Working Report 2012-22

Installation of Groundwater Observation Tubes OL-PVP36–38 and Drilling of Shallow Drillholes OL-PP70–71 at Olkiluoto in Eurajoki 2011

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ABSTRACT

In order to widen the groundwater monitoring network at Olkiluoto, Posiva Oy contracted Suomen Malmi Oy (Smoy) to install new groundwater observation tubes to three locations and to drill two shallow drillholes with standpipes. The identification numbers of the groundwater observation tubes are OL-PVP36, OL-PVP37A, 37B, 37C, OL-PVP38A, 38B, 38C and 38D, and the shallow drillholes are named OL-PP70 and OL-PP71. The observation tubes were installed and the shallow holes drilled between September 22nd and October 12th in 2011.

The drilling rig used in the installation work was a GM-200 rig. Drilling equipment consisted of casing tubes (ø 90/77 mm) with drilling bit, 55 mm geo rods and 64 mm drilling bits and T76-equipment for drilling the shallow holes. Monitoring pipes (PVC, ø 60/52 mm) were lowered into the holes inside the casings. The monitoring pipes consist of a lower section of riser pipe, a middle section of screen pipe and an upper section of riser pipe. The screen pipe slot size is 0.3 mm and the length of the screen section is two metres. Protective stainless steel covers with lock-up caps were installed around the monitoring tubes and the shallow drillholes.

In addition to the installation of the tubes, the work included water level measurements after installation. The core samples of the shallow drillholes 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.

Keywords: Groundwater, observation tube, core drilling, drillhole, Olkiluoto.

POHJAVESIPUTKIEN OL-PVP36 – 38 ASENTAMINEN JA MATALIEN REIKIEN OL-PP70 – 71 KAIRAUS EURAJOEN OLKILUODOSSA 2011

TIIVISTELMÄ

Olkiluodon pohjavedentarkkailuverkon laajentamiseen liittyen Suomen Malmi Oy (Smoy) asensi Posiva Oy:n tilauksesta uusia pohjavesihavaintoputkia kolmelle paikalle sekä kairasi kaksi matalaa kallionäytereikää. Putket ovat tunnuksiltaan OL-PVP36, OL-PVP37A, 37B, 37C, OL-PVP38A, 38B, 38C ja 38D. Matalat kairareiät ovat tunnuksiltaan OL-PP70 ja OL-PP71. Työ tehtiin 22.9. ja 12.10.2011 välisenä aikana.

Asennusreikien kairauksessa käytettiin GM-200 kairakonetta. Kairausvälineistönä olivat ø 90/77 mm maaputket terineen sekä ø 55 mm geotangot ø 64 mm terillä, sekä T76 -kairauskalusto matalilla kairarei'illä. Pohjavesiputket (PVC, ø 60/52 mm) laskettiin reikiin maaputkien sisällä. Pohjavesiputket koostuvat ylemmästä umpiputkesta, keskellä olevasta siiviläputkesta sekä alemmasta umpiputkesta. Siiviläputkien reikäkoko on 0,3 mm ja siiviläosuuden pituus kaksi metriä. Havaintoputkien ja matalien kairareikien suojaksi asennettiin teräksiset suojaputket varustettuina lukittavilla hatuilla.

Havaintoputkien asentamisen lisäksi työhön sisältyi asennuksen jälkeinen pohjavedenpinnan tarkkailu. Matalista rei'istä kairatuille kallionäytteille tehtiin geologinen kartoitus ja raportointi, joka sisälsi mm. kivilajit, suuntautuneisuuden, rakoparametrit, rakotiheyden ja RQD:n, rikkonaisuusvyöhykkeet, muuttuneisuuden, näytehukan ja kivilaadun.

Avainsanat: Pohjavesi, havaintoputki, kairaus, kairareikä, Olkiluoto.

TABLE OF CONTENTS

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 of 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 makes it possible to concentrate the research activities at Olkiluoto in Eurajoki. One part of the research is to build an underground rock characterisation facility (called “ONKALO”). ONKALO will be used to obtain information for planning the repository and to assess the safety and constructing engineering solutions. ONKALO will also enable the final disposal technology to be tested under actual conditions. Construction of the access tunnel ONKALO started in 2004.

ONKALO is an important part of the site investigations today and during next years. The construction of ONKALO will inevitably affect the rock mass and the groundwater flow system. It will also affect the chemical environment both on the surface and at depth. In order to determine the magnitude and extent of such effects, a monitoring program was established in 2003.

In order to widen the groundwater monitoring network at Olkiluoto, Posiva Oy contracted (order numbers 9464-11 and 9628-11) Suomen Malmi Oy (Smoy) to drill two shallow drillholes and to install new groundwater observation tubes in three locations. The identification numbers of the shallow drillholes are OL-PP70 (20.05 m) and OL-PP71 (21.02 m) and the groundwater observation tubes are OL-PVP36, OL-PVP37A, 37B, 37C, OL-PVP38A, 38B, 38C and 38D. Due to greater than expected overburden thicknesses, several observation tubes were installed at locations OL-PVP37 and OL-PVP38.

1.2 Scope of the work

The aim of the work was to drill two shallow drillholes (OL-PP70 and OL-PP71) for bedrock groundwater observations and to install eight soil groundwater observation tubes (OL-PVP36, OL-PVP37A, 37B, 37C, OL-PVP38A, 38B, 38C and 38D) (Figure 1). The observation tubes and drillholes allow groundwater level measurements, hydraulic conductivity measurements and hydrogeochemical sampling. In addition to the installation of the tubes, the work included geological logging of the core samples OL-PP70 and OL-PP71 and also reporting. This report documents the work done during drilling the holes, the installation of the groundwater observation tubes and geological core logging of the shallow drillholes. Geological logging and compilation of the final report was done by geologist Vesa Toropainen.

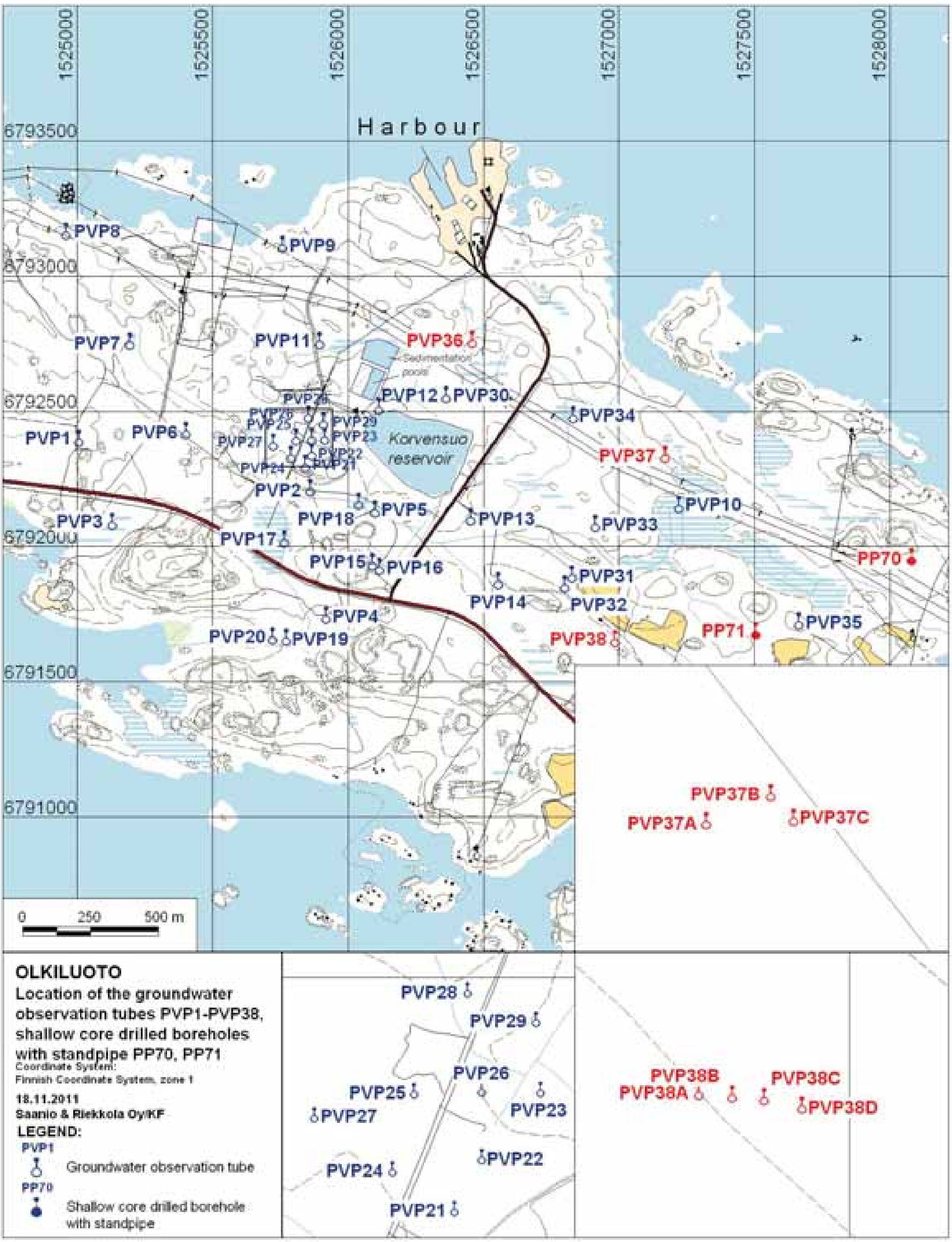

Figure 1. *The locations of the groundwater observation tubes at Olkiluoto, the new tubes and the new shallow drillholes are marked with red colour.*

2 GROUNDWATER TUBE INSTALLATION WORK

2.1 Schedule of the installation work

Drilling and installation work started on the 22nd of September 2011 at OL-PVP38A. On the 12th of October in 2011 work was finished at drillhole OL-PVP36 and drill rig was prepared ready for move. The installation schedule of the groundwater observation tubes is presented in Table 1. The shallow drillholes OL-PP70 and OL-PP71 were drilled in between the OL-PVP38D and OL-PVP37A (See chapters 3, 4 and 5).

Table 1. *Schedule of installation of the groundwater observation tubes.*

GW observation tube	Installation date
OL-PVP36	12.10.2011
OL-PVP37A	10.10.2011
OL-PVP37B	11.10.2011
OL-PVP37C	12.10.2011
OL-PVP38A	22.9.2011
OL-PVP38B	23.9.2011
OL-PVP38C	27.9.2011
OL-PVP38D	28.9.2011

2.2 Description of the installation work

The drilling rig used in the installation work was a GM-200 rig on rubber tracks. The drilling team in one shift consisted of a driller and an assistant.

The drilling started by penetrating the overburden with a casing tube (ø 90/77 mm) and drilling it (ø 105/77 mm bit size) into the bedrock. The hole was then further percussion drilled with 55 mm geo rods (ø 64 mm bit size) through the casing by drilling it to ~ 1.5 – 2.5 m depth in bedrock to ensure that bedrock was reached. The casing and the drillhole were flushed.

The monitoring pipe (PVC, ø 60/52 mm) with a bottom plug was lowered into the hole inside the casing. The monitoring pipe consists of a lower section of riser pipe, a middle section of screen pipe (a sieve section) and an upper section of riser pipe. The screen pipe slot size is 0.3 mm and the length of the screen section is one or two metres. To protect the screen pipe, the screen section is covered with filter gauze (PEH 63) that starts from the bottom of the monitoring pipe and ends approximately 0.5 metres above the screen pipe. The upper end of the protecting gauze is locked with a cable tie.

After lowering the monitoring pipe, the casing tube was lifted slowly from the hole, and filter sand (grain size 1 – 2 mm) was poured in between the monitoring pipe and the casing tube to fill the empty space between soil and the monitoring pipe. The upper surface of the filter sand reaches ~0.2 m above the top of the screen pipe.

The monitoring pipe was cut approximately 0.8 metre from the ground surface. A protective stainless steel cover was installed around the monitoring tube. The well cover is equipped with a lock-up cap. The surface water flow to the monitoring tube was prevented by sealing the cover with natural clay. The groundwater level was measured after installing the pipes.

Parallel observation tubes were installed when the thickness of overburden allowed several screen tube levels. Location OL-PVP37 has three tubes and location OL-PVP38 has four. Their screen levels are shown in Table 2. The technical details of the groundwater observation tubes and measurements of groundwater level are presented in the installation cards, Appendix 1.

Table 2. *Details of the groundwater observation tubes*

Observation tube ID	Length of the drillhole, m	Depth of the bottom end of the screen pipe, m	Depth of the top end of the screen pipe, m	Thickness of overburden, m	Length of the pipe above ground level, m
OL-PVP36	5.5	2.8	0.8	2.8	0.75
OL-PVP37A	12.0	10.0	8.0	10.0	0.75
OL-PVP37B	10.0	5.8	3.8	9.0	0.75
OL-PVP37C	9.5	2.8	0.8	8.5	0.75
OL-PVP38A	14.8	12.8	10.8	12.8	0.75
OL-PVP38B	13.7	9.7	7.7	11.7	0.70
OL-PVP38C	12.7	6.7	4.7	10.7	0.60
OL-PVP38D	11.3	3.3	1.3	9.3	0.80

2.3 Drilling water and the use of label agent

The water for drilling the installation holes and flushing was driven to the drilling locations in a tank. All drilling water was marked with the label agent sodium fluorescein. The sodium fluorescein solution was delivered by Posiva. At the TVO Olkiluoto laboratory, the sodium fluorescein was dissolved in water in 5 litre bottles. The sodium fluorescein is an organic powdery pigment, which is dispersed by UV radiation. Therefore, the label agent mixing bottles were covered. At the drilling site, dose of 10 ml of solution was taken with syringe and mixed for each cubic metre of water (the planned concentration is 250 µg/l). The pre-mixed solution was slowly added into the mixing tank at the beginning of pumping. Turbulence caused by pumping water into the tank ensured proper mixing of the label agent.

2.4 Locations of the groundwater observation tubes

The groundwater observation tubes were installed at three locations (Figure 1, Table 3). At two of the locations (37 and 38) three to four separate tubes were installed near each other in a way that the sieve sections (or screen sections) are at different depths in the overburden. The total number of the installed observation tubes is eight. Location surveys were conducted 24.10.2011 by Prismarit Oy. The ground level was calculated from the top of the plastic observation tube.

Table 3. *Surveyed coordinates of the groundwater observation tubes.*

Observation tube ID	**X**	**Y**	**Z top of PVC tube**	**Z ground level**
OL-PVP36	6792765.89	1526458.15	5.34	4.59
OL-PVP37A	6792341.37	1527169.39	3.17	2.42
OL-PVP37B	6792344.08	1527175.66	3.39	2.64
OL-PVP37C	6792341.69	1527177.91	3.39	2.64
OL-PVP38A	6791660.00	1526985.33	7.41	6.66
OL-PVP38B	6791659.73	1526988.58	7.39	6.69
OL-PVP38C	6791659.48	1526991.66	7.27	6.67
OL-PVP38D	6791658.67	1526995.34	7.48	6.68

3 DRILLING OF SHALLOW DRILLHOLES OL-PP70 AND OL-PP71

3.1 Schedule of the drilling work

The drilling of the shallow drillholes took place between two sessions of groundwater tube installations. The drilling of OL-PP71 was started on the 30th of September and the drillhole was finished on the 3rd of October 2011. The drilling of OL-PP70 was started on the 4th, and finished on the 6th of October 2011.

3.2 Description of the drilling work

The drilling rig used in the work was a GM-200 rig on rubber tracks. The drilling team in one shift consisted of a driller and an assistant.

The drilling started by penetrating the overburden with a stainless steel casing tube (ø 90/77 mm) and drilling it (ø 90 mm bit size) into the bedrock. The holes were then further drilled with T76 equipment to the final drillhole depths. The stainless steel casing tubes were cut to approximately one metre length above ground surface and equipped with lock-up caps. Drillhole nominal diameter with NQ-core barrel is 76 mm and drill core diameter is 62.0 mm. Technical information of the drillholes is presented in Appendix 2.

The drill core samples were placed in wooden core boxes immediately after emptying the core barrel. In all, six core boxes were used for OL-PP70 and six core boxes for OL-PP71. Start and end depths of the core in each core box are presented in Appendix 3. Wooden blocks separating the different lifts were placed to the core boxes to show the depth of each lift. The core drillings included 13 lifts for OL-PP70 and 14 lifts for OL-PP71. The depths of the lifts are presented in Appendix 4.

3.3 Drilling water and the use of label agent

The water for drilling the holes and flushing was taken from ONKALO freshwater pipeline via a hose. The sodium fluorescein solution was delivered by Posiva. At the TVO Olkiluoto laboratory, the sodium fluorescein was dissolved in water in 5 litre bottles. The sodium fluorescein is an organic powdery pigment, which is dispersed by UV radiation. Therefore, the label agent mixing bottles were covered. At the drilling site, dose of 10 ml of solution was taken with syringe and mixed for each cubic metre of water (the planned concentration is 250 µg/l). The pre-mixed solution was slowly added into the mixing tank at the beginning of pumping. Turbulence caused by pumping water into the tank ensured proper mixing of the label agent.

3.4 Locations of the drillholes

Location surveys were conducted 24.10.2011 by Prismarit Oy (Table 4, Figure 1). The ground level was calculated from the top of the plastic observation tube.

Table 4. *Surveyed coordinates of the groundwater observation tubes.*

Drillhole	X	Y	Z top of casing tube	Z ground level
OL-PP70	6791961.99	1528079.87	5.19	4.20
OL-PP71	6791688.11	1527504.18	6.72	5.67

4 GEOLOGICAL LOGGING

4.1 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. 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, the lifts and the core box numbers were documented.

All core boxes (Appendix 3) were digitally colour photographed, both dry and wet. The core photographs (wet) are presented at the end of the report.

The lift depths (Appendix 4) 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.

4.2 Core orientation

Core orientation was not carried out in vertical drillholes.

4.3 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).

OL-PP70

The upper part of the OL-PP70 drillcore consists of diatexitic gneiss (9.53 m, 52.7 %) and the lower part of the drillcore is veined gneiss (7.86 m, 44.3 %). There is a short vein of coarse grained pegmatitic granite inside veined gneiss at the depth of 16.66 - 17.02 m which is logged as its own lithological unit (Appendix 5). The diatexitic gneiss is mainly weakly banded or irregular by foliation with leucosome content of 50 - 60 %. There is locally weakly boudinaged structure. The veined gneiss is weakly to moderately banded and contains 20 - 30 % of leucosome. In the migmatitic gneisses sulphides and graphite occur locally.

OL-PP71

The upper part of the OL-PP71 drillcore consists mainly of tonalitic-granodioritic-granitic gneiss (13.59 m, 64.7 %) and the lower part of the drillcore is pegmatitic granite (7.43 m, 35.3 %) (Appendix 5). The TGG is medium grained with massive to weakly gneissic foliation and contains small amount (5 - 10 %) of thin leucosome veins. It is composed of feldspar, amphibole, mica and quartz. The classification of the rock type may be somewhat controversial, as the rock is not "typical" TGG. The pegmatitic granite is massive, coarse grained and with a light reddish colour in K-feldspar. It is composed mainly of K-feldspar and quartz, but also includes minor plagioclase, biotite, apatite and pyrite. At the depth of 19.74 - 20.40 m the rock is composed mainly of biotite.

4.4 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 foliation was defined for every full metre. Measurements of foliation (Appendix 6) were carried out in one metre intervals from the core sample, if possible. Only alpha-angles was measured, as the sample was not oriented.

From the core sample OL-PP70 eight measurements were made. The alpha angle varied between 30 and 45 degrees, which gives 45 - 60 degrees dip angle.

From the core sample OL-PP71 no measurements were made, as the foliation was too weak (weakly gneissic to massive) to be measured with good accuracy.

4.5 Fracturing

Fractures were numbered sequentially from the beginning to the end of the drillcore (Appendix 7). 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 5).

Fractures with a filling 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 6). 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 7) and the alteration with the joint alteration number, J_a (Table 8). The fracture shape and roughness of fracture surfaces were classified using a modification of Barton's Q-classification (Barton et al. 1974) (Table 9).

Table 5. *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 6. *Fracture filling mineral abbreviations.*

Abbreviation	Mineral	Abbreviation	Mineral
CC	= Calcite	SK	= Pyrite
SV	= Clay mineral	KA	= Kaolinite
KL	= Chlorite	IL	= Illite
BT	= Biotite	FH	= Fe-hydroxide (rust)

Table 7. *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 8. *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 9. *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.

OL-PP70
In the fracture logging, 66 separate fractures were recorded from drillcore OL-PP70 (Appendix 7). There are 47 filled fractures, ten open fractures, seven filled slickensided fractures and two tight fractures. Nine of the fractures stayed intact during drilling, and were defined as closed fractures. Most of the fractures are with undulated or stepped surfaces with high to moderate joint roughness and low joint alteration numbers, which indicate high to moderate friction fractures.

Most of the open fractures are concentrated in the uppermost eight metres of the drillcore. They have slightly rusty and flushed appearance, but also can contain filling minerals. Filled fractures are common throughout the drillcore. The thickest fillings are concentrated in the fractured zone at the drillhole depth of 9.90 - 10.17 metres, where the thickness of carbonate (with minor clays) filling commonly reaches 2 - 10 mm. Filled slickensided fractures occur in the lower part of the drillhole, at the depth of 15.78 - 20.05 metres. They are filled mainly with chlorite, illite, clay, pyrite and calcite.

The identified fracture filling minerals of OL-PP70 according to the frequency of occurrence are: chlorite, calcite, undefined clay minerals, pyrite, kaolinite, illite and biotite.

OL-PP71
In the fracture logging of the drillcore OL-PP71, 24 separate fractures were recorded (Appendix 7). There are nine filled fractures, ten tight fractures and five open fractures. Two of the fractures stayed intact during drilling, and were defined as closed fractures. All of the fractures are with undulated or stepped surfaces with high joint roughness and low joint alteration numbers, which indicate high friction fractures.

Open fractures are concentrated in the uppermost five metres of the drillhole. They have brown surfaces with ferrous hydroxides, pyrite and at one occasion small amount of sand and silt size particles as filling. Filled fractures are found scattered throughout the drillcore, with no fractured zones. The filling thicknesses are generally small 0.1 - 1 mm. The tight fractures may have traces of pyrite as filling, but the filling covers only a small fraction of the fracture surface.

The identified fracture filling minerals of OL-PP71 according to the frequency of occurrence are: pyrite, ferrous hydroxides, chlorite and calcite.

4.6 Fracture frequency and RQD

The frequencies of natural fractures, RQD (Rock Quality Designator) (see Table 12) and mechanically induced breaks were all counted on one metre depth intervals (Appendix 8). 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 OL-PP70 core is 3.7 pcs/m and the average RQD value is 94.3 %. The average natural fracture frequency of the OL-PP71 core is 1.1 pcs/m and the average RQD value is 99.1 % (Appendix 8).

4.7 Fractured zones and core loss

Fractured zones were classified according to Finnish engineering geological bedrock classification (Korhonen et al. 1974) (Table 10).

In the drillcore OL-PP70 there is one short fracture structured (RiIII) zone at the drillhole depth of 9.90 - 10.17 metres (Appendix 9). It consist of ten horizontal fractures with calcite as main filling mineral. Also open/partially open fractures occur. In the drillcore OL-PP71 no fractured zones were intersected.

Table 10. *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

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

4.8 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 11).

The drillcore OL-PP70 is mainly unweathered (Rp0), having only very weak and mostly local alteration (surface oxidation of feldspars, sulphidization with graphite), or no visible alteration at all. In the upper part of the drillhole (drillhole depth of 2.30 - 5.50 m), there is slightly weathered section of rock that shows surface alteration and weathering, classified as Rp1. The section shows epidotization, illitization and locally weak kaolinitization (Appendix 10).

The drillcore OL-PP71 is unweathered (Rp0), having only local very weak alteration (reddish surface oxidation in K-feldspar). For the most part the drillcore is unweathered and unaltered (Appendix 10).

Table 11. *Abbreviations of the weathering degree.*

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

4.9 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 OL-PP70 and OL-PP71.

5 ROCK MECHANICS

5.1 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 7). 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 12) 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 8). If the fracture interval of the relevant joint set is over one metre, the value of 1 is given to J_n (Table 12). 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 7), 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 OL-PP70 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 11. The rock quality of OL-PP70 is mainly "good" (14.69 m, 82.8 %) or "exceptionally good" (2.77 m, 15.6 %). The fractured zone at 9.90 – 10.17 m (RiIII) is classified as "poor".

The core sample of OL-PP71 was divided to seven units of variable lengths, the Q'-values of which were then calculated separately. The results of Q'-classification are presented in Appendix 11. The rock quality of OL-PP71 is mainly "extremely good" (16.71 m, 79.5 %), "exceptionally good" (2.58 m, 12.3 %), "very good" (1.34 m, 6.4 %) or "good" (0.39 m, 1.8 %).

Table 12. *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 $2.0 \times J_n$)		

6 SUMMARY

In connection with Posiva's groundwater monitoring program in Olkiluoto, Suomen Malmi Oy installed eight groundwater observation tubes (OL-PVP36, OL-PVP37A, 37B, 37C, OL-PVP38A, 38B, 38C and 38D) and drilled two shallow drillholes for bedrock groundwater observation (OL-PP70 and OL-PP71).

Installation holes and shallow drillholes were drilled with a GM-200 drill rig. In the groundwater tube installations the overburden was penetrated by drilling a casing to the bedrock contact, and the hole was continued into bedrock by percussion drilling. The monitoring pipe, consisting of riser pipes and a screen pipe was lowered into the hole inside the casing. The screen section was covered with filter gauze and the space between soil and the observation tube was filled with filter sand. A stainless steel well cover with a lock-up cap was installed around the monitoring tube. Groundwater level was measured several times after the installation of all the observation tubes. The shallow drillholes were started by drilling a stainless steel casing to the bedrock and continuing the drillhole with T76 core drilling equipment to the final drilling depth. The drilling and flushing waters was marked with sodium fluorescein.

The core samples were logged following Posiva's standard procedure. The main rock types intersected by the drillhole OL-PP70 are veined and diatexitic gneisses, and in the drillhole OL-PP71 tonalitic-granitic-granodioritic gneiss and pegmatitic granite. The rock samples are mostly unweathered or slightly weathered near the bedrock surface.

The average fracture frequencies in the drillcores OL-PP70 and OL-PP71 are 3.7 pc/m and 1.1 pc/m, and the mean RQD values are 94.3 % and 99.1 %, respectively. In the drillcore OL-PP70 one fractured zone was intersected.

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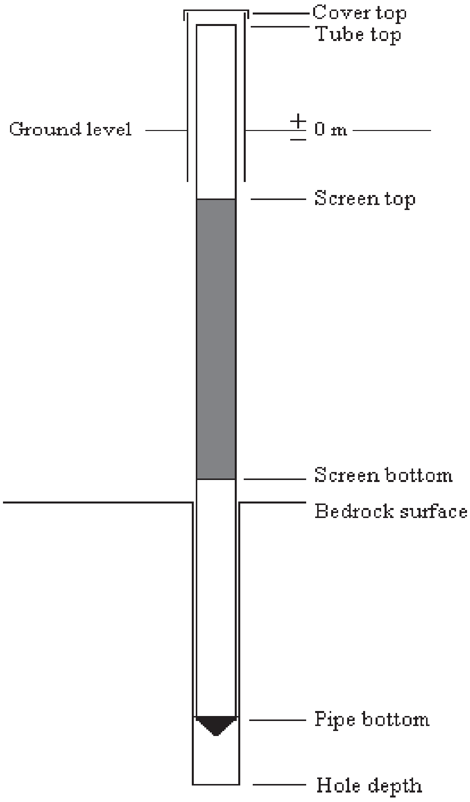
GROUNDWATER OBSERVATION TUBE CARD

Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP36
Installation date:	12.10.2011
Installer(s):	KTSA,ERL

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6792765.89
(Easting) Y:	1526458.15
Ground level Z:	4.59
Tube top Z:	5.34

Pipe lengths	**m**
Upper riser pipe	1.55
Screen pipe	2.00
Lower riser pipe	2.00
Total length:	5.55



Z Coordinate		From ground level	m
5.39		Cover top	0.80
5.34		Tube top	0.75
4.59	Ground level	± 0 m	0
3.79		Screen top	-0.80
1.79		Screen bottom	-2.80
1.79		Bedrock surface	-2.80
-0.21		Pipe bottom	-4.80
-0.91		Hole depth	-5.50

Groundwater level measurements

Date	Time	Depth from ground level m
12.10.2011	13:50	0.00
12.10.2011	14:00	0.14
12.10.2011	14:10	0.29
12.10.2011	14:20	0.35
12.10.2011	14:30	0.38
12.10.2011	14:40	0.40

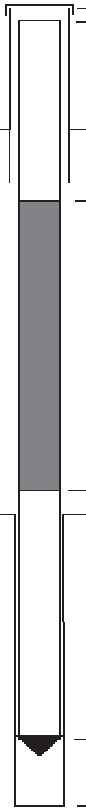
GROUNDWATER OBSERVATION TUBE CARD

Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP37A
Installation date:	10.10.2011
Installer(s):	KTSA,ERL

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6792341.37
(Easting) Y:	1527169.39
Ground level Z:	2.42
Tube top Z:	3.17

Pipe lengths	**m**
Upper riser pipe	8.75
Screen pipe	2.00
Lower riser pipe	2.00
Total length:	12.75



Z Coordinate		From ground level	m
3.22		Cover top	0.80
3.17		Tube top	0.75
2.42	Ground level	± 0 m	0
-5.58		Screen top	-8.00
-7.58		Screen bottom	-10.00
-7.58		Bedrock surface	-10.00
-9.58		Pipe bottom	-12.00
-9.58		Hole depth	-12.00

Groundwater level measurements

Date	Time	Depth from ground level m
10.10.2011	12:14	0.24
10.10.2011	12:24	0.25
10.10.2011	12:34	0.27
10.10.2011	12:44	0.28
10.10.2011	12:54	0.28
10.10.2011	13:04	0.28

GROUNDWATER OBSERVATION TUBE CARD

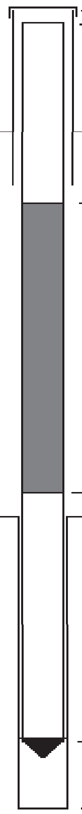
Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP37B
Installation date:	11.10.2011
Installer(s):	KTSA,ERL

DRILLCON
S M O Y

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6792344.08
(Easting) Y:	1527175.66
Ground level Z:	2.64
Tube top Z:	3.39

Pipe lengths	**m**
Upper riser pipe	4.55
Screen pipe	2.00
Lower riser pipe	4.00
Total length:	10.55



Z Coordinate	From ground level	m
3.44	Cover top	0.80
3.39	Tube top	0.75
2.64	Ground level ± 0 m	0
-1.16	Screen top	-3.80
-3.16	Screen bottom	-5.80
-6.36	Bedrock surface	-9.00
-7.16	Pipe bottom	-9.80
-7.36	Hole depth	-10.00

Groundwater level measurements

Date	Time	Depth from ground level m
11.10.2011	9:36	0.02
11.10.2011	9:40	0.08
11.10.2011	9:50	0.13
11.10.2011	10:06	0.17
11.10.2011	10:16	0.19
11.10.2011	10:26	0.20

GROUNDWATER OBSERVATION TUBE CARD

Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP37C
Installation date:	12.10.2011
Installer(s):	KTSA,ERL

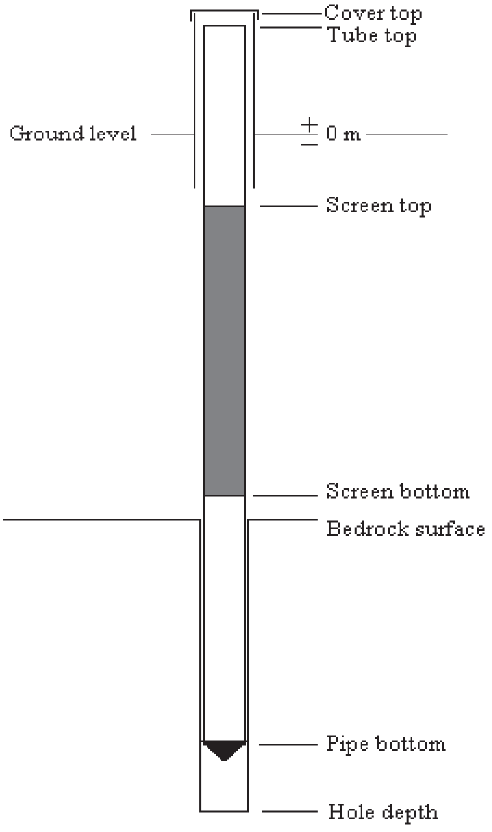
DRILLCON SMOY

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6792341.69
(Easting) Y:	1527177.91
Ground level Z:	2.64
Tube top Z:	3.39

Pipe lengths	**m**
Upper riser pipe	1.55
Screen pipe	2.00
Lower riser pipe	6.00
Total length:	9.55

Z Coordinate		**From ground level**	**m**
3.44		Cover top	0.80
3.39		Tube top	0.75
2.64	Ground level	± 0 m	0
1.84		Screen top	-0.80
-0.16		Screen bottom	-2.80
-5.86		Bedrock surface	-8.50
-6.16		Pipe bottom	-8.80
-6.86		Hole depth	-9.50



Groundwater level measurements

Date	Time	Depth from ground level m
12.10.2011	8:54	0.05
12.10.2011	9:04	0.03
12.10.2011	9:14	0.03
12.10.2011	9:24	0.03
12.10.2011	9:34	0.03
12.10.2011	9:44	0.03

GROUNDWATER OBSERVATION TUBE CARD

Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP38A
Installation date:	22.9.2011
Installer(s):	KTSA,ERL

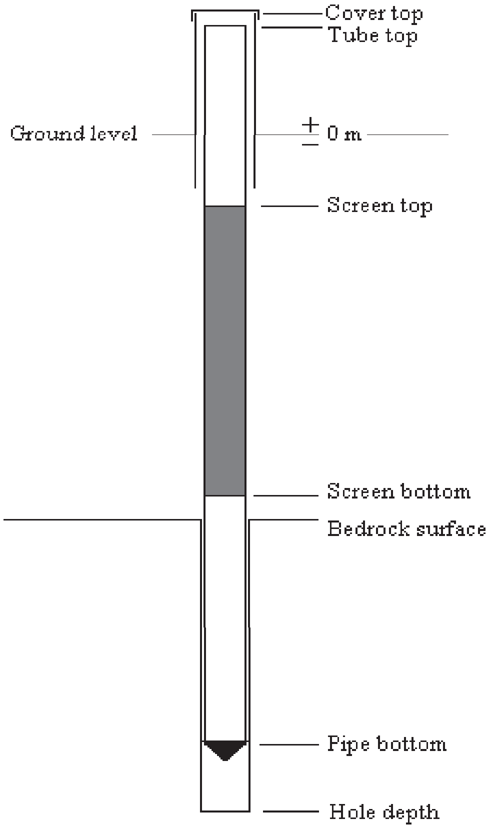
DRILLCON SMOY

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6791660.00
(Easting) Y:	1526985.33
Ground level Z:	6.66
Tube top Z:	7.41

Pipe lengths	m
Upper riser pipe	11.55
Screen pipe	2.00
Lower riser pipe	2.00
Total length:	15.55

Z Coordinate		From ground level	m
7.46		Cover top	0.80
7.41		Tube top	0.75
6.66	Ground level	± 0 m	0
-4.14		Screen top	-10.80
-6.14		Screen bottom	-12.80
-6.14		Bedrock surface	-12.80
-8.14		Pipe bottom	-14.80
-8.14		Hole depth	-14.80



Groundwater level measurements

Date	Time	Depth from ground level m
22.9.2011	14:35	2.95
22.9.2011	14:45	2.80
22.9.2011	14:55	2.70
22.9.2011	15:05	2.60
22.9.2011	15:15	2.45
22.9.2011	15:25	2.25
22.9.2011	15:35	1.95

GROUNDWATER OBSERVATION TUBE CARD

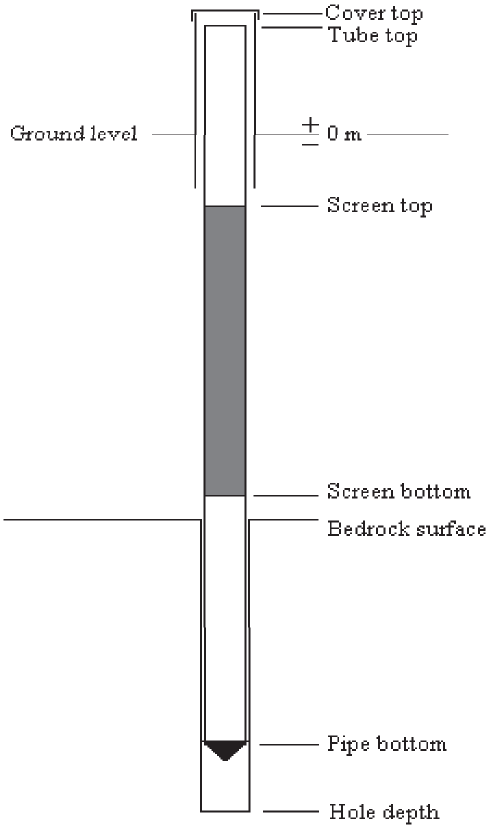
Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP38B
Installation date:	23.9.2011
Installer(s):	KTSA,ERL

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6791659.73
(Easting) Y:	1526988.58
Ground level Z:	6.69
Tube top Z:	7.39

Pipe lengths	**m**
Upper riser pipe	8.40
Screen pipe	2.00
Lower riser pipe	4.00
Total length:	14.40

Z Coordinate	Level	From ground level m
7.49	Cover top	0.80
7.39	Tube top	0.70
6.69	Ground level ± 0 m	0
-1.01	Screen top	-7.70
-3.01	Screen bottom	-9.70
-5.01	Bedrock surface	-11.70
-7.01	Pipe bottom	-13.70
-7.01	Hole depth	-13.70



Groundwater level measurements

Date	Time	Depth from ground level m
26.9.2011	8:20	3.50
26.9.2011	8:35	3.45
26.9.2011	8:50	3.45
26.9.2011	9:05	3.45
26.9.2011	9:20	3.45
26.9.2011	9:35	3.45

GROUNDWATER OBSERVATION TUBE CARD

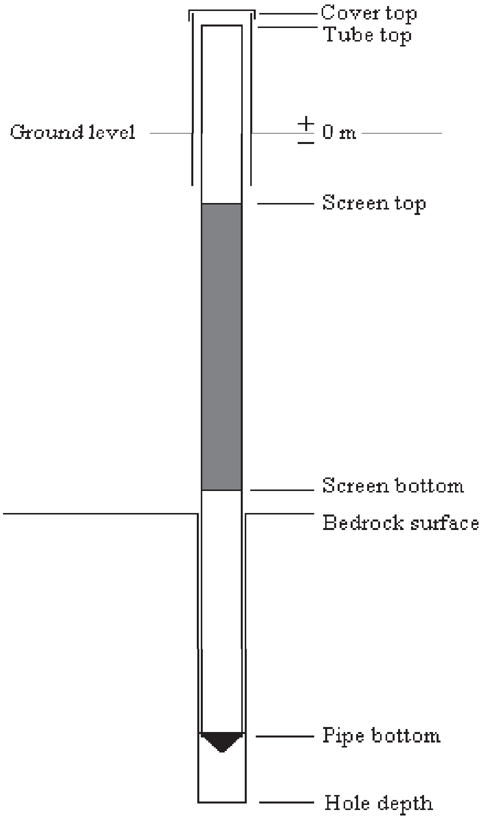
Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP38C
Installation date:	27.9.2011
Installer(s):	KTSA,ERL

DRILLCON S M O Y

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6791659.48
(Easting) Y:	1526991.66
Ground level Z:	6.67
Tube top Z:	7.27

Pipe lengths	**m**
Upper riser pipe	5.30
Screen pipe	2.00
Lower riser pipe	6.00
Total length:	13.30



Z Coordinate		From ground level m
7.42	Cover top	0.75
7.27	Tube top	0.60
6.67	Ground level	0
1.97	Screen top	-4.70
-0.03	Screen bottom	-6.70
-4.03	Bedrock surface	-10.70
-6.03	Pipe bottom	-12.70
-6.03	Hole depth	-12.70

Groundwater level measurements

Date	Time	Depth from ground level m
27.9.2011	12:40	0.76
27.9.2011	12:50	0.78
27.9.2011	13:00	0.80
27.9.2011	13:10	0.81
27.9.2011	13:20	0.85
27.9.2011	13:30	0.89

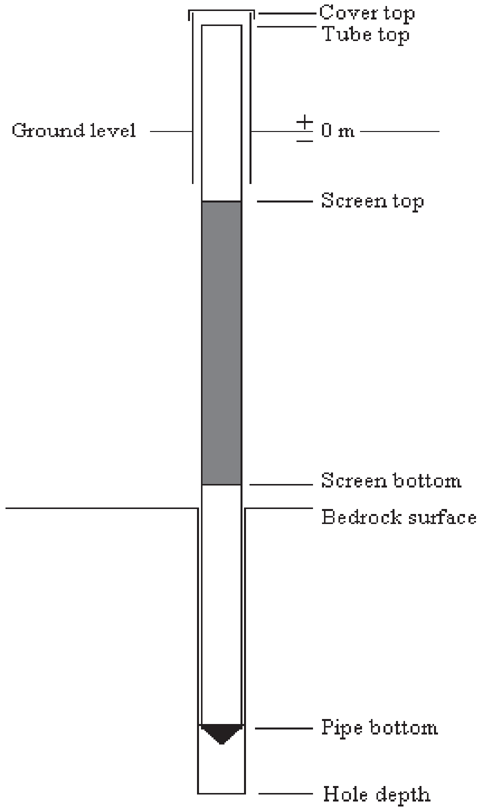
GROUNDWATER OBSERVATION TUBE CARD

Client:	Posiva Oy
Site:	Olkiluoto
Order No:	9464-11, 9628-11
Observation tube ID:	OL-PVP38D
Installation date:	28.9.2011
Installer(s):	KTSA,ERL

Tube information	
Observation tube type:	PVC
Outside diameter:	60 mm
Inside diameter:	52 mm
Screen slot size:	0.3 mm

Surveyed	
(Northing) X:	6791658.67
(Easting) Y:	1526995.34
Ground level Z:	6.68
Tube top Z:	7.48

Pipe lengths	**m**
Upper riser pipe	2.10
Screen pipe	2.00
Lower riser pipe	8.00
Total length:	12.10



Z Coordinate		From ground level m
7.48	Cover top	0.80
7.48	Tube top	0.80
6.68	Ground level	0
5.38	Screen top	-1.30
3.38	Screen bottom	-3.30
-3.12	Bedrock surface	-9.80
-4.62	Pipe bottom	-11.30
-4.62	Hole depth	-11.30

Groundwater level measurements

Date	Time	Depth from ground level m
28.9.2011	14:30	0.00
28.9.2011	14:40	0.02
28.9.2011	14:50	0.08
28.9.2011	15:00	0.14
28.9.2011	15:10	0.20
28.9.2011	15:20	0.24

HOLE ID	OL-PP70	OL-PP71
NORTHING	6791961.99	6791688.11
EASTING	1528079.87	1527504.18
ELEVATION	4.20	5.67
MAX LENGTH, m	20.05	21.02
HOLE PATH	Linear	Linear
AZIMUTH, °	-	-
DIP, °	-90.0	-90.0
LOCATION	Olkiluoto	Olkiluoto
DATE STARTED	4.10.2011	30.9.2011
DATE DRILLED	6.10.2011	3.10.2011
HOLE PURPOSE	Hydrology	Hydrology
SURVEYED BY	Prismarit Oy	Prismarit Oy
SURVEY DATE	24.10.2011	24.10.2011
SURVEY TYPE	Tachymeter	Tachymeter
GRID ID	KKJ1	KKJ1
PRECOLLAR DEPTH, m	2.90	0.80
OVERBURDEN, m	2.30	-
CASING TYPE, mm	90/77	90/77
CASING LENGTH, m	3.89	1.85
Z OF CASING	5.19	6.72
CASING ABOVE GROUND LEVEL, m	0.99	1.05
NO OF CORE BOXES	6	6
HOLE DIAMETER, mm	76.0	76.0
SAMPLE DIAMETER, mm	62.0	62.0
EQUIPMENT	T76	T76
CONTRACTOR	Suomen Malmi Oy	Suomen Malmi Oy
ORDER	9464-11	9464-11

OL-PP70

M_FROM m	M_TO m	BOX_NUMBER
2.30	5.37	1
5.37	8.80	2
8.80	12.15	3
12.15	15.78	4
15.78	18.80	5
18.80	20.05	6

OL-PP71

M_FROM m	M_TO m	BOX_NUMBER
0.00	3.60	1
3.60	6.94	2
6.94	10.63	3
10.63	14.16	4
14.16	17.67	5
17.67	21.02	6

OL-PP70

LIFT NR	LIFT DEPTH m	LENGTH m
1	3.13	0.83
2	4.60	1.47
3	6.60	2.00
4	8.10	1.50
5	9.65	1.55
6	10.65	1.00
7	12.15	1.50
8	13.66	1.51
9	15.20	1.54
10	16.70	1.50
11	18.18	1.48
12	19.65	1.47
13	20.05	0.40

OL-PP71

LIFT NR	LIFT DEPTH m	LENGTH m
1	1.40	1.40
2	2.90	1.50
3	4.40	1.50
4	5.80	1.40
5	7.95	2.15
6	8.47	0.52
7	11.00	2.53
8	12.50	1.50
9	14.00	1.50
10	15.45	1.45
11	16.77	1.32
12	18.50	1.73
13	19.74	1.24
14	21.02	1.28

OL-PP70

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
2.30	7.74	DGN	60	Weakly banded to irregular DGN with reddish leucosome. Weak to moderate epidotization and illitization as surface alteration. Sulphides and graphite are common in melanosome within the first 1.5 m of the sample. At 4.85 - 4.95 m a quartz vein.
7.74	11.83	DGN	50	Irregular and locally boudinaged DGN/VGN with reddish leucosome.
11.83	16.66	VGN	20	Weakly to moderately banded VGN with local K-feldspar porphyres. The mica content varies, and is locally quite low. Weak reddish hue in feldspars as surface alteration.
16.66	17.02	PGR		A short section of coarse grained PGR with K-feldspar and quartz, locally white mica. Feldspar is reddish coloured, by surface oxidation.
17.02	20.05	VGN	30	Moderately banded VGN with locally reddish hue in leucosome feldspar. At 18.95 - 19.35 a short PGR section with spotty kaolinitization. Weak sulphidization and graphite locally especially at contacts to PGR.

OL-PP71

M_FROM m	M_TO m	ROCK_TYPE	LEUCOSOME %	DESCRIPTION
0.00	11.60	TGG	10	Massive to weakly gneissic rock that is composed mainly of feldspars, amphibole, biotite and quartz. Medium grained. Few thin leucosome veins here and there. Unweathered/unaltered. Locally weak reddish oxidation in K-feldspar.
11.60	12.81	PGR		Coarse grained massive PGR, Mainly compose of K-feldspar and quartz, with small amounts of biotite and cordierite. Locally reddish coloured K-feldspar. Quartz veins.
12.81	14.80	TGG	5	A shorter section of the same rock type as at 0.00 - 11.60 metres.
14.80	21.02	PGR		Light red coloured massive coarse grained PGR, mainly composed of K-feldspar and quartz. Minor plagioclase, biotite, apatite, pyrite. Veins with quartz, pyrite and calcite at 15.21, 15.68, 16.26 and 17.21 metres. At 19.74 - 20.40 m the rock is composed mainly of biotite.

OL-PP70

M_FROM m	M_TO m	ELEMENT	DEPTH_M m	DIP (°)	ALPHA (°)	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE
2.30	3.00	FOL				IRR	0	DGN
3.00	4.00	FOL				IRR	0	DGN
4.00	5.00	FOL				IRR	0	DGN
5.00	6.00	FOL				IRR	0	DGN
6.00	7.00	FOL				IRR	0	DGN
7.00	8.00	FOL				IRR	0	DGN
8.00	9.00	FOL	8.35	60	30	GNE	2	DGN
9.00	10.00	FOL	9.60	55	35	GNE	2	DGN
10.00	11.00	FOL				IRR	0	DGN
11.00	12.00	FOL				IRR	0	DGN
12.00	13.00	FOL	12.74	55	35	BAN	2	VGN
13.00	14.00	FOL	13.55	55	35	BAN	2	VGN
14.00	15.00	FOL	14.54	45	45	BAN	2	VGN
15.00	16.00	FOL	15.30	50	40	GNE	2	VGN
16.00	17.00	FOL				MAS	0	PGR
17.00	18.00	FOL				GNE	1	VGN
18.00	19.00	FOL	18.63	55	35	BAN	2	VGN
19.00	20.05	FOL	19.70	45	45	BAN	2	VGN

OL-PP71

M_FROM m	M_TO m	ELEMENT	DEPTH_M m	DIP (°)	ALPHA (°)	FOLIATION TYPE	FOLIATION INTENSITY	ROCK_TYPE
0.00	1.00	FOL				GNE	1	TGG
1.00	2.00	FOL				GNE	1	TGG
2.00	3.00	FOL				GNE	1	TGG
3.00	4.00	FOL				GNE	1	TGG
4.00	5.00	FOL				GNE	1	TGG
5.00	6.00	FOL				GNE	1	TGG
6.00	7.00	FOL				GNE	1	TGG
7.00	8.00	FOL				GNE	1	TGG
8.00	9.00	FOL				GNE	1	TGG
9.00	10.00	FOL				GNE	1	TGG
10.00	11.00	FOL				GNE	1	TGG
11.00	12.00	FOL				MAS	0	PGR
12.00	13.00	FOL				MAS	0	PGR
13.00	14.00	FOL				GNE	1	TGG
14.00	15.00	FOL				GNE	1	TGG
15.00	16.00	FOL				MAS	0	PGR
16.00	17.00	FOL				MAS	0	PGR
17.00	18.00	FOL				MAS	0	PGR
18.00	19.00	FOL				MAS	0	PGR
19.00	20.00	FOL				MAS	0	PGR
20.00	21.02	FOL				MAS	0	PGR

FRACTURE	M_FROM m	CORE_ALPHA (°)	CORE_DIP (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF FILLING (mm)	TYPE	Jr	Ja	CLASS_OF_THE FRACTURED_ZONE	REMARKS
1	2.45	50	40	dark green	BT, KL	0.1	fi	sro	2		
2	2.73	40	50	dark green, light grey	KL, CC	0.1	op	sro	2		
3	2.92	80	10	dark green, light grey	KL, CC	0.1	op	sro	2		
4	2.95	80	10	dark green, light grey	KL, CC	0.1	op	sro	2		
5	3.13	20	70	black, light brown, green	BT, KL, SK	0.1	fi	usm	3		fracture along foliation
6	3.53	70	20	light grey	CC		op	sro	2		
7	3.59	80	10	light grey	CC, KA		op	sro	2		
8	4.09	15	75	black, dark green	KL, SV	0.3	fi	uro	3		
9	4.91	60	30	light brown, green	SK, SV	0.1	fi	sro	1		surrounded by
10	5.03	85	5	black, green	KL	0.2	fi	uro	3		
11	5.05	70	20	black	BT	0.1	fi	sro	2		
12	5.64	50	40	black, green	BT, KL	0.1	fi	sro	1		
13	5.67	80	10	dark green	KL,SV	0.5	fi	uro	3		
14	6.68	57	33	grey, light brown	SV, SK	0.1	fi	uro	2		
15	7.00	80	10	green	KL		fi	sro	1		
16	7.42	40	50	grey	SV		op	uro	1		
17	7.72	56	34	grey	SV		op	uro	1		
18	7.74	55	35	dark green	KL	0.2	fi	uro	0.75		closed
19	7.88	61	29	light grey	CC	0.1	fi	uro	1		
20	8.25	55	35				ti	uro	1		
21	8.43	45	45	black	KL	0.2	fi	uro	0.75		closed
22	8.80	36	54	dark green, grey	KL, SV	0.2	fi	uro	2		
23	8.88	57	33	black, green	KL, SV	1	fi	pro	4		
24	8.93	75	15	black, green, grey	KL, SV	0.5	fi	uro	4		
25	9.00	50	40	dark green	KL	0.2	fi	pro	0.75		closed
26	9.12	67	23	black, light grey	KL, SV	0.2	fi	uro	2		
27	9.36	53	37		CC		ti	uro	1		
28	9.90	70	20	white	SV	0.1	fi	pro	2	RiIII	
29	9.97	79	11	light grey	CC	10	fi	pro	2	RiIII	There is a 10mm thick calcite filled breia with small rock fragments as filling.
30	10.01	90	0	dark grey	SV, CC	0.2	op	uro	2	RiIII	cavities in rock surrounding the fracture
31	10.03	77	13	green, grey	KL, SV, CC	0.2	fi	uro	3	RiIII	
32	10.05	65	25	light grey	CC	2	op	uro	0.75	RiIII	cavities in filling, closed
33	10.07	60	30	light grey, grey	CC, SV	2	op	uro	2	RiIII	CC crystals in open space
34	10.09	59	31	grey	SV	0.2	fi	uro	3	RiIII	
35	10.12	72	18	light grey, greengrey	CC, SV	2	fi	uro	2	RiIII	
36	10.15	70	20	green, light grey	SV, CC	0.2	fi	uro	0.75	RiIII	cavities in filling, closed
37	10.17	85	5	light grey, brownish orange	CC	2	fi	uro	2	RiIII	unussual colour carbonate
38	10.80	55	35	black	KL	0.2	fi	uro	0.75		closed
39	10.81	56	34	black, white, light brown	KL, SK, KA	0.3	fi	uro	3		
40	10.99	68	22	light grey, light brown	CC, SK	0.5	fi	pro	2		
41	11.48	75	15	black, grey, white	KL, SV, KA	0.2	fi	uro	3		
42	14.27	75	15	black, light grey	KL,CC	0.4	fi	uro	3		
43	14.28	80	10	black	KL	3	fi	uro	0.75		closed
44	14.43	62	28	black, light grey	CC	0.1	fi	uro	2		

FRACTURE	M_FROM m	CORE_ALPHA (°)	CORE_DIP (°)	COLOUR_OF FRACTURE_SURFACE	FRACTURE FILLING	THICKNESS_OF FILLING (mm)	TYPE	Jr	Ja	CLASS_OF_THE FRACTURED_ZONE	REMARKS
45	14.56	70	20	black, white	KL, KA	0.1	fi	uro	0.75		closed
46	14.60	80	10	black, light grey	CC	0.1	fi	uro	2		
47	14.85	72	18	black, green, light grey	KL, CC	3	fi	uro	3		
48	14.89	75	15	black, green, light grey	KL, CC	2	fi	uro	3		
49	14.96	60	30	black, white	KL, KA	0.2	fi	uro	0.75		closed
50	14.97	70	20	black, white	KL, KA	0.4	fi	pro	3		
51	15.75	25	65	black	KL	0.2	fi	usm	4		
52	15.78	65	25	black, grey	KL, SV	0.5	fisl	usl	4		
53	16.65	25	65	black, light grey	KL, CC	0.3	fisl	usl	4		fracture along foliation
54	16.80	5	85	green, light grey	KL, CC	0.2	fisl	ssl	4		
55	17.18	60	30	black, dark green	KL, SV	0.2	fi	pro	3		
56	17.19	68	22	green, light grey	KL,CC	0.2	fi	pro	3		
57	17.70	69	21	black, light grey	KL,CC	3	fi	pro	3		
58	17.99	35	55	grey, light brown	SV, SK	0.1	fi	uro	2		
59	18.41	28	62	light grey, light brown	CC, SK	0.1	fi	uro	2		fracture along foliation
60	18.80	60	30	black, light brown	KL,SK	0.2	fi	pro	3		
61	19.50	33	57	black, light brown, light grey	KL, SK, CC	0.3	fi	usm	4		fracture along foliation
62	19.56	47	43	black, light brown, white	KL, SK, SV	0.2	fi	uro	3		fracture along foliation
63	19.68	40	50	black, light brown	KL, GR, SK	0.3	fisl	usl	4		fracture along foliation
64	19.73	69	21	black, light brown, greenish yellow	KL, IL, SK, SV, CC	1	fisl	usl	4		
65	20.00	31	59	black, light brown, greenish yellow	KL, IL, SK, SV, CC	1	fisl	usl	4		fracture along foliation
66	20.05	30	60	black, light brown, greenish yellow	KL, IL, SK, SV, CC	1	fisl	usl	4		fracture along foliation

OL-PP70

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
2.30	3.00	7	4	3	96	RQD 0.67/0.70 m
3.00	4.00	5	3	2	94	
4.00	5.00	4	2	2	100	
5.00	6.00	6	4	2	95	
6.00	7.00	4	1	3	100	
7.00	8.00	5	5	0	98	1 closed fracture
8.00	9.00	5	5	0	80	1 closed fracture
9.00	10.00	5	5	0	90	1 closed fracture
10.00	11.00	12	11	1	82	3 closed fractures
11.00	12.00	3	1	2	100	
12.00	13.00	1	0	1	100	
13.00	14.00	4	0	4	100	
14.00	15.00	9	9	0	83	3 closed fractures
15.00	16.00	2	2	0	97	
16.00	17.00	4	2	2	100	
17.00	18.00	5	4	1	99	
18.00	19.00	2	2	0	100	
19.00	20.05	5	5	0	85	RQD 0.89/1.05m

OL-PP71

M_FROM m	M_TO m	ALL_FRACTURES pieces/m	NAT_FRACTURES pieces/m	MECHANICAL_INDUCED pieces/m	RQD %	Remarks
0.00	1.00	2	1	1	100	
1.00	2.00	5	2	3	100	
2.00	3.00	1	0	1	100	
3.00	4.00	3	3	0	85	
4.00	5.00	3	3	0	100	
5.00	6.00	3	0	3	100	
6.00	7.00	4	0	4	100	
7.00	8.00	2	1	1	100	
8.00	9.00	3	3	0	100	
9.00	10.00	1	0	1	100	
10.00	11.00	2	1	1	100	
11.00	12.00	2	1	1	100	
12.00	13.00	5	4	2	96	1 closed fracture
13.00	14.00	3	0	3	100	
14.00	15.00	3	1	2	100	
15.00	16.00	3	0	3	100	
16.00	17.00	3	0	3	100	
17.00	18.00	6	1	5	100	
18.00	19.00	1	1	0	100	
19.00	20.00	4	1	3	100	
20.00	21.02	1	1	1	100	RQD 1.02/1.02m, 1 closed fracture

OL-PP70

M_FROM m	M_TO m	CLASS_OF_THE FRACTURED_ZONE	DESCRIPTION OF_ZONE	CORE LOSS m	Remarks
9.90	10.17	RiIII	A short fractured zone with 10 fractures. Calcite as main filling mineral. Also open/partially open fractures. Practically all fractures are horizontal.		

OL-PP71
No fractured zones.

OL-PP70

M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
2.30	5.50	Rp1	Surface alteration: epidotization and illitization. Locally weak kaolinitization.
5.50	20.05	Rp0	Reddish hue in feldspars, locally sulphidization and graphite.

OL-PP71

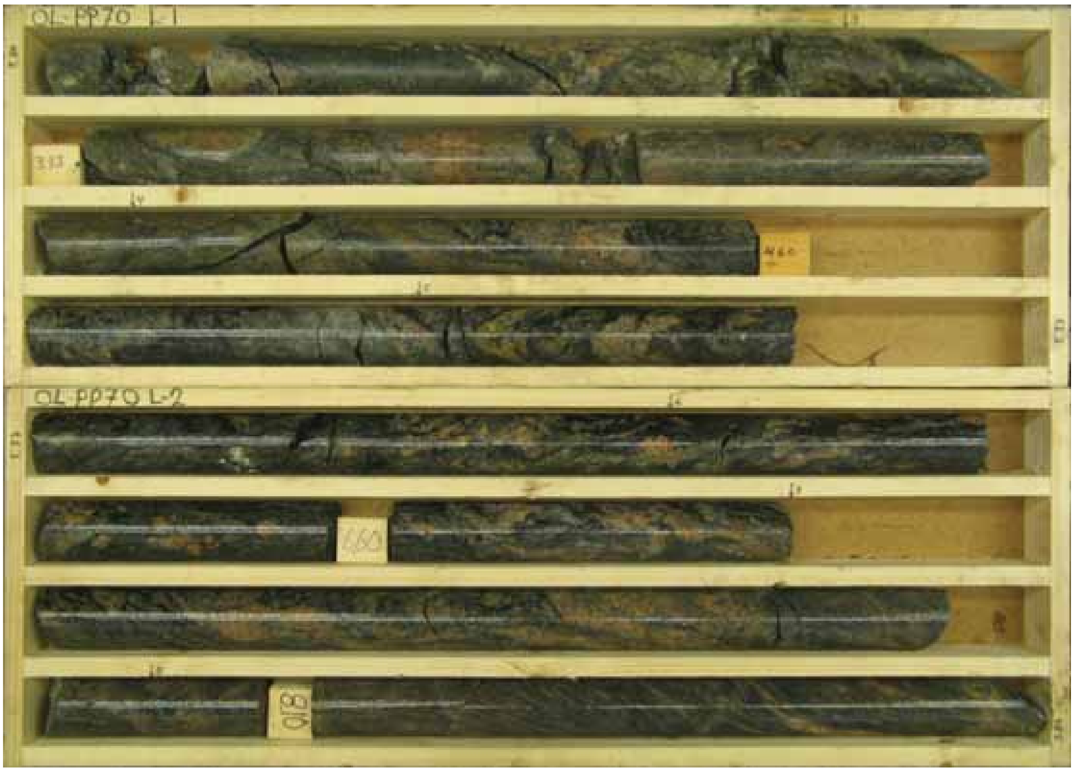
M_FROM m	M_TO m	WEATHERING DEGREE	Remarks
0.00	15.00	Rp0	Practically no weathering or alteration
15.00	21.02	Rp0	K-feldspar oxidated to red colour.

OL-PP70

M_FROM m	M_TO m	LENGTH OF SECTION	> 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´	GSI Q´
2.30	9.89	7.59	723	27	95	95	4	URO	3.0	2.00	Good				36	76
9.89	10.18	0.29	2	10	7	10	4	URO	3.0	2.00	Poor	RiIII			4	56
10.18	11.49	1.31	130	4	99	99	4	URO	3.0	2.50	Good				30	75
11.49	14.26	2.77	277	0	100	100	1		5.0	0.75	Exceptionally Good			No factures	667	103
14.26	20.05	5.79	542	24	94	94	6	URO	2.0	3.00	Good				10	65

OL-PP71

M_FROM m	M_TO m	LENGTH OF SECTION	> 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´	GSI Q´
0.00	3.54	3.54	354	3	100	100	2	URO	3.0	1.00	Extremely Good				150	89
3.54	4.88	1.34	119	6	89	89	4	URO	3.0	1.00	Very Good				67	82
4.88	7.46	2.58	258	0	100	100	1		5.0	0.75	Exceptionally Good			No factures	667	103
7.46	12.60	5.14	514	6	100	100	2	URO	3.0	1.00	Extremely Good				150	89
12.60	12.99	0.39	35	4	90	90	4	PRO	1.5	1.00	Good				34	76
12.99	17.94	4.95	495	1	100	100	1	URO	2.3	1.50	Extremely Good				150	89
17.94	21.02	3.08	308	4	100	100	2	URO	2.3	1.00	Extremely Good				113	87




OL-PP71 L-1
140
290
OL-PP71 L-2
440
580


OL-PP71 L-3
7.95
847
OL-PP71 L-4
11.00
1250
14.00