Working Report 2010-85

Bentonite Buffer Pre-Test - Core Drilling of Drillholes ONK-PP264...267 in ONKALO at Olkiluoto 2010

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December 2010

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ABSTRACT

Suomen Malmi Oy (Smoy) core drilled four drillholes for bentonite buffer pre-test in ONKALO at Eurajoki, Olkiluoto in July 2010. The identification numbers of the holes are ONK-PP264…267, and the lengths of the drillholes are approximately 4.30 metres each. The drillholes are 75.7 mm by diameter. The drillholes were drilled in a niche at access tunnel chainage 1475.

The hydraulic DE 130 drilling rig was used for the work. The drilling water was taken from the ONKALO drilling water pipeline and premixed sodium fluorescein was used as a label agent in the drilling water.

In addition to drilling, the drillcores were logged and reported by geologist. Geological logging included the following parameters: lithology, foliation, fracture parameters, fractured zones, core loss, weathering, fracture frequency, RQD and rock quality.

The main rock type in the drillholes is pegmatitic granite. The average fracture frequency in the drill cores is 4.0 pcs / m and the average RQD value 94.2 %.

Keywords: Olkiluoto, ONKALO, bentonite buffer, core drilling, drillhole, pegmatite granite, fracture

BENTONIITTIPUSKURIN ESITUTKIMUS - REIKIEN ONK-PP264…267 KAIRAUS ONKALOSSA OLKILUODOSSA VUONNA 2010

TIIVISTELMÄ

Suomen Malmi Oy (Smoy) kairasi neljä bentoniittipurkurin esitutkimuksessa käytettävää tutkimusreikää ONKALOssa Eurajoen Olkiluodossa heinäkuussa 2010. Reikien tunnukset ovat ONK-PP264…267, ja niiden pituudet ovat n. 4,30 metriä. Kairareikien halkaisija on 75,7 mm. Reiät kairattiin ajotunnelin paalulla 1475 olevasta kuprikasta.

Molempien reikien kairaustyössä käytettiin hydraulista DE 130 kairauskonetta. Reiän kairaukseen käytettiin natriumfluoresiinilla merkittyä huuhteluvettä, joka otettiin ONKALO:n porausvesilinjasta.

Kairatuille kallionäytteille tehtiin geologinen kartoitus ja raportointi, joka sisälsi mm. kivilajit, suuntautuneisuuden, rakoparametrit, rakotiheyden ja RQD:n, rikkonaisuusvyöhykkeet, muuttuneisuuden, näytehukan ja kivilaadun.

Pääkivilajina rei'issä esiintyi pegmatiittinen graniitti. Kallion rakoluku oli rei'issä keskimäärin 4,0 kpl / m ja RQD-luku on keskimäärin 94,1 %.

Avainsanat: Olkiluoto, ONKALO, bentoniittipuskuri, kairaus, kairareikä, pegmatiittigraniitti, rako

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1 INTRODUCTION

1.1 Background

Posiva Oy submitted an application to the Finnish Government in May 1999 for the Decision in Principle to choose Olkiluoto in the municipality of Eurajoki as the site for the final disposal facility for spent nuclear fuel. The Government made a positive decision at the end of 2000. The Finnish Parliament ratified the decision in May 2001.

The policy decision made it possible to concentrate the research activities at Olkiluoto in Eurajoki. Construction of an underground rock characterisation facility (called "ONKALO") is one part of the research. Construction of the access tunnel was started in autumn 2004.

Posiva Oy contracted (order number 9446-10) Suomen Malmi Oy (Smoy) to drill four short drillholes in ONKALO. The identification numbers of the drillholes are ONK-PP264...267, and their lengths are approximately four metres each. The drillholes are used as geological characterization and instrument cable drillholes for bentonite buffer pre-test (PROJECT 2.1.6: THE FIRST PHASE TEST OF BENTONITE BUFFER).

The new drillholes are located in an investigation niche in the access tunnel at chainage 1475 (Figure 1). The drillholes are vertical. The diameter of the drillholes is 75.7 mm. Summary of the technical details of the drillhole is presented in Appendix 7.1.

1.2 Scope of the work

The aim of the work was to drill four short drillholes and to document the geological conditions (continuity of rock units, fractured zones and rock quality) in the area. In addition to the drilling, the work included core logging and reporting. This report documents the work carried out during the drilling of the hole and geological logging of the drillcores.

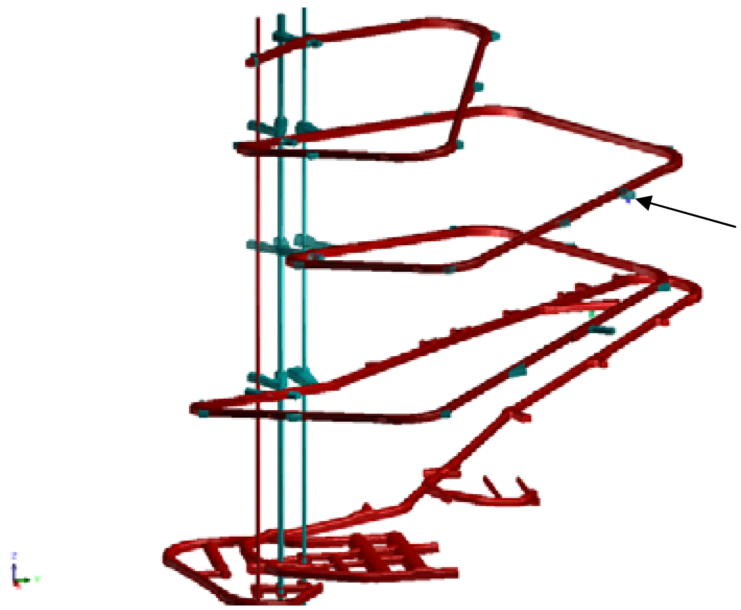

***Figure 1**. Location of the investigation niche at tunnel chainage 1475 (black arrow), where the drillholes ONK-PP264…267 were drilled in ONKALO.*

2 DRILLING WORK AND TECHNICAL DETAILS OF THE DRILLHOLES

2.1 Description of the drilling work

The diamond drill rig DE 130 was set up at the drilling site on the 19th of July in 2010. Drilling started on the 20th of July, and the four drillholes were finished on the 21st of July.

The drilling started from concrete surface with no casing drilling. The thickness of the concrete ranged from 0.20 to 0.36 metres. The drillholes were drilled using NQ2-double tube core barrel with NQ-drill rods. Drillhole diameter with NQ2 -core barrel is 75.7 mm and drill core diameter is 50.5 mm. Technical information of the drillholes is presented in Appendix 7.1.

The drilling was carried out as discontinuous shift work (one shift per day and the drilling team in each shift consisted of a driller and an assistant. Geologist Tauno Rautio was the project manager. Geological logging was done by geologist Tuomas Pere (Posiva Oy) and compilation of the final report was done by geologist Vesa Toropainen (Suomen Malmi Oy).

The drill core samples were placed in wooden core boxes immediately after emptying the core barrel. In all, four core boxes were used, one for each drillhole. Start and end depths of the core in each core box are presented in Appendix 7.2. Wooden blocks separating the different lifts were placed to the core boxes to show the depth of each lift. The core drillings included two lifts in each drillhole. The depths of the lifts are presented in Appendix 7.3.

2.2 Drilling and returning water and the use of label agent

The labelled drilling water for drillhole was taken from the water pipeline in ONKALO. The mixing of the label agent was done by Posiva Oy. The mixing was done before pumping water to the ONKALO pipeline. Practically all drilling water returned from the drillhole. Water leakage from the drillhole was so small that it couldn’t be measured.

2.3 Location surveys

Surveyed start coordinates and coordinates at 1.00 m depth of the drillholes and calculated coordinates at the ends of the surveys are presented in Table 1. The initial coordinates dips and azimuths (Appendix 7.1) were location surveyed on the 19th of September 2010 by Prismarit Oy. The coordinates, dips and azimuths were also surveyed at the depth of 1.00 m in the drillholes. The end coordinates of each the drillhole is calculated by straight line extrapolation from the starting point of the drillhole to the drillhole end depth using the dip and direction surveyed at the depth of 1.00 m.

***Table 1**. Coordinates of the drillholes ONK-PP264...267.*

Point locations	X	Y	Z	Coordinate origin
ONK-PP264				
Start coordinates	6792260.86	1525969.30	-138.06	Location survey
1 metre depth	6792260.87	1525969.31	-139.06	Location survey
End of drillhole (4.23 m)	6792260.90	1525969.31	-142.29	Calculated
ONK-PP265				
Start coordinates	6792260.12	1525968.86	-138.06	Location survey
1 metre depth	6792260.12	1525968.86	-139.06	Location survey
End of drillhole (4.19 m)	6792260.12	1525968.83	-142.25	Calculated
ONK-PP266				
Start coordinates	6792259.85	1525965.44	-138.05	Location survey
1 metre depth	6792259.85	1525965.44	-139.05	Location survey
End of drillhole (4.24 m)	6792259.86	1525965.43	-142.29	Calculated
ONK-PP267				
Start coordinates	6792259.08	1525965.00	-138.05	Location survey
1 metre depth	6792259.08	1525965.00	-139.05	Location survey
End of drillhole (4.27 m)	6792259.09	1525964.99	-142.31	Calculated

3 GEOLOGICAL LOGGING

3.1 General

The handling of the core was based on the POSIVA work instructions POS-001427 ”Core handling procedure with triple tube coring” (in Finnish). Drill core samples were placed into about one-metre long wooden core boxes immediately after emptying the core barrel.

The drill core was handled carefully during and after the drilling. The core was placed in the boxes avoiding any unnecessary breakage. Broken and clay rich parts of the core were wrapped in aluminium paper to avoid breaking them during storage and logging. If loose rock fragments from the drillhole walls were encountered during the logging, they were placed after the block marking the end of the previous sample run. Therefore, at the beginning of a sample run, there might be rock fragments not belonging to the sample run itself.

Posiva geologist Tuomas Pere logged the core in Posiva’s core logging facility at ONKALO site. The core logging followed the normal Posiva logging procedure, which has been used e.g. in pilot hole drilling programmes at Olkiluoto. The following parameters were logged: lithology, foliation, fracture parameters, fractured zones, weathering, core loss, artificial break, fracture frequency, RQD, rock quality and core discing. In addition, the lifts and the core box numbers were documented.

All core boxes (Appendix 7.2) were digitally colour photographed, both dry and wet. The core photographs (wet) are presented at the end of the report.

The lift depths (Appendix 7.3) are given as they were marked on the wooden spacing blocks separating different sample runs in the core boxes. If the length of the core in the sample run indicated that sampling depth was different from the depth measured during drilling, the true sample depth was corrected on the spacing block. Therefore, the sample run depth equals the sample depth. The drilling depth might be deeper than the sampling depth, if the core lifter slips and part of the core is left in the drillhole and is retrieved by the next lift. The measured true sample depths were marked to the core sample with short red lines perpendicular to the core direction in one metre interval. Those depth values were marked to the upper dividing wall of the core box row.

3.2 Core orientation

There was a sawed groove marking the North direction in the starts of the drillholes on concrete surface, but the orientation could not be continued to the core sample in any of the four holes, as there was shearing of sample ends in the concrete-rock-contact.

3.3 Lithology

The rocks of Olkiluoto fall into four main groups: 1) gneisses, 2) migmatitic gneisses, 3) TGG-gneisses (TGG = tonalite-granodiorite-granite) and 4) pegmatitic granites (Kärki & Paulamäki 2006). In addition, narrow diabase dykes occur sporadically. The gneisses include homogeneous mica-bearing quartz gneisses, banded mica gneisses and hornblende or pyroxene-bearing mafic gneisses. The migmatitic gneisses, which typically contain 20 – 40 % leucosome, can be divided into three subgroups in terms of their migmatite structures: veined gneisses, stromatic gneisses and diatexitic gneisses. The leucosomes of the veined gneisses show vein-like, more or less elongated traces with some features similar to augen structures. Planar leucosome layers characterize the stromatic gneisses, whereas the migmatite structure of the diatexitic gneisses is asymmetric and irregular.

The lithological classification used in the mapping follows the classification by Mattila (2006). In this classification, the migmatitic metamorphic gneisses are divided into veined gneisses (VGN), stromatic gneisses (SGN) and diatexitic gneisses (DGN). The percentage of the leucosome proportion in gneisses is reported. The non-migmatitic metamorphic gneisses are separated into mica gneisses (MGN), mafic gneisses (MFGN), quartz gneisses (QGN) and tonalitic-granodioritic-granitic gneisses (TGG). The metamorphic rocks form a compositional series that can be separated by rock texture and the proportion of neosome. Igneous rock names used in the classification are coarse-grained pegmatitic granite (PGR), K-feldspar porphyry (KFP) and diabase (DB).

The TGG gneisses are medium-grained, relatively homogeneous rocks that can show a blastomylonitic foliation, but they can also resemble plutonic, unfoliated rocks. The pegmatitic granites are leucocratic, very coarse-grained rocks, which may contain large garnet, tourmaline and cordierite crystals. Mica gneiss enclaves are typical within the larger pegmatitic bodies. Gneisses, which are weakly or not at all migmatitic, make ca. 9 % of the bedrock. The migmatitic gneisses comprise over 64 % of the volume of the Olkiluoto bedrock, with the veined gneisses accounting for 43 %, the stromatic gneisses for 0.4 % and the diatexitic gneisses for 21 %, based on drill core logging. Of the remaining lithologies, the TGG-gneisses constitute 8 % and the pegmatitic granites almost 20 % by volume (Kärki & Paulamäki 2006).

The main lithology in the drillcores ONK-PP264…267 is coarse grained K-feldspar rich massive grey coloured pegmatitic granite, which makes up to 96.4% of the total drillcore lengths of ONK-PP264…267 (Appendix 7.4). The PGR contain quartz-cordierite-aggregates and cordierite porphyroblasts. In drillcore ONK-PP266 there is a 0.58 m section of irregularly foliated, feldspar-rich cordierite-sillimanite-mica gneiss (diatexitic gneiss).

3.4 Foliation

The classification of the foliation type and intensity used in this study is based on the characterization procedure introduced by Milnes et al. (2006). The foliation type was estimated macroscopically and classified into five categories:

MAS = massive
GNE = gneissic
BAN = banded
SCH = schistose
IRR = irregular

The gneissic type (GNE) corresponds to a rock dominated by quartz and feldspars, with micas and amphiboles occurring only as minor constituents. The banded foliation type (BAN) consists of intercalated gneissic and schistose layers, which are either separated or discontinuous layers of micas or amphiboles. The schistose type (SCH) is dominated by micas or amphiboles, which have a strong orientation. Massive (MAS) corresponds to massive rock with no visible orientations and irregular (IRR) to folded or chaotic rock.

The intensity of the foliation is based on visual estimation and classified into the following four categories:

0 = massive or irregular
1 = weakly foliated
2 = moderately foliated
3 = strongly foliated

Main foliation type and intensity were logged in one metre sections from the core sample (Appendix 7.5). The pegmatitic granites are massive by foliation. In drillhole ONK-PP266 there is a short section of irregularly foliated diatexitic gneiss in the start of the drillhole.

3.5 Fracturing

Fractures were numbered sequentially from the beginning to the end of the drillcore (Appendix 7.6). Fracture depths were measured to the centre line of the core and given with an accuracy of 0.01 m. Each fracture was described individually with attributes including orientation, type, colour, fracture filling, surface shape and roughness. The abbreviations used to describe the fracture type are in accordance with the classification used by Suomen Malmi Oy (Niinimäki, 2004) (Table 2).

Fractures with a filling and an apparent colour were classified as filled, if the core was intact. The filled fractures with intact surfaces were described as closed or partly closed. In these cases, “closed” or “partly closed” has been written in the remarks column. The thickness of the filling was estimated with an accuracy of 0.1 mm.

The identification of fracture fillings was qualitative and made visually in accordance with the fracture mineral database developed by Kivitieto Oy and Posiva Oy (Table 3). Abbreviations were used during the logging. Where the recognition of a mineral was not possible, the mineral was described with a common mineral group name, such as clay, sulphide etc.

In addition to this, the morphology and alteration of fractures were also classified according to the Q-system (Grimstad & Barton 1993). The fracture morphology was described with the joint roughness number, J_r (Table 4) and the alteration with the joint alteration number, J_a (Table 5). The fracture shape and roughness of fracture surfaces were classified using a modification of Barton’s Q-classification (Barton et al. 1974) (Table 6).

Table 2. *The abbreviations used to describe fracture type (Niinimäki 2004).*

Abbreviation	Fracture type
op	Open
ti	Tight, no filling material
fi	Filled
fisl	Filled slickensided
grfi	Grain filled
clfi	Clay filled

Table 3. *Fracture filling mineral abbreviations.*

Abbreviation	Mineral	Abbreviation	Mineral
CC	= Calcite	IL	= Illite
EP	= Epidote	SK	= Pyrite
MU	= Muscovite	SV	= Clay mineral
KL	= Chlorite		

Table 4. *Concise description of joint roughness number J_r (Grimstad & Barton 1993).*

J_r	Profile	Rock wall contact, or rock wall contact before 10 cm shear.
4	SRO	Discontinuous joint or rough and stepped
3	SSM	Stepped smooth
2	SSL	Stepped slickensided
3	URO	Rough and undulating
2	USM	Smooth and undulating
1.5	USL	Slickensided and undulating
1.5	PRO	Rough or irregular, planar
1	PSM	Smooth, planar
0.5	PSL	Slickensided, planar
Note 1. Descriptions refer to small-scale features and intermediate scale features, in that order.		
J_r		**No rock-wall contact when sheared**
1		Zone containing clay minerals thick enough to prevent rock-wall contact
1		Sandy, gravely or crushed zone thick enough to prevent rock-wall contact
Note 1. Add 1 if the mean spacing of the relevant joint set is greater than 3. 2. Jr = 0.5 can be used for planar slickensided joints having lineation, provided the lineations are oriented for minimum strength.		

Table 5. *Concise description of joint alteration number J_a (Grimstad & Barton 1993).*

J_a	**Rock wall contact (no mineral filling, only coatings).**
0.75	Tightly healed, hard, non-softening impermeable filling, i.e. quartz, or epidote.
1	Unaltered joint walls, surface staining only.
2	Slightly altered joint walls. Non-softening mineral coatings, sandy particles, clay-free disintegrated rock, etc.
3	Silty or sandy clay coatings, small clay fraction (non-softening).
4	Softening or low-friction clay mineral coatings, i.e. kaolinite, mica, chlorite, talc, gypsum, and graphite, etc., and small quantities of swelling clays (discontinuous coatings, 1-2 mm or less in thickness.
	Rock wall contact before 10 cm shear (thin mineral fillings).
4	Sandy particles, clay-free disintegrated rock, etc.
6	Strongly over-consolidated, non-softening clay mineral fillings (continuous, <5 mm in thickness).
8	Medium or low over-consolidation, softening, clay mineral filling (continuous <5 mm in thickness).
8-12	Swelling-clay fillings, i.e. montmorillonite (continuous, <5 mm in thickness). Value of J_a depends on percentage of swelling clay-sized particles, and access to water, etc.
	No rock-wall contact when sheared (thick mineral fillings).
6-12	Zones or bands of disintegrated or crushed rock and clay.
5	Zones or bands of silty- or sandy-clay, small clay fraction (non-softening).
10-20	Thick, continuous zones or bands of clay.

Table 6. *Fracture surface shapes and roughness (Barton et al. 1974).*

Fracture shape	Fracture roughness
Planar	Rough
Stepped	Smooth
Undulated	Slickensided

During the fracture logging, the surface colour was also registered. The colour is often caused by the dominating fracture filling mineral or minerals, e.g. chlorite (green) or kaolinite (white). Presence of minor filling minerals usually causes some variation in the colour of the fracture surface. These colour shades were described e.g. as dark or greenish. Tight fractures typically had only a slightly different shade from the host rock colour.

In the fracture logging, 63 fractures were recorded from drillcores ONK-PP264…267. The number of fractures by drillhole ranged from 14 to 17 (Appendix 7.6). There are 60 filled fractures, two open fractures and one filled slickensided fracture.

Practically all of the fractures in ONKPP264…266 are undulated or planar in shape, have a rough profile and high joint roughness number, indicating a high friction in the fracture surface. These fractures are usually filled with low to low-moderate joint alteration numbers (0.75 – 2), in accordance with this conclusion. In the drillcore ONK-PP266 there is one low friction fracture with a slickensided surface.

In the high-friction fractures, the fracture fillings consist of hard, non-softening coatings or fillings, mainly calcite, pyrite, epidote, muscovite (filled fractures), often with small amounts of chlorite, illite or other clay minerals.

The identified fracture filling minerals of ONK-PP264…267 according to the frequency of occurrence are: pyrite, calcite, muscovite, undefined clay minerals, illite, chlorite and epidote.

The orientation of the drillholes was unsuccessful; therefore the fracture directions could not be defined.

3.6 Fracture frequency and RQD

The frequencies of natural fractures, RQD (Rock Quality Designator) (see Table 9) and mechanically induced breaks were all counted on one metre depth intervals (Appendix 7.10). The frequency of all fractures is the number of core breaks within one metre interval, including natural fractures and mechanically induced breaks. Mechanically induced breaks are caused by drilling, core handling and core discing. The natural fracture frequency is the number of natural fractures, open and closed, within one metre interval. If the frequency of all fractures is higher than the natural fracture frequency, the core must have been broken during the drilling. If the core was broken accidentally or by purpose during handling, it was marked to the core box with the letter F, and counted as a fracture or break depending on its nature. If the natural fracture frequency is higher than the frequency of all fractures, the fractures must be cohesive enough to keep the core together. The RQD gives the percentage of over 10 cm long core segments, separated by natural fractures, within one metre interval.

The average natural fracture frequency of the drillcores ONK-PP264...267 is 4.0 pcs/m and the average RQD value is 94.2 % (Appendix 7.7).

3.7 Fractured zones and core loss

Fractured zones were classified according to Finnish engineering geological bedrock classification (Korhonen et al. 1974) (Table 7). There are two short fractured zones in the drillcores, one in both drillholes ONK-PP265 and ONK-PP267. The fractures in the zones are with scarce fillings and with rough fracture surfaces (Appendix 7.8).

Core loss due to non-cohesive rock was not observed. Core loss due to rock breaking or grinding is mainly insignificant in the drillholes.

Table 7. *Classification of fractured rock (Korhonen et al. 1974).*

Broken rock mass	Zone class	Fractures / metre	Fracture filling
Block structured	RiII	3 - 10	no fillings
Fracture structured	RiIII	> 10	none or thin
Crush structured	RiIV-Rk3 RiIV-Rk4	3 - 10 > 10	filled with clay minerals
Clay structured	RiV	-	abundant clay material in rock mass

3.8 Weathering

The weathering degree of the drill core was classified according to the method developed by Korhonen et al. (1974) and Gardemeister et al. (1976) (Table 8).

The drillcores are practically completely unweathered (Rp0), having only very weak and mostly local alteration, or no visible alteration at all. There is weak saussuritization of plagioclase in the drillhole ONK-PP264 at the drillhole depth of 3 metres (Appendix 7.9).

Table 8. *Abbreviations of the weathering degree.*

Abbreviation	Description of weathering type
Rp0	Unweathered
Rp1	Slightly weathered
Rp2	Strongly weathered
Rp3	Completely weathered

3.9 Core discing

In Posiva's logging procedure, core discing is logged separately, and depth intervals where core discing occurs are documented. The number of breaks and core discs is logged. The geometry of the top and bottom surfaces of the discs is described separately using the following classification:

- Concave
- Convex
- Planar
- Saddle
- Incomplete.
-

No core discing was found in the drillcores.

4 ROCK MECHANICS

4.1 The rock quality

Rock quality was classified during the core logging using Barton's Q-classification (Rock Tunneling Quality Index; Barton, 1974 and Grimstad & Barton, 1993). The core is divided into sections, which can vary from less than a metre to several metres in length. In each section, the rock quality is as homogenous as possible. The roughness and alteration numbers are estimated for each fracture surface (Appendix 7.6). The roughness and alteration numbers (average, median and lower and higher quartiles) are then calculated for each section, and the median value is used in the Q-quality calculations.

The Q-value is calculated by Equation 1 (Barton, 1974 and Grimstad & Barton, 1993):

$$Q = \frac{RQD}{J_n} * \frac{J_r}{J_a} * \frac{J_w}{SRF} \qquad (1)$$

The RQD (Table 9) is defined as the cumulative length of core pieces longer than 10 cm in a run divided by the total length of the core run. Closed fractures are also counted in the RQD value. Some constant values are used in the calculations. All closed fractures are given joint alteration (J_a) number of 0.75 (see Table 5). If the fracture interval of the relevant joint set is over one metre, the value of 1 is given to J_n (Table 9). If the fracture interval of the relevant joint set is over three metres, the value of 1 is added to the value of $J_{r,}$ (see Table 4), and J_n is given the value of 0.5. For rock sections with no fractures, the value of 5 for J_r and the value of 0.75 for J_a are used. In the calculations, joint water (J_w) and stress reduction factors (SRF) are assumed as 1, so the result of the calculation is the Q'-value.

The core samples of the drillholes were divided into units of variable lengths, the Q'-values of which were then calculated separately. The results of Q'-classification are presented in Appendix 7.10. The rock quality (see Table 9) of the drillholes is mainly "very good" (8.56 m, 53.8 %) or "extremely good" (7.28 m, 45.7 %). The fractured zone (RiIII) in the drillhole ONK-PP265 at depth of 2.72 – 2.80 m (0.08 m) is classified as "good".

Table 9. *Description of RQD and joint set number J_n (Grimstad & Barton 1993).*

1. Rock Quality Designation		RQD
A	Very poor	0 - 25
B	Poor	25 - 50
C	Fair	50 - 75
D	Good	75 - 90
E	Excellent	90 - 100
Note: i) Where RQD is reported or measured as ≤ 10 (including 0), a nominal value of 10 is used to evaluate Q. ii) RQD intervals of 5, *i.e.*, 100, 95, 90, *etc.*, are sufficiently accurate.		
2. Joint Set Number		J_n
A	Massive, no or few joints	0.5 - 1.0
B	One joint set	2
C	One joint set plus random joints	3
D	Two joint sets	4
E	Two joint sets plus random joints	6
F	Three joint sets	9
G	Three joint sets plus random joints	12
H	Four or more joint sets, random, heavily jointed, "sugar cube", *etc.*	15
J	Crushed rock, earthlike	20
Note: i) For intersections, use ($3.0 \times J_n$) ii) For portals, use $2.0 \times J_n$)		

5 SUMMARY

As a part of the bentonite buffer pre-test in ONKALO, Suomen Malmi Oy core drilled four short drillholes (ONK-PP264...267). The lengths of the drillholes range from 4.19 to 4.27 metres. The drillholes were drilled in a niche of the access tunnel at chainage 1475. The drilling was started from concrete surface in the tunnel floor with no casing drilling.

The drill rig was DE 130. The core was drilled using a NQ2 double tube core barrel. The drillhole diameter is 75.7 mm and the sample diameter is 50.5 mm. The drilling water was taken from ONKALO pipeline and marked with sodium fluorescein.

The main rock type intersected by the drillholes is pegmatitic granite. The rock samples are mostly unweathered.

The average fracture frequency in the drillholes is 4.0 pcs/m and the mean RQD value is 94.2 %. Two fractured zones were intersected.

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HOLE_ID	ONK-PP264	ONK-PP265	ONK-PP266	ONK-PP267
NORTHING	1525969.30	1525968.86	1525965.44	1525965.00
EASTING	6792260.86	6792260.12	6792259.85	6792259.08
ELEVATION	-138.06	-138.06	-138.05	-138.05
MAX_LENGTH, m	4.23	4.19	4.24	4.27
AZIMUTH, °	12.5	270	315	315
DIP, °	-89.5	-89.6	-89.8	-89.7
VT1_CHAINAGE	1475	1475	1475	1475
LOCATION	ONKALO	ONKALO	ONKALO	ONKALO
DATE_STARTED	20.7.2010	20.7.2010	21.7.2010	21.7.2010
DATE_DRILLED	20.7.2010	20.7.2010	21.7.2010	21.7.2010
HOLE_TYPE	Drillhole	Drillhole	Drillhole	Drillhole
SURVEYED_BY	Prismarit Oy	Prismarit Oy	Prismarit Oy	Prismarit Oy
SURVEY_DATE	15.9.2010	15.9.2010	15.9.2010	15.9.2010
SURVEY_TYPE	Tachymeter	Tachymeter	Tachymeter	Tachymeter
SURVEY_NOTE	Pri-onk 919	Pri-onk 919	Pri-onk 919	Pri-onk 919
GRID_ID	KKJ1	KKJ1	KKJ1	KKJ1
OVERBURDEN*, m	0.21	0.24	0.20	0.36
CASING_TYPE	no casing	no casing	no casing	no casing
NO_OF_CORE_BOXES	1	1	1	1
HOLE_DIAMETER, mm	75.7	75.7	75.7	75.7
SAMPLE_DIAMETER, mm	50.5	50.5	50.5	50.5
EQUIPMENT	NQ2	NQ2	NQ2	NQ2

* thickness of concrete

ONK-PP264

M_FROM m	M_TO m	BOX_NUMBER	REMARKS
0.00	4.23	1	Only one box

ONK-PP265

M_FROM m	M_TO m	BOX_NUMBER	REMARKS
0.00	4.19	1	Only one box

ONK-PP266

M_FROM m	M_TO m	BOX_NUMBER	REMARKS
0.00	4.24	1	Only one box

ONK-PP267

M_FROM m	M_TO m	BOX_NUMBER	REMARKS
0.00	4.27	1	Only one box

ONK-PP264

LIFT NR	LIFT DEPTH m	LENGTH m	REMARKS
1	2.95	2.95	
2	4.23	1.28	

ONK-PP265

LIFT NR	LIFT DEPTH m	LENGTH m	REMARKS
1	2.95	2.95	
2	4.19	1.24	

ONK-PP266

LIFT NR	LIFT DEPTH m	LENGTH m	REMARKS
1	3.00	3.00	
2	4.24	1.24	

ONK-PP267

LIFT NR	LIFT DEPTH m	LENGTH m	REMARKS
1	2.76	2.76	
2	4.27	1.51	

ONK-PP264

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
0.00	0.21	CONCRETE		Concrete
0.21	4.23	PGR	100	Coarse-grained, K-feldspar -rich, massive PGR. At 3 m dhd plagioclases are slightly saussuritized, otherwise the section is unaltered. Graphic intergrowths between K-feldspar and quartz are present and quartz-cordierite aggregates (diameter <4 cm) occur throughout the whole core. Contains mainly muscovite-filled fractures.

ONK-PP265

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
0.00	0.24	CONCRETE		Concrete
0.24	4.19	PGR	100	Coarse-grained, unorientated, and unaltered K-feldspar-rich PGR (Grain size 1-60 mm). The section also contains quartz-cordierite -aggregates (diameter <3cm).

ONK-PP266

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
0.00	0.20	CONCRETE		Concrete
0.20	0.78	DGN	75	Irregularily foliated, unaltered feldspar-rich cordierite-sillimanite-mica gneiss.
0.78	4.24	PGR	100	Massive, unaltered K-feldspar-rich pegmatitc granite. Cordierite porphyroblasts occur throughout the whole section and sillimanite bands can be seen occasionally. The rock is sparsely fractured. Graphic texture in places.

ONK-PP267

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
0.00	0.36	CONCRETE		Concrete
0.36	4.27	PGR	98	The section consists of coarse-grained, K-feldspar-rich pegmatitc granite with biotite schlieren and cordierite porphyroblasts, in places sillimanite is also present. The rock is sparsely fractured and unaltered.

ONK-PP264

M_FROM m	M_TO m	ELEMENT	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE	REMARKS
0.21	1.00	FOL	MAS	0	PGR	
1.00	2.00	FOL	MAS	0	PGR	
2.00	3.00	FOL	MAS	0	PGR	
3.00	4.00	FOL	MAS	0	PGR	
4.00	4.23	FOL	MAS	0	PGR	

ONK-PP265

M_FROM m	M_TO m	ELEMENT	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE	REMARKS
0.24	1.00	FOL	MAS	0	PGR	
1.00	2.00	FOL	MAS	0	PGR	
2.00	3.00	FOL	MAS	0	PGR	
3.00	4.00	FOL	MAS	0	PGR	
4.00	4.19	FOL	MAS	0	PGR	

ONK-PP266

M_FROM m	M_TO m	ELEMENT	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE	REMARKS
0.20	1.00	FOL	IRR	0	DGN	
1.00	2.00	FOL	MAS	0	PGR	
2.00	3.00	FOL	MAS	0	PGR	
3.00	4.00	FOL	MAS	0	PGR	
4.00	4.24	FOL	MAS	0	PGR	

ONK-PP267

M_FROM m	M_TO m	ELEMENT	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE	REMARKS
0.36	1.00	FOL	MAS	0	PGR	
1.00	2.00	FOL	MAS	0	PGR	
2.00	3.00	FOL	MAS	0	PGR	
3.00	4.00	FOL	MAS	0	PGR	
4.00	4.27	FOL	MAS	0	PGR	

ONK-PP264

FRACTURE	M_FROM m	M_TO m	CORE_ALPHA (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF FILLING (mm)	TYPE	Jr Profile	Jr 3	Ja 1	CLASS_OF_THE FRACTURED_ZONE	REMARKS
1	0.59		64	grey	SK	0.1	fi	PRO	1.5	1		
2	0.71		67	grey	SK,CC	0.1	fi	PRO	1.5	1		
3	0.78		45	grey	MU	0.5	fi	URO	3	1		
4	0.79		74	grey	MU,SK	0.2	fi	PRO	1.5	1		
5	1.18		67	grey	CC	0.1	fi	PRO	1.5	1		
6	1.32		88	grey/yellow	SK,MU	0.2	fi	PSM	1	1		
7	1.42		72	grey	SK,MU	0.2	fi	URO	3	1		
8	1.69		72	grey	MU	0.1	fi	URO	3	1		
9	1.74		80	grey		0	op	URO	3	0.75		closed
10	1.84		90	yellowish	SK	0.1	fi	URO	3	1		
11	2.48	2.86	8	greyish	MU,IL,SV	0.2	fi	URO	3	2		
12	2.70		70	brownish		0	op	SRO	4	1		oxidized surface
13	2.81		72	grey	MU,CC	0.4	fi	URO	3	1		
14	2.84		78	grey	MU,SV	0.1	fi	URO	3	1		
15	2.95		90	greyish	MU,SK,EP	0.3	fi	URO	3	1		
16	3.55		52	grey	CC	0.1	fi	URO	3	1		

ONK-PP265

FRACTURE	M_FROM m	M_TO m	CORE_ALPHA (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF FILLING (mm)	TYPE	Jr Profile	Jr 3	Ja 1	CLASS_OF_THE FRACTURED_ZONE	REMARKS
1	0.30		73	grey	SK,SV	0.2	fi	PRO	1.5	1		
2	0.41		20	grey	MU,CC	0.1	fi	PRO	1.5	1		Partially closed
3	0.62		55	yellowish	SK	0,1	fi	URO	3	1		
4	0.75		57	grey	MU,CC	0.1	fi	URO	3	1		
5	0.87		78	grey	SK,CC	0.1	fi	URO	3	1		
6	1.31		62	grey		0	ti	URO	3	0.75		closed
7	1.37		53	grey	MU	0.5	fi	URO	3	1		partially closed
8	1.72		69	grey	CC,SK	0.2	fi	URO	3	1		
9	2.73		80	grey	CC,SV	0.2	fi	URO	3	1	RiIII	Possibly water-conducting
10	2.74		80	grey	KA	0.1	fi	URO	3	1	RiIII	Possibly water-conducting
11	2.77		78	grey	KA	0.1	fi	URO	3	1	RiIII	Possibly water-conducting
12	2.78		69	grey	SV	0.1	fi	URO	3	1	RiIII	Possibly water-conducting
13	2.79		71	grey	SV	0.1	fi	URO	3	1	RiIII	Possibly water-conducting
14	3.36		68	grey/yellow	CC,SK	0.2	fi	PRO	1.5	1		

ONK-PP266

FRACTURE	M_FROM m	M_TO m	CORE_ALPHA (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF FILLING (mm)	TYPE	Jr Profile	Jr 2	Ja 1	CLASS_OF_THE FRACTURED_ZONE	REMARKS
1	0.27		80	yellow	SK	0.2	fi	URO	3	1		
2	0.31		68	grey	SK	0.2	fi	PRO	1.5	1		
3	0.40		60	green	KL,SK,SV	0.3	fi	URO	3	1		
4	0.61		80	green	KL,SK	0.2	fi	USM	2	1		Almost striated
5	0.82		88	grey	CC,SK	0.2	fi	PRO	1.5	1		
6	1.19		80	grey	CC	0.2	fi	URO	3	1		
7	1.26		82	grey		0	ti	URO	3	0.75		partially open
8	1.38		82	grey	CC,SK	0.1	fi	PRO	1.5	1		
9	2.82		70	grey	CC	0.1	fi	USM	2	1		
10	3.00		57	grey	CC	0.2	fi	PRO	1.5	1		partially closed
11	3.16		78	grey	CC	0.1	fi	USM	2	1		
12	3.36		80	green	KL,IL	0.4	fisl	USL	1.5	2		
13	3.54		70	grey	SK	0.3	fi	PSM	1	1		
14	3.90		35	grey	MU	0.5	fi	PRO	1.5	0.75		closed
15	3.91		78	grey	CC,SK	0.1	fi	URO	3	1		
16	4.20		73	greenish	KL,SK	0.2	fi	URO	3	1		

ONK-PP267

FRACTURE	M_FROM m	M_TO m	CORE_ALPHA (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF FILLING (mm)	TYPE	Jr Profile	Jr 3	Ja 1	CLASS_OF_THE FRACTURED_ZONE	REMARKS
1	0.39		63	grey	SK,CC	0.2	fi	URO	3	1	RiIII	
2	0.42		76	grey	SK,CC	0.2	fi	URO	3	1	RiIII	
3	0.48		70	grey	CC	0.3	fi	PRO	1.5	1	RiIII	
4	0.60		72	grey	CC,KA	0.2	fi	URO	3	1	RiIII	
5	0.64		70	dark grey	KL, MU	0.3	fi	USM	2	2	RiIII	
6	0.65		77	dark grey	KL,MU,SK	0.3	fi	URO	3	2	RiIII	
7	0.74		74	grey/yellow	SK	0.1	fi	PRO	1.5	1	RiIII	
8	0.86		90	greyish	SK	0.1	fi	PRO	1.5	1	RiIII	
9	1.11		80	green/yellow	SK,EP	0.2	fi	URO	3	1		
10	1.31		80	green	SV,SK	0.2	fi	URO	3	1		
11	2.46		82	grey/shiny	SK	0.2	fi	PRO	1.5	1		
12	2.59		72	grey/green	CC,EP	0.1	fi	URO	3	1		
13	3.08		70	grey	SK	0.1	fi	URO	3	1		
14	3.40		70	grey	CC,MU	0.1	fi	URO	3	1		
15	3.60		68	greyish	CC,SK,SV	0.2	fi	URO	3	1		
16	3.97		80	grey	CC,SK,EP	0.2	fi	URO	3	1		
17	4.19		62	grey	CC,SK	0.2	fi	SRO	4	1		

ONK-PP264

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
0.21	1.00	11	4	7	90	RQD 0.71 m/0.79 m
1.00	2.00	6	6	0	75	
2.00	3.00	10	5	5	97	
3.00	4.00	5	1	4	100	
4.00	4.23	1	0	1	100	RQD 0.23 m/0.23 m

ONK-PP265

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
0.24	1.00	8	5	3	100	RQD 0.76 m/0.76 m
1.00	2.00	4	3	1	94	
2.00	3.00	9	5	4	94	
3.00	4.00	5	1	4	100	
4.00	4.19	1	0	1	100	RQD 0.19 m/0.19 m

ONK-PP266

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
0.20	1.00	7	5	2	84	RQD 0.67 m/0.80 m
1.00	2.00	4	3	1	93	
2.00	3.00	2	1	1	100	
3.00	4.00	7	6	1	99	
4.00	4.24	2	1	1	100	RQD 0.24 m/0.24 m

ONK-PP267

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
0.36	1.00	9	8	1	64	RQD 0.41 m/0.64 m
1.00	2.00	5	2	3	100	
2.00	3.00	5	2	3	100	
3.00	4.00	4	4	0	100	
4.00	4.27	1	1	0	100	RQD 0.27 m/0.27 m

ONK-PP265

M_FROM m	M_TO m	CLASS_OF_THE FRACTURED_ZONE	DESCRIPTION OF_ZONE	CORE LOSS m	Remarks
2.73	2.79	RiIII	Five fractures in PGR. The fracture surfaces are relatively unaltered and the dominating fracture profile is URO. No slickenside fractures. Possibly water-conducting.		

ONK-PP267

M_FROM m	M_TO m	CLASS_OF_THE FRACTURED_ZONE	DESCRIPTION OF_ZONE	CORE LOSS m	Remarks
0.39	0.86	RiIII	Increased fracture density, scarce fracture fillings.		

ONK-PP264

M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
0.21	4.23	Rp0	

ONK-PP265

M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
0.24	4.19	Rp0	

ONK-PP266

M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
0.20	4.24	Rp0	

ONK-PP267

M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
0.36	4.27	Rp0	

ONK-PP264

M_FROM m	M_TO m	LENGTH OF SECTION, m	> 10 cm cm	Number_of fractures	RQD %	RQD >10	Jn	Jr profile	Jr median	Ja median	ROCK_QUALITY_CLASS Q'	CLASS_OF_THE FRACTURED_ZONE	Core loss (m)	REMARKS	Q´
0.21	4.23	4.02	366	16	91.0	91.0	3	URO	3.0	1.00	Very Good				91

ONK-PP265

M_FROM m	M_TO m	LENGTH OF SECTION, m	> 10 cm cm	Number_of fractures	RQD %	RQD >10	Jn	Jr profile	Jr median	Ja median	ROCK_QUALITY_CLASS Q'	CLASS_OF_THE FRACTURED_ZONE	Core loss (m)	REMARKS	Q´
0.24	2.72	2.48	242	8	97.6	97.6	2	URO	3.0	1.00	Extremely Good				146
2.72	2.80	0.08	2	5	25.0	25.0	2	URO	3.0	1.00	Good	RiIII			38
2.80	4.19	1.39	139	1	100.0	100.0	2	PRO	2.3	1.00	Extremely Good				113

ONK-PP266

M_FROM m	M_TO m	LENGTH OF SECTION, m	> 10 cm cm	Number_of fractures	RQD %	RQD >10	Jn	Jr profile	Jr median	Ja median	ROCK_QUALITY_CLASS Q'	CLASS_OF_THE FRACTURED_ZONE	Core loss (m)	REMARKS	Q´
0.20	4.24	4.04	383	16	94.8	94.8	2	URO	2.0	1.00	Very Good				95

ONK-PP267

M_FROM m	M_TO m	LENGTH OF SECTION, m	> 10 cm cm	Number_of fractures	RQD %	RQD >10	Jn	Jr profile	Jr median	Ja median	ROCK_QUALITY_CLASS Q'	CLASS_OF_THE FRACTURED_ZONE	Core loss (m)	REMARKS	Q´
0.36	0.86	0.50	27	7	54.0	54.0	3	URO	3.0	1.00	Very Good	RiIII			54
0.86	4.27	3.41	341	10	100.0	100.0	2	URO	3.0	1.00	Extremely Good				150

ONK-PP264

ONK-PP265

ONK-PP266

ONK-PP267