Working Report 2007-14

Optical Imaging of Drillholes OL-KR40, OL-KR41, OL-KR41B, OL-KR42, OL-KR42B, OL-KR43 and OL-KR43B at Olkiluoto, 2006 and 2007

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March 2007

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ABSTRACT

Optical imaging of drillholes OL- KR40, OL-KR41, OL-KR41B, OL-KR42, OL-KR42B, OL-KR43 and OL-KR43B at Olkiluoto, 2006 and 2007

28.2.2007

Anna-Maria Tarvainen, Suomen Malmi Oy

Suomen Malmi Oy carried out optical imaging of drillholes OL-KR40, OL-KR41, OL-KR41B, OL-KR42, OL-KR42B, OL-KR43 and OL-KR43B at Olkiluoto site in Eurajoki during July, August, November and December 2006 as well as January 2007. The survey is a part of Posiva Oy's detailed investigation program for the final disposal of spent nuclear fuel. The assignment included the field work and the data processing. This report describes the field operation, the equipment as well as the processing procedures and shows the obtained results and their quality. The raw and processed data are delivered digitally in WellCAD and PDF format.

Key words: Geophysics, borehole logging, structural geology, nuclear waste disposal

TIIVISTELMÄ

Kairareikien OL-KR40, OL-KR41, OL-KR41B, OL-KR42, OL-KR42B, OL-KR43 ja OL-KR43B optinen kuvantaminen Olkiluodossa vuonna 2006 ja 2007

28.2.2007

Anna-Maria Tarvainen, Suomen Malmi Oy

Suomen Malmi Oy teki geofysikaalisia mittauksia kairarei'issä OL-KR40, OL-KR41, OL-KR41B, OL-KR42, OL-KR42B, OL-KR43 ja OL-KR43B Olkiluodon tutkimusalueella heinä-, elo-, marras- ja joulukuussa 2006 sekä tammikuussa 2007. Työ tehtiin Posiva Oy:n tilauksesta osana yksityiskohtaisia kallioperätutkimuksia käytetyn polttoaineen loppusijoitusta varten. Toimeksiantoon kuuluivat kenttätyöt ja aineiston tuloskäsittely. Raportissa on kuvattu kenttätöiden kulku, käytetty kalusto ja tehdyt korjaukset sekä esitetty tulosten laatu. Tulokset on toimitettu tilaajalle digitaalisesti WellCAD- ja PDF-muotoisina tiedostoina.

Avainsanat: Geofysiikka, reikämittaukset, rakennegeologia, ydinjätteen loppusijoitus

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1 INTRODUCTION

In 1999, Posiva Oy filed an application for a policy decision from the council of state for a construction permit to build a final disposal facility for spent fuel at the Olkiluoto area in the Eurajoki municipality. In December 2000, the Council of State made a positive policy decision and in May 2001, the Parliament ratified the decision. The policy makes it possible to concentrate the research activities at Olkiluoto.

Suomen Malmi Oy (Smoy) carried out optical imaging of drillholes OL-KR40, OL-KR41, OL-KR41B, OL-KR42, OL-KR42B, OL-KR43 and OL-KR43B for Posiva Oy in July, August, November and December 2006 as well as January 2007 according to the purchase order 9824/06/ISAA. Optical imaging contributes to fracture detection and orientation as well as further description of the crystalline bedrock at Olkiluoto Site.

Field surveys were coordinated by geophysical foreman Antero Saukko. Data processing (raw data quality control, depth matching and image orientation) was conducted by Eero Heikkinen, Pöyry Environment Oy. Finishing of optical images and reporting was conducted by Anna-Maria Tarvainen. This report describes the field operation and the data processing. The quality of the results is shortly analysed and the data presented in Appendices.

2 EQUIPMENT AND METHODS

Optical imaging was carried out using Advanced Logic Technology's (ALT) OBI-40 optical televiewer which is property of Smoy. OBI-40 is a high-resolution optical borehole imagery for wells and boreholes. The tool is used for fracture detection and evaluation, lithological interpretation etc.

OBI-40 creates a 360 degree image of borehole wall by using a CCD camera and a prism. Orientation measurement is controlled with a 3-axes magnetometer and 3 accelerometers. This makes possible to measure borehole azimuth and dip and create accurate orientation of the image.

1000 meter cable is operated by a motorised winch. The cable is 3/16'' steel reinforced 4-conductor cable and manufactured by Mount Sopris. The depth measurement is triggered by pulses of sensitive depth encoder, installed on a pulley wheel. The cable is marked with 10 m intervals for controlling the depth measurement to adjust any cable slip and stretch.

OBI-40 tool diameter is 42 mm. Tool maximum azimuthal resolution is 720 pixels and vertical resolution is 0.5 mm. Survey rate is 12 – 20 cm/min. Smoy has prepared special centralisers for 76 mm boreholes. Tool configuration is shown in Figure 2 and optical assembly in Figure 3. Probe and logging control unit are also presented in Appendix 2.

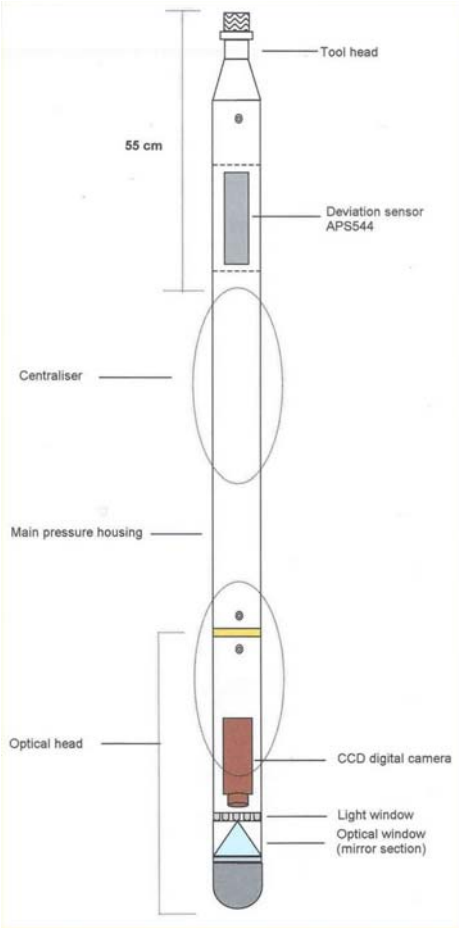

Figure 1. *OBI40 configuration, length 1.7 m (ALT, Optical Borehole Televiewer Operator Manual).*

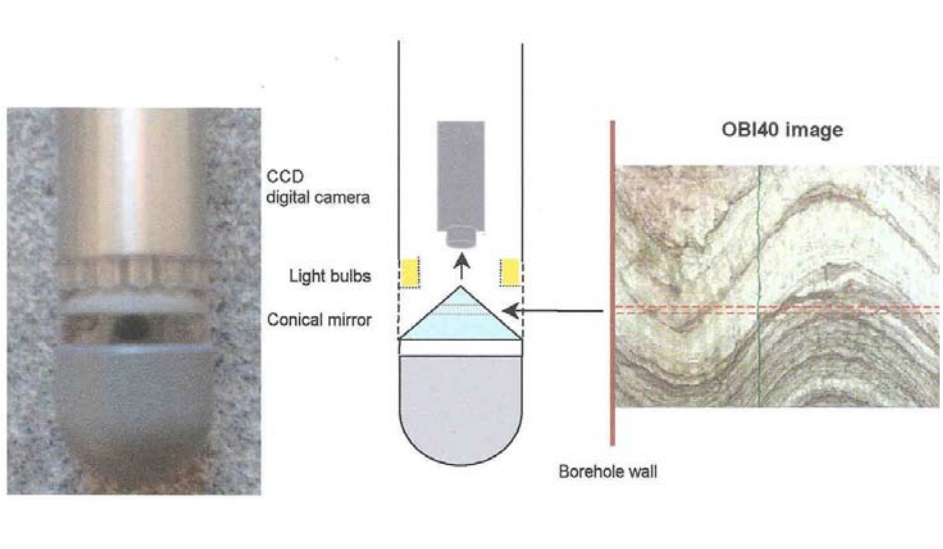

Figure 2. *OBI40 Optical assembly. The high sensitivity CCD digital camera with Pentax optics is located above a conical mirror. The light source is a ring of light bulbs located in the optical head (ALT, Optical Borehole Televiewer Operator Manual).*

3 FIELD WORK

The field work was carried out within 12 working days, in July, August, November and December 2006 as well as January 2007. The total survey amount was approximately 2427 meters. The drillhole specifications are listed in Table 1. Field work in OL-KR43 was cancelled at depth of 471 m due to weakened image quality starting below 300 m (drillhole length 1000 m). The image quality is good in all other drillholes of this campaign. The duration of the field work is listed in Table 2.

Table1: *Specifications of the drillholes surveyed.*

Drillhole	***Azimuth***	***Dip***	***X***	***Y***	***Z***	***Measured Length [m]***
OL-KR40	270.0	-70.3	6791968.19	1526888.57	4.77	1023.6
OL-KR41	269.7	-69.9	6792814.62	1526496.58	4.44	399.6
OL-KR41B	270.0	-68.9	6792817.72	1526497.18	4.32	45.1
OL-KR42	269.0	-70.3	6792546.54	1526158.53	6.96	398.1
OL-KR42B	269.2	-69.9	6792549.29	1526158.89	6.74	44.5
OL-KR43	357.3	-61.5	6792974.00	1524697.43	13.06	470.9
OL-KR43B	359.5	-60.2	6792973.92	1524693.82	13.01	44.8
					Total length [m]	***2426.6***

Table2: *Duration of the field work.*

Date	***Drillhole***	***Surveyors***
19.7.	OL-KR42B	AS, JK
20.7.	OL-KR41B	AS, JK
2.8.	OL-KR42	JK, LJ
3.8.	OL-KR42	JK, LJ
4.8.	OL-KR42	JK, LJ
23.8.	OL-KR41	JK, AS
24.8.	OL-KR41	JK, AS, KV
25.8.	OL-KR41	JK
28.11.	OL-KR43	AS, LH
29.11.	OL-KR43	AS, LH
30.11.	OL-KR43	AS, LH
14.12.	OL-KR43B	AS
2.1.	OL-KR40	AS, LH, LJ
3.1.	OL-KR40	AS, LH, LJ
4.1.	OL-KR40	AS, LH, LJ
5.1.	OL-KR40	AS, LH, LJ
9.1.	OL-KR40	AS, LH

4 DATA PROCESSING AND RESULTS

The data processing of the drillholes included dept matching and image correction. The applied survey parameters of drillhole imaging were determined according to earlier optical televiewer works in the Olkiluoto (Lahti 2004a, Lahti 2004b).

The quality of the image was controlled during survey by taking samples of the image and applying histogram analysis. Also the vertical resolution was checked using captured images. The survey was never left unsupervised. The overlapping of data between recorded intervals was ensured by rerunning of the last 0.5 m of each recording.

Initial depth match is based on 10 m cable mark control of depth pulse encoder data. Locations of rock type contacts and fractures were used in final depth matching like presented on Posiva's working report 2004-43 (Lahti, 2004a). The images were produced to depth matched and oriented to high side presentations including 3-D image.

All images are saved as WellCAD and PDF documents. Images can be reviewed with Well CAD Reader/Software and Adobe Reader/ Acrobat software. An example of the image log in shown in Appendix 1. PDF documents are found in a CD as an appendix of this report.

5 CONCLUSIONS

The total survey amount the drillholes OL-KR40, OL-KR41, OL-KR41B, OL-KR42, OL-KR42B, OL-KR43, OL-KR43B was approximately 2427 m and the surveys were concluded within July, August, November and December 2006 as well as January 2007. The processed and interpreted data is delivered to the Client in digital format. The draft report was compiled in February 2006.

The quality of the data widely achieves the required level. The quality was observed and validated by the Client's representative Pöyry Environment Oy.

References

ALT 2001. WellCAD user's guide for version 3.0. Advanced Logic Technologies, Luxembourg, 831 p.

Lahti, M & Heikkinen, E. 2004. Geophysical borehole logging of the borehole PH1 in Olkiluoto, Eurajoki 2004. Posiva Oy. Working report 2004-43. 30 p.

Lahti, M., Tammenmaa J. & Hassinen P. 2001. Kairanreikien OL-KR13 ja OL-KR14 geofysikaaliset reikämittaukset Eurajoen Olkiluodossa vuonna 2001 (Geophysical borehole logging of the boreholes OL-KR13 and OL-KR14 in Olkiluoto, Eurajoki, 2001). Työraportti 2001-30. Posiva Oy, 136 p.

Appendices

Appendix 1: An example of a drillhole image

Appendix 2: Tool technical information: Optical televiewer OBI40

CD: Results

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Borehole Imaging

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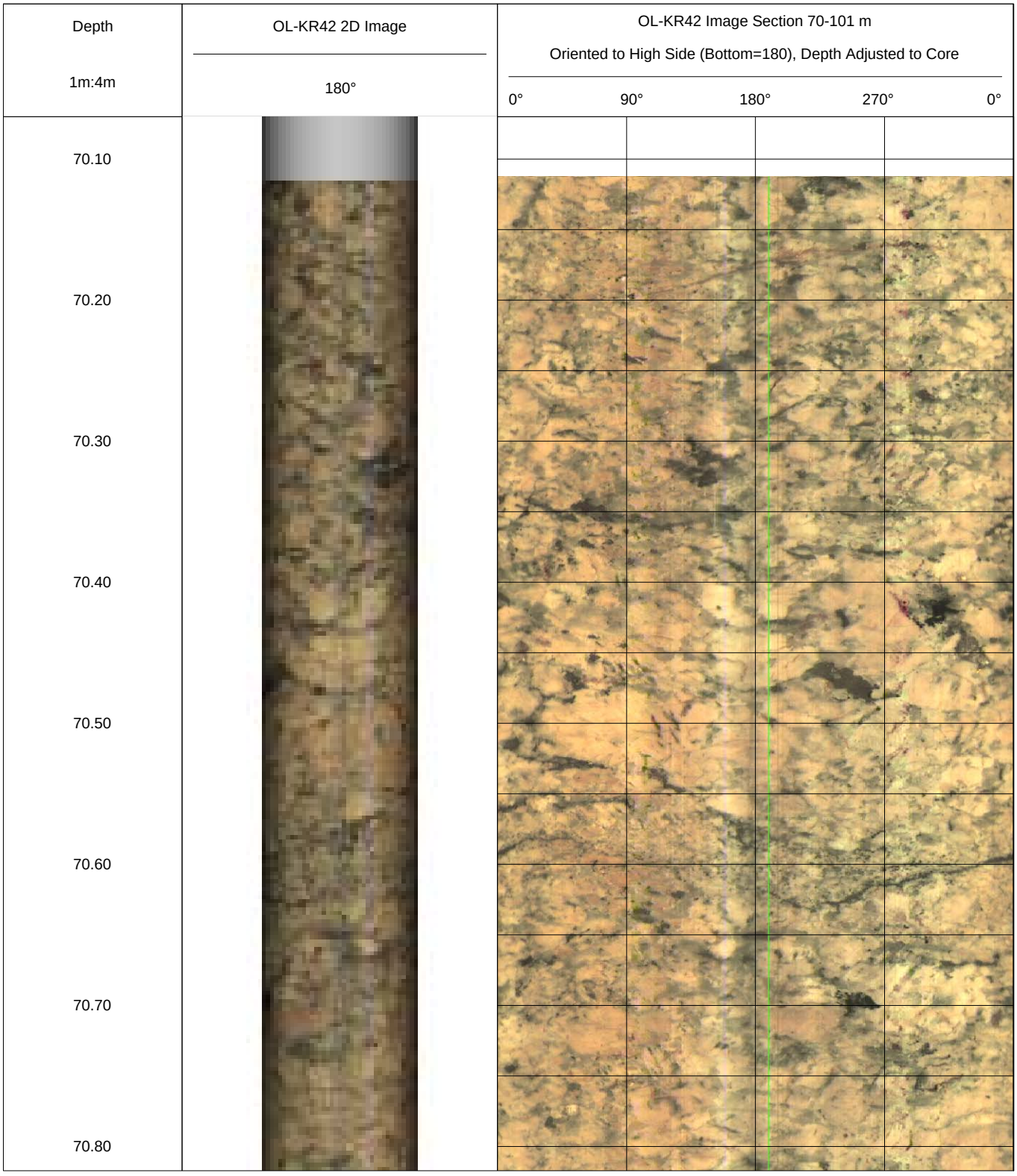
Client: Posiva Oy
Site: Olkiluoto
Project no: 9824/06/ISAA

Hole no: OL-KR42
X: 6792 564.53
Y: 1526 158.40
Z: 6.56

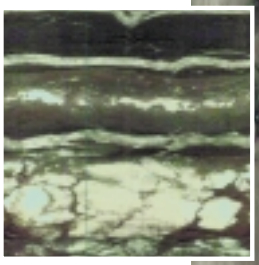
Ø: 76
Length: 400.85
Azimuth: 269
Dip: 70.3

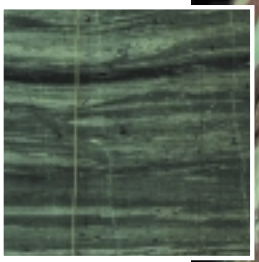
Surveyed by: JK, AS, KV
Survey date: 02-04.08.06
Reported by: AT
Report date: 28.02.07



OBI 40

slimhole optical televiewer





The tool generates a continuous oriented 360° image of the borehole wall using an optical imaging system. (downhole CCD camera which views a image of the borehole wall in a prism). The tool includes a orientation device consisting of a precision 3 axis magnetometer and 3 accelerometers thus allowing accurate borehole deviation data to be obtained during the same logging run (accurate and precise orientation of the image).

Optical and acoustic televiewer data are complimentary tools especially when the purpose of the survey is structural analysis.

A common data display option is the projection on a virtual core that can be rotated and viewed from any orientation. Actually, an optical televiewer image will complement and even replace coring survey and its associated problem of core recovery and orientation.

The optical televiewer is fully downhole digital and can be run on any standard wireline (mono, four-conductor, seven-conductor). Resolution is user definable (up to 0.5mm vertical resolution and 720 pixels azimuthal resolution)

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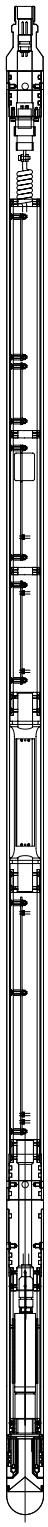
OBI 40

slimhole optical televiewer



Applications:

The purpose of the optical imaging tool is to provide detailed, oriented, structural information. Possible applications are :

- fracture detection and evaluation
- detection of thin beds
- bedding dip
- lithological characterization
- casing inspection

Technical specifications

Diameter	40mm
Length	approx. 1.7m
Weight	approx 7 kgs
Max temp	50°C
Max pressure	200 bars
Borehole diameter	1 3/4" to 24" depending on borehole conditions
Logging speed	variable function of resolution and wireline

Cable:

Cable type	mono, four-conductor, seven-conductor
Digital data transmission	up to 500 Kbps depending on wireline, realtime compressed
Compatibility	ALTlogger- ALT-Abox- Mount Sopris MgXII (limited to 41 Kbps)

sensor:

Sensor type	downhole DSP based digital CCD camera
Optics	plain polycarbonate conic prism system
Azimuthal resolution	user definable 90/180/360 or 720 pixels /360°
Vertical resolution	user definable, depth or time sampling rate
Color resolution	24 bit RGB value
White balance:	automatic or user adjustable
Aperture & Shutter	automatic or user adjustable
Special functions	User configurable real time digital edge enhancing User configurable ultra low light condition mode
Orientation	3 axis magnetometer and 3 accelerometers.
Inclination accuracy	0.5 degree
Azimuth accuracy:	1.0 degree

Logging parameters:

- 360° RGB orientated optical image
- Borehole azimuth and dip
- Tool internal Temperature

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