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Oskarshamn site investigation

Geological single-hole interpretation of KLX21B and HLX40

Seje Carlsten, Karl-Johan Mattsson, Allan Stråhle
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Carl-Henric Wahlgren, Geological Survey of Sweden

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Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 250, SE-101 24 Stockholm
Tel +46 8 459 84 00

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Keywords: Geophysics, Rock unit, Borehole, Deformation zone, Fractures, Alteration.

Abstract

This report contains geological single-hole interpretation of the cored borehole KLX21B and the percussion borehole HLX40 at Laxemar. The interpretation combines the geological core mapping, interpreted geophysical logs and borehole radar measurements to identify rock units and possible deformation zones in the boreholes.

The geological single-hole interpretation shows that three rock units (RU1–RU3) occur in KLX21B. However, the borehole can be divided into four separate sections due to the repetition of RU1 (RU1a and RU1b). In general, borehole KLX21B is dominated by Ävrö granite (501044). A larger section in the lower central part of the borehole is dominated by fine-grained dioritoid (501030) and the bottom of the borehole is dominated by quartz monzodiorite (501036). Subordinate rock types comprise occurrences of diorite/gabbro (501033), fine-grained granite (511058), fine-grained diorite-gabbro (505102), pegmatite (501061) and granite (501058). Twelve possible deformation zones are identified in KLX21B (DZ1–DZ12).

One rock unit (RU1) occurs in HLX40. The borehole is dominated by Ävrö granite (501044). Subordinate rock types comprise occurrences of diorite/gabbro (501033), fine-grained granite (511058), pegmatite (501061) and fine-grained diorite-gabbro (505102). One possible deformation zone is identified in HLX40 (DZ1).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålet KLX21B och hammarborrhålet HLX40 i Laxemar. Den geologiska enhålstolkningen syftar till att utifrån den geologiska karteringen, tolkade geofysiska loggar och borrhålsradarmätningar identifiera olika litologiska enheters fördelning i borrhålen samt möjliga deformationszoners läge och utbredning.

Den geologiska enhålstolkningen visar att KLX21B kan delas in i tre litologiska enheter (RU1–RU3). Baserat på repetition av enheten RU1 (RU1a och RU1b) kan borrhålet delas in i fyra sektioner. Generellt sett domineras borrhålet av Ävrögranit (501044). En större sektion i den nedre centrala delen av borrhålet domineras av finkornig dioritoid (501030) och nedersta delen av borrhålet domineras av kvartsmonzodiorit (501036). Diorit/gabbro (501033), finkornig granit (511058), finkornig diorit-gabbro (505102), pegmatit (501061) och granit (501058) förekommer som underordnade bergarter. Tolv möjliga deformationszoner har identifierats i KLX21B (DZ1–DZ12).

En litologisk enhet (RU1) förekommer i hammarborrhål HLX40. Borrhålet domineras av Ävrögranit (501044). Diorit/gabbro (501033), finkornig granit (511058), pegmatit (501061) och finkornig diorit-gabbro (505102) förekommer som underordnade bergarter. En möjlig deformationszon har identifierats i HLX40 (DZ1).

Contents

1 Introduction 7

2 Objective and scope 9

3 Data used for the geological single-hole interpretation 11

4 Execution 15
4.1 General 15

5 Results 19
5.1 KLX21B 19
5.2 HLX40 22

6 Comments 23

7 References 25

Appendix 1 Geological single-hole interpretation of KLX21B 27

Appendix 2 Geological single-hole interpretation of HLX40 31

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 v. 3.0, SKB internal controlling document).

This document reports the results gained by the geological single-hole interpretation of boreholes KLX21B and HLX40 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 400-07-042. 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.

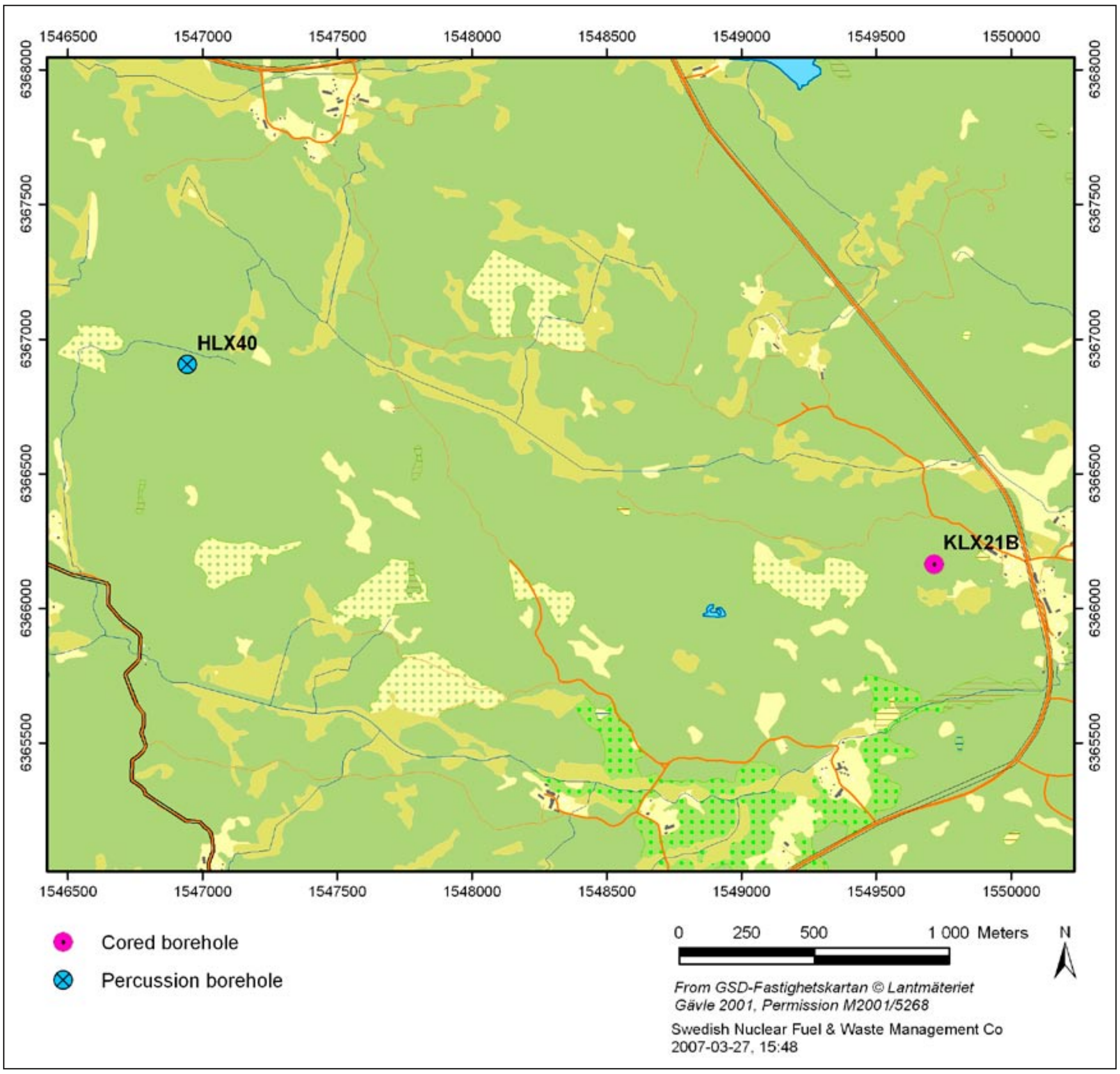

Figure 1-1. *Map showing the position of the cored borehole KLX21B and the percussion drilled borehole HLX40.*

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

Activity plan	Number	Version
Geologisk enhålstolkning av KLX21B, HLX40	AP PS 400-07-042	1.0
Method description	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	3.0

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. The work reported here concerns stage 1 in the single-hole interpretation, as defined in the method description.

3 Data used for the geological single-hole interpretation

The following data have been used in the single-hole interpretation of boreholes KLX21B and HLX40:

- Boremap data (including BIPS and geological mapping data) /2, 3/.
- Generalized geophysical logs and their interpretation /4, 5/.
- Radar data and their interpretation /6, 7/.

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

9: Length along the borehole

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 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.

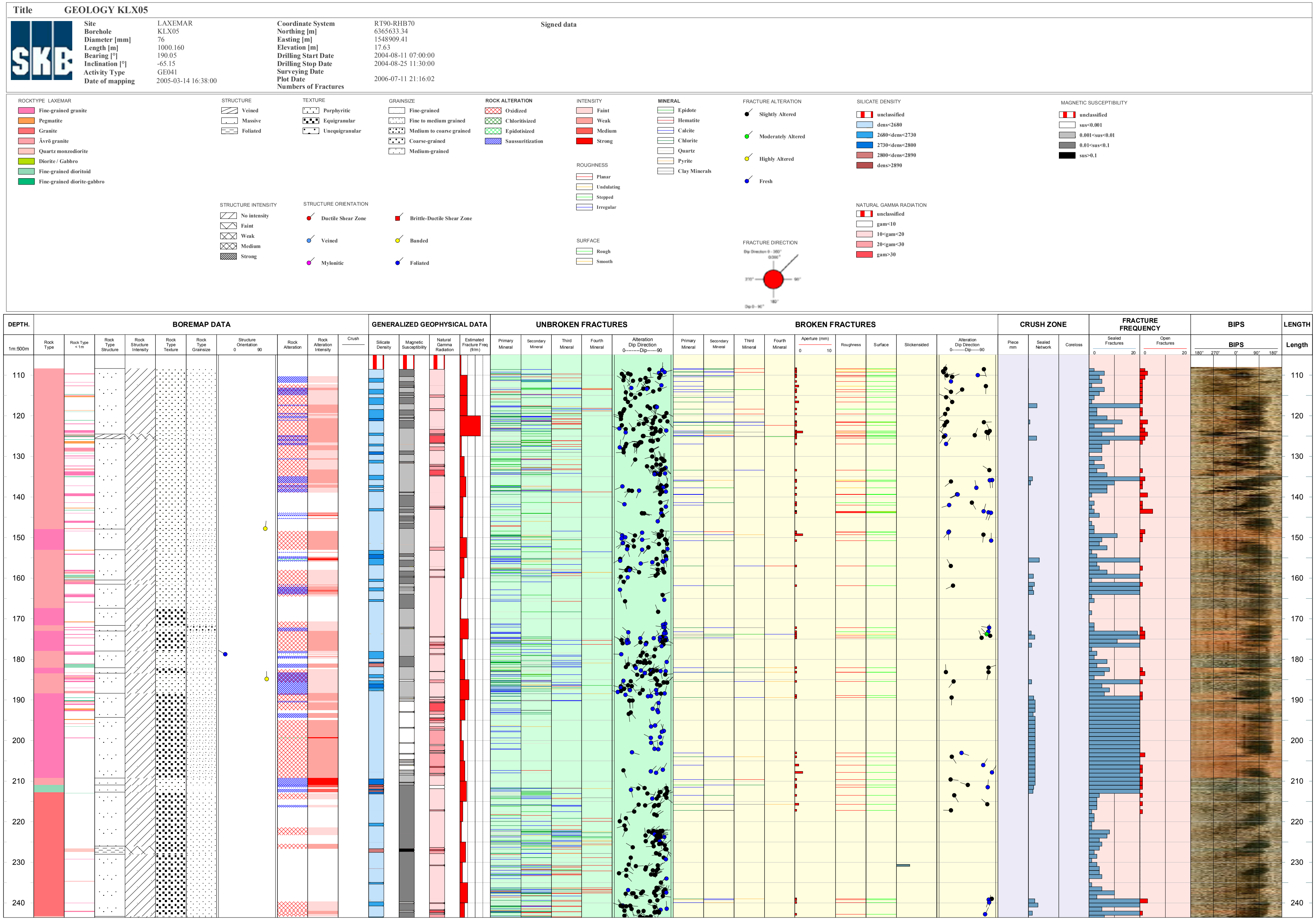

Figure 3-1. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.

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. All data to be used (see Chapter 3) 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.

The first step 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. This includes a brief description of the rock types affected by the possible deformation zone. The confidence in the interpretation of a rock unit is made on the following basis: 3 = high, 2 = medium and 1 = low.

The second step in the working procedure is to identify possible 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 possible 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 possible deformation zone is made on the following basis: 3 = high, 2 = medium and 1 = low.

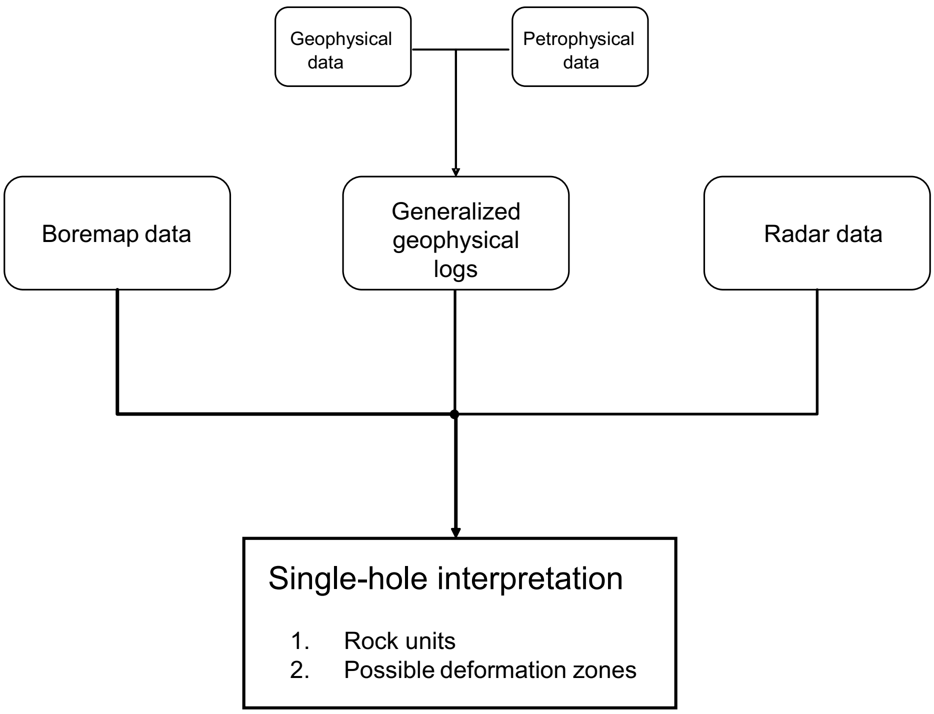

Figure 4-1. *Schematic block-scheme of single-hole interpretation.*

Inspection of BIPS images is carried out whenever 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.

Possible deformation zones that are ductile or brittle in character have been identified primarily on the basis of occurrence of protomylonitic to mylonitic foliation and the frequency of fractures, respectively, according to the recommendations in /1/. Both the transitional parts and the core part have been included in each zone (Figures 4-2 to 4-4). The fracture/m values in Figure 4-4 may serve only as examples. 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 primarily the brittle structures.

Since the frequency of fractures is of key importance for the definition of the possible deformation zones, a moving average plot for this parameter is shown for the cored borehole KLX21B (Figure 4-5). A 5 m window and 1 m steps have been used in the calculation procedure. The moving averages for open fractures alone, the total number of open fractures (open, partly open and crush), the sealed fractures alone, and the total number of sealed fractures (sealed and sealed fracture network) are shown in a diagram.

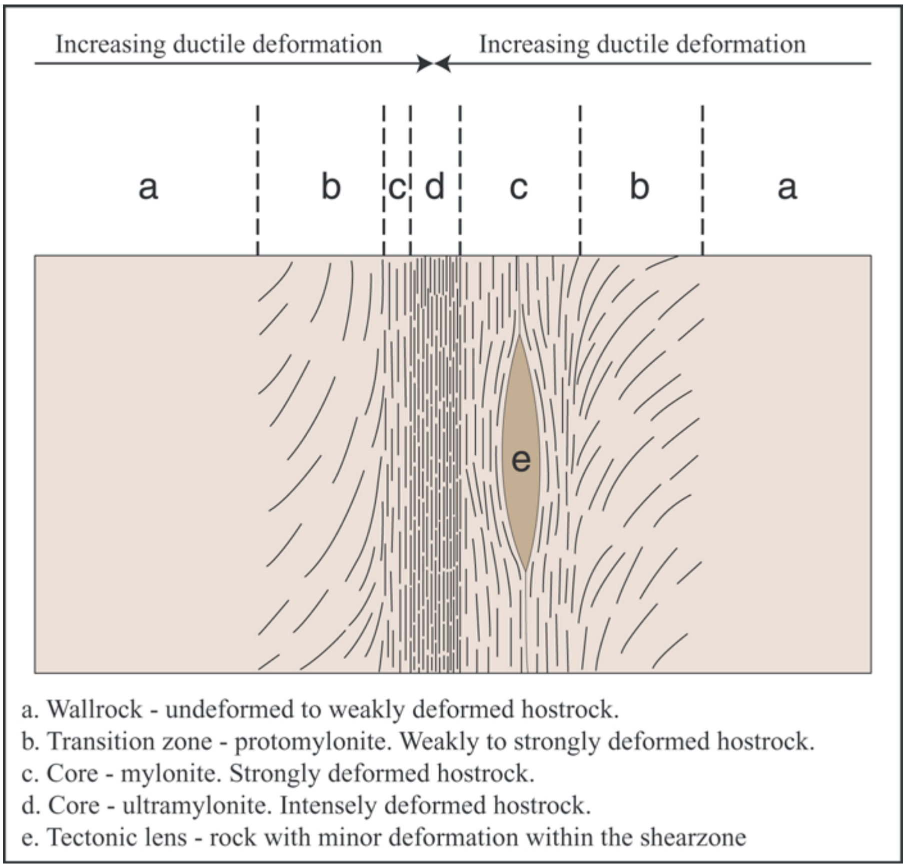

Figure 4-2. *Schematic example of a ductile shear zone. Homogeneous rock which is deformed under low- to medium-grade metamorphic conditions (after /1/).*

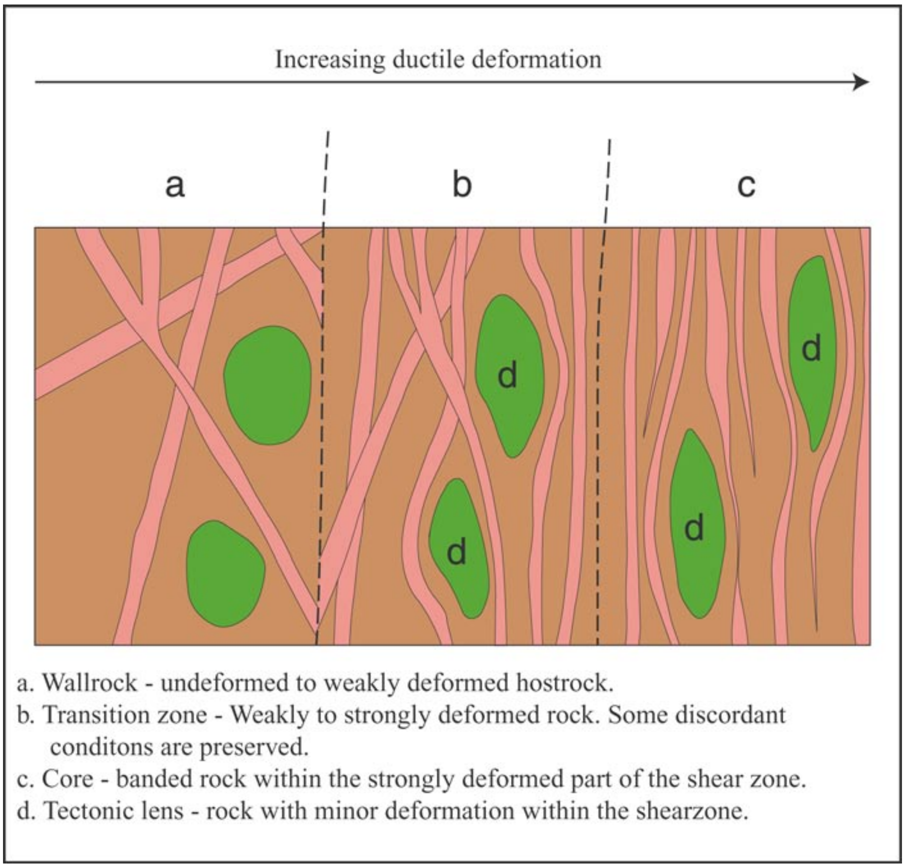

Figure 4-3. *Schematic example of a ductile shear zone. Heterogeneous rock which is deformed under low- to high-grade metamorphic conditions (after /1/).*

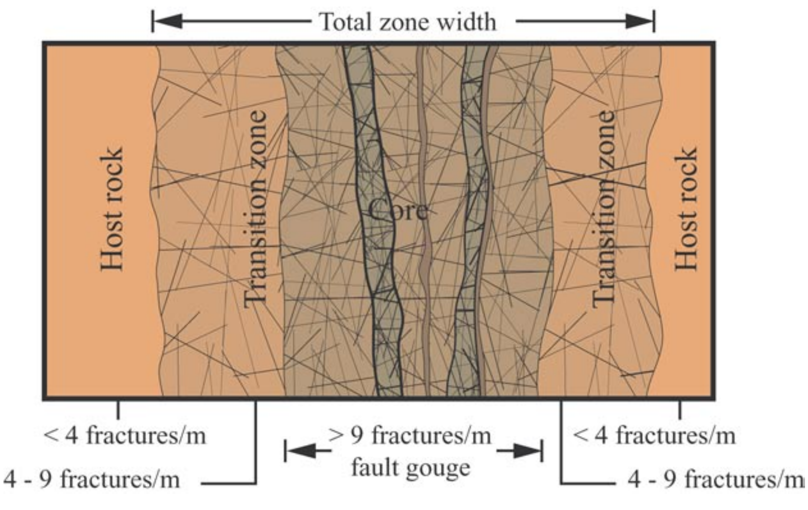

Figure 4-4. *Schematic example of a brittle deformation zone (after /1/).*

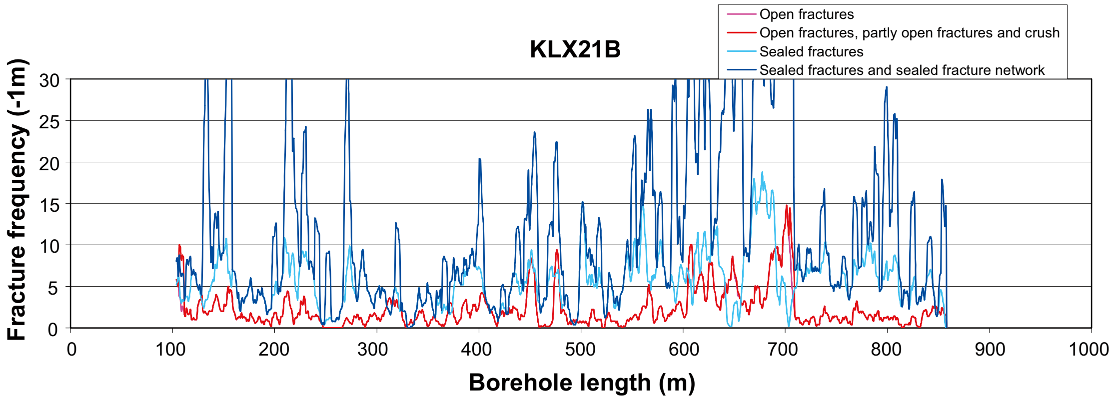

Figure 4-5. *Fracture frequency plot for KLX21B. Moving average with a 5 m window and 1 m steps.*

The occurrence and orientation of radar anomalies within these possible deformation zones are used during the identification of zones. Overview of the borehole radar measurement in KLX21B is shown in Figure 4-6 and for HLX40 in Figure 4-7. 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 strike/dip using the right-hand-rule method, e.g. 040/80 corresponds to a strike of N40°E and a dip of 80° to the SE.

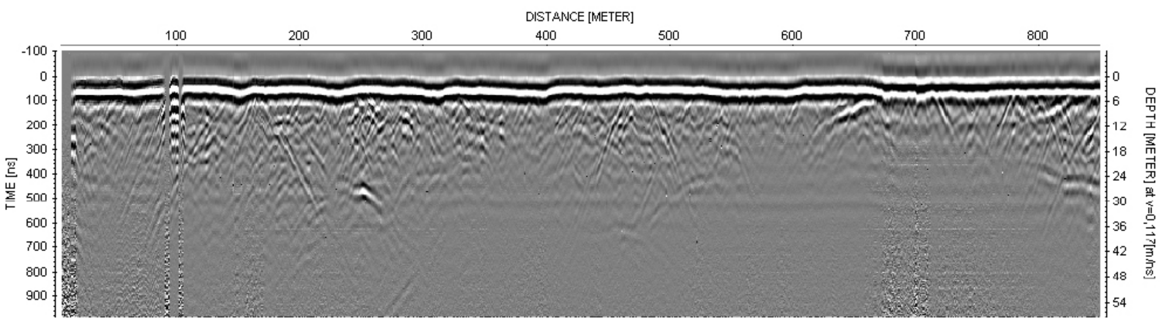

Figure 4-6. *Overview (20 MHz data) of the borehole radar measurement in KLX21B.*

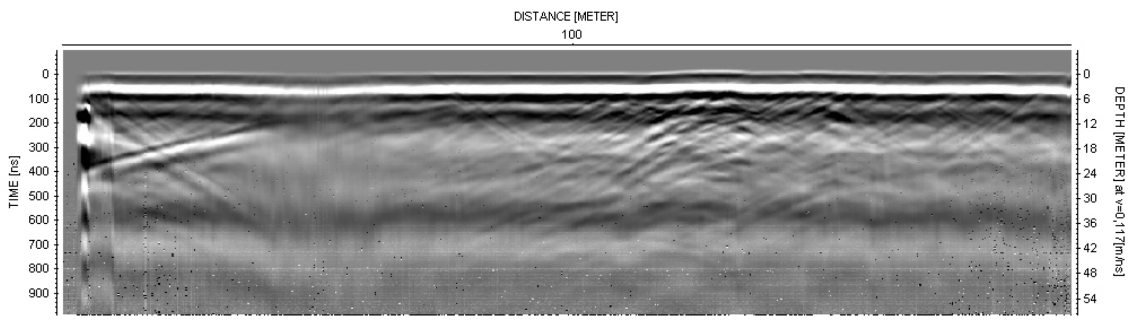

Figure 4-7. *Overview (20 MHz data) of the borehole radar measurement in HLX40.*

5 Results

The detailed result of the single-hole interpretation is presented as print-out from the software WellCad (Appendix 1 for KLX21B and Appendix 2 for HLX40).

5.1 KLX21B

Rock units

The borehole consists of three rock units (RU1, RU2 and RU3). However, due to repetition of RU1 (RU1a and RU1b) the borehole can be divided into four sections.

100.83–670.46 m

RU1: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained dioritoid (501030), diorite/gabbro (501033), fine-grained granite (511058), fine-grained diorite-gabbro (505102), pegmatite (501061) and granite (501058). The major part of the rock unit is characterized by faint to medium foliation. The Ävrö granite shows a bimodal density distribution with a density of around 2,680 kg/m^3 for about half of the section length and 2,720–2,760 kg/m^3 for the other half. The low density sections have a natural gamma radiation of 20–27 µR/h and the high density sections 15–22 µR/h .The magnetic susceptibility is in the range 0.02–0.04 SI. Confidence level = 3.

670.46–706.03 m

RU2: Totally dominated by fine-grained dioritoid (501030). Subordinate rock types comprise Ävrö granite (501044) and minor occurrences of granite (501058) and pegmatite (501061). The rock unit is characterized by faint foliation. Confidence level = 3.

706.03–768.11 m

RU1b: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), granite (501058) and fine-grained dioritoid (501030). The rock unit is characterized by faint to weak foliation. The Ävrö granite has a density in the range 2,710–2,750 kg/m^3. Confidence level = 3.

768.11–858.41 m

RU3: Dominated by quartz monzodiorite (501036). Subordinate rock types comprise scattered ≤ 10 m long sections of Ävrö granite (501044), diorite/gabbro (501033), fine-grained granite (511058), granite (501058) and very sparse occurrences of pegmatite (501061) and fine-grained diorite-gabbro (505102). The section 768–825 m is characterized by faint to medium foliation. Confidence level = 3.

Possible deformation zones

Twelve possible deformation zones have been recognised in KLX21B (DZ1–DZ12).

105.27–105.73 m

DZ1: Minor brittle deformation zone which is characterized by a slight increase in open fractures. Low electric resistivity. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

108.37–108.82

DZ2: Minor brittle deformation zone which is characterized by increased frequency of open and sealed fractures, crush and weak silicification. Low resistivity and P-wave velocity and caliper anomaly. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

150.00–157.80 m

DZ3: Brittle-ductile deformation zone characterized by cataclasites and breccia, weak red staining, inhomogeneous faint epidotization and medium chloritization, increased frequency of sealed fractures and sealed network. The most intensely deformed section is 155.40–156.92 m. Low resistivity, P-wave velocity and magnetic susceptibility, and caliper anomalies. One oriented and two non-oriented radar reflectors occur within DZ3. The oriented reflector occurs at 155.8 m with the orientation 111/31 or 302/71. The reflector is strong and can be observed to a distance of 24 m outside the borehole. The non-oriented reflectors occur at 152.0 m and 152.5 m with the angle 44° and 32° to borehole axis, respectively. Low radar amplitude occurs in the interval 135–161 m. The host rock is dominated by Ävrö granite (501044). Subordinate rock types are fine-grained granite (511058) and granite (501058). Confidence level = 3.

209.08–216.82 m

DZ4: Brittle deformation zone characterized by increased frequency of sealed fractures, cataclasites, faint to medium red staining, inhomogeneous faint epidotization, minor saussuritization and slickensides. Low resistivity, P-wave velocity and magnetic susceptibility. One oriented and two non-oriented radar reflectors occur within DZ4. The oriented reflector occurs at 213.5 m with the orientation 118/38. The reflector is medium in strength and can be observed to a distance of 10 m outside the borehole. The non-oriented reflectors occur at 209.3 m and 213.9 m with the angle 76° and 39° to borehole axis, respectively. Low radar amplitude occurs in the interval 212–242 m. The host rock is dominated by Ävrö granite (501044). Subordinate rock type is fine-grained granite (511058). Confidence level = 3.

229.70–231.50 m

DZ5: Brittle deformation zone characterized by increased frequency of sealed fractures, cataclasites, and medium to weak red staining. Low resistivity, P-wave velocity and magnetic susceptibility. One non-oriented reflector occurs at 231.4 m with the angle 50° to borehole axis. Low radar amplitude occurs in the interval 212–242 m. The host rock is dominated by Ävrö granite (501044). Subordinate rock type is very sparse occurrence of fine-grained granite (511058). Confidence level = 3.

396.95–397.10 m

DZ6: Brittle deformation zone characterized by cataclasites and slickensides. Minor low-resistivity anomaly. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

400.64–403.49 m

DZ7: Brittle deformation zone characterized by increased frequency of sealed fractures, cataclasites, weak to medium red staining, inhomogeneous weak epidotization and slickensides. Low resistivity, P-wave velocity and magnetic susceptibility. Two non-oriented reflectors occur at 400.6 m and 403.8 m with the angle 42° and 59° to borehole axis, respectively. The host rock is a mixture of Ävrö granite (501044) and fine-grained diorite-gabbro (505102). Subordinate rock types are sparse occurrences of fine-grained granite (511058) and pegmatite (501061). Confidence level = 3.

452.06–455.90 m

DZ8: Brittle deformation zone characterized by increased frequency of sealed fractures, slight increased frequency of open fractures, cataclasites, faint to medium red staining and minor strong epidotization. Low P-wave velocity and magnetic susceptibility. One oriented and one non-oriented radar reflector occurs within DZ8. The oriented reflector occurs at 454.0 m with the orientation 193/63. The reflector is medium in strength and can be observed to a distance of 6 m outside the borehole. The non-oriented reflector occurs at 454.3 m with the angle 50° to borehole axis. The host rock is dominated by Ävrö granite (501044). Subordinate rock type is sparse occurrence of fine-grained granite (511058). Confidence level = 3.

474.41–478.10 m

DZ9: Brittle deformation zone characterized by increased frequency of sealed fractures, moderate increase in open fractures and weak red staining. Low resistivity, P-wave velocity and magnetic susceptibility, and caliper anomalies. Two non-oriented radar reflectors occur at 475.0 m and 477.5 m with the angle 40° and 49° to borehole axis, respectively. The reflector at 475.0 m is strong and can be observed to a distance of 11 m outside the borehole. Low radar amplitude occurs in the interval 470–476 m. The host rock is dominated by fine-grained granite (511058). Subordinate rock type is Ävrö granite (501044). Confidence level = 3.

558.90–571.75 m

DZ10: Inhomogeneous brittle deformation zone characterized by increased frequency of sealed fractures, slight increase in open fractures, breccias, cataclasites, weak to medium red staining and slickensides. Low resistivity, P-wave velocity and magnetic susceptibility. One oriented and three non-oriented radar reflectors occur within DZ10. The oriented reflector occurs at 565.9 m with the orientation 037/16 or 289/45. The non-oriented reflectors occur at 561.3 m, 567.0 m and 570.4 m with the angle 66°, 74° and 46° to borehole axis, respectively. Low radar amplitude occurs in the interval 566–571 m. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

577.67–578.06 m

DZ11: Brittle-ductile deformation zone. Increased frequency of sealed fractures, medium red staining and slickensides. Minor low-resistivity anomaly. One non-oriented radar reflector occurs at 578.2 m with the angle 56°. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

595.45–706.95 m

DZ12: Inhomogeneous low-grade, ductile deformation zone overprinted by brittle deformation. It is characterized by increased frequency of sealed fractures, moderate increase in open fractures, some of which have large apertures, three crush zones, mylonites, cataclasites, brittle-ductile shear zones, breccias, faint to strong red staining, inhomogeneous faint to weak epidotization and slickensides. The most intensely deformed sections are 605.05–609.70 m (mainly ductile), 638.78–657.88 m and 672.60–706.95 m. Low magnetic susceptibility throughout the entire section. Low resistivity and P-wave velocity in the sections 605–609 m, 624–631 m and 670–706 m. Three oriented reflectors occur at 615.0 (orientation 318/67), 675.9 m (orientation 331/74) and at 706.9 m (orientation 054/41). The reflectors are rather strong and can be observed to a distance of 9–12 m outside the borehole. 18 non-oriented reflectors occur within DZ12. The angle to borehole axis is from 9° to 76°. Low radar amplitude occurs in the interval 660–707 m. The host rock is dominated by Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types are diorite/gabbro (501033), fine-grained granite (511058), pegmatite (501061), granite (501058) and fine-grained diorite-gabbro (505102). Confidence level = 3.

5.2 HLX40

Rock units

The borehole consists of one rock unit (RU1).

6.81–199.06 m

RU1: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise diorite/gabbro (501033), fine-grained granite (511058), pegmatite (501061) and fine-grained diorite-gabbro (505102). Confidence level = 3.

Possible deformation zones

One possible deformation zone has been recognised in HLX40 (DZ1).

49.8–59.6 m

DZ1: Brittle deformation zone characterized by slight increase in open fractures, apertures, one of which is 10 mm, and medium red staining. Low resistivity, P-wave velocity and magnetic susceptibility, caliper anomalies. One non-oriented radar reflector occurs at 53.3 m with the angle 90° to borehole axis. Host rock is dominated by Ävrö granite (501044). Confidence level = 2.

6 Comments

The results from the geological single-hole interpretation of KLX21B and HLX40 are presented in a WellCad plot (Appendices 1–2). The WellCad plot consists of the following columns:

In data Boremap	1: Depth (Length along the borehole)
	2: Rock type
	3: Rock alteration
	4: Frequency of sealed fractures
	5: Frequency of 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)

7 References

/1/ **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 R-03-07, Svensk Kärnbränslehantering AB.

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/6/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX11B, KLX11C, KLX11D, KLX11E, KLX11F, KLX18A, KLX20A, HLX38 and HLX40 and BIPS and deviation logging in KLX19A. SKB P-06-159. Svensk Kärnbränslehantering AB.

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Appendix 1

Geological single-hole interpretation of KLX21B

Title	SINGLE HOLE INTERPRETATION KLX21B					
Site	LAXEMAR	Inclination [°]	-70.85	Elevation [m.a.s.l.]	10.61	Signed data
Borehole	KLX21B	Date of mapping	2007-01-30 15:06:00	Drilling Start Date	2006-09-20 07:00:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2006-09-25 19:00:00	
Length [m]	858.780	Northing [m]	6366163.18	Surveying Date		
Bearing [°]	225.05	Easting [m]	1549715.15	Plot Date	2007-10-14 22:03:05	

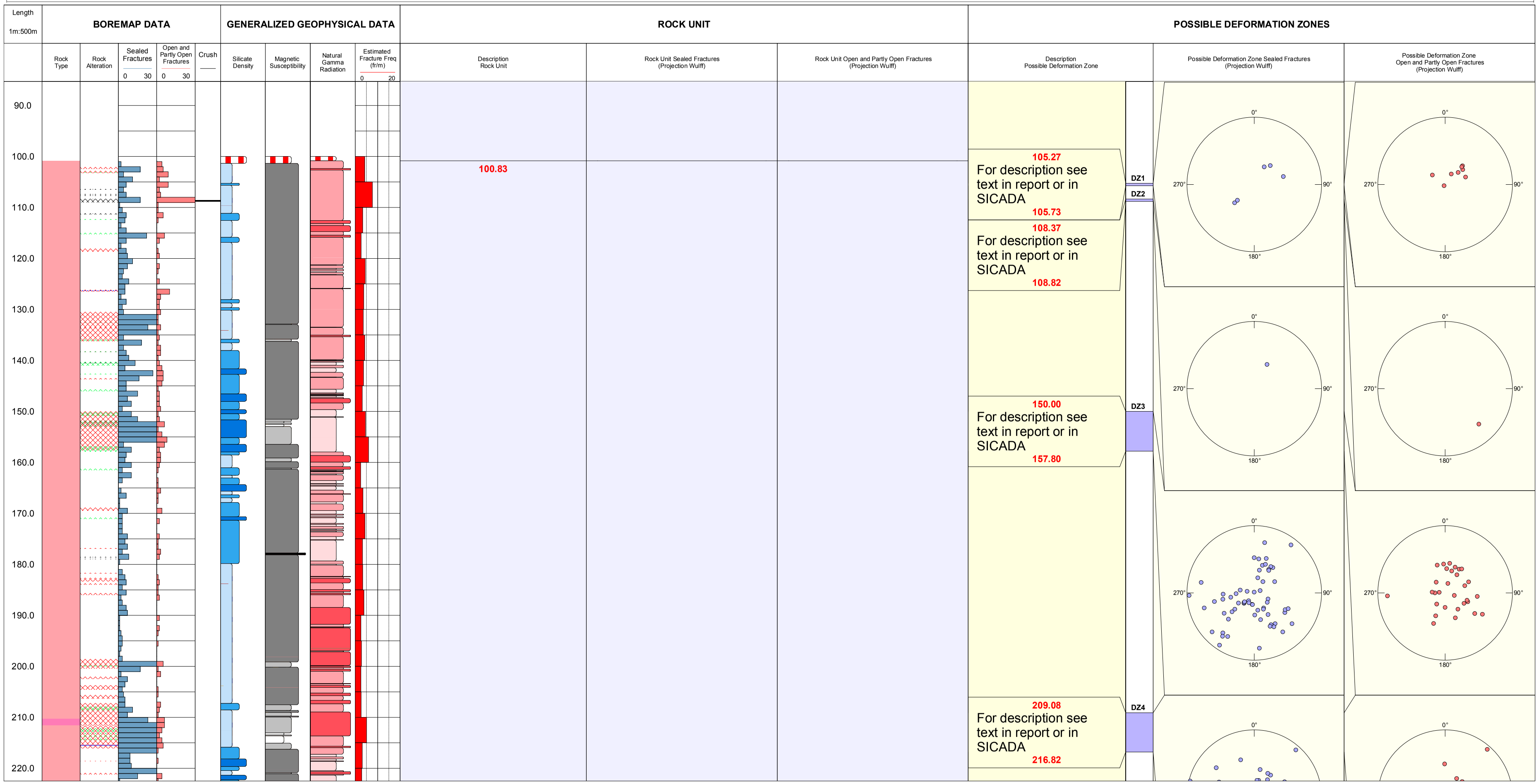
ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Quartz monzodiorite
- Diorite / Gabbro
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

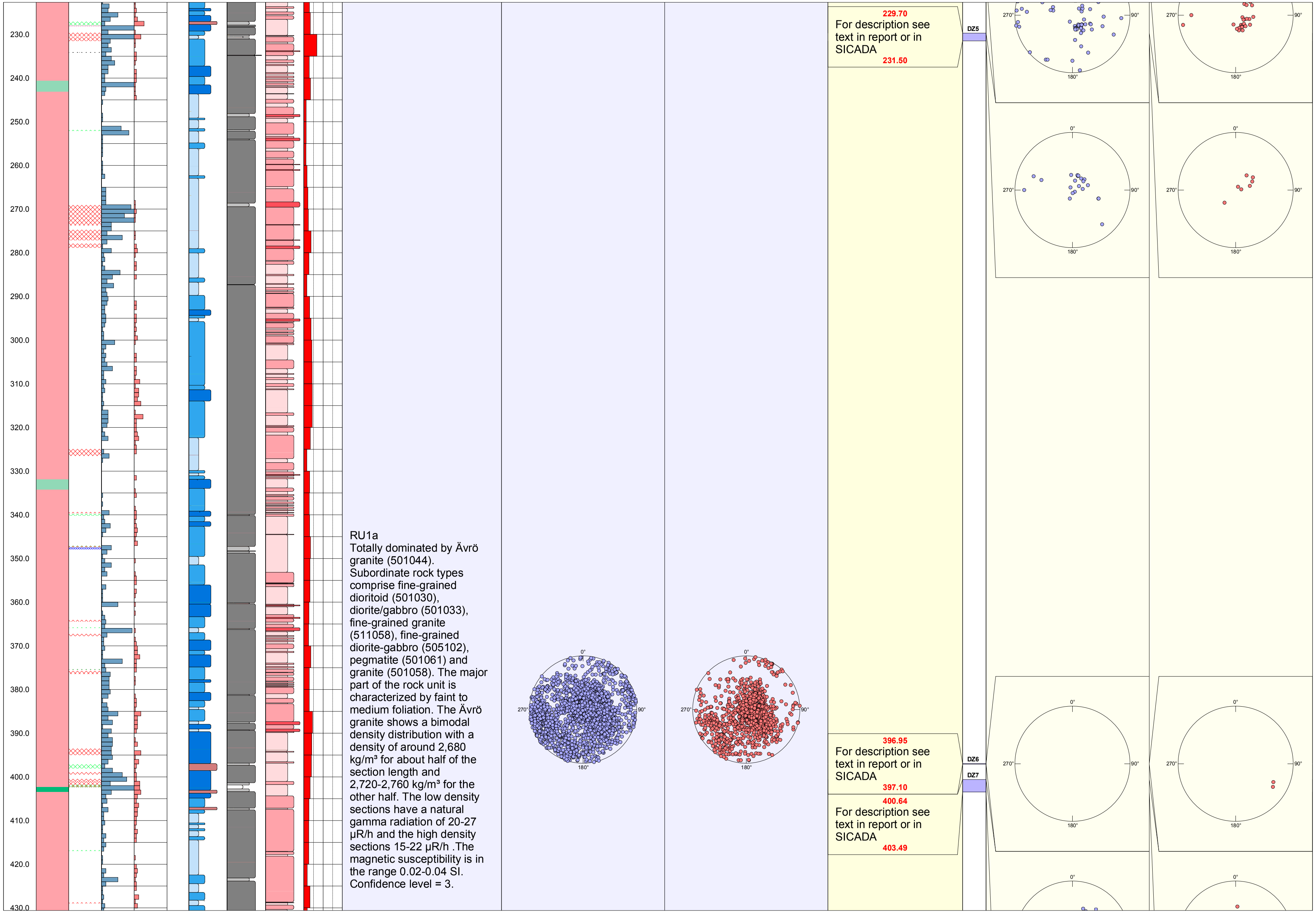
ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Silicification
- Albitization
- Saussuritization

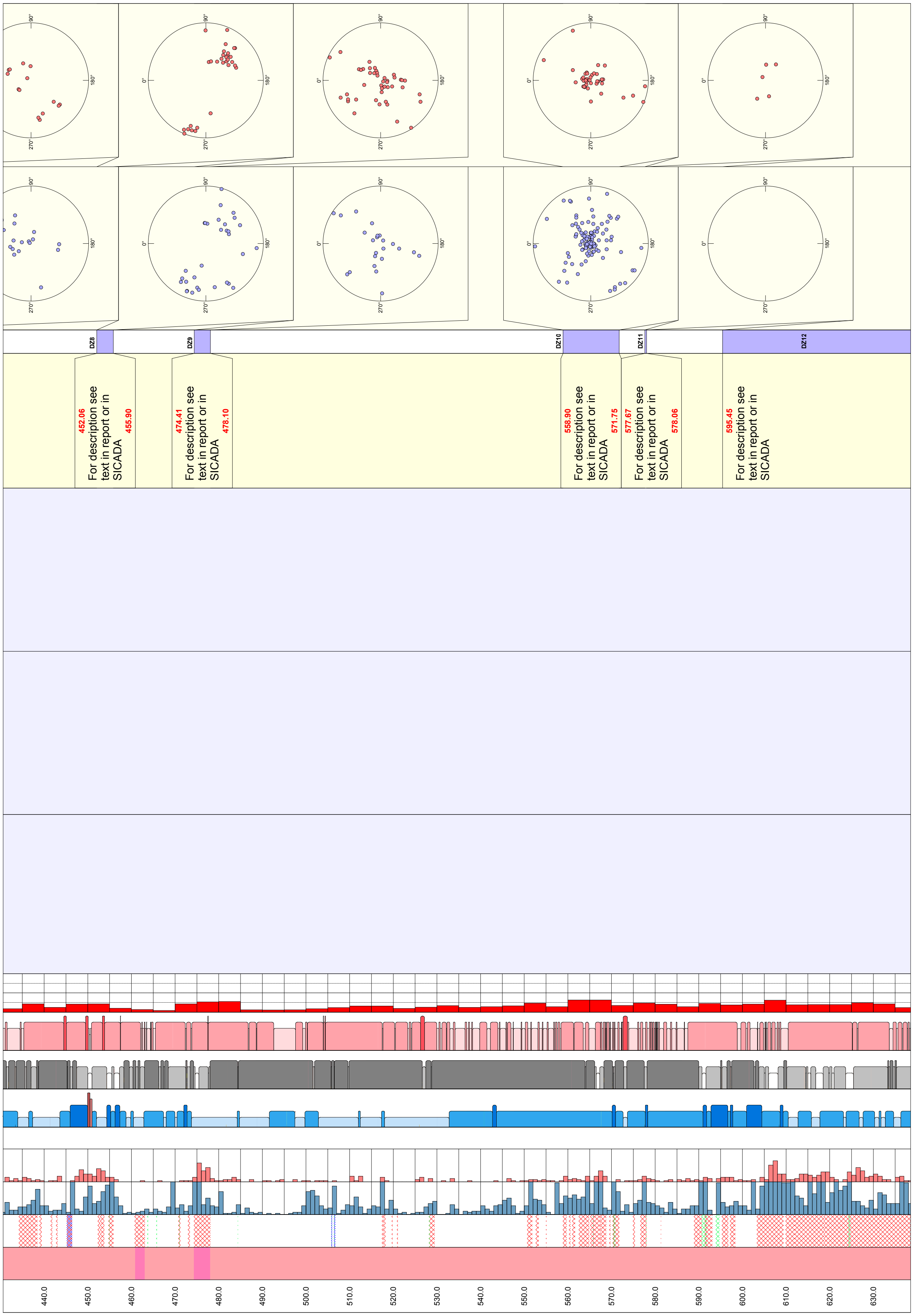
SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2730<dens<2800
- 2800<dens<2890
- dens>2890

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




230.0
240.0
250.0
260.0
270.0
280.0
290.0
300.0
310.0
320.0
330.0
340.0
350.0
360.0
370.0
380.0
390.0
400.0
410.0
420.0
430.0
RU1a
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained dioritoid (501030), diorite/gabbro (501033), fine-grained granite (511058), fine-grained diorite-gabbro (505102), pegmatite (501061) and granite (501058). The major part of the rock unit is characterized by faint to medium foliation. The Ävrö granite shows a bimodal density distribution with a density of around 2,680 kg/m³ for about half of the section length and 2,720-2,760 kg/m³ for the other half. The low density sections have a natural gamma radiation of 20-27 μR/h and the high density sections 15-22 μR/h .The magnetic susceptibility is in the range 0.02-0.04 SI. Confidence level = 3.
229.70
For description see text in report or in SICADA
231.50
396.95
For description see text in report or in SICADA
397.10
400.64
For description see text in report or in SICADA
403.49
DZ5
DZ6
DZ7


DZ8
DZ9
DZ10
DZ11
DZ12
452.06 For description see text in report or in SICADA 455.90
474.41 For description see text in report or in SICADA 478.10
558.90 For description see text in report or in SICADA 571.75
577.67 For description see text in report or in SICADA 578.06
595.45 For description see text in report or in SICADA
440.0
450.0
460.0
470.0
480.0
490.0
500.0
510.0
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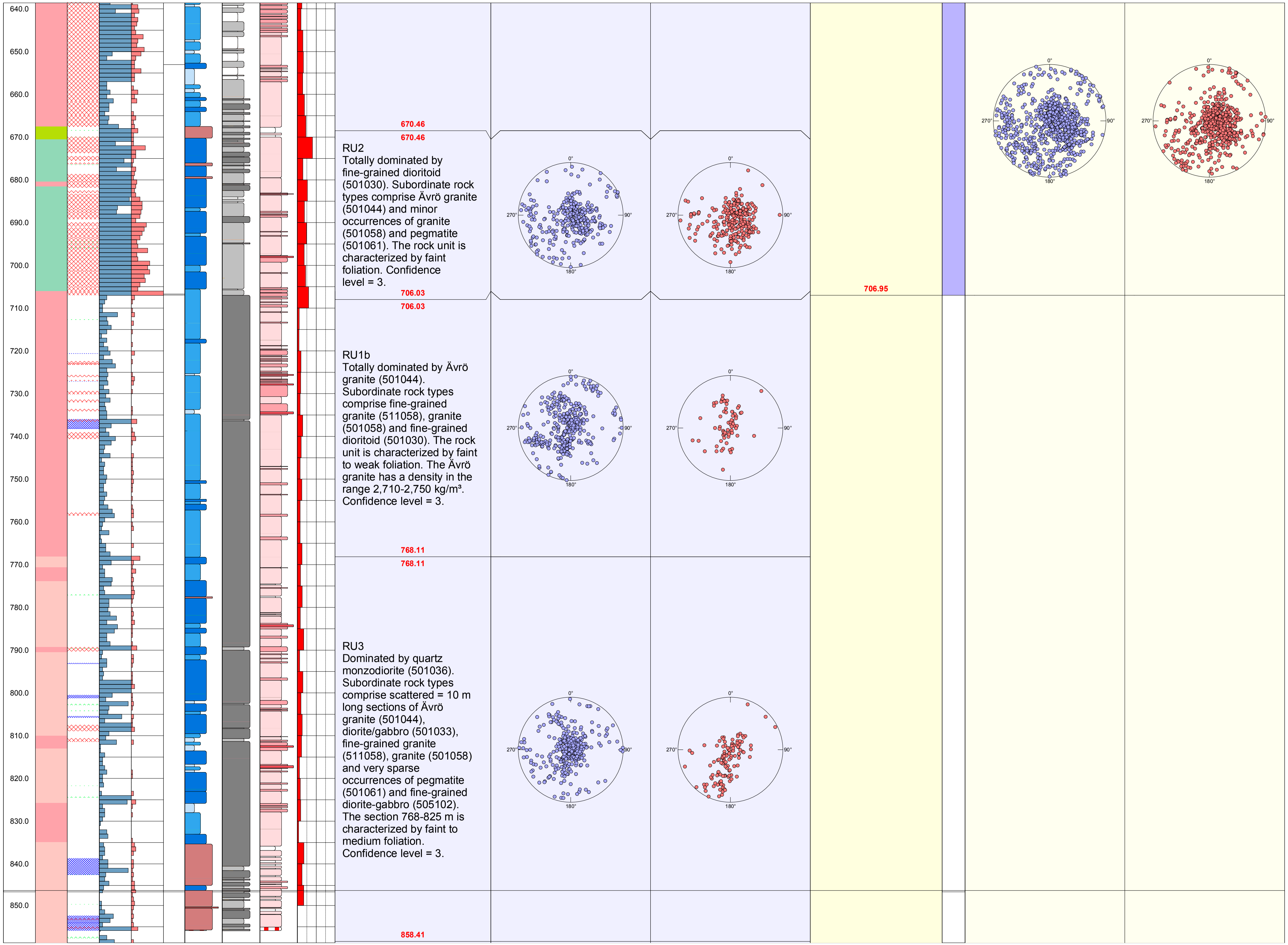
620.0
630.0


640.0
650.0
660.0
670.0
680.0
690.0
700.0
710.0
720.0
730.0
740.0
750.0
760.0
770.0
780.0
790.0
800.0
810.0
820.0
830.0
840.0
850.0
670.46
670.46
RU2
Totally dominated by fine-grained dioritoid (501030). Subordinate rock types comprise Ävrö granite (501044) and minor occurrences of granite (501058) and pegmatite (501061). The rock unit is characterized by faint foliation. Confidence level = 3.
706.03
706.03
RU1b
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), granite (501058) and fine-grained dioritoid (501030). The rock unit is characterized by faint to weak foliation. The Ävrö granite has a density in the range 2,710-2,750 kg/m³. Confidence level = 3.
768.11
768.11
RU3
Dominated by quartz monzodiorite (501036). Subordinate rock types comprise scattered = 10 m long sections of Ävrö granite (501044), diorite/gabbro (501033), fine-grained granite (511058), granite (501058) and very sparse occurrences of pegmatite (501061) and fine-grained diorite-gabbro (505102). The section 768-825 m is characterized by faint to medium foliation. Confidence level = 3.
858.41
706.95
0°
90°
180°
270°

Appendix 2

Geological single-hole interpretation of HLX40

Title SINGLE HOLE INTERPRETATION HLX40

Site	LAXEMAR	**Inclination [°]**	-59.81	**Elevation [m.a.s.l.]**	25.74	**Signed data**
Borehole	HLX40	**Date of mapping**	2006-07-04 16:59:00	**Drilling Start Date**	2006-05-02 16:15:00	
Diameter [mm]	138	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2006-05-09 12:30:00	
Length [m]	199.500	**Northing [m]**	6366906.76	**Surveying Date**		
Bearing [°]	11.03	**Easting [m]**	1546943.95	**Plot Date**	2007-10-15 22:03:14	

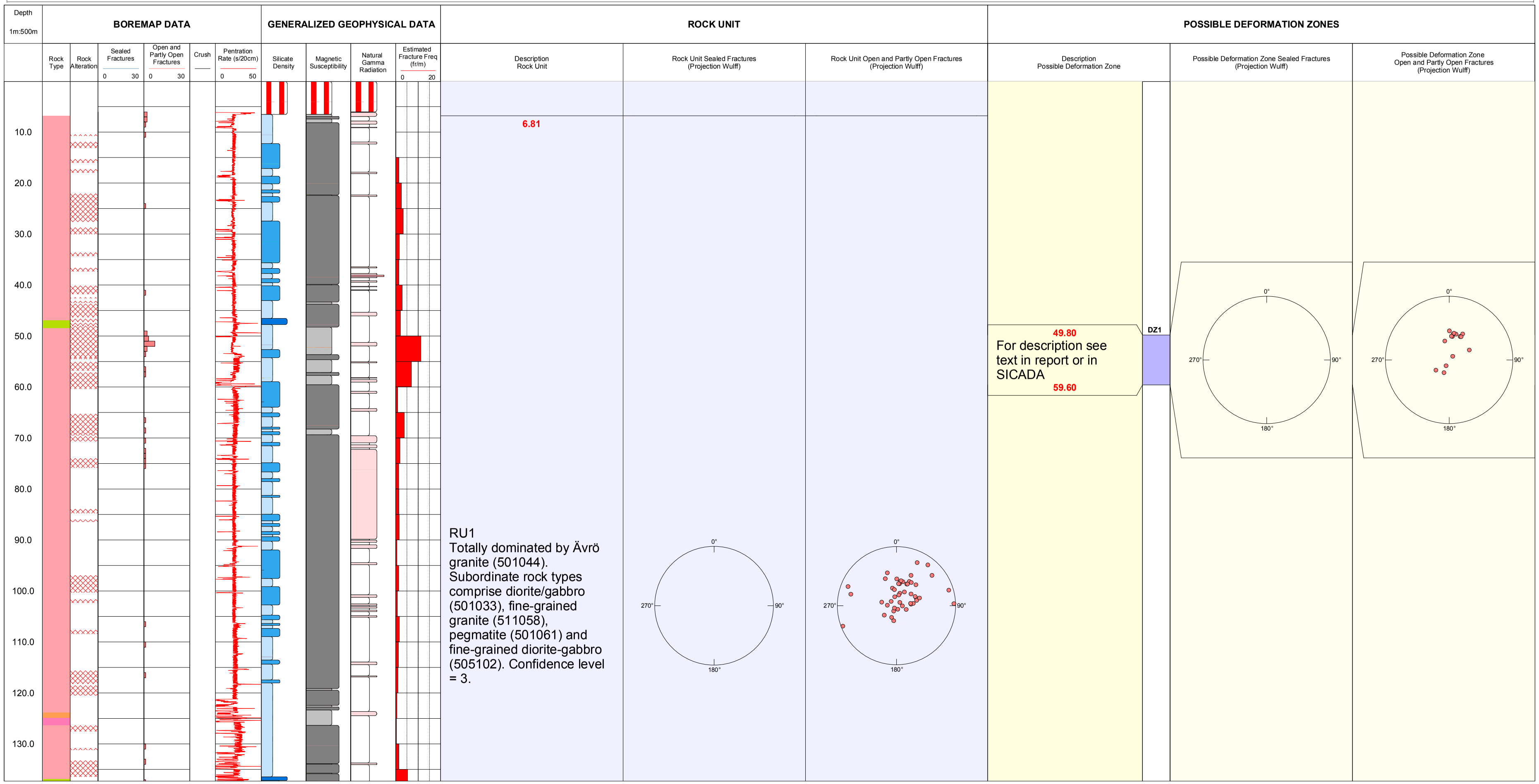
ROCKTYPE LAXEMAR
- Fine-grained granite
- Pegmatite
- Ävrö granite
- Diorite / Gabbro

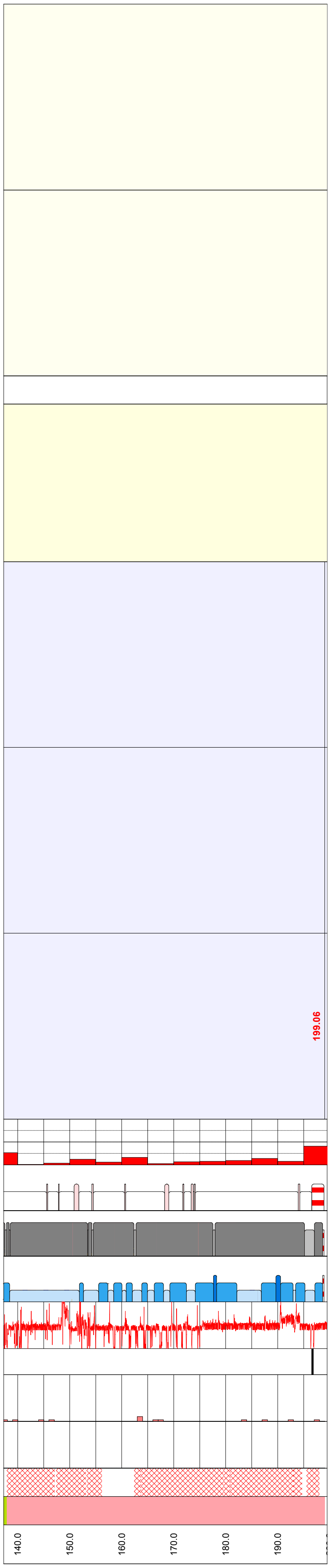
ROCK ALTERATION
- Oxidized

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

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

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




199.06
140.0
150.0
160.0
170.0
180.0
190.0