DATA BASIS FOR THE DECISION

ADDITIONAL INFORMATION ON THE SITING PROPOSAL

As a result of extensive field and laboratory investigations conducted in recent years, the site selection and the safety demonstration are now based on a comprehensive and solid database.

The present document supplements the report on the siting proposal with more detailed information on the available data. Based on selected data types of particular importance to the project, this document shows how the data basis for Northern Switzerland has evolved since 1980.

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EVOLUTION OF THE GEOLOGICAL DATA BASIS FOR THE PERIOD 1980 – 2022

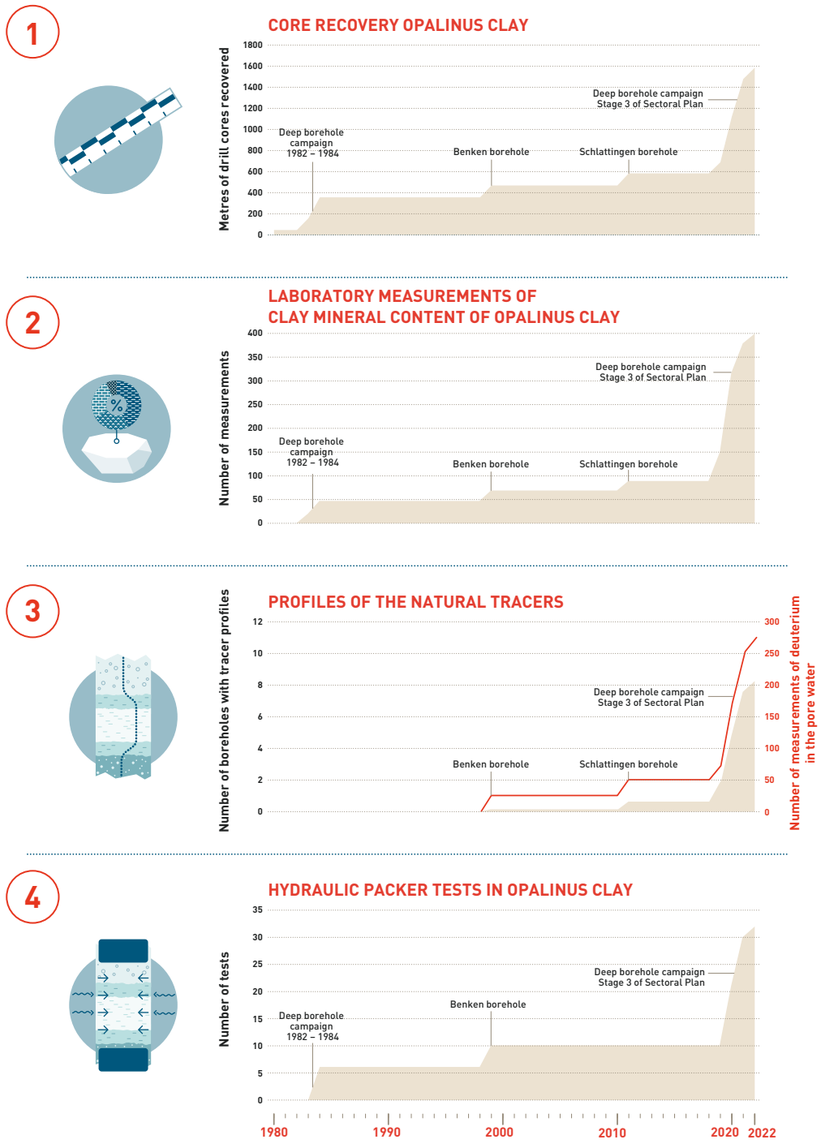


FIGURE 1: Evolution of the geological data basis in Northern Switzerland in the period 1980 – 2022. This figure presents the accumulated values over time, with the exception of section 8, which shows the number of measurement stations active at the corresponding time.

As a result of the investigations conducted within the framework of Stage 3 of the Sectoral Plan for Deep Geological Repositories, the geological data basis for Northern Switzerland was significantly expanded between 2015 and 2022. Figure 1 shows this based on eight examples that will be briefly explained and described in the following.

1 CORE RECOVERY OPALINUS CLAY

Drill cores from the Opalinus Clay are needed to describe the rock in detail and to carry out different types of laboratory measurements. Available Opalinus Clay core material was almost tripled by the deep borehole campaign conducted from 2019 to 2022. If all the Opalinus Clay cores were to form one long line, they would reach a length of around 1.6 kilometres. The investigations confirmed that the composition of the Opalinus Clay is very similar in all three siting regions and that it has a low lateral variability. The investigation results are therefore highly representative of the areas between the boreholes.

2 LABORATORY MEASUREMENTS OF CLAY MINERAL CONTENT OF OPALINUS CLAY

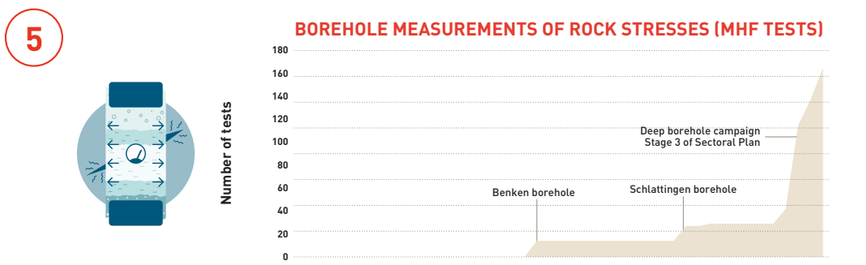
The clay mineral content is an important indicator for different transport properties. Rocks with a high clay mineral content, for example, have a low hydraulic conductivity. A high clay mineral content also indicates a high self-sealing capacity for tectonic faults. Today, there are around 400 mineralogy measurements from the Opalinus Clay, which is four times as many as before the deep borehole campaign. The high clay mineral content and the comparatively low mineralogical variability of the Opalinus Clay could be confirmed.

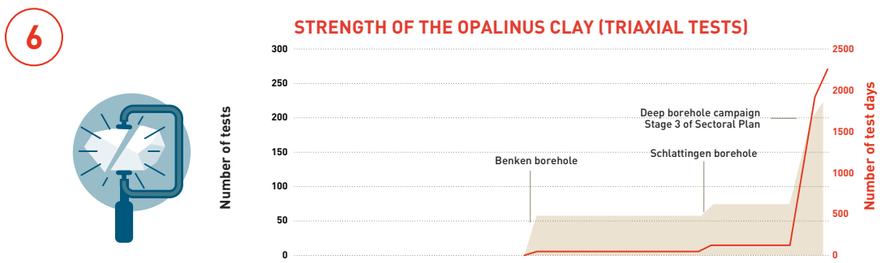
3 PROFILES OF THE NATURAL TRACERS

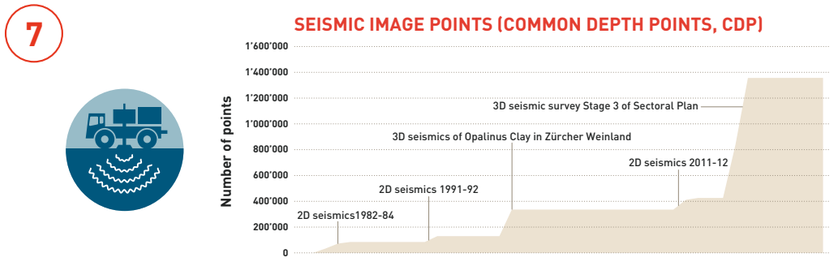
The chemical composition of the porewater contains valuable information regarding past transport processes. The representation of the vertical change in specific hydrochemical components (so-called natural tracers such as the chloride content or the isotope composition of the water molecule) along a borehole is particularly valuable. Based on the form of these profiles of the natural tracers, it is possible to distinguish between tight zones with a very slow, diffusion-dominated transport and more permeable zones with active groundwater flow. With these profiles, it is possible to draw conclusions on the transport processes in the rock over the last 100,000 to 1,000,000 years. While data were only available from two boreholes prior to the deep borehole campaign, there are now natural tracer profiles from eleven boreholes in Northern Switzerland. As more samples were measured per borehole during the course of the deep borehole campaign than before, the new boreholes have a higher resolution, allowing for more reliable statements. The profiles of the natural tracers correspond well with the results from the hydraulic packer tests. They confirm the low permeability of the Opalinus Clay and the surrounding rock. The tracer profiles also form an important basis for determining the distance between the Opalinus Clay and the nearest aquifer (groundwater-bearing layer) within the framework of the site comparison.

4 HYDRAULIC PACKER TESTS IN OPALINUS CLAY

Using packer tests in the borehole, it is possible to derive the hydraulic conductivities of the different rock formations. Thanks to the deep borehole campaign, data have now been obtained from more than 30 tests conducted in the Opalinus Clay, which is three times more than before the campaign. Many of these tests were carried out in areas with tectonic faults and have confirmed the low permeability of faults in the Opalinus Clay.







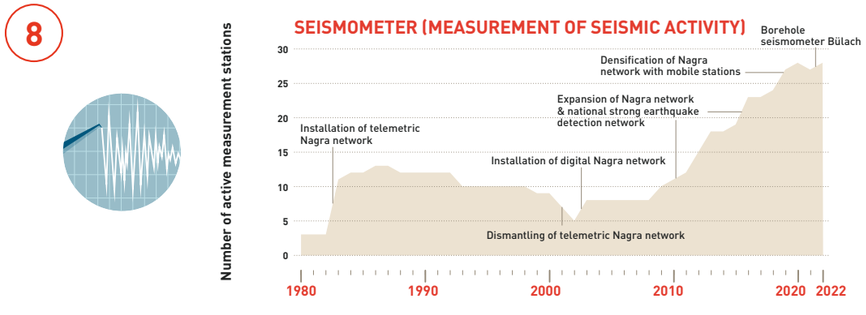


FIGURE 1 (CONT.)

5 BOREHOLE MEASUREMENTS OF ROCK STRESSES (MHF TESTS)

A good understanding of rock stresses is relevant for structural engineering and for the assessment of the long-term stability. Using the MHF (Micro-Hydraulic Fracturing) method, it is possible to determine the underground stress conditions at different depth intervals of the borehole by successively increasing water pressure until this leads to the formation or opening of a fracture. The data set could be considerably expanded during the deep borehole campaign and, with over 150 measurement points, constitutes one of the most comprehensive data sets of this kind worldwide. The new data show that the differences in the stress conditions in the Opalinus Clay between the siting regions mainly depend on the depth.

6 STRENGTH OF THE OPALINUS CLAY (TRIAXIAL TESTS)

During triaxial tests, cylindrical rock samples obtained from the boreholes are subjected to stress in a controlled laboratory environment until they fail. The goal of these tests is to determine the strength and deformation behaviour of the rocks. Reliable tests on clay rocks are very challenging due to the complex hydromechanical interactions and the low permeability, and tests must therefore be carried out slowly and over long measurement periods. While the number of measured samples strongly increased during the deep borehole campaign, even more importantly, the reliability of the results could be significantly improved due to the long measurement periods for each borehole sample (roughly 15 days on average). Today, there are around 150 high-quality measurements for the Opalinus Clay. With this complex measurement programme, a solid geomechanical basis was created for assessing the construction feasibility as part of the site comparison and the general licence application.

7 SEISMIC IMAGE POINTS (COMMON DEPTH POINTS, CDP)

Thanks to the 3D seismic survey conducted from 2017 to 2019, it was possible to obtain a significantly improved image of the underground. While only individual 2D measurement lines were available up to Stage 2 of the Sectoral Plan (except for the Zürich Nordost (ZNO) siting region), leaving much room for interpretation, three-dimensional, high-resolution seismic surveys have meanwhile been conducted throughout the three regions. This allows any type of cross-sections and three-dimensional views of the underground to be prepared. Consequently, we were able to map the layer geometries and tectonic structures in the three siting regions in detail and could significantly reduce uncertainties regarding thickness and depth. These aspects form an important and robust basis for the site comparison and general licence application. The 3D seismic dataset also contributes to an improved understanding of the geological evolutionary history.

8 SEISMOMETER (MEASUREMENT OF SEISMIC ACTIVITY)

The seismic monitoring network for investigating natural seismic activity has been considerably expanded in recent years. With its help, even earthquakes with extremely small magnitudes can be detected and reliably localised. As a result, it is significantly easier to identify which tectonic fault systems are active today and which are most likely to be activated again in the future.

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