tunnel network was excavated in 1983/84 using a full-face boring machine and blasting techniques and has since been extended three times.

Internationally recognised research centre

More than 20 partner organisations from various countries as well as the EU are participating in the research projects being conducted at the Grimsel Test Site. The underground rock laboratory makes a significant contribution to the long-term preservation and transfer of accumulated know-how to future generations.

Not a laboratory in the conventional sense

Deep inside the mountain, geological conditions range from fractured sections of rock to others that are intact. Water flow occurs in the former but not in the latter. The Test Site thus provides ideal boundary conditions for examining the performance of geological and engineered safety barriers of deep geological repositories. In addition, experiments are being conducted on a 1:1 scale and under natural conditions. For example, very small amounts of radioactive substances are used in a radiation controlled zone to examine the migration behaviour of these substances directly in the rock.

Geology

Some 300 million years ago, magmas solidified to form granitic rocks in the Grimsel area. New molten masses penetrated into fissures of the cooling rock and solidified as dyke rocks. The Alpine orogeny shaped the Grimsel area around 40 million years ago when Alpine nappes were thrust northwards over the rocks of the Aar Massif, which sank to a depth of approx. twelve kilometres. The rocks were then overprinted under high temperature and pressure conditions, resulting in the formation of shear zones and fracture systems. 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.

Visit us!
From June to October, Nagra offers groups the opportunity to experience free guided tours of the Grimsel Test Site. Join the thousands of people who have already visited us and witness first-hand how internationally renowned research is conducted in the laboratory. You can also combine a visit to the Test Site with a hike in the beautiful Grimsel region. More information on the Test Site is available at: fuehrungen.nagra.ch.

Registration for a guided tour
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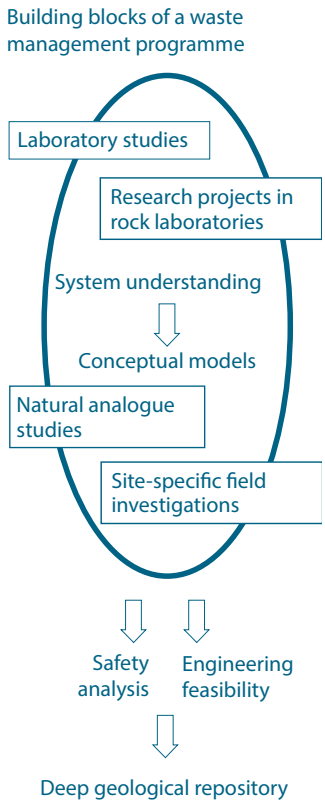
Grimsel Test Site

Participating countries

With a view to deep geological disposal



Taking responsibility

Our generation is producing radioactive waste and it is our duty to dispose of this waste in a responsible and sustainable way. The waste producers have entrusted Nagra with developing and implementing a waste management solution.

The road to deep disposal

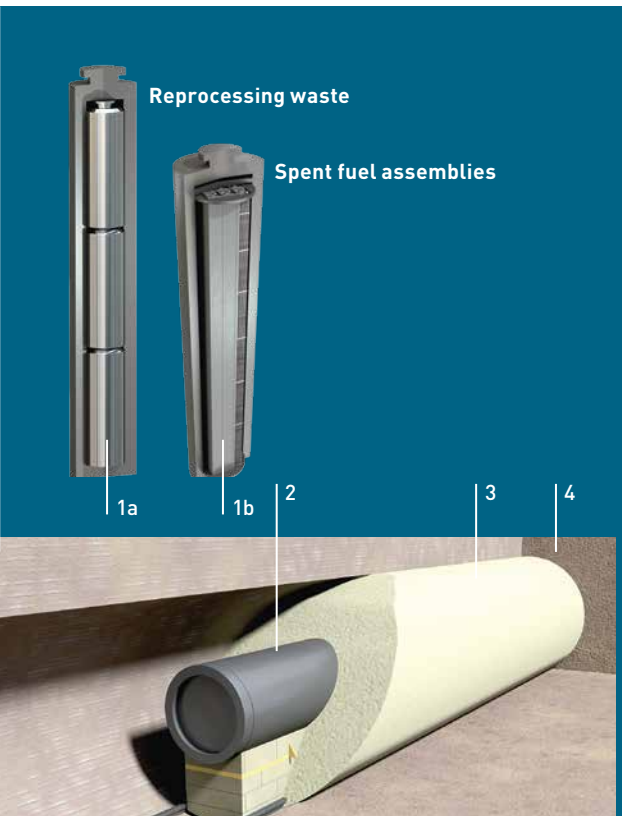
Experts worldwide agree that deep geological disposal is a safe, long-term solution for radioactive waste. In Switzerland, it is required by law. Nagra outlines the steps to be taken on the road to deep geological disposal in its Waste Management Programmes.

The Grimsel Test Site (Canton Bern) and the Mont Terri Rock Laboratory (Canton Jura) are important research centres both for the Swiss waste disposal programme and for international collaboration. Research in these laboratories focuses on gaining and expanding expertise concerning the safety of deep geological repositories, the characterisation of rocks and the functioning of the engineered safety barriers. These research activities are complemented by external laboratory studies and observations of similar processes found in nature (so-called natural analogues).

Contribution of the rock laboratories

Rock laboratories contribute significantly to answering questions concerning long-term safety and also to verifying the technical feasibility of constructing deep geological repositories for radioactive waste. The focus of research activities includes:

- Geological and hydrogeological characterisation of rock formations that are suitable for deep geological disposal
- Properties and long-term behaviour of the components of the engineered safety barriers
- Migration behaviour and retention properties of radioactive substances in the engineered safety barriers and in the surrounding rock
- Verification of the data and calculation models used in safety analyses
- Technologies for tunnel construction and waste emplacement
- International collaboration and exchange of know-how
- Providing information to the public, politicians and the authorities.



Safety barriers of a deep geological repository

Several successive barriers confine the radioactive waste. The waste is shielded from impacts that could compromise safety and the radioactive substances are retained until they have decayed to natural levels.

The engineered barriers of a deep geological repository for high-level waste consist of a low-solubility waste matrix (1a glass or 1b nuclear fuel) containing the radioactive substances, a thick-walled steel canister (2; one-metre diameter) and a drift backfill of bentonite (3; mixture of clay minerals). The geological barrier is formed by the host rock (4) that surrounds the emplacement drifts.

More than 30 years of research at the Grimsel Test Site

Current experiments at the Grimsel Test Site

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

CIM (C-14/I-129 Migration through aged cement) Testing the transport properties of C-14 and I-129 through cement barriers

EBS Lab (Engineered Barrier System Laboratory) Experiments with components of the engineered barriers and measurement of parameters

FEBEX (Full-Scale Engineered Barriers Experiment) 1:1-scale demonstration experiment of the emplacement concept for high-level waste

GAST (Gas Permeable Seal Test) Gas sealing experiment: gas-permeable tunnel seals for the L/ILW repository under realistic conditions and on a realistic scale

HotBENT (High-Temperature Bentonite Project) Investigations of the safety function of bentonite barriers exposed to elevated temperatures

ISC (In-Situ Stimulation and Circulation Test) Controlled hydraulic stimulation of existing fault zones (Experiment of the Swiss Competence Center for Energy Research – Supply of Electricity)

LASMO (Large Scale Monitoring) Monitoring and characterisation of the geosphere

LCS (Long-term Cement Studies) Cement injection experiment: long-term interactions between cement solutions, porewaters and rock

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

MaCoTe (Material Corrosion Test) Corrosion experiments with engineered barrier components

MoDeRn (Monitoring Developments for Safe Repository Operation and Staged Closure) Work package of the EU project on testing wireless monitoring systems (TEM)

Focus of research to date

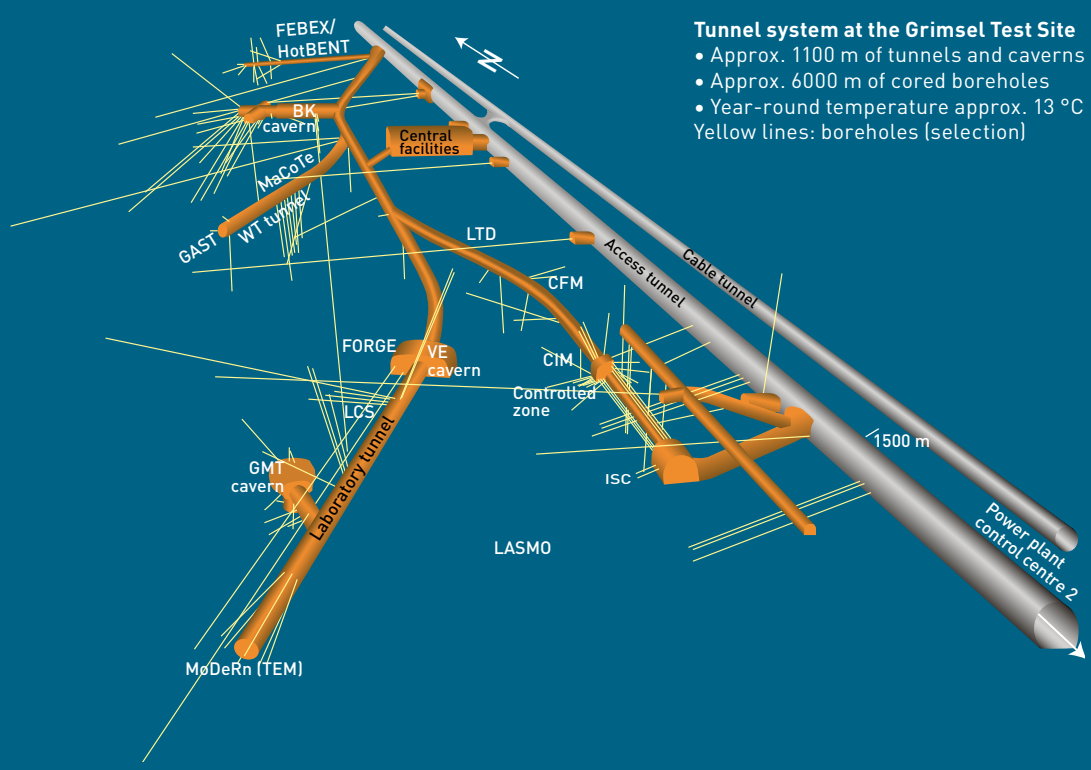
Research activities have focused mainly on the following:

- Developing techniques for site investigations. One example is the remote imaging of rocks using seismic tomography.
- Testing technologies for repository construction and evaluating their impact on the functioning of the geological barrier. Examples include investigating the sealing of boreholes or small changes to the rock caused by tunnel excavation.
- Developing and testing the engineered barrier system. These experiments also provide important data for predicting the long-term evolution of a deep geological repository.
- Verifying models and databases used in safety analyses. This includes experiments on the transport and retention of radioactive substances (radionuclides) in the rock or the effect of colloids and highly alkaline solutions on the migration behaviour of radionuclides.

Present and future

Many deep repository projects will be refined and implemented in the 21st century. The research conducted at the Grimsel Test Site provides important groundwork for these developments. When planning experiments, the main focus is on the feasibility and operational safety of the repositories. These experiments aim to determine the behaviour of disposal systems over 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 functioning of the engineered and geological barrier system of a deep geological repository. To better quantify slowly occurring coupled processes, the conditions prevailing in the repositories must be simulated over many years.
- Development of new technologies for the emplacement of radioactive waste (e.g. remote handling and monitoring technologies).
- Education and training of technical experts and students.



Tunnel system at the Grimsel Test Site
- Approx. 1100 m of tunnels and caverns
- Approx. 6000 m of cored boreholes
- Year-round temperature approx. 13 °C

Yellow lines: boreholes (selection)

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

How are radioactive substances retained in the rock and what influences their mobility?

Most waste disposal concepts plan to use cement-based materials which, together with groundwater, can form high-pH solutions. This can alter both the flow properties of water contained in the rock pores and the capacity of the rock for retaining released radioactive substances (radionuclides).

The LCS experiment (duration: 2005 to 2016) explored the interaction between the rock and highly alkaline solutions.

The focus of the LTD project is on the diffusion of radionuclides in undisturbed rock, where they are partly retained.

The CFM experiment investigates the influence of colloids in the vicinity of fractures and shear zones on the migration (mobility) of radionuclides. Such in-situ experiments are carried out directly in the rock under boundary conditions that are as realistic as possible. The investigations also provide important information about the erosion behaviour of bentonite.

What happens to gases produced in a waste emplacement drift?

In a backfilled repository, the corrosion of metals and the degradation of organic materials produce gases. The GAST experiment is a large-scale sealing experiment investigating the saturation behaviour and controlled gas transport through the backfill material. In addition, the experiment provides know-how concerning the engineering feasibility of such sealing structures.

What effect does the heat emitted by high-level waste have on the drift backfill and the surrounding rock?

The FEBEX experiment is a demonstration experiment for high-level waste emplacement conducted on a 1:1 scale. It was installed at the Grimsel Test Site in 1997 and excavated in 2015 after an 18-year running time. The analysis of the vast amount of data and information is still ongoing. The results will help scientists to predict the behaviour of the engineered barriers in the immediate vicinity of a heat-producing waste canister as accurately as possible, resulting in the ability to make robust statements about the long-term safety of a future repository.

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

Diffusion
The passive concentration balance of gaseous or dissolved substances between higher and lower concentration levels is called diffusion.

Colloids
Colloids are microparticles of organic or inorganic origin (e.g. fine clay particles) that are minutely dispersed in a medium (e.g. water).

FEBEX
Under the lead of the Spanish waste disposal organisation ENRESA, and based on the Spanish disposal concept, an emplacement drift for spent fuel was simulated in the "Full-Scale Engineered Barriers Experiment".

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