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Oskarshamn site investigation

Geological single-hole interpretation of KLX04, HLX21, HLX22, HLX23, HLX24 and HLX25

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Abstract

This report contains geological single-hole interpretations of the cored borehole KLX04 and the percussion boreholes HLX21, HLX22, HLX23, HLX24 and HLX25 at Laxemar. Each interpretation combines the geological core mapping, interpreted geophysical logs and borehole radar measurements to identify rock units and possible deformation zones in the boreholes.

Three rock units have been identified in borehole KLX04 (RU1–RU3). The borehole is dominated by Ävrö granite. Also, there is a mixture of Ävrö granite and quartz monzodiorite and a section with quartz monzodiorite in the borehole. Subordinate rock types are granite, fine-grained dioritoid, fine- grained granite, diorite to gabbro, fine-grained diorite to gabbro and pegmatite. Six possible deformation zones have been identified in KLX04 (DZ1–DZ6).

The percussion borehole HLX21 is dominated by Ävrö granite, which constitutes one rock unit (RU1). Two possible deformation zones have been identified in HLX21 (DZ1–DZ2).

One rock unit (RU1), which is dominated by Ävrö granite has been identified in the percussion borehole HLX22. One possible deformation zone has been identified in HLX22 (DZ1).

One rock unit has been identified in HLX23 (RU1). The unit is dominated by Ävrö granite. Three possible deformation zones have been identified in HLX23 (DZ1–DZ3).

One rock unit has been identified in HLX24 (RU1). The unit is dominated by Ävrö granite. Three possible deformation zones have been identified in HLX24 (DZ1–DZ3).

Three rock units have been identified in HLX25 (RU1–RU3). Some are recurrent in the borehole due to variations in subordinate rock types. For this reason, the borehole is divided into five rock sections. The units are dominated by Ävrö granite. Subordinate rock types are granite, diorite to gabbro and fine-grained diorite to gabbro. Four possible deformation zones have been identified in HLX25 (DZ1–DZ4).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålet KLX04 samt hammarborrhålen HLX21, HLX22, HLX23, HLX24 och HLX25 i Laxemar. Den geologiska enhålstolkningen syftar till att utifrån den geologiska karteringen, tolkade geofysiska loggar och borrhålsradarmätningar identifiera olika litologiska enheter och möjliga deformationszoner i borrhålen.

Tre olika litologiska enheter (RU1–RU3) har identifierats i KLX04. Borrhålet domineras av Ävrögranit. Det förekommer även en sektion med en blandning av Ävrögranit och kvartsmonzodiorit och en sektion med kvartsmonzodiorit i borrhålet. Underordnade bergarter utgörs av granit, finkornig dioritoid, finkornig granit, diorit till gabbro och pegmatit. Sex möjliga deformationszoner har identifierats i KLX04 (DZ1–DZ6).

I HLX21 finns en litologisk enhet som domineras av Ävrögranit (RU1). Två möjliga deformationszoner har identifierats i HLX21 (DZ1–DZ2).

I HLX22 finns en litologisk enhet som domineras av Ävrögranit (RU1). En möjlig deformationszon har identifierats i HLX22 (DZ1).

I HLX23 finns en litologisk enhet som domineras av Ävrögranit (RU1). Tre möjliga deformationszoner har identifierats i HLX23 (DZ1–DZ3).

I HLX24 finns en litologisk enhet som domineras av Ävrögranit (RU1). Tre möjliga deformationszoner har identifierats i HLX24 (DZ1–DZ3).

I HLX25 finns tre litologiska enheter. Baserat på variationer i underordnade bergarter kan borrhålet delas in i fem sektioner. Generellt domineras hålet av Ävrögranit, i mindre omfattning finns granit, diorit till gabbro och finkornig diorit till gabbro (RU1–RU3). Fyra möjliga deformationszoner har identifierats i HLX25 (DZ1–DZ4).

Contents

1 Introduction

Much of the primary geological and geophysical borehole data stored in the SKB database SICADA need to be integrated and synthesized before they can be used for modeling in the 3D-CAD system Rock Visualization System (RVS). The end result of this procedure is a geological single-hole interpretation, which consists of integrated series of different loggings and accompanying descriptive documents (SKB MD 810.003, SKB internal controlling document).

This document reports the results gained by the geological single-hole interpretation of the cored borehole KLX04 and the percussion drilled boreholes HLX21 to HLX25 at Laxemar (Figure 1-1), which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plan AP PS 400-04-101. The controlling documents for performing this activity are listed in Table 1-1. Both activity plan and method description are SKB's internal controlling documents. Rock type nomenclature that has been used is shown in Table 1-2.

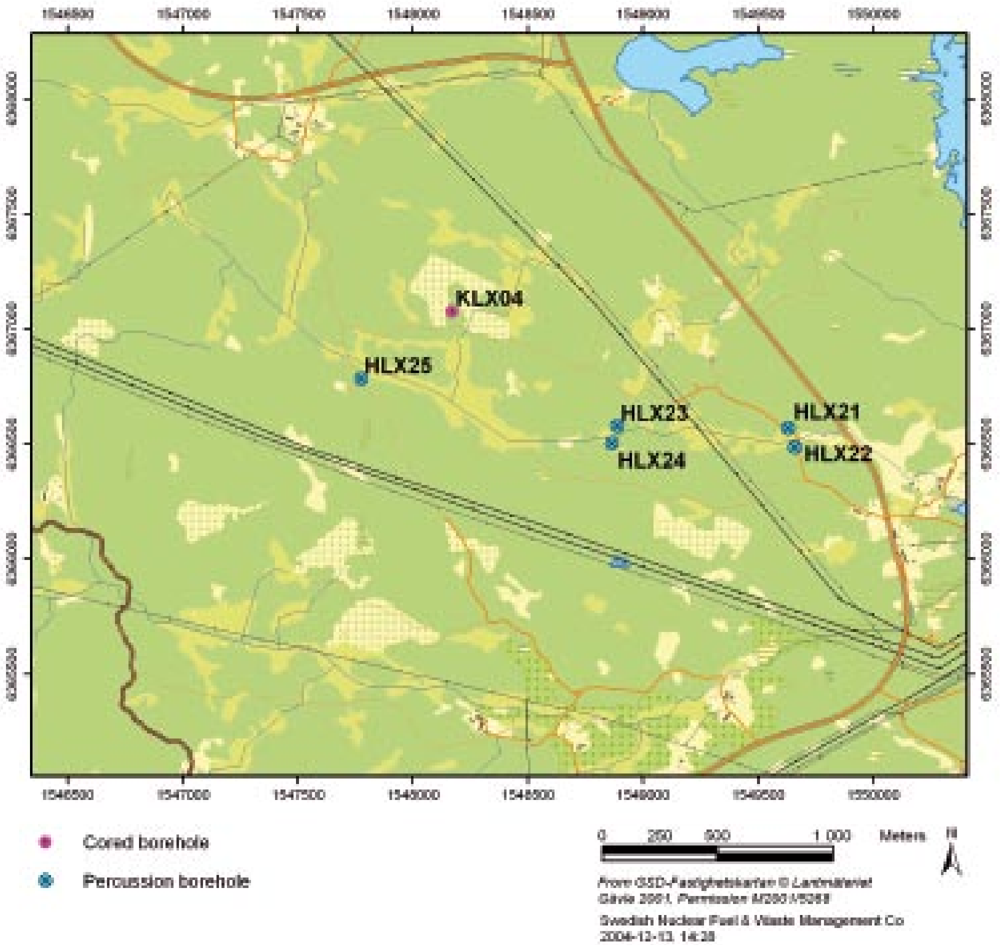

Figure 1-1. *Map showing the position of the cored borehole KLX04 and the percussion drilled boreholes HLX21 to HLX25.*

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Geologisk enhålstolkning av KLX04, HLX21 till HLX25	AP PS 400-04-101	1.0
Method description	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	1.0

Table 1-2. Rock type nomenclature for the site investigation at Oskarshamn.

Rock type	Rock code	Rock description
Dolerite	501027	Dolerite
Fine-grained Götemar granite	531058	Granite, fine- to medium-grained, (”Götemar granite”)
Coarse-grained Götemar granite	521058	Granite, coarse-grained, (”Götemar granite”)
Fine-grained granite	511058	Granite, fine- to medium-grained
Pegmatite	501061	Pegmatite
Granite	501058	Granite, medium- to coarse-grained
Ävrö granite	501044	Granite to quartz monzodiorite, generally porphyritic
Quartz monzodiorite	501036	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic
Diorite/gabbro	501033	Diorite to gabbro
Fine-grained dioritoid	501030	Intermediate magmatic rock
Fine-grained diorite-gabbro	505102	Mafic rock, fine-grained
Sulphide mineralization	509010	Sulphide mineralization
Sandstone	506007	Sandstone

2 Objective and scope

A geological single-hole interpretation is carried out in order to identify and to describe briefly the characteristics of major rock units and possible deformation zones within a borehole. The work involves an integrated interpretation of data from the geological mapping of the borehole (Boremap), different borehole geophysical logs and borehole radar data. The geological mapping of the cored boreholes involves a documentation of the character of the bedrock in the drill core. This work component is carried out in combination with an inspection of the oriented image of the borehole walls that is obtained with the help of the Borehole Image Processing System (BIPS). The geological mapping of the percussion boreholes focuses more attention on an integrated interpretation of the information from the geophysical logs and the BIPS images. For this reason, the results from the percussion borehole mapping are more uncertain. The interpretations of the borehole geophysical and radar logs are available when the single-hole interpretation is performed. The result from the geological single-hole interpretation is presented in a WellCad plot.

3 Equipment

The following data have been used in the single-hole interpretations of the boreholes KLX04 and HLX21 to HLX25:

- Boremap data (including BIPS and geological mapping data) /1, 2/.
- Generalized geophysical logs and their interpretation /3/.
- Radar data and their interpretation /4, 5/.
- Reflection seismic data and their interpretation /6/.

The reflection seismic measurements were not carried out in the borehole but on the ground surface. The reflectors used in this report correspond to those that were predicted to intersect the borehole /6/.

As a basis for the geological single-hole interpretation a combined WellCad plot consisting of the above mentioned data sets were used. An example of a WellCad plot used during the geological single-hole interpretation is shown in Figure 3-1. The plot consists of ten main columns and several subordinate columns. These include:

1: Length along the borehole.

2: Boremap data.
  2.1: Rock type.
  2.2: Rock type < 1 m.
  2.3: Rock type structure.
  2.4: Rock structure intensity.
  2.5: Rock type texture.
  2.6: Rock type grain size.
  2.7: Structure orientation.
  2.8: Rock alteration.
  2.9: Rock alteration intensity.
  2.10: Crush.

3: Generalized geophysical data.
  3.1: Silicate density.
  3.2: Magnetic susceptibility.
  3.3: Natural gamma radiation.
  3.4: Estimated fracture frequency.

4: Unbroken fractures.
  4.1: Primary mineral.
  4.2: Secondary mineral.
  4.3: Third mineral.
  4.4: Fourth mineral.
  4.5: Alteration, dip direction.

5: Broken fractures.
  5.1: Primary mineral.
  5.2: Secondary mineral.
  5.3: Third mineral.
  5.4: Fourth mineral.
  5.5: Aperture (mm).
  5.6: Roughness.
  5.7: Surface.
  5.8: Slickenside.
  5.9: Alteration, dip direction.

6: Crush zones.
   6.1: Piece (mm).
   6.2: Sealed network.
   6:3 Core loss.

7: Fracture frequency.
   7.1: Sealed fractures.
   7.2: Open fractures.

8: BIPS.

The geophysical logs are described below:

Magnetic susceptibility: The rock has been classified into sections of low, medium, high, and very high magnetic susceptibility. The susceptibility is strongly connected to the magnetite content in the different rock types.

Natural gamma radiation: The rock has been classified into sections of low, medium, and high natural gamma radiation. Low radiation may indicate mafic rock types and high radiation may indicate younger, fine- grained granite or pegmatite.

Possible alteration: This parameter has not been used in the geological single-hole interpretation in the area.

Silicate density: This parameter indicates the density of the rock after subtraction of the magnetic component. It provides general information on the mineral composition of the rock types, and serves as a support during classification of rock types.

Estimated fracture frequency: This parameter provides an estimate of the fracture frequency along 5 m sections, calculated from short and long normal resistivity, SPR, p-wave velocity as well as focused resistivity 140 and 300. The estimated fracture frequency is based on a statistical connection after a comparison has been made between the geophysical logs and the mapped fracture frequency. The log provides an indication of sections with low and high fracture frequencies.

Close inspection of the borehole radar data was carried out during the interpretation process, especially during the identification of possible deformation zones. The occurrence and orientation of radar anomalies within the possible deformation zones are commented upon in the text that describes these zones.

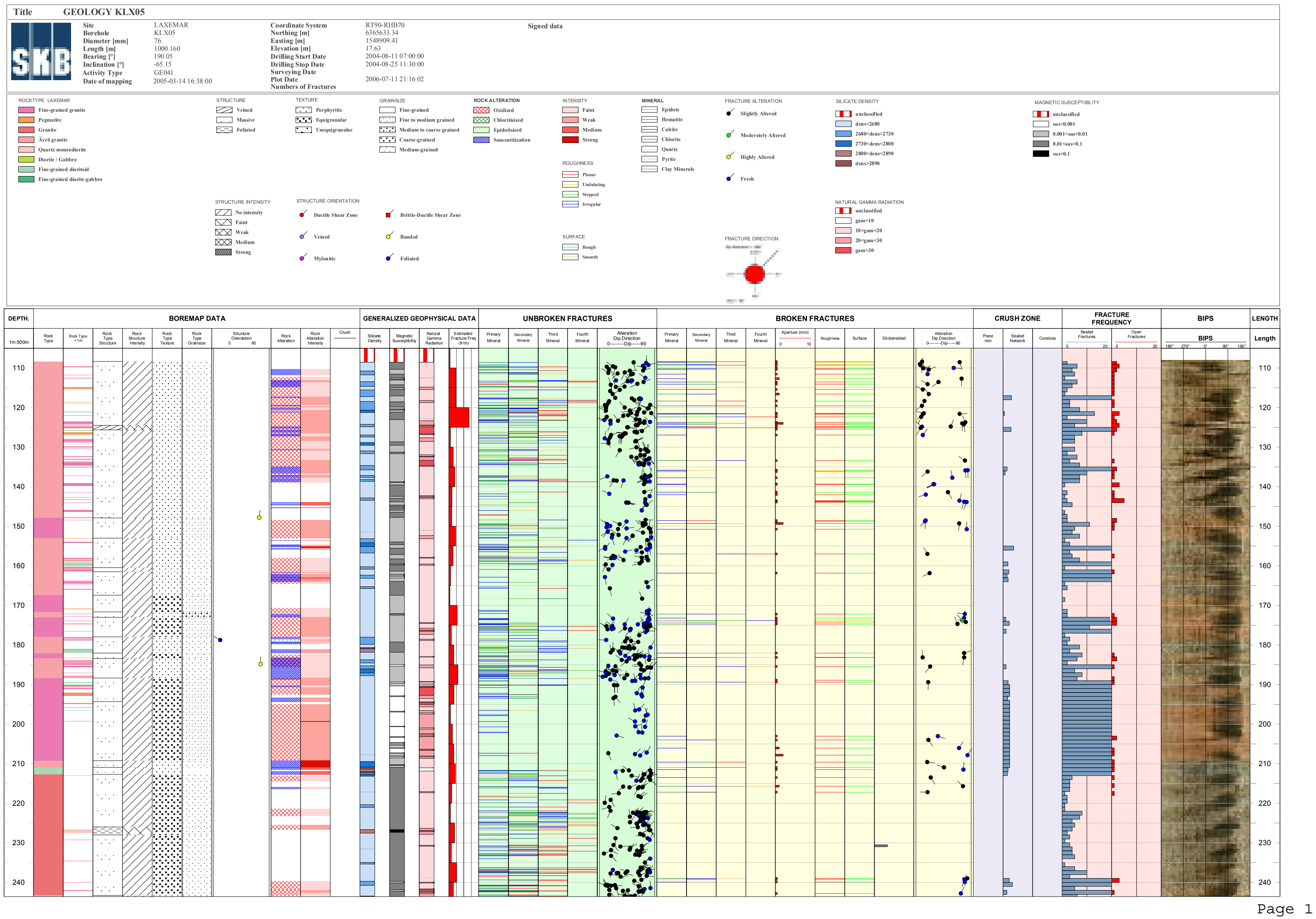

***Figure 3-1**. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.*

4 Execution

4.1 General

The geological single-hole interpretation has been carried out by a group of geoscientists consisting of both geologists and geophysicists. Several of these geoscientists previously participated in the development of the source material for the single-hole interpretation. All data to be used (see above) are visualized side by side in a borehole document extracted from the software WellCad. The working procedure is summarized in Figure 4-1 and in the text below.

Stage 1 in the working procedure is to study all types of data (rock type, rock alteration, silicate density, natural gamma radiation, etc.) related to the character of the rock type and to merge sections of similar rock types, or sections where one rock type is very dominant, into rock units (minimum length of c. 5 m). Each rock unit is defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. The frequencies of open and sealed fractures have been assessed in the identification procedure, and the character of the rock unit has been presented in stereo plot in appendices. Partly open fractures are included together with open fractures. The confidence in the interpretation of a rock unit is made on the following basis: 3 = high, 2 = medium, 1 = low and 0 = not estimated.

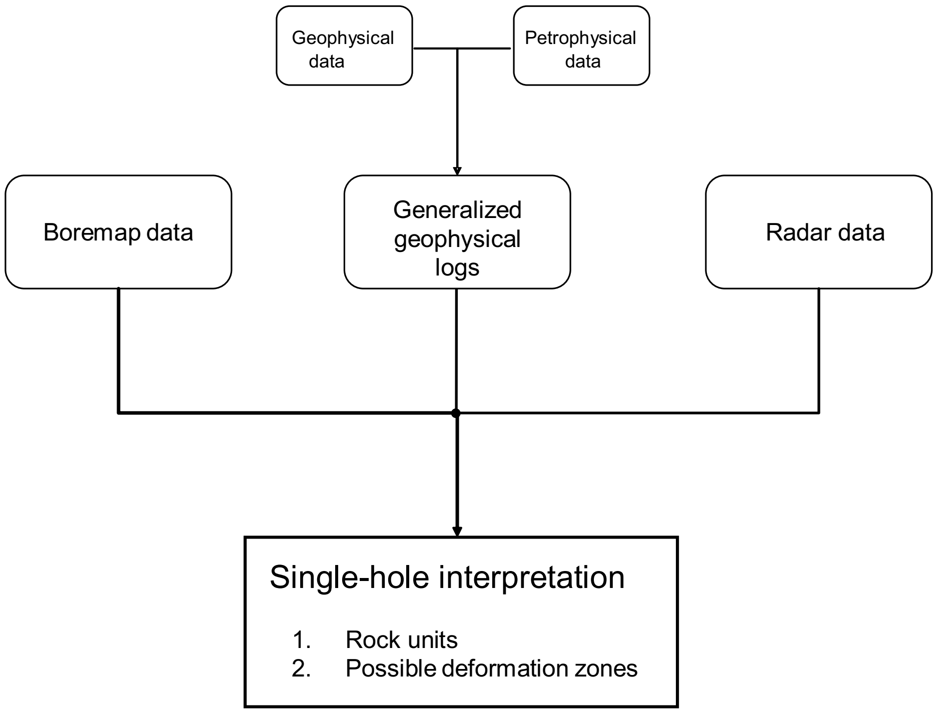

Figure 4-1. *Schematic block-scheme of single-hole interpretation.*

Step 2 in the working procedure is to identify deformation zones by visual inspection of the results of the geological mapping (fracture frequency, fracture mineral, aperture, alteration, etc.) in combination with the geophysical logging and radar data. The section of each identified deformation zone is defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. The confidence in the interpretation of a deformation zone is made on the following basis: 3 = high, 2 = medium, 1 = low and 0 = not estimated.

Inspection of BIPS images is carried out wherever it is judged necessary during the working procedure. Furthermore, following definition of rock units and deformation zones, with their respective confidence estimates, the drill cores are inspected in order to check the selection of the boundaries between these geological entities. If judged necessary, the location of these boundaries is adjusted.

Deformation zones that are brittle in character have been identified primarily on the basis of the frequency of fractures, according to the recommendations in /7/. Both the transitional part, with a fracture frequency in the range 4–9 fractures/m, and the cored part, with a fracture frequency > 9 fractures/m, have been included in each zone (Figure 4-2). The frequencies of open and sealed fractures have been assessed in the identification procedure, and the character of the zone has been described accordingly. Partly open fractures are included together with open fractures in the brief description of each zone. The presence of bedrock alteration, the occurrence and, locally, inferred orientation of radar reflectors, the resistivity, SPR, P-wave velocity, caliper and magnetic susceptibility logs have all assisted in the identification of the zones.

4.2 Nonconformities

In some cases alternative orientations for oriented radar reflectors are presented. One of the alternatives is considered to be correct, but due to uncertainty in the interpretation of radar data, a decision concerning which of the alternatives that represent the true orientation cannot be made.

Orientations from directional radar are presented as dip/strike using the right-hand rule.

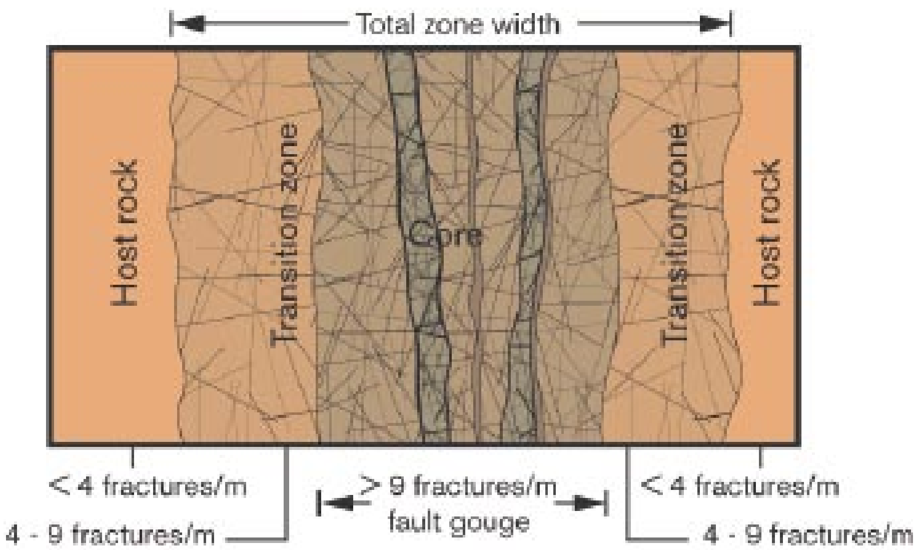

***Figure 4-2.** Terminology for brittle deformation zones (after /7/).*

5 Results

The detailed results of the geological single-hole interpretations are presented as print-outs from the software WellCad (Appendix 1 for KLX04, Appendix 2 for HLX21, Appendix 3 for HLX22, Appendix 4 for HLX23, Appendix 5 for HLX24 and Appendix 6 for HLX25). The legend of the WellCad is presented in Chapter 6. In 5.1 to 5.6 all identified rock units and possible deformation zones in KLX03, HLX21, HLX22, HLX23, HLX24 and HLX25 are presented.

5.1 KLX04

The borehole can be divided into three different rock units, RU1–RU3. Some rock units are recurrent in the borehole depending on variations of the occurrence of subordinate rock types.

RU1: 101.481–385 m

Totally dominated by Ävrö granite. Subordinate rock types comprise scattered ≤ 5 m long sections of granite, fine-grained dioritoid, fine- grained granite, and a few thin sections of diorite to gabbro. The section 318–338 m is foliated. Confidence: 3.

RU2: 385–555 m

Mixture of Ävrö granite and quartz monzodiorite. Subordinate rock types comprise ≤ ca. 17 m long sections of granite, fine-grained dioritoid, fine- grained granite, diorite to gabbro and fine-grained diorite to gabbro. Scattered up to 5 m long sections are foliated. Confidence: 3.

RU1: 555–680 m

Totally dominated by Ävrö granite. In the lower part of the section, fine-grained diorite to gabbro constitute an important subordinate rock type. Furthermore, subordinate rock types comprise scattered sections of fine-grained dioritoid and a few scattered narrow sections of fine- grained granite. Confidence: 3.

RU3: 680–727.307 m

Dominated by quartz monzodiorite with a ca. 17 m long section (705–722 m) of fine- grained granite. Subordinate rock types comprise Ävrö granite, pegmatite and fine- grained granite. A major part of this unit is foliated. Confidence: 3.

RU1: 727.307–991.151 m

Totally dominated by Ävrö granite. Subordinate rock types comprise scattered ≤ 4 m long sections of fine-grained diorite to gabbro, and scattered minor sections of fine-grained granite, fine-grained dioritoid and some pegmatite. The section 787–790 m is foliated. Confidence: 3

Six deformation zones have been recognised in KLX04:

DZ1: 227–230 m

Strongly brecciated. Crush and chlorite-healed fractures. Low resistivity, low density, very low susceptibility and caliper anomaly. A borehole radar reflector occurs at 229.1 m with the orientation 15/333. Seismic reflector with an interpreted intersection depth at 240 m, and an orientation of 27/295. Confidence: 3

DZ2: 254–258 m

One meter crush including severe alteration. Reactivated zone. Low resistivity, variable p-wave velocity, low density, low susceptibility and caliper anomaly. One non-oriented radar reflector with the angle 59° to borehole axis at 255.2 m and one oriented at 258.4 m with the orientation 38/094. Confidence: 3.

DZ3: 295–298 m

Zone core centre at 296–297 m. Low resistivity, low p-wave velocity, low density, very low susceptibility and caliper anomaly. Radar reflectors at 296.8 m and 298.8 m with the angle 70° to borehole axis. Seismic reflector with the orientation 20/095 intersects the borehole at 290 m. Confidence: 3.

DZ4: 325–326 m

Brecciated, strongly altered rock. Low resistivity and low susceptibility. One radar reflector at 325.4 m with the angle 89° to borehole axis and one at 327.0 m with the angle 82°. Seismic reflector with orientation of 15/295 intersects the borehole at 330 m. Confidence: 3.

DZ5: 346–355 m

Brittle deformation with brecciation (sealed network). Low resistivity, variable p-wave velocity, very low susceptibility and small caliper anomaly. Radar reflectors at 350.7 m with the angle 70° to borehole axis and at 352.1 m with the angle 20° to borehole axis. Confidence: 3.

DZ6: 873–973 m

Repeated crush and sealed network. Alteration in upper part, but missing in the central part. High frequency of open fractures. Zone core centre with strong inhomogeneous brittle deformation. The most intensely deformed part of the zone is between c. 930 and 973 m. An intensely crushed part at 936–946 m, correlates with a seismic reflector with the orientation 30/120 at 940 m. Low resistivity, variable p-wave velocity, very low susceptibility in upper (875–895 m) and lower (935–971 m) part and minor caliper anomalies. Several radar reflectors occur within the zone. Thirteen are non-oriented and two are oriented. Oriented reflector at 877.5 m with the orientation 25/109 and at 970.7 m with the orientation 20/134. Eleven radar reflectors have angles in the interval 52–88° to borehole axis, one at 915.7 m has an angle of 31° to borehole axis and one reflector at 888.5 m has the angle 21° to borehole axis. The dominant rock type in the deformation zone is interpreted to be Ävrö granite. Confidence: 3.

5.2 HLX21

The borehole contains one rock unit:

RU1: 9.10–151.02 m

Totally dominated by Ävrö granite. Subordinate rock types comprise fine- grained granite and pegmatite. Confidence: 2.

Two possible deformation zones have been identified in HLX21:

DZ1: 18–24 m

Low resistivity, low p-wave velocity, low density, low susceptibility and caliper anomaly. Two radar reflectors with the intersection angles 67° and 59° to the borehole axis. Confidence: 2.

DZ2: 83–110 m

Inhomogeneous brittle deformation zone characterized by certain distinctly deformed sections, with increased fracture frequency. Low resistivity, low p-wave velocity, partly low density, low susceptibility and caliper anomaly. Five radar reflectors with the intersection angles 47°, 42°, 40°, 85°, and 40° to borehole axis. Confidence: 2.

5.3 HLX22

The borehole contains one rock unit:

RU1: 9.10–163.17 m

Totally dominated by Ävrö granite. Subordinate rock types comprise fine- grained granite and fine-grained diorite to gabbro. Confidence: 2.

One possible deformation zone has been identified in HLX22:

DZ1: 116–119 m

Geophysical loggings show low resistivity, low p-wave velocity, low density, low susceptibility and minor caliper anomaly. One radar reflector with the intersection angle 60° to the borehole axis occurs in the section. Confidence: 2.

5.4 HLX23

The borehole contains one rock unit:

RU1: 6.10–161.00 m

Totally dominated by Ävrö granite. Subordinate rock types comprise fine- grained granite and fine-grained diorite to gabbro. Confidence: 2.

Three possible deformation zones have been identified in HLX23:

DZ1: 47–54 m

Strongly altered and a narrow section with increased fracturing. Low resistivity, low p-wave velocity, low density, low susceptibility and caliper anomaly. Four radar reflectors with the intersection angles 28°, 73°, 41°, and 28° to borehole axis. Confidence: 2.

DZ2: 62–67 m

Strongly altered and a narrow section with increased fracturing. Low resistivity, low p-wave velocity, low susceptibility and caliper anomaly. Two radar reflectors with the intersection angles 38° and 60° to borehole axis. Confidence: 2.

DZ3: 77–82 m

Strongly altered and a narrow section with increased fracturing. Low resistivity, low p-wave velocity, low density, low susceptibility and minor caliper anomaly. Three radar reflectors with the intersection angles 46°, 55°, and 39° to borehole axis. Confidence: 2.

5.5 HLX24

The borehole contains one rock unit:

RU1: 9.10–176.07 m

Totally dominated by Ävrö granite. Subordinate rock types comprise fine-grained diorite to gabbro, fine- grained granite, and pegmatite. Confidence: 2.

Three possible deformation zones have been identified in HLX24:

DZ1: 27–40 m

Medium alteration and increased fracturing. Distinct anomalies in all geophysical logs. Two radar reflectors with the intersection angles 59° and 53° to borehole axis. Confidence: 1.

DZ2: 58–64 m

Weak to medium alteration and rather high fracture frequency. Low resistivity, low p-wave velocity, low density, low susceptibility and major caliper anomaly. Two radar reflectors with the intersection angles 63° and 56° to borehole axis. Confidence: 2.

DZ3: 137–145 m

Medium alteration. Low p-wave velocity, low density, low susceptibility and caliper anomaly. Increased penetration rate. Three radar reflectors with the intersection angles 49°, 55°, and 56° to borehole axis. Confidence: 2.

5.6 HLX25

The borehole contains three rock units, one of which is recurrent in the borehole due to variations of subordinate rock types. For this reason, the borehole is divided into five rock sections:

RU1: 6.12–23.39 m

Totally dominated by Ävrö granite. Subordinate rock types comprise granite and pegmatite. Confidence: 2.

RU2: 23.39–81.50 m

Totally dominated by granite. Subordinate rock types comprise Ävrö granite, pegmatite, fine-grained diorite to gabbro and fine- grained granite. Confidence: 2.

RU1: 81.50–145.91 m

Totally dominated by Ävrö granite. Subordinate rock types include fine-grained diorite to gabbro, fine-grained dioritoid, granite, fine- grained granite and pegmatite. Confidence: 2.

RU3: 145.91–177.11 m

Totally dominated by diorite to gabbro. Subordinate rock types comprise pegmatite and Ävrö granite. There is largely increased density and low natural gamma radiation and low magnetic susceptibility along the section 145–185 m. Confidence: 2.

RU1: 177.11–202.72 m

Totally dominated by Ävrö granite. Subordinate rock types comprise fine- grained diorite to gabbro and pegmatite. There is largely increased density and low natural gamma radiation and low magnetic susceptibility along the section 145–185 m. Confidence: 2.

Four possible deformation zones have been identified in HLX25:

DZ1: 47–52 m

Strong alteration and a crush zone. Low resistivity, low p-wave velocity, low density, major caliper anomaly and low susceptibility. One radar reflector with the intersection angle 73° to borehole axis. Confidence: 2.

DZ2: 66–74 m

Weak to medium alteration and increased fracture frequency. Low resistivity, low p-wave velocity and low susceptibility. Three radar reflectors with the intersection angles 53°, 39°, and 70° to borehole axis. Confidence: 2.

DZ3: 111–116 m

Weak to no alteration, increased fracturing and a narrow crush zone. Low resistivity, low p-wave velocity, variable density, low susceptibility and caliper anomaly. Two radar reflectors with the intersection angles 84° and 63° to borehole axis. Confidence: 2.

DZ4: 176–183 m

Medium alteration and a narrow crush zone. Low resistivity, low p-wave velocity, low density and low susceptibility. Two radar reflectors with the intersection angles 59° and 65° to borehole axis. Confidence: 2.

6 Comments

The result from the geological single-hole interpretation of KLX04, HLX21, HLX22, HLX23, HLX24 and HLX25 are presented in WellCad plots (Appendix 1–6). The WellCad plots consist of the following columns:

In data Boremap

1: Depth (Length along the borehole).

2: Rock type.

3: Rock alteration.

4: Sealed fractures.

5: Open and partly open fractures.

6: Crush zones.

In data Geophysics

7: Silicate density.

8: Magnetic susceptibility.

9: Natural gamma radiation.

10: Estimated fracture frequency.

Interpretations

11: Description: Rock unit.

12: Stereogram for sealed fractures in rock unit (blue symbols).

13: Stereogram for open and partly open fractures in rock unit (red symbols).

14: Description: Possible deformation zone.

15: Stereogram for sealed fractures in possible deformation zone (blue symbols).

16: Stereogram for open and partly open fractures in possible deformation zone (red symbols).

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/7/ **Munier R, Stenberg L, Stanfors R, Milnes A G, Hermanson J, Triumf CA, 2003.** Geological site descriptive model. A strategy for the model development during site investigations. SKB report R-03-07, Svensk Kärnbränslehantering AB.

Appendix 1

Geological single-hole interpretation of KLX04

Title	SINGLE HOLE INTERPRETATION KLX04					
Site	LAXEMAR	Inclination [°]	-84.71	Elevation [m.a.s.l.]	24.02	Signed data
Borehole	KLX04	Date of mapping	2004-07-22 10:00:00	Drilling Start Date	2004-02-11 11:30:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-02-18 14:00:00	
Length [m]	993.490	Northing [m]	6367076.37	Surveying Date		
Bearing [°]	1.62	Easting [m]	1548171.99	Plot Date	2006-07-13 21:14:56	

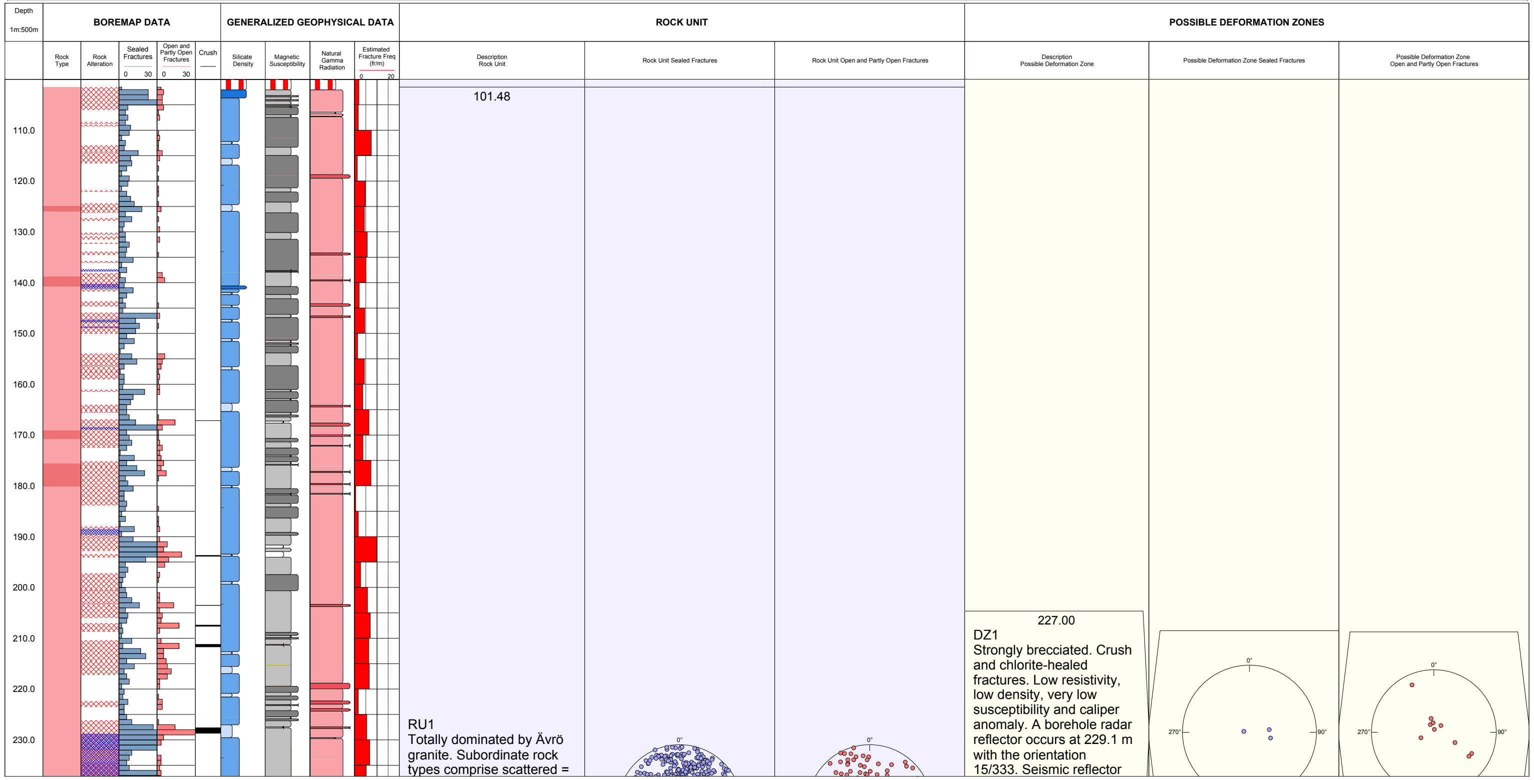
ROCKTYPE LAXEMAR
- Fine-grained granite
- Granite
- Ävrö granite
- Quartz monzodiorite
- Diorite / Gabbro
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Quartz dissolution
- Saussuritization

SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2730<dens<2800
- 2800<dens<2890
- dens>2890

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1
- sus>0.1

NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30



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Appendix 2 Geological single-hole interpretation of HLX21

Title	SINGLE HOLE INTERPRETATION HLX21					
Site	LAXEMAR	Inclination [°]	-56.98	Elevation [m.a.s.l.]	10.31	Signed data
Borehole	HLX21	Date of mapping	2004-10-21 16:15:00	Drilling Start Date	2004-08-30 08:00:00	
Diameter [mm]	138	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-09-02 09:00:00	
Length [m]	150.300	Northing [m]	6366568.75	Surveying Date		
Bearing [°]	185.54	Easting [m]	1549632.36	Plot Date	2006-07-13 21:14:56	

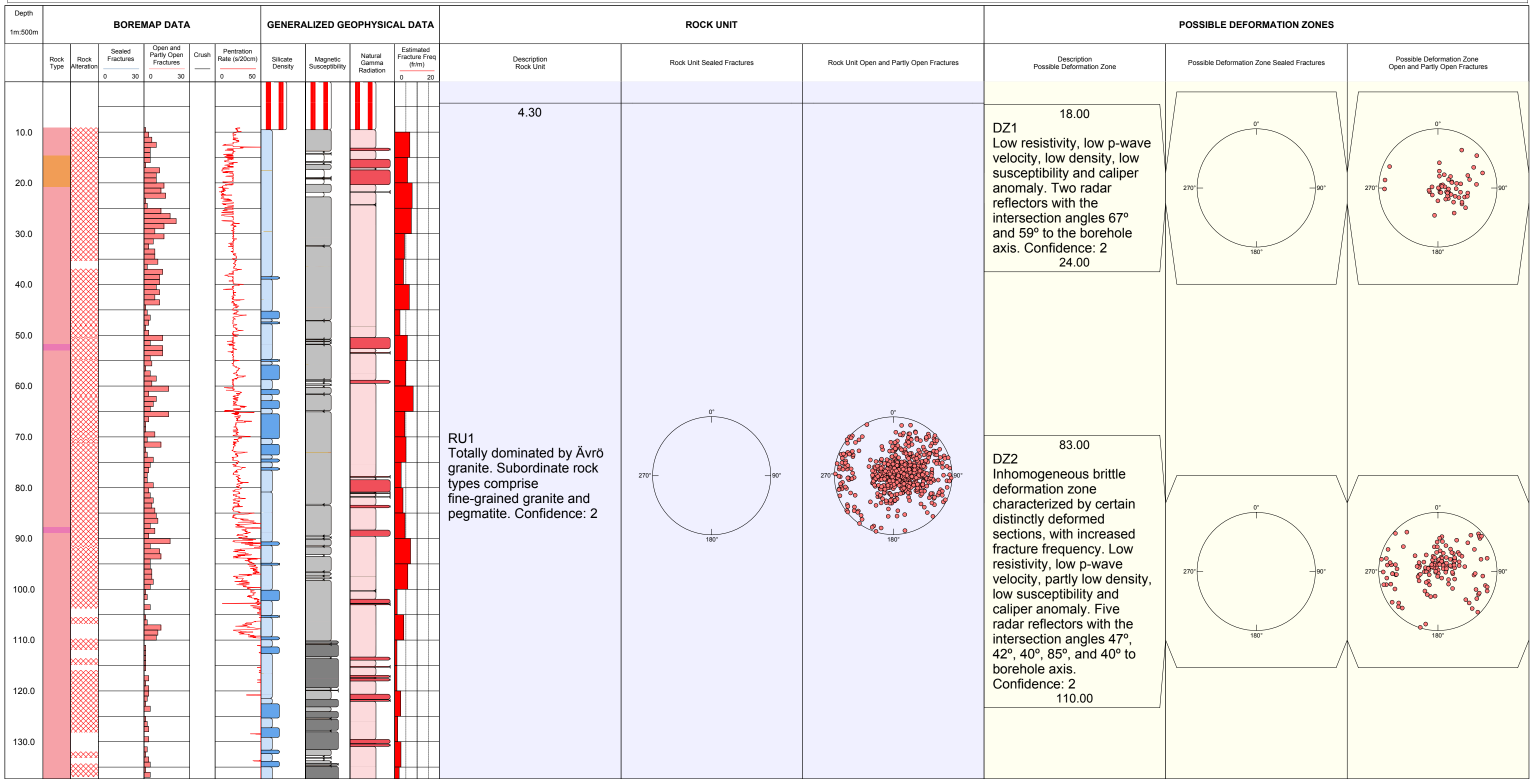
ROCKTYPE LAXEMAR
- Fine-grained granite
- Pegmatite
- Ävrö granite

ROCK ALTERATION
- Oxidized

SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- 10<gam<20
- gam>30



Appendix 3 — Geological single-hole interpretation of HLX22

Title	SINGLE HOLE INTERPRETATION HLX22					
Site	LAXEMAR	Inclination [°]	-59.43	Elevation [m.a.s.l.]	10.06	Signed data
Borehole	HLX22	Date of mapping	2004-10-27 13:17:00	Drilling Start Date	2004-08-23 15:30:00	
Diameter [mm]	138	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-08-26 09:30:00	
Length [m]	163.200	Northing [m]	6366487.83	Surveying Date		
Bearing [°]	13.45	Easting [m]	1549661.54	Plot Date	2006-07-13 21:14:56	

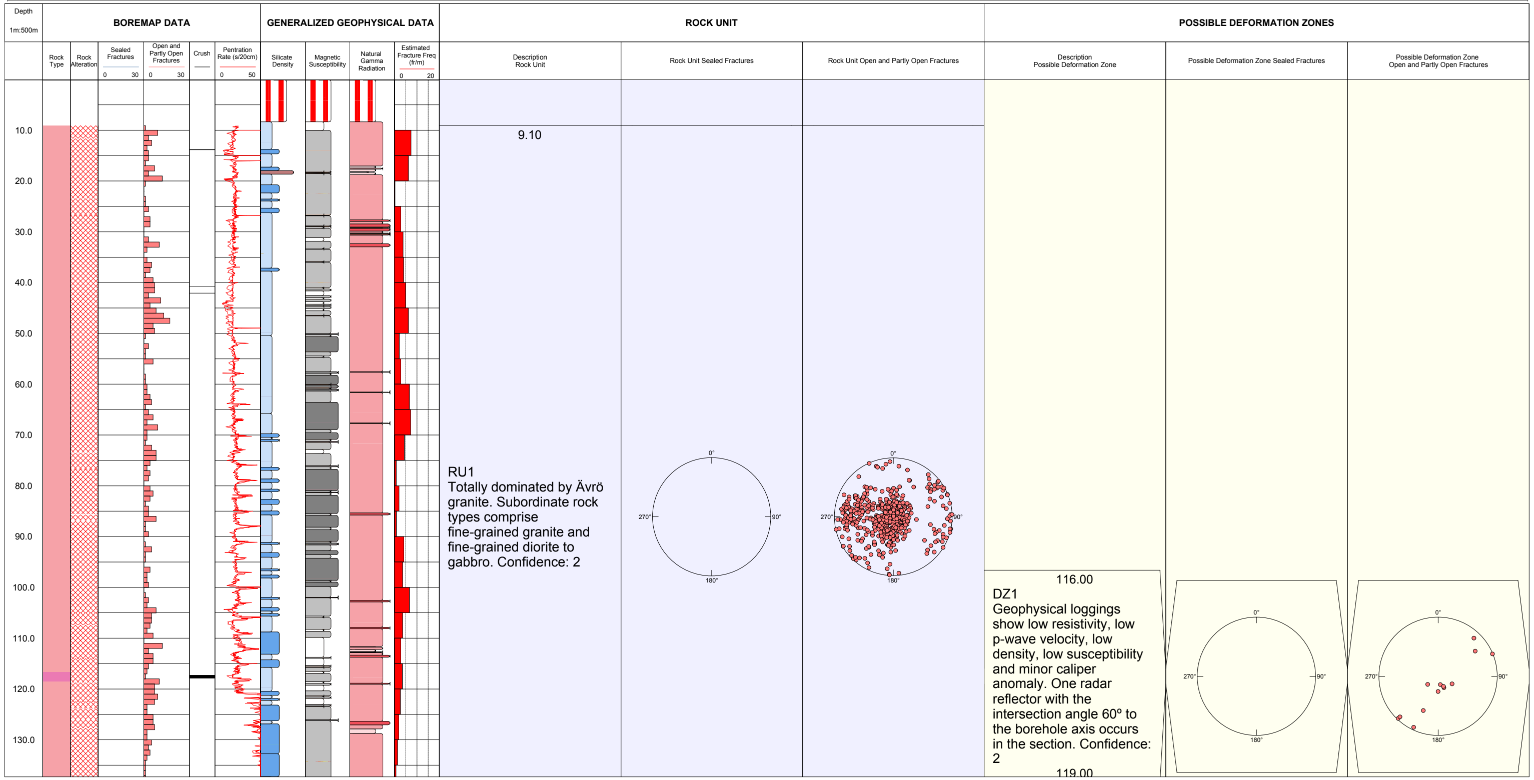
ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite

ROCK ALTERATION
- Oxidized

SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2800<dens<2890

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30



Appendix 4 — Geological single-hole interpretation of HLX23

Title SINGLE HOLE INTERPRETATION HLX23

Site	LAXEMAR	**Inclination [°]**	-58.17	**Elevation [m.a.s.l.]**	14.69	**Signed data**
Borehole	HLX23	**Date of mapping**	2004-11-01 13:54:00	**Drilling Start Date**	2004-09-13 12:30:00	
Diameter [mm]	139	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2004-09-16 10:00:00	
Length [m]	160.200	**Northing [m]**	6366578.01	**Surveying Date**		
Bearing [°]	182.89	**Easting [m]**	1548888.67	**Plot Date**	2006-07-13 21:14:56	

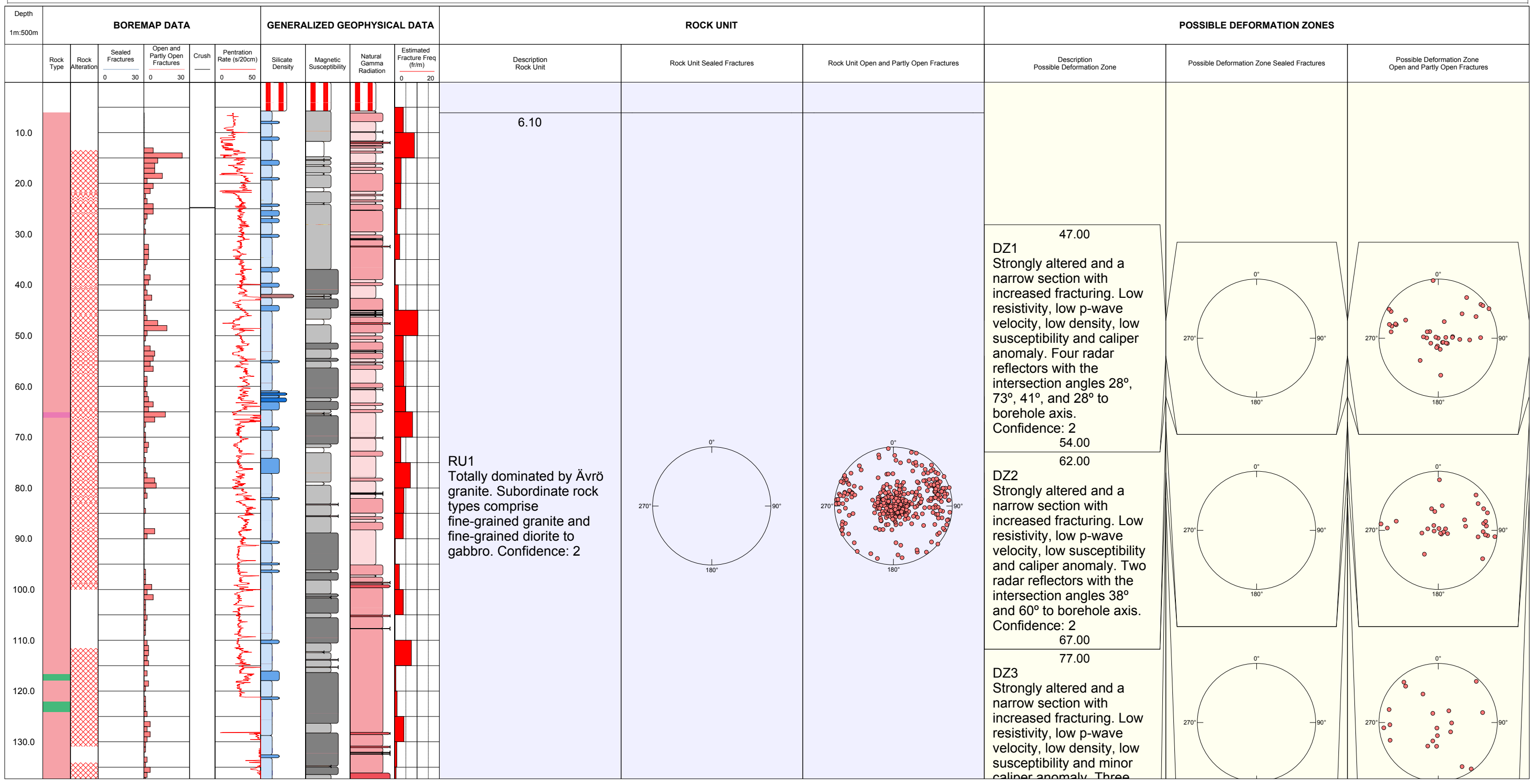
ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Fine-grained diorite-gabbro

ROCK ALTERATION
- Oxidized

SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2730<dens<2800
- 2800<dens<2890

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- 10<gam<20
- 20<gam<30
- gam>30



Appendix 5 Geological single-hole interpretation of HLX24

Title	SINGLE HOLE INTERPRETATION HLX24						
Site	LAXEMAR	Inclination [°]	-58.38	Elevation [m.a.s.l.]	12.77	Signed data	
Borehole	HLX24	Date of mapping	2004-11-03 07:43:00	Drilling Start Date	2004-09-06 13:00:00		
Diameter [mm]	139	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-09-09 10:00:00		
Length [m]	175.200	Northing [m]	6366503.72	Surveying Date			
Bearing [°]	358.69	Easting [m]	1548865.89	Plot Date	2006-07-13 21:14:56		

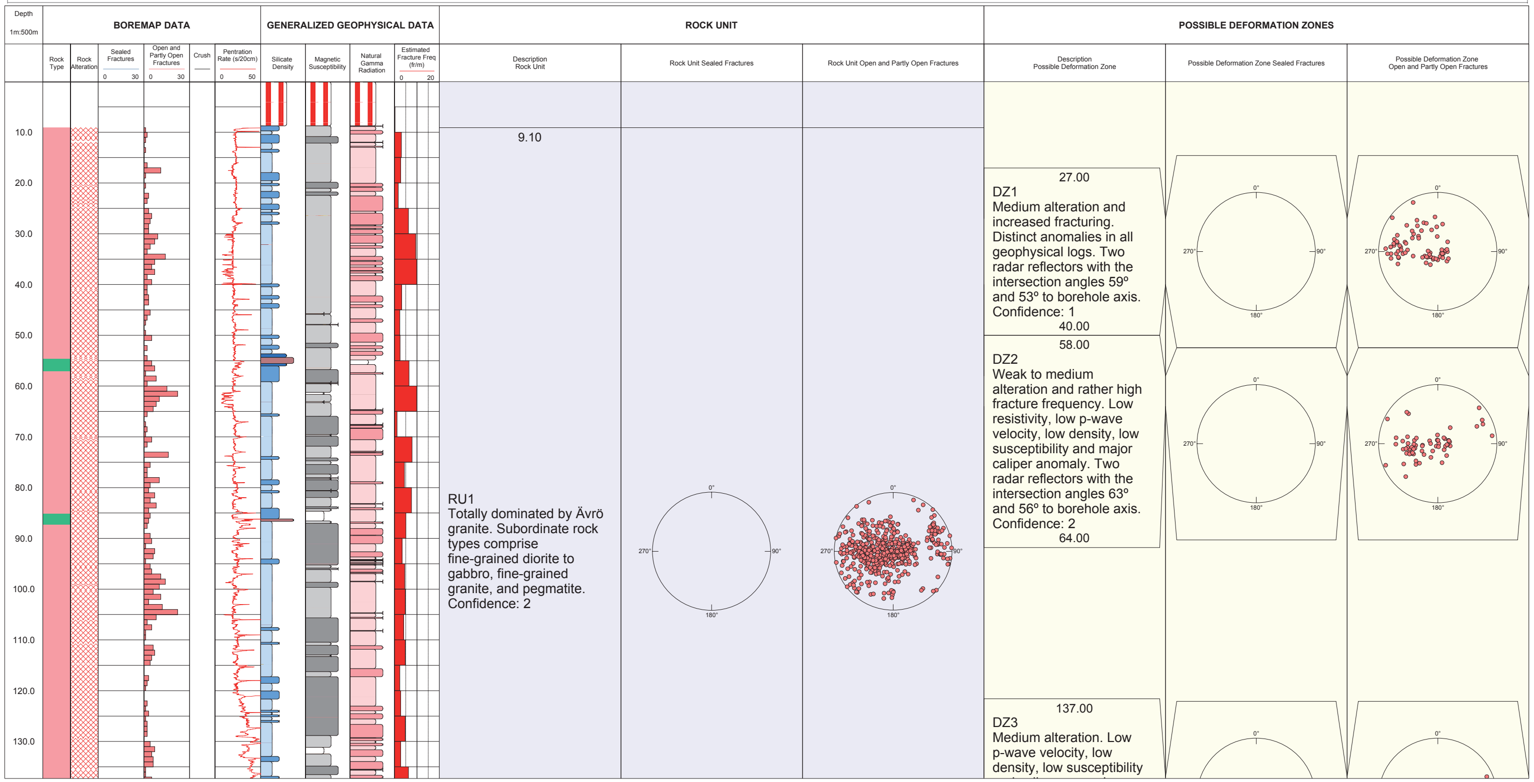
ROCKTYPE LAXEMAR
- Ävrö granite
- Fine-grained diorite-gabbro

ROCK ALTERATION
- Oxidized

SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2730<dens<2800
- 2800<dens<2890

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30



Appendix 6 Geological single-hole interpretation of HLX25

Title	SINGLE HOLE INTERPRETATION HLX25						
Site	LAXEMAR	Inclination [°]	-58.58	Elevation [m.a.s.l.]	20.66	Signed data	
Borehole	HLX25	Date of mapping	2004-10-14 17:43:00	Drilling Start Date	2004-08-17 00:00:00		
Diameter [mm]	135	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-08-19 00:00:00		
Length [m]	202.500	Northing [m]	6366783.97	Surveying Date			
Bearing [°]	17.94	Easting [m]	1547776.32	Plot Date	2006-07-13 21:14:56		

ROCKTYPE LAXEMAR
- Pegmatite
- Granite
- Ävrö granite
- Diorite / Gabbro
- Fine-grained diorite-gabbro

ROCK ALTERATION
- Oxidized

SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2730<dens<2800
- 2800<dens<2890
- dens>2890

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30