mont terri rock laboratory

Visit the Mont Terri Rock Laboratory

research on the safe geological disposal of radioactive waste

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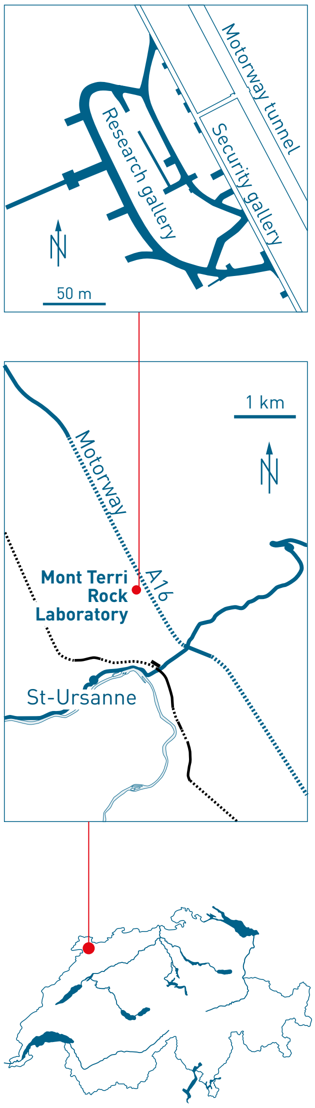
A rock laboratory in a clay formation



300 metres deep

The Mont Terri Rock Laboratory lies to the north of the town of St-Ursanne in Canton Jura. It is located at a depth of around 300 metres below the earth's surface and is accessed through the security gallery of the Mont Terri tunnel of the A16 motorway, which passes through the Jura mountains. The research galleries in the Opalinus Clay layer have a total length of around 600 metres.

The first experiments in 1996 were carried out in eight small niches along the security gallery. A separate, dedicated research gallery was then constructed in 1998 and extended in 2004, 2008 and 2012.

The Rock Laboratory infrastructure is for research purposes only; the disposal of radioactive waste in the facility does not come into question.

Geology – rock from an ancient sea

In the Jurassic period, around 173 million years ago, the Opalinus Clay was formed by the deposition of fine mud particles on the bottom of the sea that covered the area at that time. During the folding of the Jura mountains around ten million years ago, an anticline was formed and thrust towards the north-west over the Tabular Jura of the Ajoie. In the area where the Rock Laboratory is located, the rock strata dip towards the south-east at an angle of around 35 to 45 degrees and are displaced by small fault zones. The thickness of the Opalinus Clay layer at Mont Terri is around 150 metres.

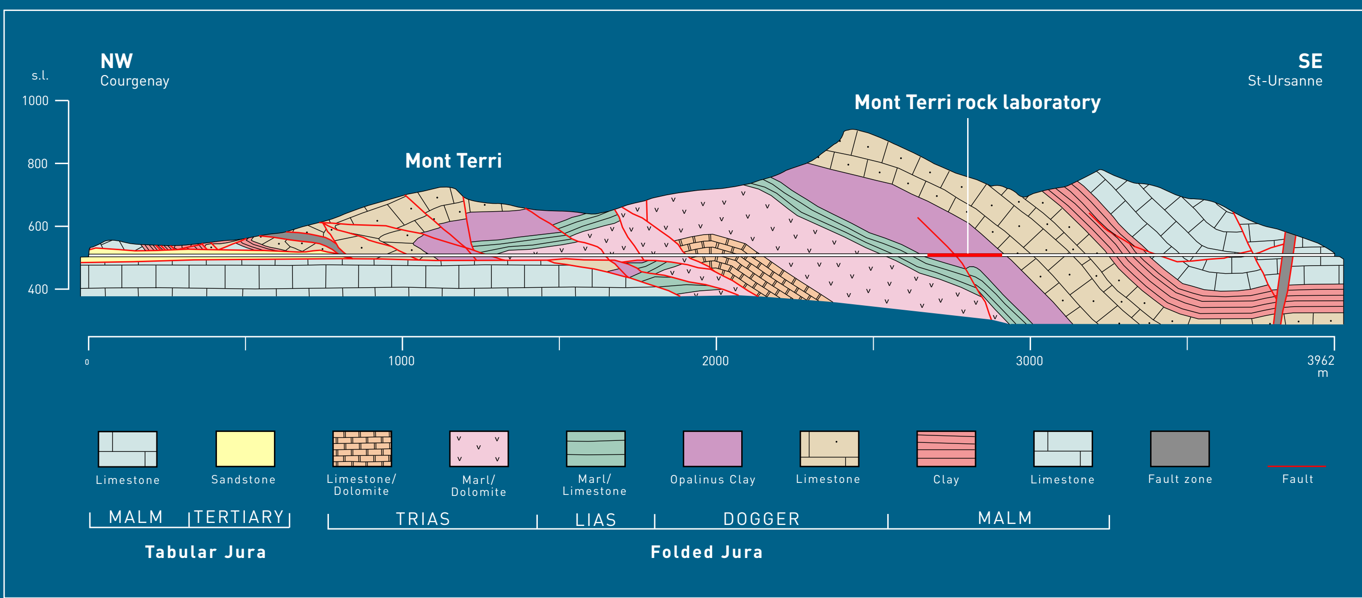
Clay minerals make up between 40 and 80 percent of the Opalinus Clay. Around 10 percent of these minerals are capable of swelling. Contact with water leads to an increase in the rock volume, which in turn allows the self-sealing of small fissures. Other components of the Clay include quartz, calcite, feldspar, siderite and pyrite.

Water originating from the sea

The Opalinus Clay has a very low permeability and the porewater in the formation is practically immobile. Investigations have shown that up to 20 grams of salts are dissolved in every litre of porewater. The water in the fine pores still contains components of seawater that is many millions of years old. By comparison, present-day seawater contains around 37 grams of salts per litre.

Construction technology

Because clays often prove to be insufficiently stable during tunnel construction, the tunnel walls are secured using rock anchors and shotcrete.



Geological profile along the Mont Terri motorway tunnel (around 4 km long).

Projects in the Mont Terri Rock Laboratory

Experiments

1 – Understanding processes in undisturbed Opalinus Clay

DR-A/DR-B Radionuclide diffusion and retention

DS Determination of rock stresses

HT Diffusion of hydrogen in clay

PC-C State of equilibrium between porewater and dissolved gases

SM-C Seismic monitoring underground

SO/VA Sedimentology of Opalinus Clay, variability of sedimentary structures

2 – Experiments in disturbed clay

CD Cyclic deformations, self-sealing of fissures

DM-A, DM-B Long-term deformation measurements around boreholes

EZ-B Fracture formation in the excavation damaged zone

HG-A, HG-D Gas flowpaths through the rock and along seals, gas transport

MA Microbial analyses

SE-H/TIMODAZ Self-sealing of fissures in the excavation damaged zone

3 – Experiments related to repository performance during operation and post closure

CI, BN Cement-clay interaction, bitumen-nitrate-clay interaction

FE 1:1 emplacement experiment with three heater canisters, long-term measurement of heat penetration into the rock and saturation

HE-E In situ heater experiment in various sand-clay mixtures

IC, IC-A Corrosion experiments

MO Development of measuring methods for the long-term monitoring of deep geological repositories

International research platform

International research has been ongoing in the Mont Terri Rock Laboratory since 1996. The Federal Office of Topography (swisstopo) is responsible for the operation of the facility and manages the Mont Terri project.

Numerous organisations from Belgium, Canada, France, Germany, Japan, Spain, Switzerland and the USA are involved in the underground research projects. Various other countries are also looking at clays as potential host rocks for the deep geological disposal of radioactive waste. A host rock is the geological medium in which emplacement tunnels for radioactive waste are constructed.

Regular meetings of the project partners are held to discuss the results of ongoing experiments. Every year, the partners have the opportunity to decide anew which particular experiments they wish to participate in.

Know-how for all

In the future, the know-how built up at the Mont Terri Rock Laboratory can be exchanged with other research branches, for example in connection with geothermal energy or gas storage.

Research and development

The experiments in the Mont Terri Rock Laboratory focus on three main areas:

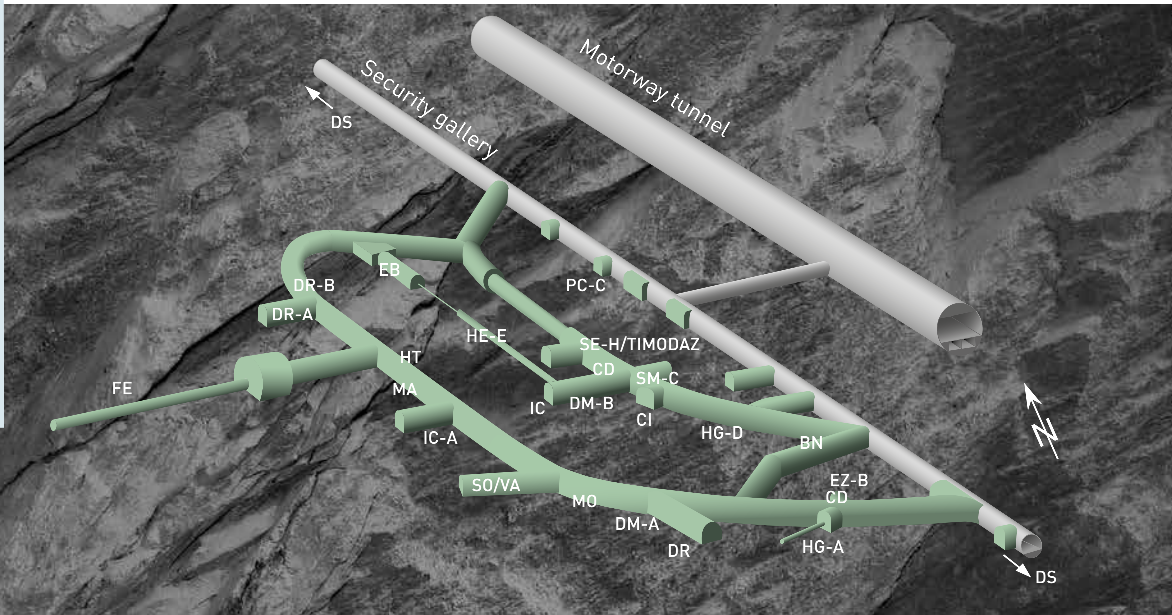
1) Methodology development

As there is effectively no flowing water in clay, special hydrogeological test techniques and programmes have to be developed for evaluating measured data. This applies, for example, to measuring porewater pressures, determining permeability and collecting water samples.

Drilling and core sampling techniques have to be modified and improved to allow stable boreholes to be drilled and undisturbed drillcores to be recovered.

Methods used today in crystalline formations for determining the stress field in the rock and around excavated tunnels have only limited application in clay, and further developments are therefore necessary in this area.

Coupled processes (the mutual influence of e.g. temperature, water content and pressure regime) present new challenges in terms of developing and applying suitable methods for understanding the processes being studied in the Rock Laboratory.



Tunnel system of the Mont Terri Rock Laboratory showing the experiment locations

2) Characterisation of the Opalinus Clay

The isolation capacity of the Opalinus Clay is determined by its physical and chemical properties. The main aspects of interest are its permeability and ability to self-seal, as well as the diffusion behaviour of radionuclides.

The Opalinus Clay swells when moisture penetrates into open unloading fractures, thus sealing open fissures that formed during tunnel construction. This self-sealing process reduces the permeability, which can return to values equivalent to those of the undisturbed rock. These interactions are being looked at in a number of experiments.

The diffusion of radionuclides and the retention capacity were investigated in the DR experiment. An isolated test interval in a small borehole was saturated with water and a defined volume of tracer (e.g. tritium) was then added. After more than one year, the small borehole was overcored and the new, larger-diameter drillcore was used to investigate how far the tracer had penetrated into the rock. "Non-retarded" radionuclides such as tritium were seen to migrate faster than strongly "retarded" nuclides such as caesium or cobalt, which will be present in a repository for high-level waste. The activity of the radionuclides used for this experiment was well below specified clearance limits.

3) Demonstration experiments

Demonstration experiments are used to test procedures for emplacing waste containers. They aim to show the feasibility of constructing and sealing a deep geological repository.

The FE experiment (see images below) is a further development of a previous experiment. The emplacement concept for spent fuel assemblies is being investigated on a 1:1 scale, with simulation of the heat produced by radioactive decay using heater elements. Observations are carried out over many years to determine how temperature affects the backfill materials and the rock.

Demonstration experiments of this type are also suitable for explaining the concept of deep geological disposal to the public in a clear and understandable way.

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

Radionuclides
Chemical elements have stable and spontaneously decaying (= radioactive) isotopes. Radioactive isotopes are also called radionuclides.

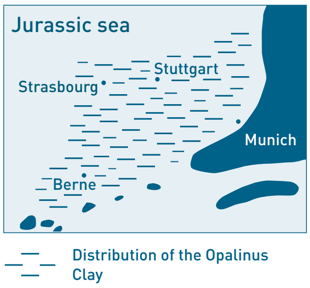
Clearance limits
A clearance limit is a legally defined activity value up to which the use of radioactive materials is permitted without a licence.

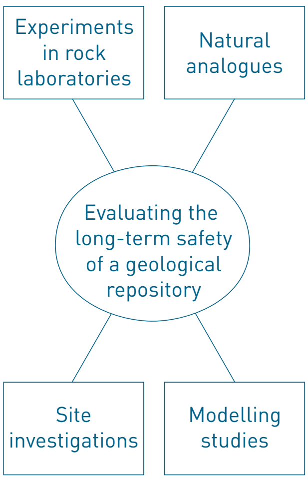
Current research
Information on the experiments that are presently ongoing in the Mont Terri Rock Laboratory can be found on the website www.mont-terri.ch.

Free guided tours of the Mont Terri Rock Laboratory are offered year-round.

Setting up the FE demonstration experiment at the Mont Terri Rock Laboratory:
Top: Bentonite blocks are used as pedestals for the test canisters.
Bottom: The backfilling machine in the FE tunnel

Questions and answers





What is Opalinus Clay?

Opalinus Clay is an argillaceous rock that was formed about 173 million years ago in a shallow sea during the Jurassic period. The name of the formation comes from the opalescent sheen of fossil shells of the ammonite "Leioceras opalinum" that are found in the Clay.

What is the purpose of a rock laboratory?

A rock laboratory offers more realistic test conditions than can be achieved in conventional laboratory studies. Experiments can be carried out on a 1:1 scale and provide important information on the feasibility and safety of deep geological disposal. However, rock laboratories alone are not enough. To assess the long-term safety of a deep geological repository (safety analysis), it is necessary to complement the experiments in underground laboratories with natural analogue studies, modelling studies and site investigations.

How is an experiment conducted?

The feasibility of a test concept is first checked by predictive calculations. When it is clear that the objectives cannot be achieved with conventional laboratory experiments, a test location in a rock laboratory is selected. Before carrying out the experiment, the initial and boundary conditions are determined directly at the test location. Only then do activities such as drilling, instrumentation and measurement begin. After months or years, the results are analysed, interpreted and compared with the predictive calculations.

Why is Opalinus Clay being investigated?

Opalinus Clay has several properties that are favourable for the long-term safety of a deep geological repository. Besides its good isolation capacity, very low hydraulic permeability and predominantly diffusive transport of dissolved substances, these include a homogeneous structure, the retention of radionuclides on clay mineral surfaces and the ability to seal fissures and fractures through swelling.

Is it possible to visit the Rock Laboratory?

Tours of the Rock Laboratory for visitor groups (starting at about ten participants) can be organised all year round. Information is available from:

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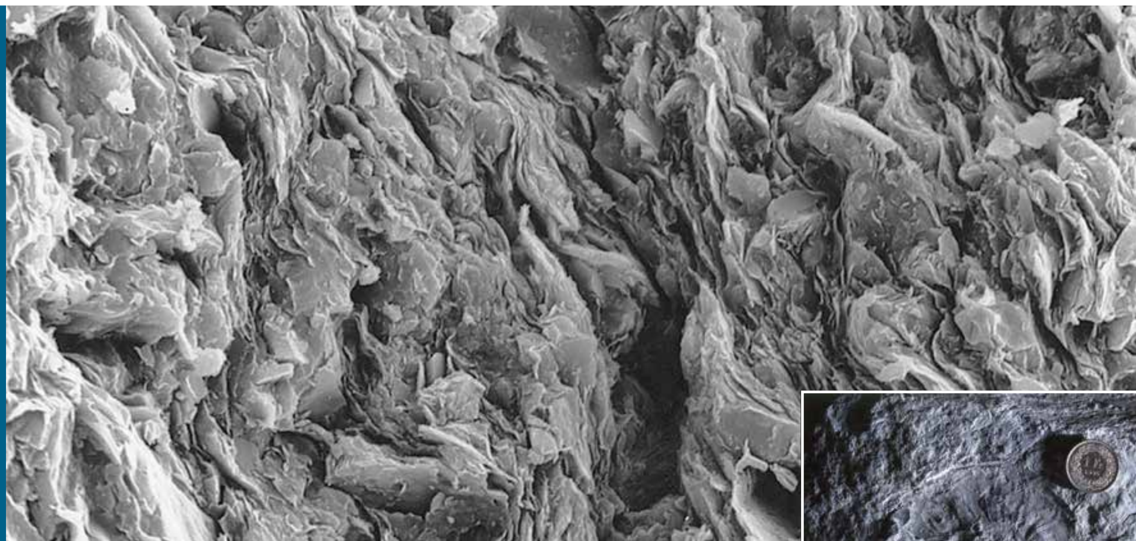

Large picture: Opalinus Clay under the scanning electron microscope. The plate-like clay minerals are surface-active and can immobilise water molecules and particles of toxic substances (image width approx. 0.07 mm).
Small picture: Impression made by a shell of the Opalinus Clay index fossil "Leioceras opalinum".

Project management
Federal Office of Topography (swisstopo)

Mont Terri Project

Project partners

Switzerland	swisstopo	Federal Office of Topography
	ENSI	Swiss Federal Nuclear Safety Inspectorate
	NAGRA	National Cooperative for the Disposal of Radioactive Waste
Belgium	SCK•CEN	Studiecentrum voor Kernenergie • Centre d'Etude de l'Energie
	FANC	Federaal Agentschap voor Nucleaire Controle
Germany	BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
	GRS	Gesellschaft für Anlagen- und Reaktorsicherheit mbH
France	ANDRA	Agence Nationale pour la Gestion des Déchets Radioactifs
	IRSN	Institut de Radioprotection et de Sûreté Nucléaire
Japan	OBAYASHI	Obayashi Corporation
	JAEA	Japan Atomic Energy Agency
	CRIEPI	Central Research Institute of Electric Power Industry
Canada	NWMO	Nuclear Waste Management Organisation
Spain	ENRESA	Empresa Nacional de Residuos Radiactivos, S. A.
USA	US DOE	U.S. Department of Energy
	CHEVRON	Chevron Energy Technology Company

Co-financing of selected experiments
EU European Union

Supporting research organisation
PSI Paul Scherrer Institute

Owner of the rock, permits
RCJU République et Canton du Jura
DEN Department of the Environment

National Cooperative for the Disposal of Radioactive Waste

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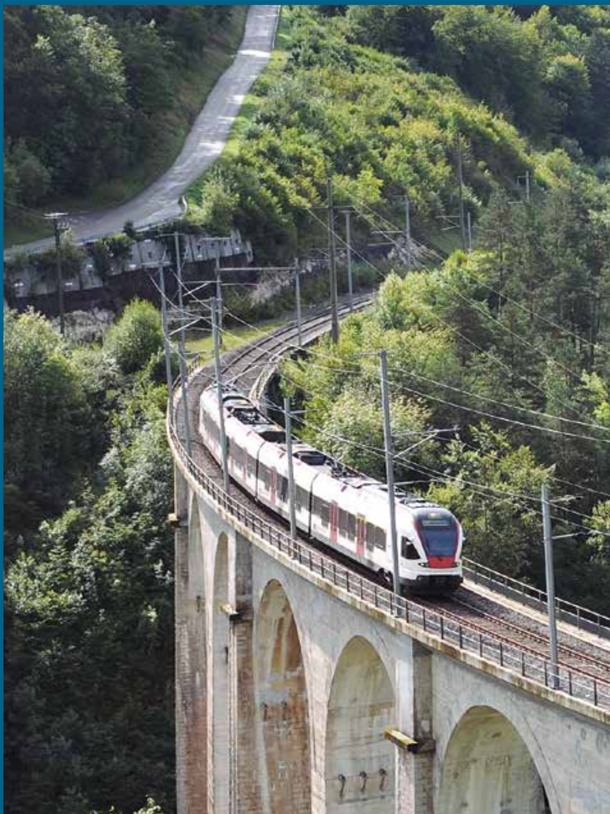

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Revised reprint December 2017
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