UNDERGROUND CHARACTERISATION AND RESEARCH FACILITY ONKALO

ANTTI IKONEN, MIA YLÄ-MELLA, TIMO ÄIKÄS
POSIVA Oy
27160 Olkiluoto, Finland

ABSTRACT

Posiva's repository for geological disposal of the spent fuel from Finnish nuclear reactors will be constructed at Olkiluoto. The selection of Olkiluoto was made based on site selection research programme conducted between 1987-2001. The next step is to carry out complementary investigations of the site and apply for the construction license for the disposal facility. The license application will be submitted in 2012. To collect detailed information of the geological environment at planned disposal depth an underground characterisation and research facility will be built at the site. This facility, named as ONKALO, will comprise a spiral access tunnel and two vertical shafts. The excavation of ONKALO is in progress and planned depth (400 m) will be reached in 2009. During the course of the excavation Posiva will conduct site characterisation activities to assess the stucture and other properties of the site geology. The aim is that construction will not compromise the favourable conditions of the planned disposal depth or introduce harmful effects in the surroundig bedrock which could jeopardize the long-term safety of the geological disposal.

1. Introduction

The geologic disposal of spent fuel from the Finnish nuclear power plants – Loviisa 1&2, Olkiluoto 1&2 and later Olkiluoto 3 – will be executed by Posiva Oy, a company owned jointly by the two nuclear power producers Fortum Oyj and Teollisuuden Voima Oy. Preparations for nuclear waste management were started already in the 1970s when the first power plants were still under construction. In 1983, the Finnish Government confirmed a target schedule for nuclear waste management, in which the construction of the disposal facility was scheduled for the 2010s and the start of actual final disposal for the year 2020.

Potential sites for the disposal of spent fuel were screened in the 1980s, followed by detailed site investigations in the 1990s and an environmental impact assessment in late 1990s. In 1999, Posiva submitted an application to the Government for a Decision-in-Principle to choose Olkiluoto as the site of the final disposal facility. After the mandatory local consent was received and a favourable safety statement issued by the regulator, the Finnish Government issued a Decision-in-Principle in favour of the project in December 2000. The Finnish Parliament approved the decision by 159 votes in favour and 3 against in May 2001.

The disposal project has progressed to the next stage – constructing an underground characterisation facility, known as ONKALO, at Olkiluoto. Work on the entire disposal project is progressing so that disposal can commence in 2020. ONKALO will be used to obtain further information to plan the repository in detail and to assess long-term safety and construction engineering solutions. ONKALO will also enable final disposal technology to be tested under actual conditions. ONKALO is not intended solely for research premises, but has also been designed to serve as an access route to the repository when constructed. ONKALO will take about 10 years to complete. Construction is scheduled for 2004–2014 and investigations will be made from the start of construction in conjunction with excavation. Once ONKALO has been completed, work will start on building the encapsulation plant and final disposal repository in the 2010s /1/.

2. ONKALO

The site characterisation programme already included the assumption that an underground rock characterisation facility would be required at the site confirmation stage to allow a detailed repository design to be developed and the preliminary safety assessment to be produced. The plans of the facility were realised after the Decision in Principle was issued. A decision was made to excavate the underground rock characterisation facility, ONKALO, at Olkiluoto. The approach adopted was that ONKALO facility shall be constructed in such a manner that it allows further characterisation and research work to be carried out without jeopardising the long-term safety of the repository site. In addition, it should be possible later to link the ONKALO to the repository so that they are integrated (Fig. 1).

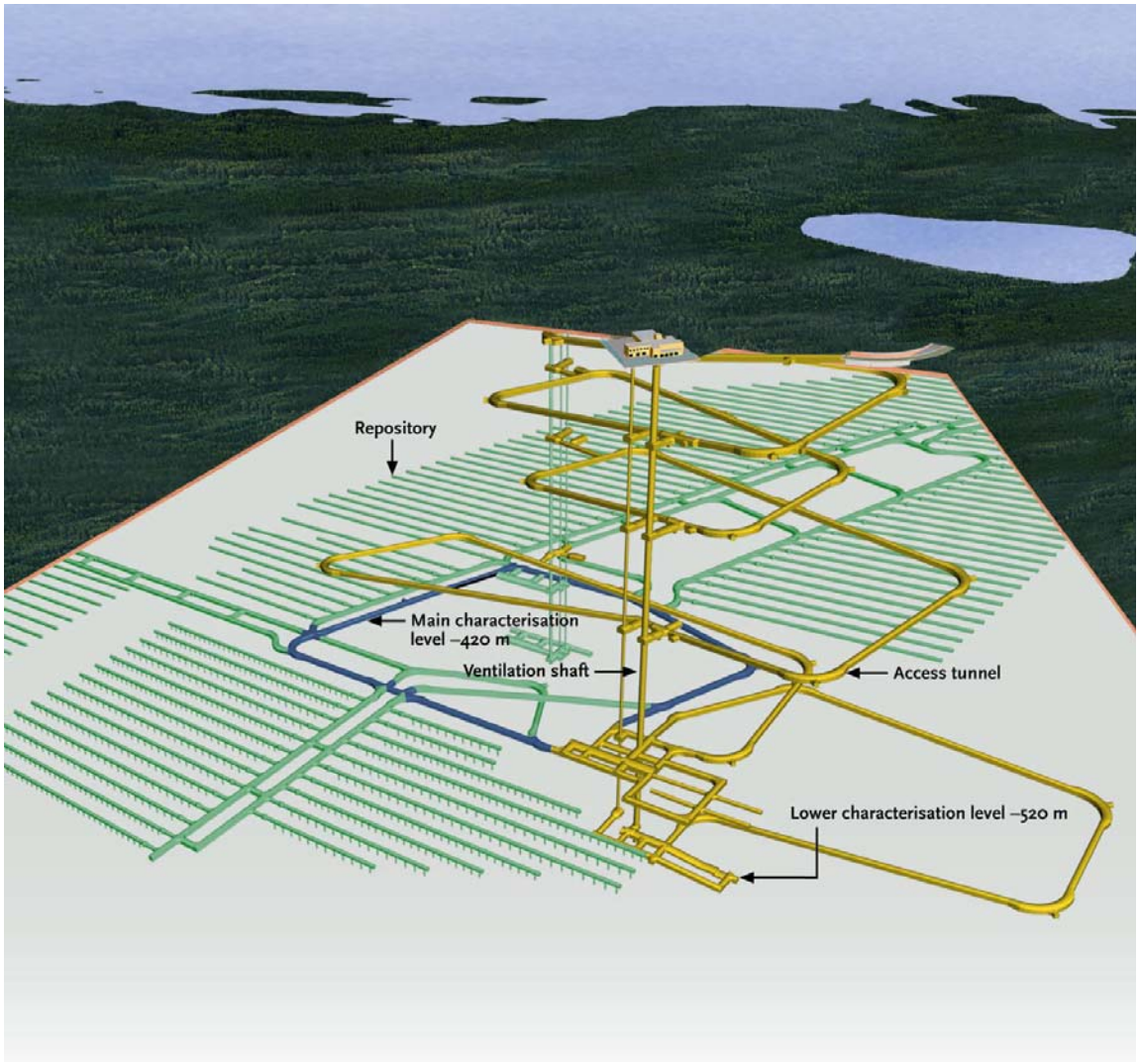

Fig. 1. *Concept design for deep repository in Olkiluoto. The ONKALO is marked with yellow.*

The location of the tunnel entrance is in the central part of the Olkiluoto island, some two kilometres away from the Olkiluoto nuclear power plant near the southern border of the existing site investigations area (Fig. 2). The location was decided based on comparison between a number of alternatives. In this comparison one of the main criteria was the anticipated disturbance to geological environment of the repository. In particular, the inflow of groundwater to the tunnel was to be kept to the minimum. After the systematic comparison of various alternative concepts, the decision was made

in 2002 that the access to the repository depth would be provided by a combination of an access tunnel and a vertical shaft attached to it. The main aspects in favour of the combined tunnel-shaft concept were the increased flexibility as regards the planned future use of the facility as a part of the planned repository, the logistic benefits as well as the greater opportunities for characterisation work during construction.

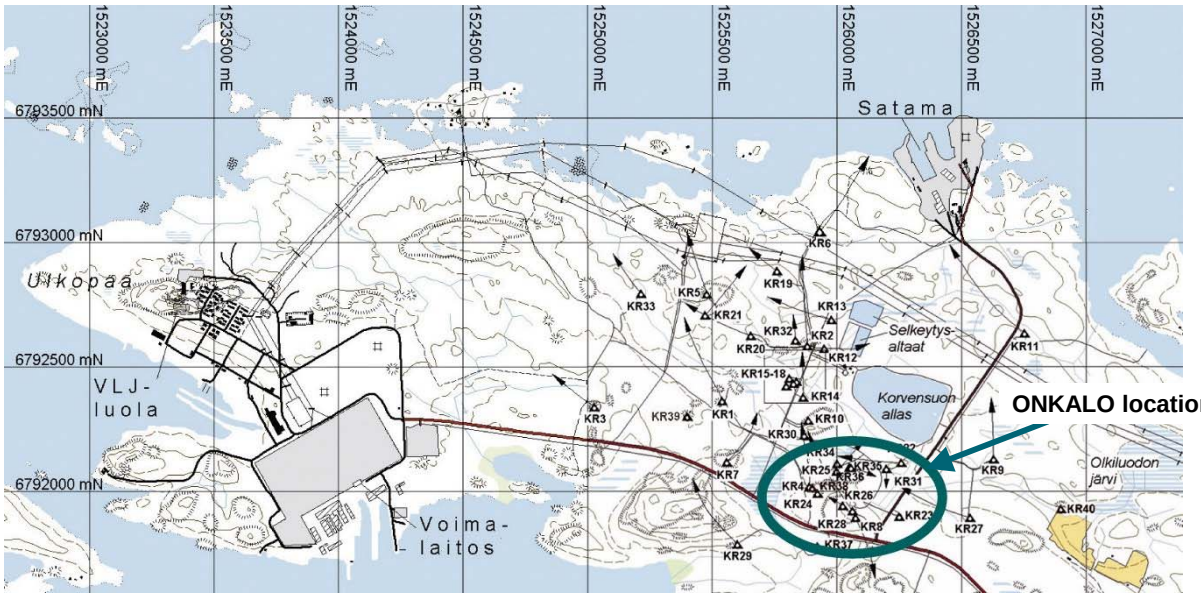

Fig. 2. *Map of Olkiluoto site. Location of ONKALO is marked together with the location of deep investigation boreholes.*

The present design of the ONKALO is presented in Fig. 1 The main characterisation level is at the depth of 420 metres below the sea level. The lower characterisation level is 100 metres beneath the main level. The inclination of the tunnel is 1:10, which means that the length of the access tunnel will be approximately 5.5 km. The total length of the tunnels and shafts will be about 9 km. A total of 365 000 m^3 of rock will be excavated.

The site preparations for the facility were started in 2003 and the actual excavation work began in September 2004. The tunnelling work is carried out by traditional drill & blast techniques. Raise boring method has been used for the first section of the exhaust shaft.

By the end of August 2006, the excavation of ONKALO had proceeded 1350 metres to a level of -126 m. The excavated tunnel meets the specified quality requirements, the management of leakage waters being one of the most significant requirements (Fig. 3). Due to the fractured nature of the surface rock, quite extensive grouting of the rock has been necessary.

The infrastructure of the site is almost completed. The concrete walls of the tunnel entrance, the washing hall, the fuel distribution station and the asphalting of the machine field and roads are completed. The site office has been built, the site perimeter has been fenced and site surveillance has been organised.

3. Underground characterisation and research

A programme for the underground characterisation and research (UCRP) to be carried out in the ONKALO has been established /2/. What Posiva aims at achieving with the activities proposed for the ONKALO is, of course, that the general suitability of the site will be demonstrated. It is only with such confirmation that it will be possible to proceed to the application for a construction licence for the repository. The programme during the tunnelling stage includes mapping of the tunnel faces,

drilling of pilot and characterisation holes with subsequent rock mechanical, geological, geophysical and geohydrological studies, hydrogeochemical sampling and measurements, determination of fracture and flow data plus various rock-mechanical tests and measurements.

Investigations in ONKALO started in September 2004 at the same time with the excavation work by geological mapping of the tunnel roof and walls. The first stage of geological mapping is done right after excavation under last round and basic information about rock quality mainly for the rock support and grouting planning is collected. The systematic mapping follows the construction work about 100 to 200 meters behind the tunnel face. During this second stage the rock is investigated more carefully and this is actually the real rock investigation phase. Systematic bedrock sampling is also done for mineralogical studies.

Probe holes, which are bored to tunnel face after every fourth excavation round and pilot holes, which are core drilled boreholes inside the tunnel periphery makes possible to do different boreholes investigations during excavation work. From probe holes flow measurements are made and the results are used in the grouting planning and later also in the hydrogeological modelling. Geophysical logging, borehole imaging, flow measurements and groundwater sampling are standard investigations in the pilot holes. The results from the pilot hole drilling and related studies are used in excavation planning and in different modelling exercises. Results from the pilot hole studies are an important part of the prediction outcome studies. Prediction-outcome process is used to predict the rock conditions further along the tunnel line. These predictions assist in the further design of the facility and make an important part of the learning process built into the whole ONKALO programme. So far five pilot holes have been drilled and investigated.

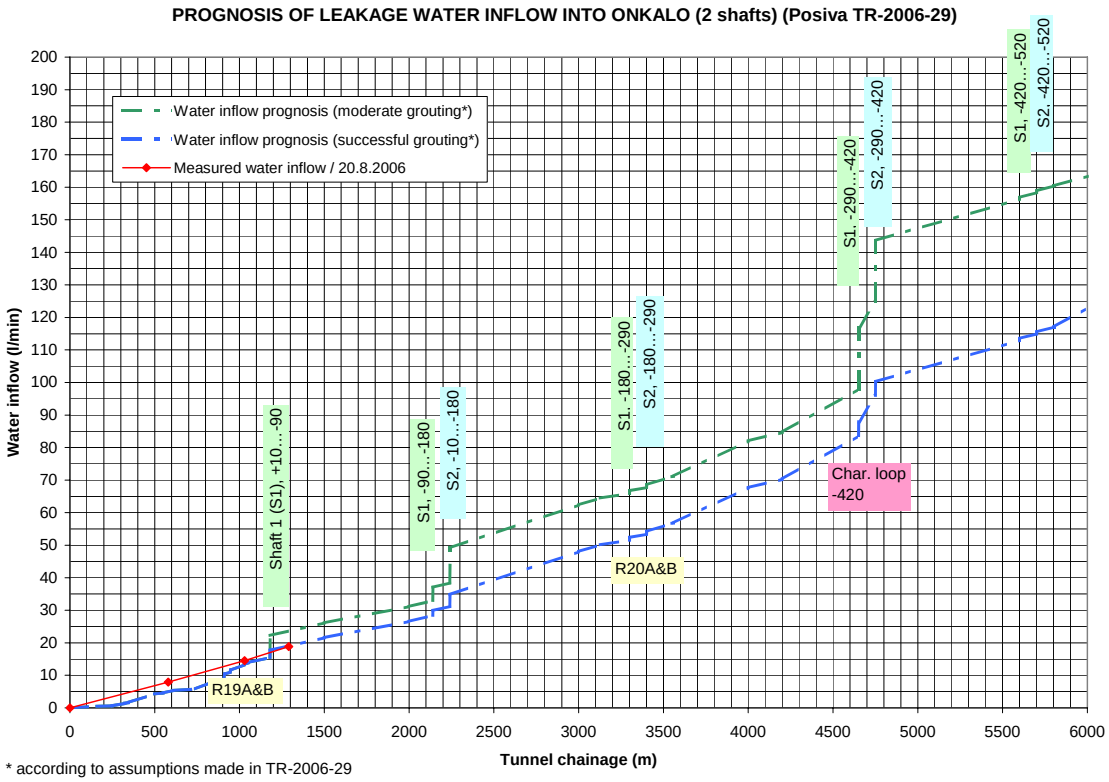

Fig. 3. *Prediction of leakage water into ONKALO (green, blue) and measured water inflow 20.8.2006 (red). Location of two major fracture zones (R19A&b, R20) are shown in yellow.*

The fact that the ONKALO is planned to become a part of the repository means that it has to be designed and constructed according to the rules and requirements for nuclear facilities, for example,

the quality assurance criteria posed by STUK. One very important issue from the long term safety point of view is to limit the groundwater inflow to the ONKALO. The amount of leaking water is followed regularly with flow mapping and with measurements done from the measuring weirs. Later on the measuring weirs will be put into the automatic monitoring system so the amount of leakage can be followed on line. At this moment the total leakage to tunnel is at chainage 1290 about 19 l/min (See Fig. 3). Also control of the excavation damages (EDZ) during excavation work is essential. Studies of the EDZ from the ONKALO tunnel wall, floor and roof started in spring and results will be reported by the end of 2006. At the same time procedures how to investigate EDZ are under development.

Groundwater quality is monitored to see the possible changes caused by the ONKALO construction. For this purpose permanent monitoring points will be put into the tunnel. Basically the monitoring point called groundwater station is core drilled borehole, which length is some tens of meters. Station has been equipped double packer system and with automatic monitoring equipment, which measures pH, electrical conductivity, dissolved oxygen and redox potential of the groundwater on line. By groundwater quality monitoring is also possible to investigate the influence and properties of the used cements. Experiment to investigate low pH cement has already started in ONKALO.

Long term experiments need to have place for the set up in the tunnel. For that purpose investigation niches, small tunnel ends, are planned to construct. The first one will be excavated during autumn 2006 and first experiments to start will be rock stress measurements and small-scale hydrogeological interference test. These tests will be followed with geochemical and geomicrobiological studies.

In parallel with the construction of the ONKALO the fieldwork at surface continues, consisting of deep drillings (43 deep drillholes by the end of 2006), groundwater sampling, geophysical and geohydraulic measurements, geological mapping and various monitoring networks. The fact that the site investigations are now focused on Olkiluoto makes it possible to employ new efficient methods for data gathering, e.g., investigations trenches, which nicely complement the lithological and fracturing data so far obtained only from the rather rare outcrops on the Olkiluoto island.

Because the construction of the ONKALO and later final disposal facility will affect the surrounding rock mass, a monitoring programme was established /3/. During ONKALO construction rock mechanical, hydrological, chemical and environmental monitoring is carried out both from surface and from ONKALO and the quality and quantity of foreign materials used in ONKALO are measured and registered. The main aim is to observe possible changes in the host rock and obtain information on responses of the host rock to the excavation. The results of the monitoring are compared to the baseline values presented in 2003 /4/.

All the data achieved with different investigation methods will pass several different modelling steps. The interpretation and modelling of the field investigations data aim at building a consistent picture of the site. A special effort is made to integrate the differerent disciplines of the site knowledge by a specific Olkiluoto Modelling Task Force. The purpose of the Task Force work is to coordinate the work of different disciplines in such a way that a coherent picture of the site can be produced.

4. References

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/2/ Posiva 2003a. ONKALO underground characterization and research programme (UCRP). POSIVA 2003-03. Posiva Oy, Eurajoki.

/3/Posiva 2003b. Programme of monitoring at Olkiluoto during ONKALO construction. POSIVA 2003-05. Posiva Oy, Eurajoki.

/4/ Posiva 2003c. Baseline conditions at Olkiluoto. POSIVA 2003-02, Posiva Oy, Eurajoki.