Working Report 2011-71

Core Drilling of Hydco Drillholes ONK-PP262 and ONK-PP274 in ONKALO at Olkiluoto 2010

Vesa Toropainen

October 2011

POSIVA OY
Olkiluoto
FI-27160 EURAJOKI, FINLAND
Tel +358-2-8372 31
Fax +358-2-8372 3809

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ABSTRACT

Suomen Malmi Oy (Smoy) core drilled two drillholes for HYDCO-program in ONKALO at Eurajoki, Olkiluoto in 2010. The drillhole ONK-PP262 was drilled in May 2010 and the drillhole ONK-PP274 in December 2010. The lengths of the drillholes are 25.02 and 23.88 m respectively. The drillholes are 75.7 mm by diameter. The drillholes were drilled in the investigation niche 4 at the access tunnel chainage 3747.

The hydraulic DE 130 drilling rig was used. 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. The drillholes were measured with EMS deviation survey tool.

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 types in the drillholes are veined gneiss and pegmatitic granite. The average fracture frequencies in both drill cores are 1.4 pcs/m. The average RQD values in the drillcores are 97.2 % (ONK-PP262) and 98.6 % (ONK-PP274).

Keywords: Olkiluoto, ONKALO, groundwater, core drilling, drillhole, veined gneiss, pegmatite granite, fracture

HYDCO-REIKIEN ONK-PP262 JA ONK-PP274 KAIRAUS ONKALOSSA OLKILUODOSSA VUONNA 2010

TIIVISTELMÄ

Suomen Malmi Oy (Smoy) kairasi kaksi HYDCO-ohjelmaan kuuluvaa tutkimusreikää ONKALOssa Eurajoen Olkiluodossa vuonna 2010. Reikä ONK-PPP262 kairattiin toukokuussa, ja reikä ONK-PP274 joulukuussa 2010. Reikien pituudet ovat 25,02 ja 23,88 metriä. Kairareikien halkaisija on 75,7 mm. Reiät kairattiin ajotunnelin paalulla 3747 sijaitsevasta tutkimuskuprikka 4:stä.

Reiän kairaustyössä käytettiin hydraulista DE 130 kairauskonetta. Reiän kairaukseen käytettiin natriumfluoresiinilla merkittyä huuhteluvettä, joka otettiin ONKALO:n porausvesilinjasta. Reikien taipumat mitattiin EMS taipumamittauslaitteella.

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

Pääkivilajeina esiintyvät suonigneissi ja pegmatiittinen graniitti. Kallion keskimääräinen rakoluku on molemmissa rei'issä 1,4 kpl/m. Keskimääräiset RQD-luvut rei'issä ovat 97,2 % (ONK-PP262) ja 98,6 % (ONK-PP274).

Avainsanat: Olkiluoto, ONKALO, pohjavesi, kairaus, kairareikä, suonigneissi, 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 9269-10) Suomen Malmi Oy (Smoy) to drill drillholes for hydrological experiments (HYDCO-program) in ONKALO. The identification number of the drillholes are ONK-PP262 and ONK-PP274. The lengths of the drillholes are 25.02 m and 23.88 m, respectively.

The new drillholes are located in the investigation niche 4 at the access tunnel chainage 3747 (Figure 1). The initial azimuth of the drillhole ONK-PP262 is 300.0° and the initial dip is -40.0° from the horizontal. The initial azimuth of the drillhole ONK-PP274 is 299.6° and the initial dip is -38.5° from the horizontal. The diameter of the drillholes is 75.7 mm. Summary of the technical details of the drillholes is presented in Appendix 1.

1.2 Scope of the work

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

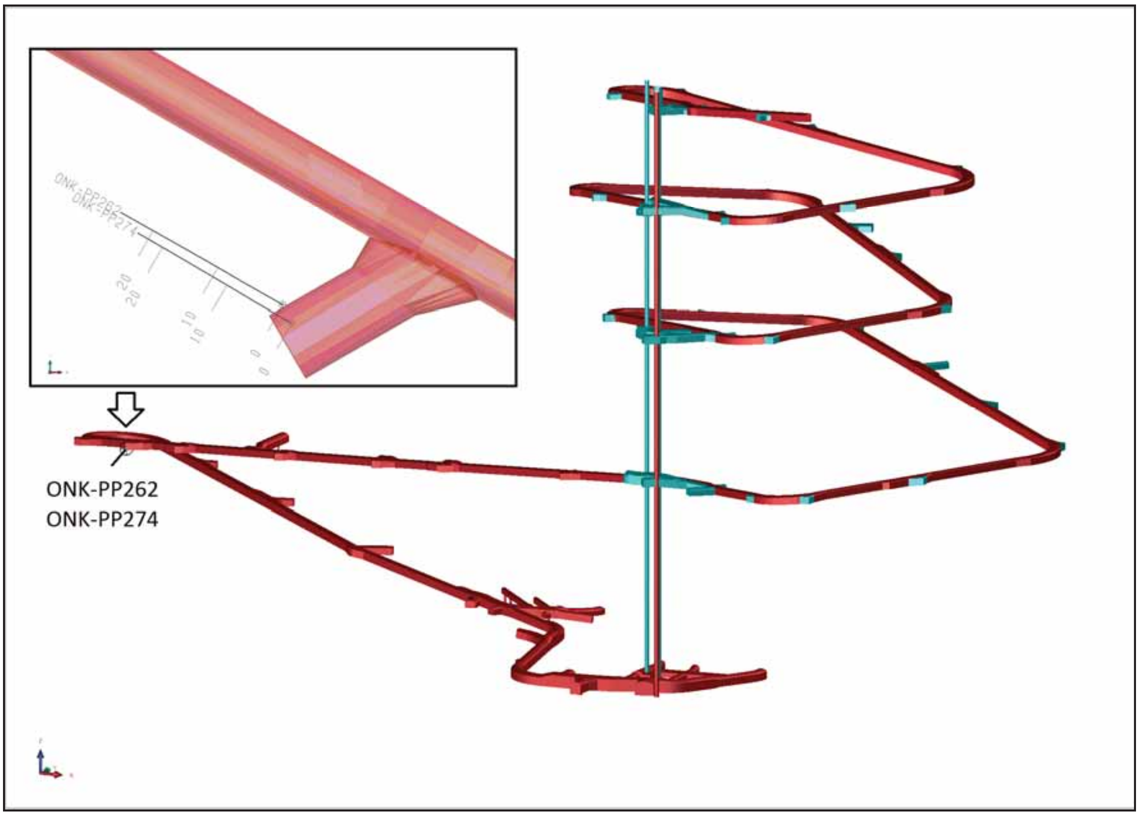

***Figure 1**. Locations of the drillholes ONK-PP262 and ONK-PP274 in ONKALO, and in the investigation niche 4 (small image).*

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 ONK-PP262 on the 4th of May in 2010. Drilling started on the 5th of May, and the drillhole was finished on the next day.

The drill rig was set up at the drilling site ONK-PP274 on the 9th of December in 2010. Drilling started on the 9th of December, and the drillhole was finished on the 13th.

The drilling of the ONK-PP262 and ONK-PP274 started from the tunnel wall/floor with 90 mm bit size to accommodate a 90/77 mm stainless steel casing. The drilling depth with 90 mm bit size was 0.80 m in ONK-PP262 and 0.92 m in ONK-PP274. The rest of the drillholes were drilled using NQ-triple tube core barrel (NQ3) with NQ-drill rods. The casings were cemented to the starts of the drillholes afterwards.

Drillhole diameter with NQ3-core barrel is 75.7 mm and drillcore diameter is 50.2 mm. Technical information of the drillholes is presented in Appendix 1.

The drilling was carried out as discontinuous shift work (two shifts per day and the drilling team in each shift consisted of a driller and an assistant. Geologist Vesa Toropainen was the project manager and Matti Alaverronen the drilling supervisor. Geological logging and compilation of the final report was done by geologist Vesa Toropainen.

The drillcore samples were placed in wooden core boxes immediately after emptying the core barrel. In all, six core boxes were used for both ONK-PP262 and ONK-PP274. Start and end depths of the core in each core box are presented in Appendix 2. Wooden blocks separating the different lifts were placed to the core boxes to show the depth of each lift. The core drillings included 11 lifts for both drillholes. The depths of the lifts are presented in Appendix 3.

2.2 Drilling and returning water and the use of label agent

The labelled drilling water for the drillholes 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 drillholes. Water leakages from the drillholes were so small that they couldn’t be measured.

2.3 Location and deviation surveys

Surveyed coordinates of the drillhole starting point and calculated coordinates at the end of the drillhole are presented in Table 1. The initial dip of the drillhole ONK-PP262 is -40.0 degrees and the initial azimuth is 300.0 degrees (location surveyed by Prismarit Oy, Pri-onk 888). The initial dip of the drillhole ONK-PP274 is -38.5 degrees and the initial azimuth is 299.6 degrees (location surveyed by Prismarit Oy).

The EMS survey tool measures the drillhole dip with an electronic accelerometer and the azimuth relative to the magnetic north with a three-component fluxgate magnetometer. According to the manufacturer, the accuracy of the azimuth is ± 0.5 degrees and the accuracy of the dip is ± 0.2 degrees, provided there are no magnetic anomalies. No significant magnetic anomalies were detected during the measurements. The azimuth was measured to magnetic north, but declination correction of +6.3 degrees was made to the results; the results are, therefore, to geographic north.

The drillholes ONK-PP262 and ONK-PP274 were measured with Reflex EMS deviation survey tool. The drillhole ONK-PP262 was measured to the depth of 24 metres, and the drillhole ONK-PP274 to the final drillhole depth of 23.88 m. The initial directions measured by Prismarit Oy were used as the initial azimuths in EMS surveys. For initial dips, the dips measured by the EMS tool were used. The azimuths were evened over the first 6 metres, as there was probable magnetic influence by the drill rig or other metal at present. The measurement of ONK-PP262 was extrapolated to the final drillhole depth of 25.02 metres by straight line extrapolation, using the dip and direction of the last measurement station. According to the EMS surveys, the deviations of both drillholes are minimal and within the margin of error of the survey method (Appendix 4).

***Table 1**. Coordinates of the drillholes ONK-PP262 and ONK-PP274.*

Point location	**X**	**Y**	**Z**	**Coordinate origin**
ONK-PP262				
Tunnel wall surface	6792337.52	1525340.87	-357.00	Location survey
End of drillhole (25.02 m)	6792347.11	1525324.25	-373.05	EMS-survey
ONK-PP274				
Tunnel floor surface	6792335.65	1525341.79	-357.48	Location survey
End of drillhole (23.88 m)	6792344.92	1525325.97	-372.78	EMS-survey

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). Drillcore samples were placed into about one-metre long wooden core boxes immediately after emptying the core barrel.

The drillcore 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.

Geologist Vesa Toropainen logged the cores in Posiva’s core logging facility at ONKALO site. The core logging of the drillcores 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, core orientation, the lifts and the core box numbers were documented.

All core boxes (Appendix 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 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

Core orientation was carried out by using the Ezy-Mark Ori-Block in ONK-PP262 and the traditional spear system in the drillhole ONK-PP274. The starting depths of the oriented lifts and the start and end depths and lengths of the oriented parts of the sample were recorded (Appendix 5).

Five orientations were made during the drilling of ONK-PP262, and 73.8 % (18.37 m) of the drillcore was oriented. The reliability of the orientation is considered to be good.

Four orientations were made during the drilling of ONK-PP274, and 66.1 % (15.78 m) of the drillcore was oriented. The reliability of the orientation is considered to be good.

The orientation bottom line drawn to the drillcore sample on the basis of the orientation marks acted as a ground for direction measurements of fractures and other linear and planar features in the core (Figure 2). From the oriented drillcore sections, core alpha and beta angles of every measurable fracture and chosen foliation measurement points were determined. Each alpha and beta value was recalculated to the real dip and dip directions using the drillhole orientation at the start of the drillhole, measured by Prismarit Oy.

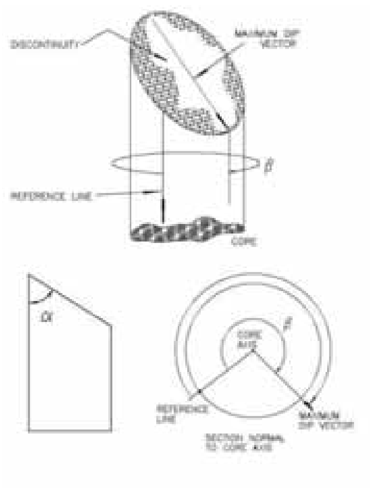

Figure 2. *Fracture and foliation orientation measurements from orientated core. The core alpha (α) angle is measured relative to core axis. The core beta (β) angle is measured clockwise relative to a reference line, looking downward the core axis in direction of drilling. Figure modified from Rocscience Inc. Orientation Parameters for Borehole Data, Dips (v. 5.0) Features (Rocscience Inc., 2003).*

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 drillcore logging. Of the remaining lithologies, the TGG-gneisses constitute 8 % and the pegmatitic granites almost 20 % by volume (Kärki & Paulamäki 2006).

The ONK-PP262 drillcore consists of veined gneiss (58.2 %) and pegmatitic granite (41.8 %) (Appendix 6). The pegmatitic granite and veined gneiss occur alternately with sections of variable lengths. The pegmatitic granite is coarse grained, light grey with locally red hue. It frequently contains garnet. The pegmatitic granite shows illitized shear banding, especially near to contacts to veined gneiss. The veined gneiss is mainly homogenic, moderately banded, but locally weakly banded or irregular. It contains sillimanite in melanosome and cordierite in PGR veins.

The ONK-PP274 drillcore consists mainly of veined gneiss (52.1 %), pegmatitic granite (39.3 %), diatexitic gneiss (5.9 %) and quartz gneiss (2.7 %) (Appendix 6). The veined gneiss is mainly moderately banded or gneissic, and locally irregularly foliated. The leucosome content of veined gneiss ranges from 10 to 30 %, and at 19.36 - 19.86 m it includes a short section of MGN/QGN section with no leucosome. It contains sillimanite in melanosome and small amounts of cordierite in PGR veins. The pegmatitic granite is pale coloured at the start of the drillcore, but show reddish hue in the following PGR sections. It contains locally garnet and cordierite. The DGN section is irregular to massive, showing shadow-like gneissic mica stripes and cordierite-mica-aggregates. At the drillhole depth of 17.35 - 18.00 m there is a short section of fine grained weakly gneissic grey coloured quartz-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

The type and intensity of the dominant foliation was defined for every full metre. Measurements of foliation (Appendix 7) were carried out in one metre intervals from the core sample, if possible.

From the core sample ONK-PP262 12 measurements were made, all of them from veined gneiss that showed mainly moderate banded foliation. The main foliation direction in the core samples ONK-PP262 is towards south-southeast (163°/45°) (Figure 3).

From the core sample ONK-PP274 12 measurements were made, most of them from weakly to moderately banded veined gneiss. The main foliation direction in the core samples ONK-PP274 is towards south (170°/38°) (Figure 3).

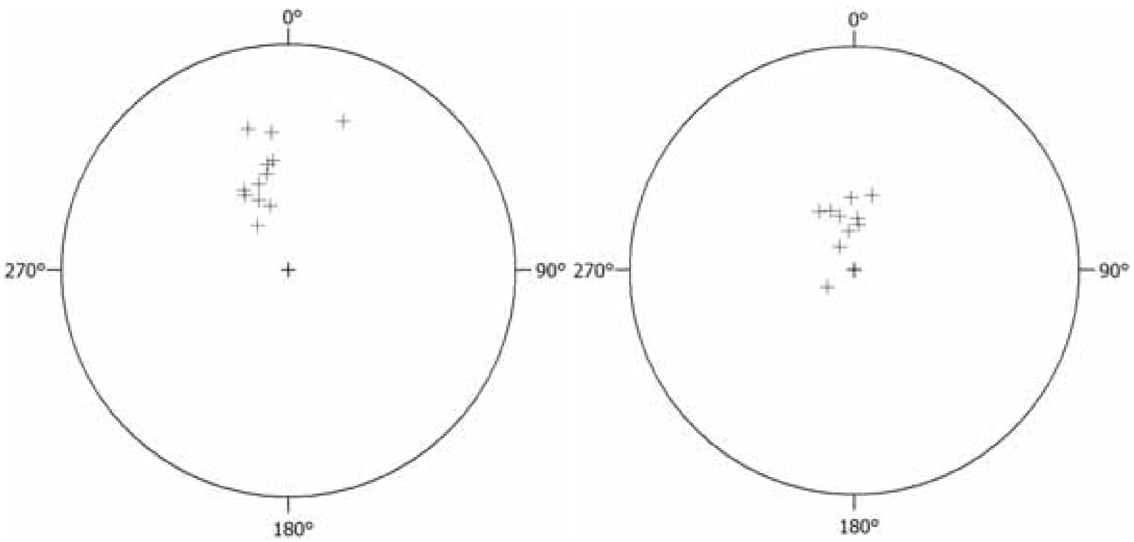

Figure 3. *Measurements of foliations from the drillcores ONK-PP262 (left) and ONK-PP274 (right) on a lower hemisphere equal angle projections.*

3.5 Fracturing

Fractures were numbered sequentially from the beginning to the end of the drillcore (Appendix 8). 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	SK	= Pyrite
SV	= Clay mineral	KA	= Kaolinite
KL	= Chlorite	IL	= Illite
BT	= Biotite	MU	= Muscovite

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.

ONK-PP262

In the fracture logging, 35 separate fractures were recorded from drillcore ONK-PP262 (Appendix 8). There are 20 filled fractures and 15 filled slickensided fractures. Additionally, there is unknown number (probably few) of fractures at the drillhole depth of 3.33 - 5.28 m, where drilling has caused breaking of the core sample in a fragile, possibly microfractured, PGR rock.

The drillcore ONK-PP262 can be divided into three sections, where the properties of fractures clearly differ from each other. The first section is 0.00 - 11.45 m, where high friction fractures with undulated shapes, rough surfaces and low joint alteration fractures dominate. The fractures are filled with thin calcite, kaolinite, chlorite, pyrite and illite filllings. Closed fractures are also common. The second section is at the drillhole depth 11.45 - 17.26 m, where filled slickensided fractures dominate. The fractures are undulated or planar by shape, have smooth or slickensided surfaces and are filled with low friction fillings (illite, kaolinite, chlorite and various clay minerals). The section includes a fractured zone at the drillhole depth of 16.99 - 17.26 m. The third section contains various kinds of fractures, with mainly planar profiles and surfaces ranging from rough to slickensided. The third section include also two closed fractures.

Almost 90 % of the logged fractures were in the oriented core sample sections (31 fractures). There are two strong joint sets, of which one is aligned subparallel to foliation (150°/30°) and the other is of vertical fracturing at direction 265°/90°. There is also a weaker joint set at direction 060°/30°, though the separate fractures in it have quite a variable directions.

ONK-PP274

In the fracture logging of the drillcore ONK-PP274, 34 separate fractures were recorded (Appendix 8). There are 27 filled fractures, eight filled slickensided fractures and one tight fracture. Most of the fractures are undulated or planar by shape, and have rough profile with low to medium joint alteration numbers, indicating high friction fractures. There fractures occur mainly in the upper section of the drillhole (0 - 7.61 m) or the lower section of the drillhole (17.48 - 23.88 m). Fractures in these sections have usually calcite and pyrite fillings with small amounts of illite, kaolinite or other clay minerals. Low friction fractures with planar or undulated profiles and smooth to slickensided surfaces with medium to high surface alteration numbers occur at the drillhole depth section of 7.61 - 17.48 m. They are filled with kaolinite, illite, chlorite, and clay, with some pyrite and calcite.

85 % of the logged fractures were in the oriented core sample sections (29 fractures). There are two strong joint sets, of which one is aligned with foliation (155°/25°) and the other is almost vertical fracturing at direction 280°/85°. There are also some randomly oriented fractures.

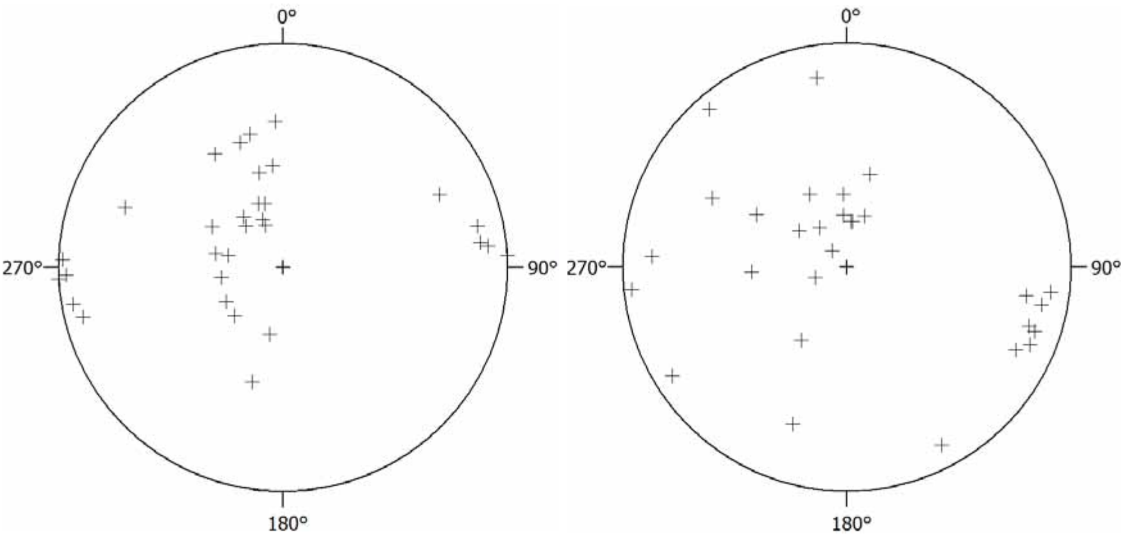

Figure 6. *Measurements of fracture directions from the drillcores ONK-PP262 (left) and ONK-PP274 (right) on a lower hemisphere equal angle projections.*

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 9). 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 frequencies of both drillholes are 1.4 pcs/m. The average RQD values are 97.2 % (ONK-PP262) and 98.6 % (ONK-PP274) (Appendix 9).

3.7 Fractured zones and core loss

Fractured zones were classified according to Finnish engineering geological bedrock classification (Korhonen et al. 1974) (Table 7).

In the drillcore ONK-PP262 there is one short fractured zone (RiIII) at the depth interval 16.99 - 17.26 m with slickensided fracturing in two joint sets (Appendix 10). In the drillcore ONK-PP274 there is no fractured zones.

Significant core loss due to non-cohesive rock was observed in the drillcore ONK-PP262. There is approximately 0.49 m of core loss at depth section 3.33 - 5.28 m due to very fragile and possibly microfractured PGR. This has caused breaking of sample and grinding of sample ends. Core loss due to rock breaking or grinding is mainly insignificant in the drillhole ONK-PP274.

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

Broken rock mass	Zone class	Fractures / m	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 drillcore was classified according to the method developed by Korhonen et al. (1974) and Gardemeister et al. (1976) (Table 8).

The drillcore ONK-PP262 is unweathered (Rp0), having only very weak and mostly local alteration (kaolinitization, epidotization, illitization), or no visible alteration at all. The rock contains shear bands that show weak illitization. (Appendix 11).

The drillcore ONK-PP274 is unweathered, having only local very weak alteration (spotty and stripy kaolinitization) (Appendix 11).

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 ONK-PP262 and ONK-PP274.

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 et al. 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 8). 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 rock quality calculations.

The Q-value is calculated by Equation 1 (Barton et.al. 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 sample of ONK-PP262 was divided to six units of variable lengths, the Q’-values of which were then calculated separately. The results of Q’-classification are presented in Appendix 12. The rock quality (see Table 9) of ONK-PP262 is mainly “good” (12.26 m, 49.3 %) or “fair” (7.25 m, 29.1 %). The fractured zone at 9.79 – 17.27 m (RiIII) is classified as "very poor". At the start of the drillhole there are sections of "extremely good" (0.14 – 3.33 m) and "exceptionally good" (3.33 – 5.28 m) rock. However, the Q'-classification of the depth section 3.33 - 5.28 m is unreliable, as there is core loss which has hidden possible fractures in the section.

The core sample of ONK-PP274 was divided to five units of variable lengths, the Q’-values of which were then calculated separately. The results of Q’-classification are presented in Appendix 12. The rock quality (see Table 9) of ONK-PP274 is mainly “fair” (8.48 m, 35.5 %), “good” (8.13 m, 34.0 %), “extremely good” (7.27 m, 30.5 %).

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 HYDCO-program in ONKALO, Suomen Malmi Oy core drilled two drillholes (ONK-PP262 and ONK-PP274). The lengths of the drillholes are 25.02 m and 23.88 m respectively. The drillholes were drilled from the investigation niche 4 at the access tunnel chainage 3747. The drilling was started from the tunnel wall with casing drilling.

The drill rig was DE 130. The cores were drilled using a NQ3 triple tube core barrel. The drillhole diameter is 75.7 mm and the sample diameter is 50.2 mm. The drilling water was taken from ONKALO pipeline and marked with sodium fluorescein.

The main rock types intersected by the drillhole are veined and veined and diatexitic gneisses and pegmatitic granite. The rock samples are mostly unweathered.

The average fracture frequencies in both drillholes ONK-PP262 and ONK-PP274 are 1.4 pcs/m, and the mean RQD values are 97.2 % and 98.6 %, respectively. In the drillcore ONK-PP262 one fractured zone was intersected.

In the drillcore ONK-PP262 73.8 % and in the drillcore ONK-PP274 66.1 % of the core sample was oriented.

REFERENCES

Barton, N., Lien, R. & Lunde, J. 1974. Engineering classification of rock masses for the design of tunnel support. Rock Mechanics. December 1974. Vol. 6 No. 4. SpringerVerlag. Wien, New York. 189-236 pp.

Gardemeister, R., Johansson, S., Korhonen, P., Patrikainen, P., Tuisku, T. & Vähäsarja, P. 1976. Rakennusgeologisen kallioluokituksen soveltaminen. (The application of Finnish engineering geological bedrock classification, in Finnish). Espoo: Technical Recearch Centre of Finland, Geotechnical laboratory. 38 p. Research note 25.

Grimstad, E. & Barton, N. 1993. Updating of the Q-system for NMT. Proceedings ofSprayed Concrete, 18-21 December 1993. Fagernäs, Norway

Korhonen, K-H., Gardemeister, R., Jääskeläinen, H., Niini, H. & Vähäsarja, P. 1974. Rakennusalan kallioluokitus. (Engineering geological bedrock classification, in Finnish). Espoo: Technical Research Centre of Finland, Geotechnical laboratory. 78 p. Research note 12.

Kärki, A. & Paulamäki, S. 2006. Petrology of Olkiluoto. POSIVA 2006-02. Posiva Oy, Eurajoki.

Mattila, J. 2006. A System of Nomenclature for Rocks in Olkiluoto. Eurajoki, Finland:Posiva Oy. Posiva Working report 2006-32.

Milnes, A. G., Hudson, J., Wikström, L. & Aaltonen, I. 2006. Foliation: Geological Background, Rock Mechanics Significance, and Preliminary Investigations at Olkiluoto. Working Report 2006-03. Posiva Oy, Eurajoki.

Niinimäki, R. 2004. Core drilling of Pilot Hole OL-PH1 at Olkiluoto in Eurajoki 2003-2004. Eurajoki, Finland: Posiva Oy. Posiva Working report 2004-05, 95 p.

Rocscience Inc., Dips (v5.0) Features [WWW-document]. 2003. <http://www.rocscience.com/products/dips/InputData.asp>. (Read 3.2.2009).

HOLE_ID	ONK-PP262	ONK-PP274
NORTHING	6792337.52	6792335.65
EASTING	1525340.87	1525341.79
ELEVATION	-357.00	-357.48
MAX_LENGTH, m	25.02	23.88
AZIMUTH, °	300.0	299.6
DIP, °	-40.0	-38.5
DH_SURVEY_DIP, °	-40.0	-39.6
TUNNEL_CHAINAGE	17.0	17.0
VT1_CHAINAGE	3747	3747
DATE_STARTED	5.5.2010	9.12.2010
DATE_DRILLED	6.5.2010	13.12.2010
SURVEYED_BY	Prismarit Oy	Prismarit Oy
SURVEY_DATE	10.6.2010	
SURVEY_NOTE	Pri-onk 888	after drilling coordinates
PRECOLLAR_DEPTH, m	0.80	0.92
OVERBURDEN, m	0.14 Concrete	0
CASING_TYPE, mm	90/77	90/77
CASING_LENGTH, m	0.96	1.1
Z_OF_CASING	-356.90	-357.37
CASING_ABOVE_GROUND_LEVEL, m	0.16	0.18
NO_OF_CORE_BOXES	6	6
HOLE_DIAMETER, mm	75.7	75.7
SAMPLE_DIAMETER, mm	50.2	50.2
EQUIPMENT	NQ3	NQ3
ORDER	9269-10	9269-10

ONK-PP262

M_FROM m	M_TO m	BOX_NUMBER	REMARKS
0.00	2.63	1	first 0.14 m concrete
2.63	7.36	2	
7.36	12.02	3	
12.02	16.54	4	
16.54	20.40	5	
20.40	25.02	6	

ONK-PP274

M_FROM m	M_TO m	BOX_NUMBER	REMARKS
0.00	4.46	1	
4.46	8.77	2	
8.77	13.44	3	
13.44	17.95	4	
17.95	22.57	5	
22.57	23.88	6	

ONK-PP262

LIFT NR	LIFT DEPTH m	LENGTH m	REMARKS
1	0.91	0.91	first 0.14 m concrete
2	2.63	1.72	
3	5.28	2.65	
4	6.28	1.00	
5	8.93	2.65	
6	12.02	3.09	
7	14.80	2.78	
8	17.88	3.08	
9	20.52	2.64	
10	23.21	2.69	
11	25.02	1.81	

ONK-PP274

LIFT NR	LIFT DEPTH m	LENGTH m	REMARKS
1	0.55	0.55	
2	1.65	1.10	
3	3.95	2.30	
4	5.80	1.85	
5	8.20	2.40	
6	11.20	3.00	
7	14.20	3.00	
8	17.20	3.00	
9	20.22	3.02	
10	23.23	3.01	
11	23.88	0.65	

ONK-PP262

Station Metres	Dip (°)	Azimuth (°)	E	N	Z	Remarks
0	-40.0	300.0	1525340.87	6792337.52	-357.00	
3	-39.9	300.4	1525338.88	6792338.67	-358.93	Azim. interpolated
6	-39.9	300.8	1525336.89	6792339.83	-360.85	
9	-39.9	300.2	1525334.90	6792340.99	-362.78	
12	-39.9	299.9	1525332.91	6792342.15	-364.70	
15	-39.9	299.8	1525330.92	6792343.30	-366.62	
18	-39.9	299.8	1525328.92	6792344.44	-368.55	
21	-39.9	299.6	1525326.93	6792345.59	-370.47	
24	-39.9	299.6	1525324.93	6792346.73	-372.40	
25.02	-39.9	299.6	1525324.25	6792347.11	-373.05	Extrapolated

ONK-PP274

Station Metres	Dip (°)	Azimuth (°)	E	N	Z	Remarks
0	-39.6	299.6	1525341.79	6792335.65	-357.48	
3	-39.8	300.4	1525339.79	6792336.80	-359.40	Azim. interpolated
6	-40.0	301.0	1525337.81	6792337.97	-361.32	
9	-39.9	300.7	1525335.83	6792339.14	-363.25	
12	-39.8	300.5	1525333.84	6792340.31	-365.17	
15	-39.7	300.5	1525331.85	6792341.48	-367.09	
18	-39.9	300.1	1525329.87	6792342.64	-369.01	
21	-39.9	300.3	1525327.88	6792343.81	-370.93	
23.88	-39.9	300.2	1525325.97	6792344.92	-372.78	

ONK-PP262

MARK_NR	MARK_DEPTH m	M_FROM m	M_TO m	LENGTH m	REMARKS
1	2.63				no mark
2	6.28	5.28			-20, EM OB, corrected by VTOR
3	12.02				Base mark, EM OB
4	17.88				0, EM OB
5	23.21		23.65	18.37	-15, EM OB

ONK-PP274

MARK_NR	MARK_DEPTH m	M_FROM m	M_TO m	LENGTH m	REMARKS
1	8.20	5.80			Base mark, SN
2	11.20		17.20	11.40	+10, SN
3	17.20	17.20	17.35	0.15	Base mark, SN
4	23.23	19.65	23.88	4.23	Base mark, SN

ONK-PP262

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
0.00	0.14	CONCRETE		
0.14	7.96	PGR		Coarse grained light grey PGR with netlike shear bands appearing with dark mica and garnet. Shear bands are illitized locally.
7.96	13.47	VGN	15	Homogenic moderately banded VGN with sillimanite, cordierite in leucosome. Melanosome has almost gneissic foliation. Unaltered/unweathered.
13.47	14.72	PGR		Coarse grained PGR with garnet. Lots of shear bands, especially at upper contact to VGN. Weak epidotization and illitization.
14.72	23.05	VGN	25	Starts with irregularly foliated VGN with few longer PGR sections (15.36 - 15.73 m, 16.45 - 17.20 m) untill at 17.20 m continues with weakly to moderately banded more homogenic VGN. Thicker PGR veins are with reddish hue and weak to moderate illitization. In the lower VGN there is only weak spotty kaolinitization.
23.05	24.37	PGR		Coarse grained PGR with light red hue. Illitized shear bands.
24.37	25.02	VGN	10	Short section of moderately banded homogenic VGN with sillimanite, cordierite in leucosome. Locally weak spotty illitization. At 22.53 m black tourmaline in PGR leucosome.

ONK-PP274

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
0.00	7.40	PGR		Pale coloured K-feldspar rich coarse grained PGR. Locally garnet and cordierite. Graphic intergrowth of quartz and K-feldspar at places. Weak shear bands, which are locally weakly illitized.
7.40	13.60	VGN	20	Moderately banded (near to gneissic) medium grained VGN with sillimanite. Small amounts of cordierite in leucosome. Locally very weak spotty kaolinitization.
13.60	15.00	DGN	80	Irregular/massive DGN that is close to being TGG. Shadow-like gneissic mica stripes. Cordierite-quartz-patches.
15.00	16.72	VGN	30	Irregular/weakly banded VGN with sillimanite. Cordierite in leucosome. Very weak spotty kaolinitization locally.
16.72	17.35	PGR		Short section of medium-coarse grained PGR with light red colored K-feldspar. Weak illitization. Cordierite at bottom end of the section.
17.35	18.00	QGN	1	Short section of fine grained moderately gneissic grey QGN. Unweathered.
18.00	19.36	PGR		Medium-coarse grained PGR with light red colored K-feldspar. Locally garnet and cordierite. Some mica rich gneiss stripes at centre of the section.
19.36	23.88	VGN	10	Moderately banded (near to gneissic) medium grained VGN with sillimanite. The first 0.5 m of the section is fine-medium grained QGN/MGN with some garnets. Small amounts of cordierite in leucosome. Locally very weak spotty kaolinitization. Chloritization around some fractures.

ONK-PP262

M_FROM m	M_TO m	DEPTH_M m	DIP_DIR (°)	DIP (°)	ALPHA (°)	BETA (°)	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE
0.14	1.00						MAS	0	PGR
1.00	2.00						MAS	0	PGR
2.00	3.00						MAS	0	PGR
3.00	4.00						MAS	0	PGR
4.00	5.00						MAS	0	PGR
5.00	6.00						MAS	0	PGR
6.00	7.00						MAS	0	PGR
7.00	8.00						MAS	0	PGR
8.00	9.00	8.8	151	44	67	115	BAN	2	VGN
9.00	10.00	9.31	161	44	60	115	BAN	2	VGN
10.00	11.00	10.33	145	27	63	155	BAN	2	VGN
11.00	12.00	11.52	157	37	62	130	BAN	2	VGN
12.00	13.00	12.7	164	33	57	135	BAN	2	VGN
13.00	14.00						MAS	0	PGR
14.00	15.00						MAS	0	PGR
15.00	16.00	15.15	150	42	67	120	BAN	1	VGN
16.00	17.00						IRR	0	VGN
17.00	18.00	17.78	173	63	45	90	BAN	1	VGN
18.00	19.00	18.45	169	51	53	105	BAN	2	VGN
19.00	20.00	19.7	167	47	55	110	BAN	2	VGN
20.00	21.00	20.35	200	70	20	100	BAN	2	VGN
21.00	22.00	21.6	164	66	50	80	BAN	2	VGN
22.00	23.00	22.34	172	52	50	105	BAN	2	VGN
23.00	24.00						MAS	0	PGR
24.00	25.02						MAS	0	PGR

ONK-PP274

M_FROM m	M_TO m	DEPTH_M m	DIP_DIR (°)	DIP (°)	ALPHA (°)	BETA (°)	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE
0.00	1.00						MAS	0	PGR
1.00	2.00						MAS	0	PGR
2.00	3.00						MAS	0	PGR
3.00	4.00						MAS	0	PGR
4.00	5.00						MAS	0	PGR
5.00	6.00						MAS	0	PGR
6.00	7.00						MAS	0	PGR
7.00	8.00						MAS	0	PGR
8.00	9.00	8.50	59	16	46	200	BAN	2	VGN
9.00	10.00	9.48	149	34	65	140	BAN	1	VGN
10.00	11.00	10.36	165	28	55	145	BAN	2	VGN
11.00	12.00	11.80	149	34	65	140	BAN	2	VGN
12.00	13.00	12.57	183	26	47	145	BAN	2	VGN
13.00	14.00	13.40	158	32	60	140	SCH	2	VGN
14.00	15.00						IRR	0	DGN
15.00	16.00	15.80	185	23	46	150	BAN	2	VGN
16.00	17.00	16.57	177	36	50	130	BAN	2	VGN
17.00	18.00						MAS	0	PGR
18.00	19.00						MAS	0	PGR
19.00	20.00	19.80	193	38	40	130	GNE	2	VGN
20.00	21.00						IRR	0	VGN
21.00	22.00	21.70	193	38	40	130	BAN	1	VGN
22.00	23.00	22.60	172	20	50	155	BAN	2	VGN
23.00	23.88	23.73	147	14	52	170	BAN	2	VGN

FRACTURE	M_FROM	M_TO	CORE_ALPHA (°)	CORE_BETA (°)	CORE_GAMMA (°)	CORE_DIR (°)	CORE_DIP (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF T FILLING (mm)	YPE	Jr Profile	Ja 4	CLASS_OF_THE FRACTURED_ZONE	REMARKS
1	2.47		60					green	IL, MU	0.1	fi	uro	2		
2	8.00		56	155		157	23	black, greenish yellow	KL, IL	0.3	fisl	usl	4		
3	9.80		38	305		80	87	black, light grey, light brown	KL, CC, SK	0.8	fi	psm	4		
4	10.31		11	235		15	56	white	KA, CC	0.7	fi	uro	0.75		closed
5	10.34		37	300		76	85	green	KL, CC	0.2	fi	uro	0.75		closed
6	10.69		34	315		264	85	light grey, light brown	CC, SK	0.2	fi	pro	2		
7	11.45		29	310		258	83	green	KL, CC	0.2	fi	uro	0.75		closed
8	12.51		56	110		166	47	black, light grey	BT, KL, IL	0.1	fi	usm	3		
9	12.70		57	135		164	33	black, white, greenish yellow	KL, IL, SV	0.3	fisl	psl	4		
10	13.15		58	150		157	26	black, white, greenish yellow	KL, IL, SV	0.3	fisl	psl	4		
11	13.22		32	315		263	83	light grey, light brown	SV, SK	0.2	fi	pro	2		
12	14.71		80	180		120	40	black, white, greenish yellow	KL, IL, SV	0.3	fisl	usl	4		
13	14.74		60	135		159	34	black, white	KL, SV	0.2	fi	usm	4		
14	15.27		56	155		157	23	black, white, greenish yellow	KL, IL, SV	0.3	fi	usm	4		
15	15.34		65	160		138	28	black, white, greenish yellow	KL, IL, SV	0.3	fisl	usl	4		
16	16.49		65	200		102	28	greenish yellow, white	IL, SV	0.3	fi	pro	4		
17	16.54		70	210		102	34	black, greenish yellow	KL, IL	0.2	fisl	usl	4		
18	16.99		48	225	180	59	33	black, greenish yellow, white	IL, KA, KL	0.3	fisl	usl	4	RiIII	
19	17.05		50	85	70	166	63	black, greenish yellow, white	IL, KA, KL	0.3	fisl	usl	4	RiIII	
20	17.07		59	220	30	81	31	black, greenish yellow, white	IL, KA, KL	1	fisl	usl	4	RiIII	
21	17.16		55	85		161	61	black, greenish yellow, white	IL, KA, KL	0.4	fisl	usl	4	RiIII	splitted
22	17.18		64	75		149	61	black, greenish yellow	KL, IL	0.2	fisl	usl	4	RiIII	
23	17.21		65	340	70	111	74	black, greenish yellow, white	IL, KA, KL	1	fisl	usl	4	RiIII	
24	17.26		40	90	160	177	66	black, greenish yellow, white	IL, KA, KL, SK	0.5	fisl	psl	4	RiIII	
25	17.52		23	215		11	34	light grey, light brown, white	CC, SK, KA	0.6	fi	uro	2		
26	18.26		15	305		245	75	light grey	CC	0.2	fi	uro	0.75		closed
27	20.04		40	315		267	90	black, white	KL, KA	0.3	fi	psm	3		
28	20.19		43	320		92	89	light grey	CC	0.2	fi	pro	2		
29	20.52		40	225		45	34	light grey	CC	0.1	fi	pro	2		
30	22.32		50	110		174	49	black	KL	0.1	fi	psm	3		
31	22.88		42	315		88	88	green	KL	0.1	fi	uro	0.75		closed
32	22.97		67	150		142	32	black	BT, KL	0.1	fi	pro	3		
33	24.38		90					black, white	KL, KA	0.2	fi	usm	3		
34	24.52		48		40			black, greenish yellow, light brow	KL, IL, SK	0.3	fisl	usl	4		
35	24.59		55		120			black, greenish yellow	kl, IL, SV	0.4	fisl	psl	4		

FRACTURE	M_FROM	M_TO	CORE_ALPHA (°)	CORE_BETA (°)	CORE_GAMMA (°)	CORE_DIR (°)	CORE_DIP (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF T FILLING (mm)	YPE	Jr Profile	Ja 3	CLASS_OF_THE FRACTURED_ZONE	REMARKS
1	4.46		50								ti	pro	1		microfracture in PGR
2	7.28		35	40		332	84	white	KA	0.1	fi	uro	2		
3	7.61		50	175	100	138	11	light grey, black	IL, KL	0.3	fisl	usl	4		
4	7.67		70	170	110	127	30	white, light grey, black	KA, IL, KL	0.3	fisl	usl	4		
5	8.30		65	250	40	87	46	white, light grey, black	KA, IL, KL	0.8	fisl	usl	4		
6	8.77		40	335	50	281	83	black, light grey	IL, KL	0.3	fisl	psl	4		
7	9.38		50	30		139	86	light grey	SV	0.1	fi	pro	2		
8	10.80		3	250		19	73	white, light grey	CC, SV	1	fi	uro	3		
9	11.33		35	335		279	78	black, light grey, light brown	KL, CC, SK	0.6	fi	psm	4		
10	12.70		42	345		289	83	black		0.3	fi	pro	0.75		closed
11	13.36		50	145	120	176	26	light grey, black	IL, KL	0.3	fisl	usl	4		
12	13.44		65	125		153	40	light grey, black	IL, KL, BT	0.2	fi	usm	3		
13	13.56		72	350		117	68	black	KL	0.1	fi	uro	3		
14	13.80		35	70		171	81	light grey	CC	0.1	fi	uro	0.75		closed
15	14.62		40	345		288	81	white, light brown	KA, SK	0.1	fi	uro	2		
16	15.76		90			120	50	greenish grey	IL	0.4	fi	uro	4		
17	15.80		46	150		185	23	greenish grey, white, black	IL, KA, KL, SV	0.5	fisl	psl	4		
18	16.43		60	160		145	24	light grey, black	CC, KL	0.2	fi	usm	4		
19	16.56		50	130		177	36	black	BT	0.1	fi	pro	3		
20	16.70		37	120		194	46	white, black	KA, KL	0.2	fi	uro	3		
21	16.74		50	200		72	17	greenish yellow	IL, KA	0.1	fi	uro	2		
22	16.79		30	230		32	42	greenish yellow	IL, KA	0.1	fi	pro	2		
23	17.35		70					black, greenish yellow	KL, IL	0.3	fisl	usl	4		
24	17.48		60					black, greenish yellow	KL, IL	0.3	fisl	usl	4		
25	17.95		50					greenish grey	CC, SV	0.2	fi	uro	2		
26	19.32		40					light grey, light brown	CC, SK	0.1	fi	uro	1		
27	19.73		25	285		58	85	light grey	CC	0.2	fi	pro	2		
28	19.94		50	315		93	82	greenish grey	CC, SV	0.2	fi	pro	2		
29	21.49		45	150		187	23	black, white	KL, KA	0.2	fi	pro	3		
30	21.50		40	330		277	85	greenish yellow, black	IL, KL	0.2	fi	psm	3		
31	22.12		40	355		296	80	black, grey	KL, SV, CC	0.1	fi	pro	2		
32	22.17		42	350		293	83	light grey	CC	0.1	fi	pro	0.75		closed
33	23.12		40	145		199	27	black	BT, KL	0.1	fi	usm	2		
34	23.86		40	310		84	88	greenish yellow	IL	0.3	fi	uro	3		partly closed

ONK-PP262

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
0.14	1.00	8	0	8	100	RQD 0.86m/0.86m
1.00	2.00	1	0	1	100	
2.00	3.00	3	1	2	100	
3.00	4.00	6	0	6	100	4 m point arbitrary because of core loss
4.00	5.00	8	0	8	100	5 m point arbitrary because of core loss
5.00	6.00	5	0	5	100	
6.00	7.00	4	0	4	100	
7.00	8.00	1	0	1	100	
8.00	9.00	3	1	2	100	
9.00	10.00	2	1	1	100	
10.00	11.00	4	3	1	97	2 closed fractures
11.00	12.00	2	1	1	100	1 closed fracture
12.00	13.00	3	2	1	100	
13.00	14.00	3	2	1	93	
14.00	15.00	2	2	0	97	
15.00	16.00	3	2	1	93	
16.00	17.00	3	3	0	94	
17.00	18.00	9	7	2	74	
18.00	19.00	3	1	2	100	1 closed fracture
19.00	20.00	2	0	2	100	
20.00	21.00	4	3	1	100	
21.00	22.00	1	0	1	100	
22.00	23.00	4	3	1	91	1 closed fracture
23.00	24.00	2	0	2	100	
24.00	25.00	5	3	2	93	
25.00	25.02	0	0	0	100	RQD 0.02m/0.02m

ONK-PP274

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
0.00	1.00	7	0	7	100	
1.00	2.00	4	0	4	100	
2.00	3.00	3	0	3	100	
3.00	4.00	6	0	6	100	
4.00	5.00	1	1	0	100	
5.00	6.00	3	0	3	100	
6.00	7.00	2	0	2	100	
7.00	8.00	6	3	3	94	
8.00	9.00	2	2	0	100	
9.00	10.00	2	1	1	100	
10.00	11.00	3	1	2	100	
11.00	12.00	3	1	2	100	
12.00	13.00	1	1	1	100	1 closed fracture
13.00	14.00	4	4	0	92	1 closed fracture
14.00	15.00	4	1	3	100	
15.00	16.00	5	2	3	96	
16.00	17.00	9	5	4	91	
17.00	18.00	5	3	2	100	
18.00	19.00	2	0	2	100	
19.00	20.00	6	3	3	100	
20.00	21.00	1	0	1	100	
21.00	22.00	4	2	2	99	
22.00	23.00	4	2	3	95	1 closed fracture
23.00	23.88	3	2	1	100	RQD 0.88m/0.88m

ONK-PP262

M_FROM m	M_TO m	CLASS_OF_THE FRACTURED_ZONE	DESCRIPTION OF_ZONE	CORE LOSS m	Remarks
3.33	5.28			0.49	Core loss by breaking and shearing of sample in fragile PGR.
16.99	17.26	RiIII	Short fractured zone with slickensided fractures (KL, IL, SV) in two joint sets.		

ONK-PP262

M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
0.14	25.02	Rp0	Locally weak illitization, epidotization or spotty kaolinitization. Mainly unweathered/unaltered.

ONK-PP274

M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
0.00	23.88	Rp0	Locally very weak spotty/stripy kaolinitization. Mostly unweathered/unaltered.

ONK-PP262

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´
0.15	3.33	3.18	318	1	100	100	1	URO	3.0	2.00	Extremely Good				150.0
3.33	5.28	1.95	195	0	100	100	1		5.0	0.75	Exceptionally Good		0.49	The section is sheared and crushed by drilling, possibly includes few fractures. Q' class unreliable.	666.7
5.28	9.79	4.51	451	1	100	100	1	USL	1.5	4.00	Good				37.5
9.79	17.04	7.25	695	16	96	96	6	URO	1.5	4.00	Fair				6.0
17.04	17.27	0.23	1	6	4	10	4	USL	1.5	4.00	Very Poor	RiIII			0.9
17.27	25.02	7.75	759	11	98	98	4	PSL	1.5	3.00	Good				12.2

ONK-PP274

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´
0.00	7.27	7.27	727	1	100	100	1	PRO	1.5	1.0	Extremely Good				150.0
7.27	15.75	8.48	834	14	98	98	9	USL	1.5	3.0	Fair				5.5
15.75	17.49	1.74	161	9	93	93	3	URO	1.5	4.0	Good				11.6
17.49	21.48	3.99	399	4	100	100	4	PRO	2.3	2.0	Good				28.1
21.48	23.88	2.40	235	6	98	98	4	PRO	1.5	2.5	Good				14.7


ONK-PP262 1-1
ONK-PP262 1-2
5.28


ONK-PP262 1-3
ONK-PP262 1-4
480


ONK-PP274 L-1
0.55
1.65
ONK-PP274 L-2
580
820


ONK-PP274 L-3
1120
SU→
ONK-PP274 L-4
1420
1730
SU→