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Data in SKB's database can be changed for different reasons. Minor changes in SKB's database will not necessarily result in a revised report. Data revisions may also be presented as supplements, available at www.skb.se.

A pdf version of this document can be downloaded from www.skb.se.

Abstract

This report contains geological single-hole interpretation of the cored borehole KLX09 and the percussion borehole HLX37 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 borehole.

Seven rock units are indicated in KLX09 (RU1–RU7). However, the borehole can be divided into nine separate sections due to the repetition of RU1 and RU4 (RU1a, RU1b, RU4a and RU4b). In general KLX09 is dominated by Ävrö granite (501044) and a mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). A section in the central part of the borehole contains fine-grained diorite-gabbro (505102). Subordinate rock types comprise occurrences of fine-grained diorite-gabbro (505102), fine-grained granite (511058), quartz monzodiorite (501036), fine-grained dioritoid (501030), granite (501058), diorite/gabbro (501033) and pegmatite (501061). Eighteen possible deformation zones are identified in KLX09 (DZ1–DZ18).

The geological single-hole interpretation shows that two rock units (RU1–RU2) occur in percussion borehole HLX37. However, the borehole can be divided into three separate sections due to the repetition of RU1 (RU1a and RU1b). The borehole is dominated by quartz monzodiorite (501036) in the upper and lower parts, and by dolerite (501027) in the central part of the borehole. Subordinate rock type comprises fine-grained granite (511058). One possible deformation zone is identified in HLX37 (DZ1).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhål KLX09 och hammarborrhål HLX37 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.

Sju litologiska enheter (RU1–RU7) har identifierats i KLX09. Baserat på repetition av enheterna RU1 och RU4 (RU1a, RU1b, RU4a och RU4b) kan borrhålet delas in i nio sektioner. Generellt sett domineras borrhålet av Ävrögranit (501044) och av en blandning mellan Ävrögranit (501044) och finkornig dioritoid (501030). En sektion i den centrala delen av borrhålet består av finkornig diorit-gabbro (505102). Finkornig diorit-gabbro (505102), finkornig granit (511058), kvartsmonzodiorit (501036), finkornig dioritoid (501030), granit (501058), diorit/gabbro (501033) och pegmatit (501061) förekommer som underordnade bergarter. Arton möjliga deformationszoner har identifierats i KLX09 (DZ1–DZ18).

Den geologiska enhålstolkningen visar att det förekommer två litologiska enheter i hammarborrhål HLX37 (RU1–RU2). Baserat på en repetition av enheten RU1 (RU1a och RU1b) kan borrhålet delas in i tre sektioner. Den övre och den undre delen av borrhålet domineras av kvartsmonzodiorit (501036), medan den centrala delen domineras av diabas (501027). Finkornig granit (511058) förekommer som underordnad bergart. En möjlig deformationszon har identifierats i HLX37 (DZ1).

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 interpretations of boreholes KLX09 and HLX37 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 Plans AP PS 400-06-047 and AP PS 400-06-018. 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.

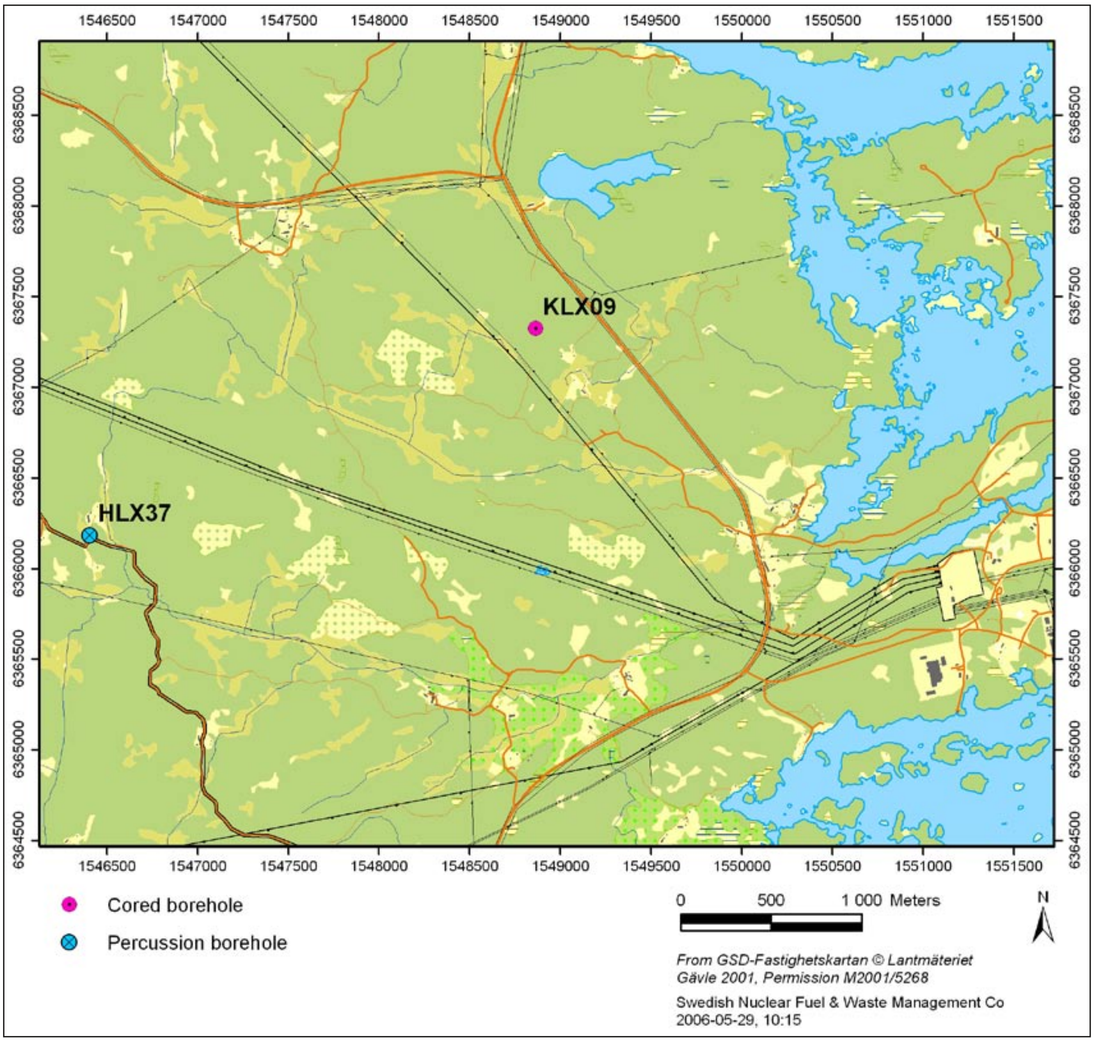


Figure 1-1. *Map showing the position of the cored borehole KLX09 and the percussion borehole HLX37.*

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

Activity Plan	Number	Version
Geologisk enhålstolkning av KLX09 och HLX37	AP PS 400-06-047	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 *S*ystem (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 the boreholes KLX09 and HLX37:

- Boremap data (including BIPS and geological mapping data) /2, 3/.
- Generalized geophysical logs and their interpretation /4, 5/.
- Radar data and their interpretation /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 nine main columns and several subordinate columns. These include nine main:

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 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.

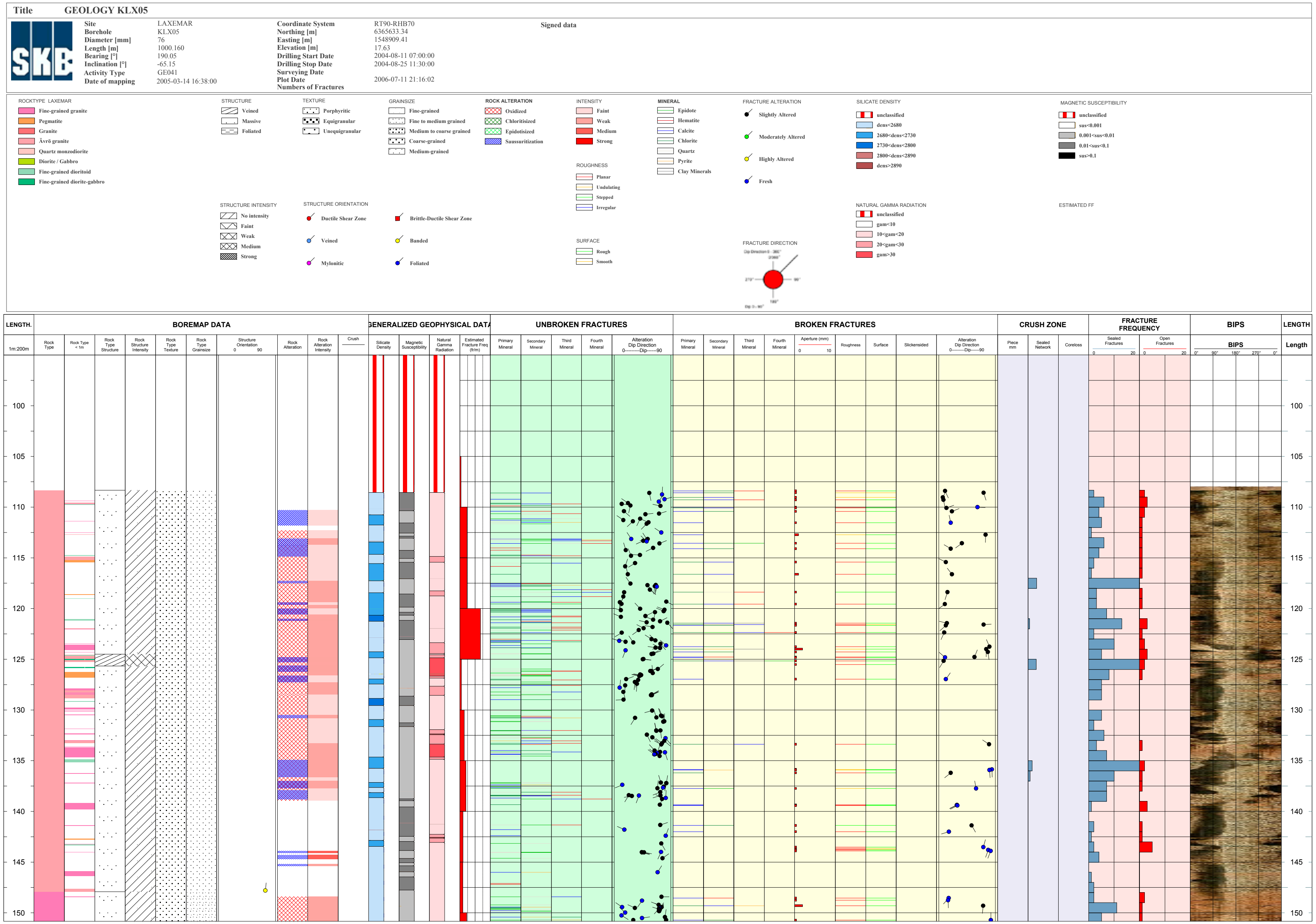


Figure 3-1. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.

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. 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.

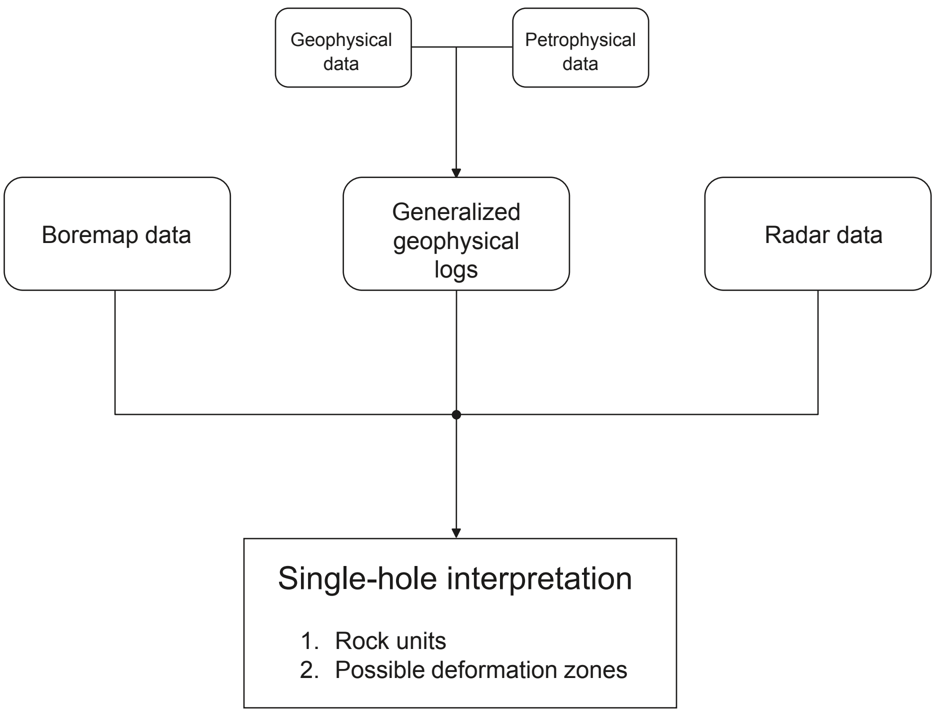
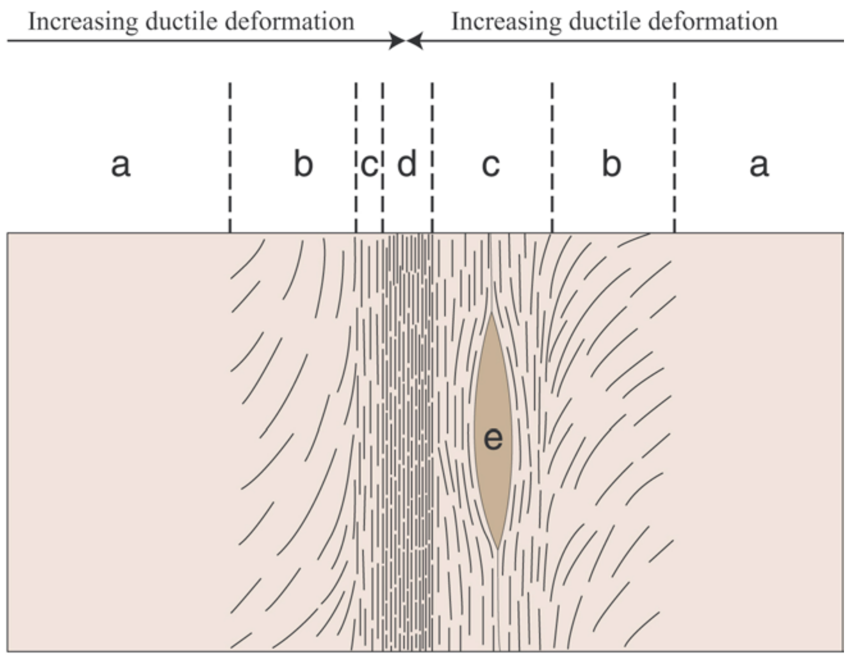


Figure 4-1. Schematic block-scheme of single-hole interpretation.

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 KLX09 (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.



a. Wallrock - undeformed to weakly deformed hostrock.
b. Transition zone - protomylonite. Weakly to strongly deformed hostrock.
c. Core - mylonite. Strongly deformed hostrock.
d. Core - ultramylonite. Intensely deformed hostrock.
e. Tectonic lens - rock with minor deformation within the shearzone

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

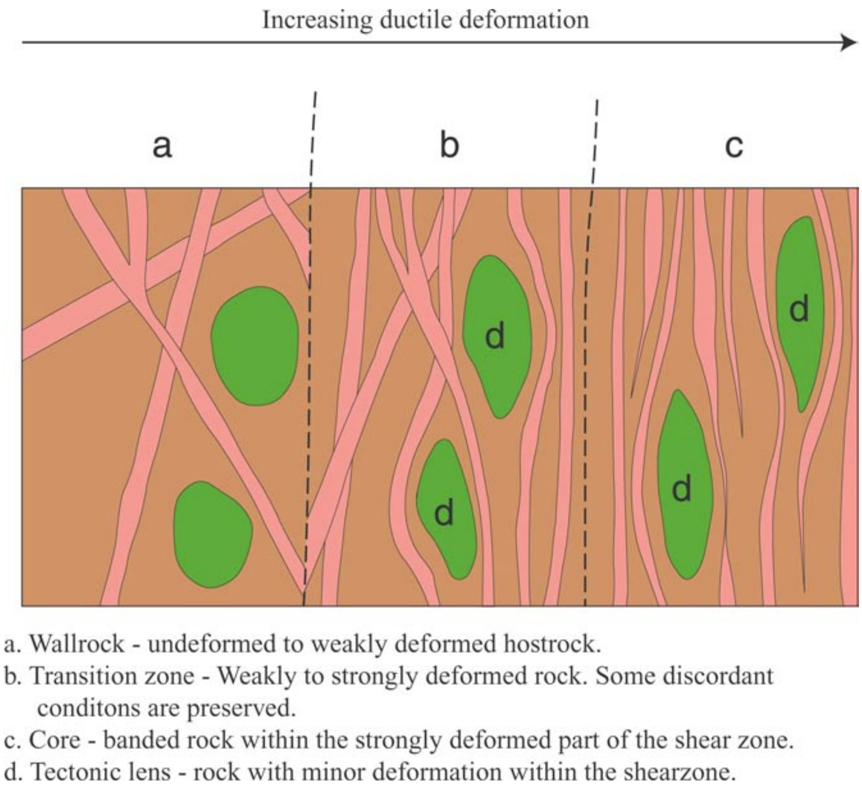


Figure 4-3. *Schematic example of a ductile shear zone. Heterogeneous rock which is deformed under low to high grade metamorphic conditions (after /1/).*

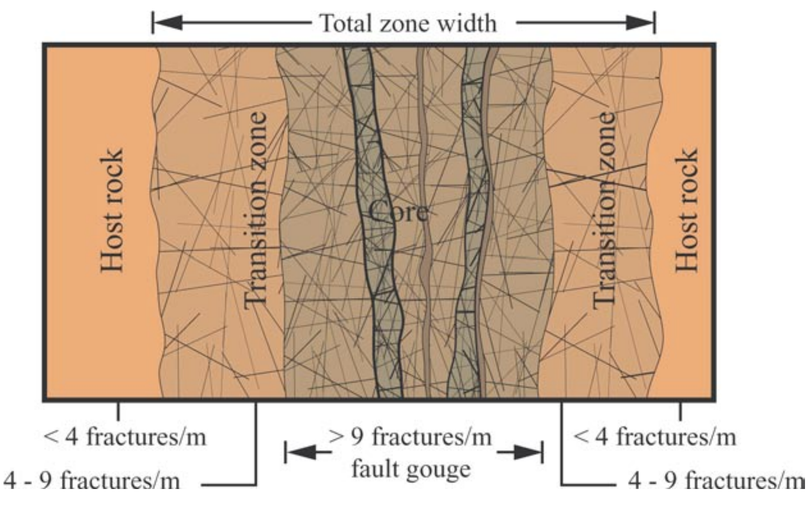


Figure 4-4. *Schematic example of a brittle deformation zone (after /1/).*

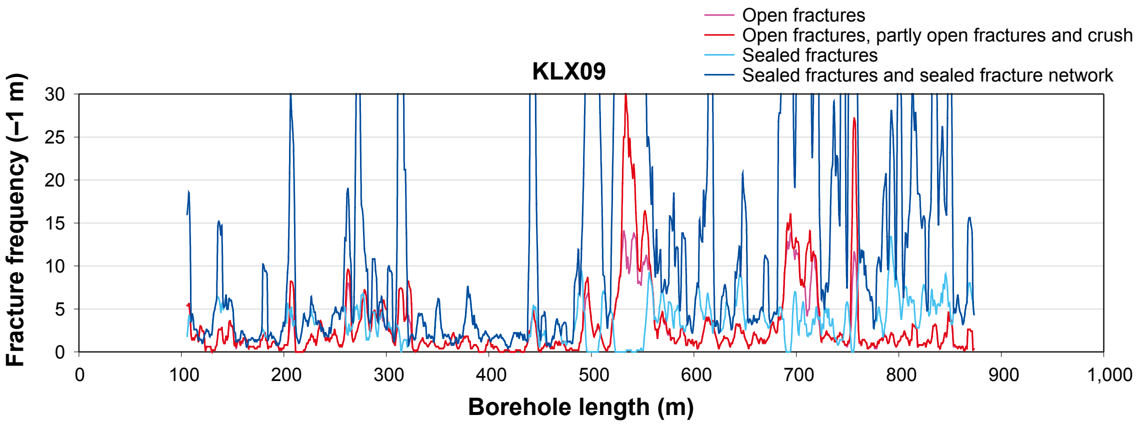


***Figure 4-5.** Fracture frequency plot for KLX09. Moving average with a 5 m window and 1 m steps.*

The occurrence and orientation of radar anomalies within these possible deformation zones are used during the identification of zones. Overviews of the borehole radar measurement in KLX09 and HLX37 are shown in Figures 4-6 and 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.

4.2 Nonconformities

The result from the kinematics investigation performed by NGU (Norwegian Geological Survey) was available during the single-hole interpretation of KLX09.

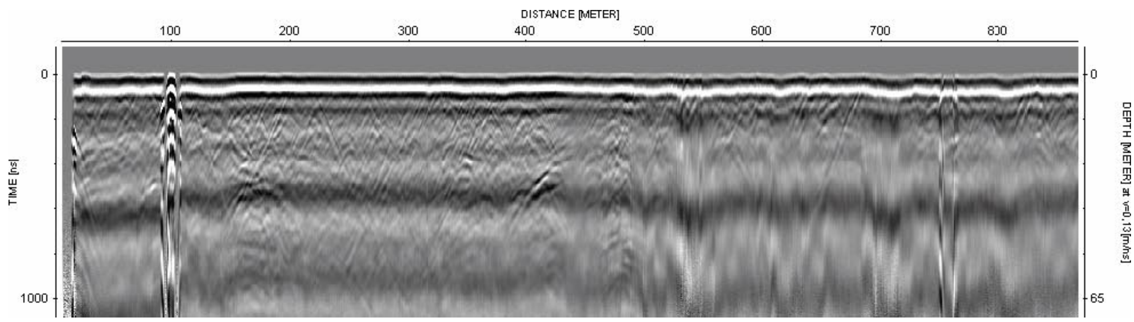


***Figure 4-6.** Overview (20 MHz data) of the borehole radar measurement in KLX09.*

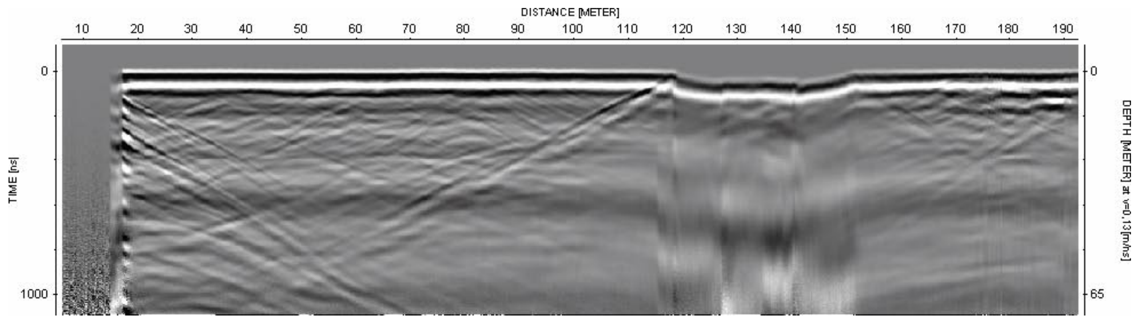


***Figure 4-7.** Overview (20 MHz data) of the borehole radar measurement in HLX37.*

5 Results

The detailed results of the single-hole interpretations are presented as print-outs from the software WellCad (Appendix 1 for KLX09 and Appendix 2 for HLX37).

5.1 KLX09

Rock units

The borehole can be divided into seven rock units (RU1–RU7). However, the borehole can be divided into nine separate sections due to the repetition of RU1 and RU4 (RU1a, RU1b, RU4a and RU4b).

102.02–319.55 m

RU1a: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise minor occurrences of fine-grained granite (511058), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030), quartz monzodiorite (501036), granite (501058) and pegmatite (501061). Scattered ≤ c. 7 m long sections are foliated. The Ävrö granite has a density in the range 2,650–2,685 kg/m^3, except for a section ranging from 119 m to 148 m that has a density of 2,720–2,770 kg/m^3. Confidence level = 3.

319.55–408.58 m

RU2: Mixture of Ävrö granite (501044) and fine-grained diorite-gabbro (505102). Subordinate rock type comprises fine-grained dioritoid (501030), granite (501058), pegmatite (501061) and fine-grained granite (511058). The Ävrö granite has a density in the range 2,650–2,670 kg/m^3. Scattered ≤ c. 7 m long sections are foliated. Confidence level = 3.

408.58–485.11 m

RU3: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise ≤ c. 7 m long sections of quartz monzodiorite (501036) and scattered minor sections of fine-grained granite (511058), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030) and pegmatite (501061). The Ävrö granite has a density in the range 2,650–2,680 kg/m^3. Scattered minor sections are foliated. Confidence level = 3.

485.11–535.85 m

RU4a: Mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030), granite (501058) and pegmatite (501061). The Ävrö granite has a density in the range 2,620–2,650 kg/m^3 (the recorded density is possibly affected by overprinting deformation zone, see below). High frequency of sealed fractures. Confidence level = 3.

535.85–553.01 m

RU1b: Totally dominated by Ävrö granite (501044). Subordinate rock type comprises fine-grained granite (511058), fine-grained dioritoid (501030), granite (501058) and pegmatite (501061). The Ävrö granite has a density in the range 2,620–2,650 kg/m^3 (the recorded density is possibly affected by overprinting deformation zone, see below). High frequency of sealed fractures. Confidence level = 3.

553.01–589.72 m

RU5: Totally dominated by fine-grained diorite-gabbro (505102). Subordinate rock types comprise Ävrö granite (501044), minor sections of fine-grained granite (511058), fine-grained dioritoid (501030), granite (501058) and pegmatite (501061). High frequency of sealed fractures. Confidence level = 3.

589.72–728.11 m

RU6: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), especially between c. 633 and 637 m, diorite/gabbro (501033), especially between c. 641 and 647 m, quartz monzodiorite (501036), especially between c. 653 and 658 m, and fine-grained diorite-gabbro (505102) and fine-grained dioritoid (501030). The Ävrö granite has a density in the range 2,650–2,720 kg/m^3. Scattered sections are foliated. High frequency of sealed fractures. Confidence level = 3.

728.11–794.16 m

RU4b: Mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types comprise fine-grained granite (511058), pegmatite (501061) and fine-grained diorite-gabbro (505102). Scattered up to 12 m long sections are foliated. The Ävrö granite has a density in the range 2,670–2,740 kg/m^3. High frequency of sealed fractures. Confidence level = 3.

794.16–873.94 m

RU7: Totally dominated by Ävrö granite (501044). Subordinate rock type comprises fine-grained granite (511058), diorite/gabbro (501033), fine-grained dioritoid (501030), quartz monzodiorite (501036), pegmatite (501061) and granite (501058). The Ävrö granite has a density in the range 2,650–2,750 kg/m^3. The section c. 872–873.94 m is foliated. High frequency of sealed fractures. Confidence level = 3.

Possible deformation zones

Eighteen possible deformation zones have been recognised in KLX09.

105.80–106 m

DZ1: Minor brittle and ductile deformation zones including mylonites and cataclasite. Low P-wave velocity, low resistivity and low magnetic susceptibility. One strong and persistent oriented radar reflector occurs at 105.7 m with the orientation 353/39. The host rock is totally dominated by Ävrö granite (501044). Confidence level = 3.

137.6–138 m

DZ2: Red staining and thin cataclastic zones. Low P-wave velocity, low resistivity and low magnetic susceptibility. One non-oriented radar reflector occurs at 138.2 m with the angle 53° to borehole axis. The host rock is totally dominated by Ävrö granite (501044). Confidence level = 3.

147–148 m

DZ3: Increased frequency of sealed and open fractures. The section is characterized by red staining. Low P-wave velocity, low resistivity, caliper anomaly and low magnetic susceptibility. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock type is fine-grained granite (511058). Confidence level = 3.

206–209 m

DZ4: Increased frequency of sealed and open fractures and sealed network. Crush rock in the section 207.66–208.14 m. The section is characterized by red staining. Low P-wave velocity, low resistivity and low magnetic susceptibility. One strong and persistent oriented radar reflector occurs at 208.3 m with the orientation 066/46 or 261/42. Two non-oriented radar reflectors at 207.2 m and 208.9 m with the angle 55° and 65° to borehole axis, respectively. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock type is fine-grained granite (511058). Confidence level = 3.

261.8–264 m

DZ5: Increased frequency of sealed and open fractures and sealed network. The section is characterized by red staining. Crush rock in the section 262.29–262.46 m. Low P-wave velocity, low resistivity and low magnetic susceptibility. One oriented radar reflector occurs at 262.8 m with the orientation 088/22 or 301/26 and one non-oriented at 261.8 m with the angle 67° to borehole axis. The host rock is totally dominated by Ävrö granite (501044). Confidence level = 3.

272–276 m

DZ6: Increased frequency of sealed and open fractures and sealed network. The section is characterized by red staining. Low P-wave velocity and low magnetic susceptibility. One non-oriented radar reflector occurs at 272.2 m with the angle 62° to borehole axis. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock type is fine-grained granite (511058). Epidote filled fractures and cataclastic bands parallel with core axis. Confidence level = 3.

313–323.2 m

DZ7: Increased frequency of sealed and open fractures and sealed network. Crush rock in the section 322.39–322.90 m. Some fractures with large apertures. The section is characterized by red staining. Low P-wave velocity, low resistivity and low magnetic susceptibility. Three non-oriented radar reflectors occur at 315.4 m, 319.8 m and 323.2 m with the angle 45°, 49° and 54° to borehole axis, respectively. The host rock is dominated by Ävrö granite (501044). Fine-grained diorite-gabbro constitutes an important subordinate rock type. In addition, minor occurrences of fine-grained granite (511058) and pegmatite 8501061). Red staining, crush and cataclasite are present. Confidence level = 3.

440–446 m

DZ8: High frequency of sealed fractures and increased frequency of open fractures and sealed network. The section is characterized by intense red staining. Low resistivity and low magnetic susceptibility. Three non-oriented radar reflectors occur at 441.9 m, 442.7 m and 442.7 m with the angle 47°, 68° and 53° to borehole axis, respectively. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock type is fine-grained granite (511058). Red staining, inhomogeneously epidotization (442–443 m) and cataclasite (443.3–443.5 m).
Confidence level = 3.

492.4–509 m

DZ9: High frequency of sealed and open fractures and sealed network. Crush rock in the section 494.78–494.84 m. Some fractures with large apertures. The section is characterized by red staining. Low P-wave velocity, low resistivity and low magnetic susceptibility. Three non-oriented radar reflectors occur at 493.6 m, 495.9 m and 500.6 m with the angle 61°, 71° and 25° to borehole axis, respectively. The host rock is dominated by a mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types comprise fine-grained granite (511058) and granite (501058). Confidence level = 3.

520–554 m

DZ10: High frequency of sealed and open fractures and sealed network. Several sections with crush rock in the interval. Several fractures with large apertures. Core loss in the interval 538.59–539.14 m and 540.69–540.78 m due to drill technical reason. The section is characterized by intense red staining. Low P-wave velocity, low resistivity, caliper anomaly and low magnetic susceptibility. Two relatively strong oriented radar reflectors occur at 530.3 m with the orientation 302/30 or 096/25 and at 541.6 m with the orientation 066/42 or 263/37. Seven non-oriented radar reflectors occur in the section with angles in the interval 50–69° to borehole axis and one non-oriented with the angle 36°. The host rock is dominated by a mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types comprise fine-grained granite (511058), granite (501058), fine-grained diorite-gabbro (505102) and pegmatite (501061). Confidence level = 3.

611–618.30 m

DZ11: Increased frequency of sealed and open fractures and sealed network. The section is characterized by inhomogeneous distribution of red staining and cataclastic bands. Low resistivity. Three non-oriented radar reflectors occur at 613.4 m, 614.3 m and 616.5 m with the angle 83°, 38° and 77° to borehole axis, respectively. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058) and fine-grained diorite-gabbro (505102). Confidence level = 3.

648.60–649.6 m

DZ12: Increased frequency of sealed fractures. Inhomogeneous distribution of red staining and cataclastic bands in the section. One relatively strong non-oriented radar reflector occurs at 649.7 m with the angle 47° to borehole axis. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058) and granite (501058). Confidence level = 3.

682–722 m

DZ13: High frequency of sealed fractures and increased frequency of open fractures and sealed network. Crush rock in the sections 692.84–692.89 m, 700.53–700.82 m, 710.80–712.37 m and 720.20–720.30 m. Some fractures with large apertures. The section is characterized by intense red staining and increased distribution of cataclastic bands. Low P-wave velocity, low resistivity and low magnetic susceptibility. Three relatively strong and persistent oriented radar reflectors occur at 690.7 m with the orientation 319/44, at 703.5 m with the orientation 192/70 and at 713.8 m with the orientation 160/21 or 345/34. Six non-oriented radar reflectors occur in the section with angles in the interval 55–78° to borehole axis and one non-oriented with the angle 31°. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite-gabbro (505102) and pegmatite (501061). Confidence level = 3.

744.5–761 m

DZ14: High frequency of sealed and open fractures and sealed network. Some fractures with large apertures. Three sections with crush rock at 755.83–756.0 m, 756.72–756.80 m and 757.18–757.58 m. Core loss in the interval 756.0–756.2 m. The section is characterized by red staining and scattered cataclastic bands. 754.5–761 m is the most damaged part. Low P-wave velocity, low resistivity, caliper anomaly and low magnetic susceptibility. Four relatively strong and persistent non-oriented radar reflectors occur at 746.2 m, 752.7 m, 754.6 m and 758.5 m with the angles 69°, 41°, 32° and 24° to borehole axis, respectively. The host rock is dominated by a mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite-gabbro (505102) and pegmatite (501061). Confidence level = 3.

799.60–803 m

DZ15: Increased distribution of red staining. Strongly quartz and epidote sealed section in the interval 800.60–801.23 m. Strong epidotization in the interval 802.90–803.40 m. Low resistivity and low magnetic susceptibility. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058) and fine-grained dioritoid (501030). Confidence level = 3.

815–815.25 m

DZ16: Minor deformation zone including red staining and cataclastic bands. Low P-wave velocity, low resistivity and low magnetic susceptibility. One non-oriented radar reflector occurs at 815.0 m with the angle 55° to borehole axis. The host rock is totally dominated by Ävrö granite (501044). Confidence level = 3.

848.7–852.60 m

DZ17: Increased distribution of red staining and scattered cataclastic bands. Low resistivity, caliper anomaly and low magnetic susceptibility. One non-oriented radar reflector occurs at 852.1 m with the angle 46° to borehole axis. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058). Confidence level = 3.

867.8–869.7 m

DZ18: Increased distribution of red staining, scattered cataclastic bands. Low resistivity and low magnetic susceptibility. The host rock is totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058). Confidence level = 3.

5.2 HLX37

Rock units

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

12.10–122.27 m

RU1a: Totally dominated by quartz monzodiorite (501036). Subordinate rock type comprises fine-grained granite (511058). Confidence level = 2.

122.27–146.70 m

RU2: Totally dominated by dolerite (501027). Confidence level = 2.

146.70–199.58 m

RU1b: Totally dominated by quartz monzodiorite (501036). Subordinate rock type comprises fine-grained granite (511058). Confidence level = 2.

Possible deformation zones

One deformation zone has been recognized in HLX37.

122.0–146.70 m

DZ1: High frequency of open fractures. Very low electric resistivity, low P-wave velocity and low magnetic susceptibility. Caliper anomalies at the margins of the zone. Four non-oriented radar reflectors occur in the section with angles in the interval 47–66° to borehole axis. Two of them are very strong and persistent and occur at 125.1 m (47°) and at 144.0 m (66°). Very low radar amplitude in the interval 120–150 m. The host rock is totally dominated by dolerite (501027). Confidence level = 2.

6 Comments

The results from the geological single-hole interpretations of KLX09 and HLX37 are presented in WellCad plots (Appendix 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 C A, 2003.** Geological site descriptive model. A strategy for the model development during site investigations. SKB R-03-07, Svensk Kärnbränslehantering AB.

/2/ **Rauséus G, Mattsson K-J, Ehrenborg J, 2006.** Oskarshamn site investigation. Boremap mapping of core drilled borehole KLX09. SKB P-06-240, Svensk Kärnbränslehantering AB.

/3/ **Sigurdsson O, 2005.** Oskarshamn site investigation. Simplified Boremap mapping of percussion boreholes HLX34 and 35 on lineament NS059 and of percussion boreholes HLX36 and HLX37 on lineament NS001. SKB P-05-279, Svensk Kärnbränslehantering AB.

/4/ **Mattsson H, Keisu M, 2006.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX09. SKB P-06-124, Svensk Kärnbränslehantering AB.

/5/ **Mattsson H, Keisu M, 2005.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX09. SKB P-06-124, Svensk Kärnbränslehantering AB.

/6/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC and BIPS logging in boreholes KLX09, HLX36 and HLX37 and deviation logging in HLX36 and HLX37. SKB P-06-48, Svensk Kärnbränslehantering AB.

Appendix 1

Geological single-hole interpretation of KLX09

Title	SINGLE HOLE INTERPRETATION KLX09					
Site	LAXEMAR	Inclination [°]	-84.93	Elevation [m.a.s.l.]	23.38	Signed data
Borehole	KLX09	Date of mapping	2006-02-02 14:40:00	Drilling Start Date	2005-06-02 13:00:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2005-06-13 17:30:00	
Length [m]	880.380	Northing [m]	6367322.63	Surveying Date		
Bearing [°]	267.41	Easting [m]	1548863.22	Plot Date	2007-10-14 22:03:05	

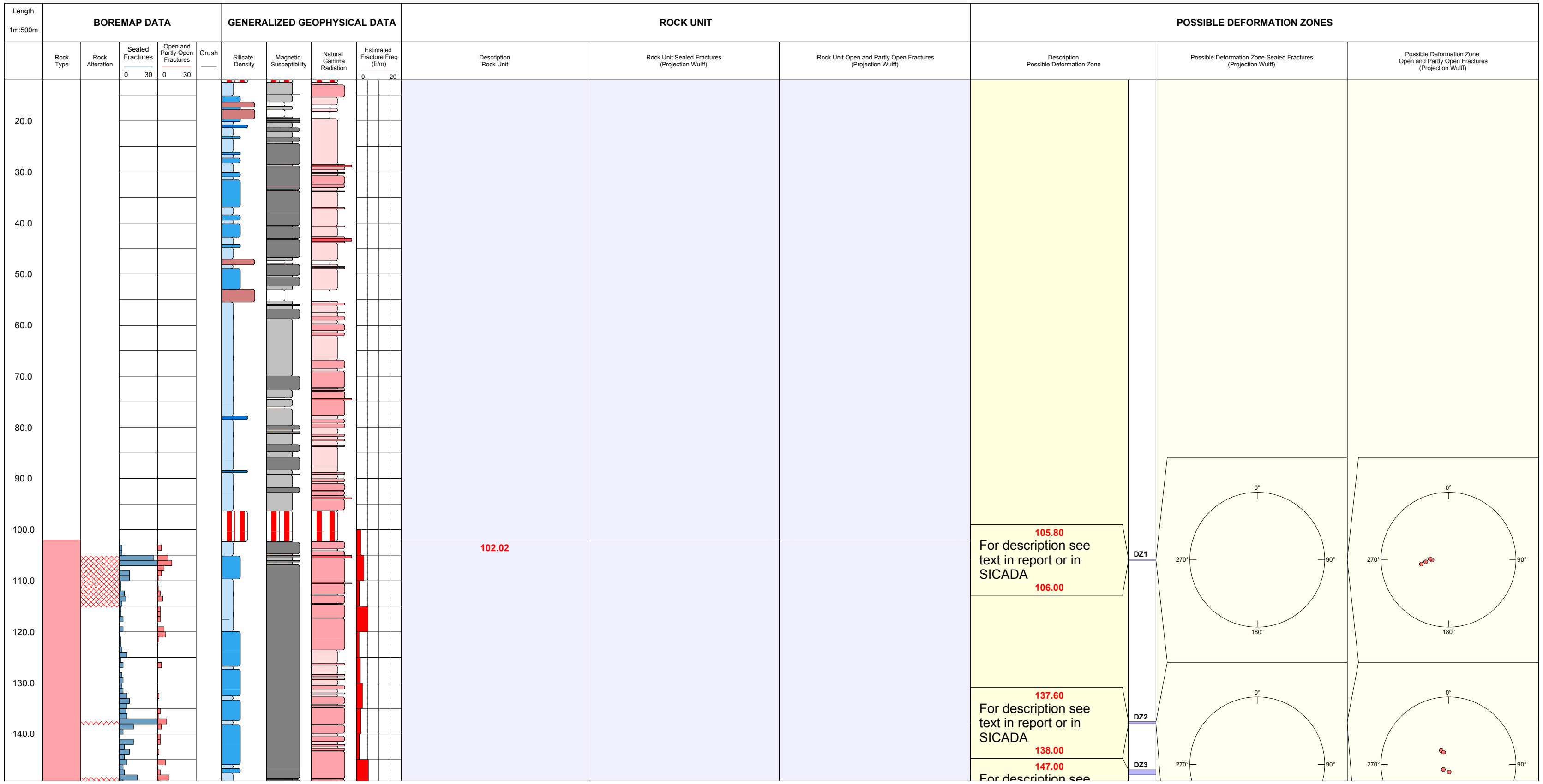
ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Quartz monzodiorite
- Diorite / Gabbro
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

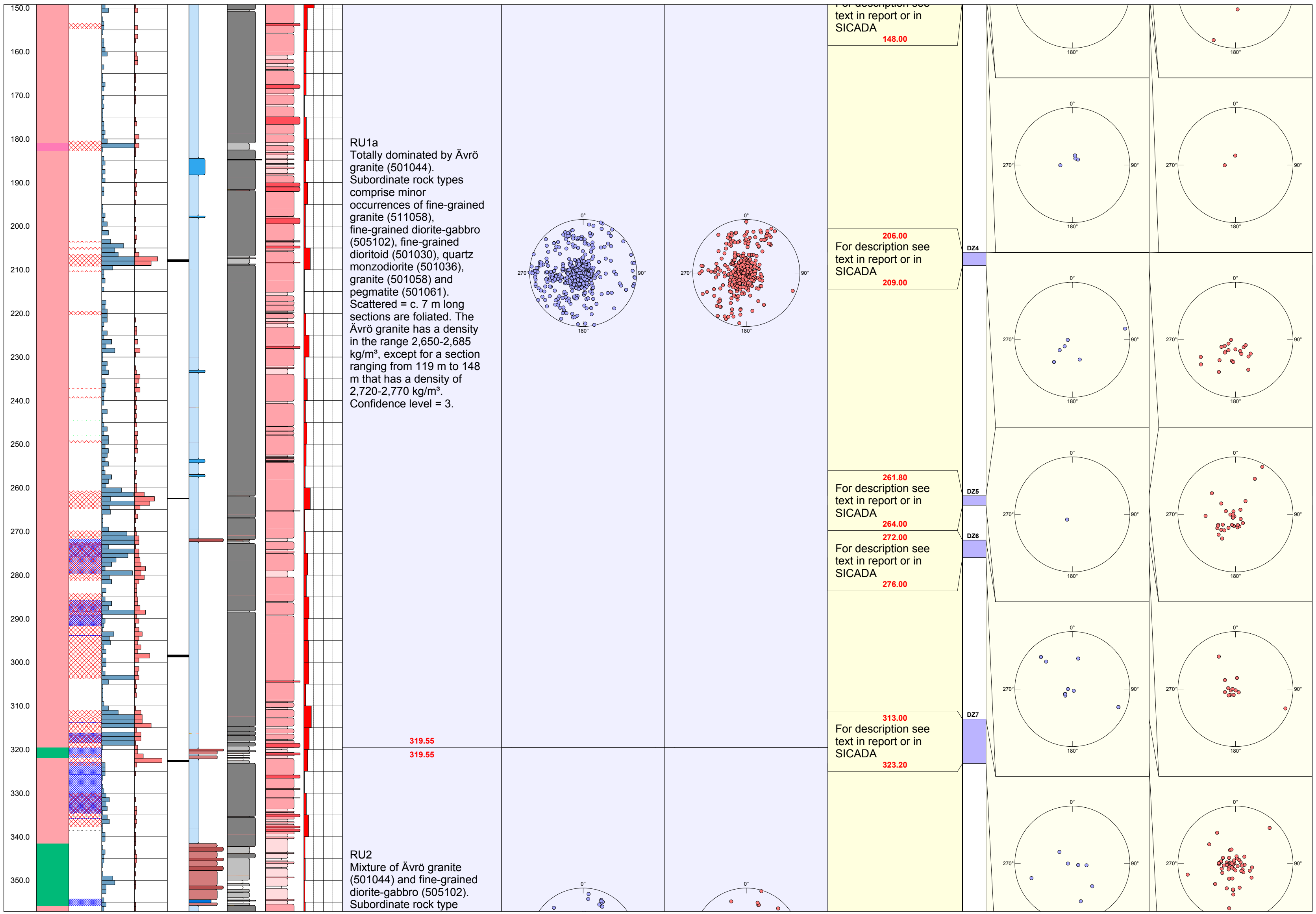
ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Quartz dissolution
- Silicification
- Argillization
- Saussuritization

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

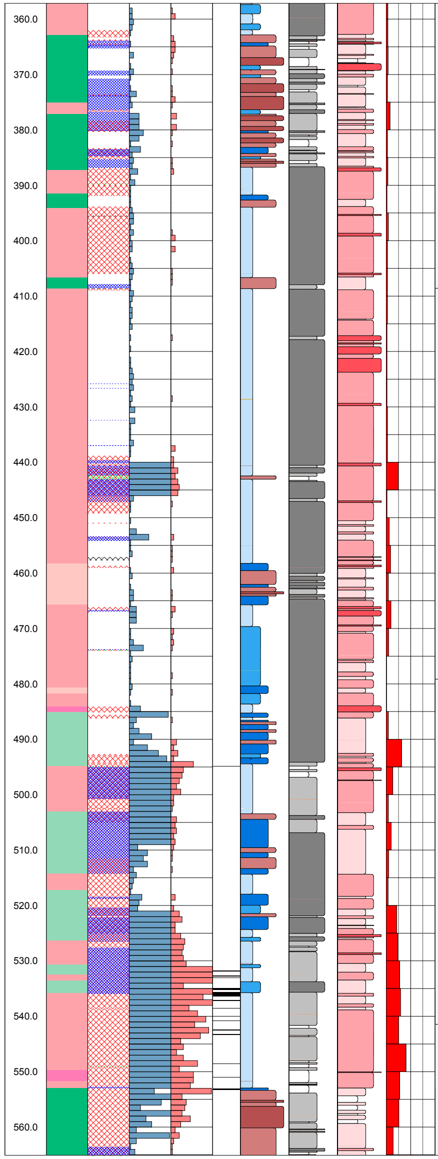
SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1
- sus>0.1

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





150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
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
RU1a
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise minor occurrences of fine-grained granite (511058), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030), quartz monzodiorite (501036), granite (501058) and pegmatite (501061). Scattered = c. 7 m long sections are foliated. The Ävrö granite has a density in the range 2,650-2,685 kg/m³, except for a section ranging from 119 m to 148 m that has a density of 2,720-2,770 kg/m³. Confidence level = 3.
319.55
319.55
RU2
Mixture of Ävrö granite (501044) and fine-grained diorite-gabbro (505102). Subordinate rock type
text in report or in SICADA
148.00
206.00
For description see text in report or in SICADA
209.00
DZ4
261.80
For description see text in report or in SICADA
264.00
DZ5
272.00
For description see text in report or in SICADA
276.00
DZ6
313.00
For description see text in report or in SICADA
323.20
DZ7
0°
90°
180°
270°



comprises fine-grained dioritoid (501030), granite (501058), pegmatite (501061) and fine-grained granite (511058). The Ävrö granite has a density in the range 2,650-2,670 kg/m³. Scattered = c. 7 m long sections are foliated. Confidence level = 3.

408.58

408.58

RU3
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise = c. 7 m long sections of quartz monzodiorite (501036) and scattered minor sections of fine-grained granite (511058), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030) and pegmatite (501061). The Ävrö granite has a density in the range 2,650-2,680 kg/m³. Scattered minor sections are foliated. Confidence level = 3.

485.11

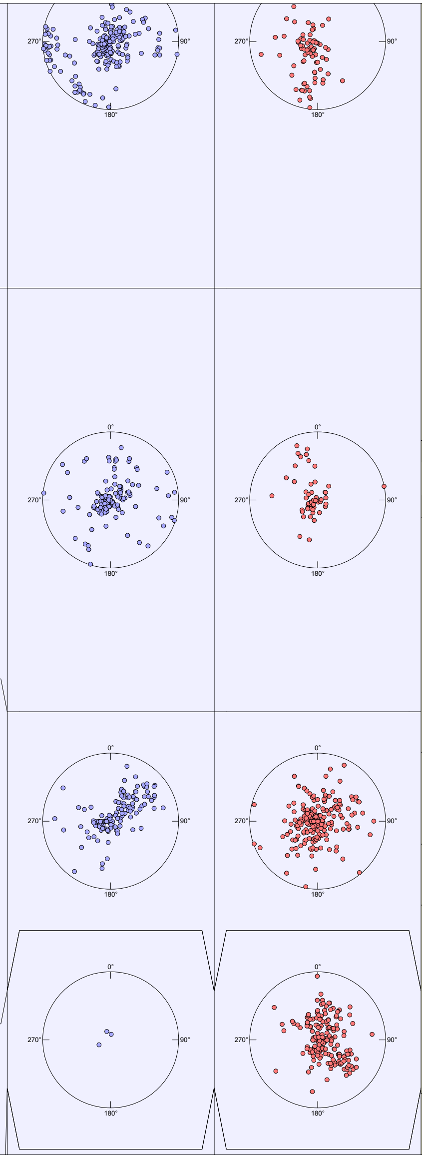
485.11

RU4a
Mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030), granite (501058) and pegmatite (501061). The Ävrö granite has a density in the range 2,620-2,650 kg/m³ (the recorded density is possibly affected by overprinting deformation zone, see below). High frequency of sealed fractures. Confidence level = 3.

535.49

535.49

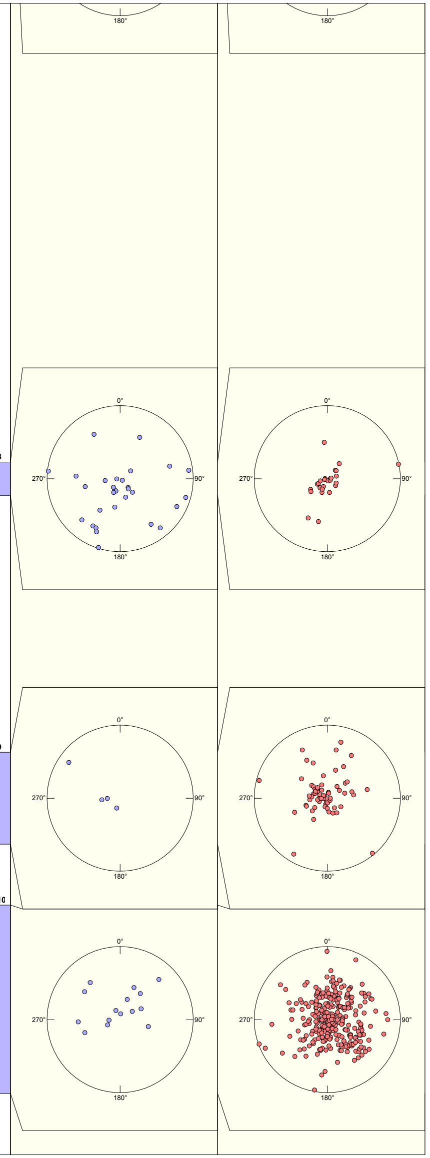
RU1b
Totally dominated by Ävrö granite (501044). Subordinate rock type comprises fine-grained granite (511058), fine-grained dioritoid (501030), granite (501058)

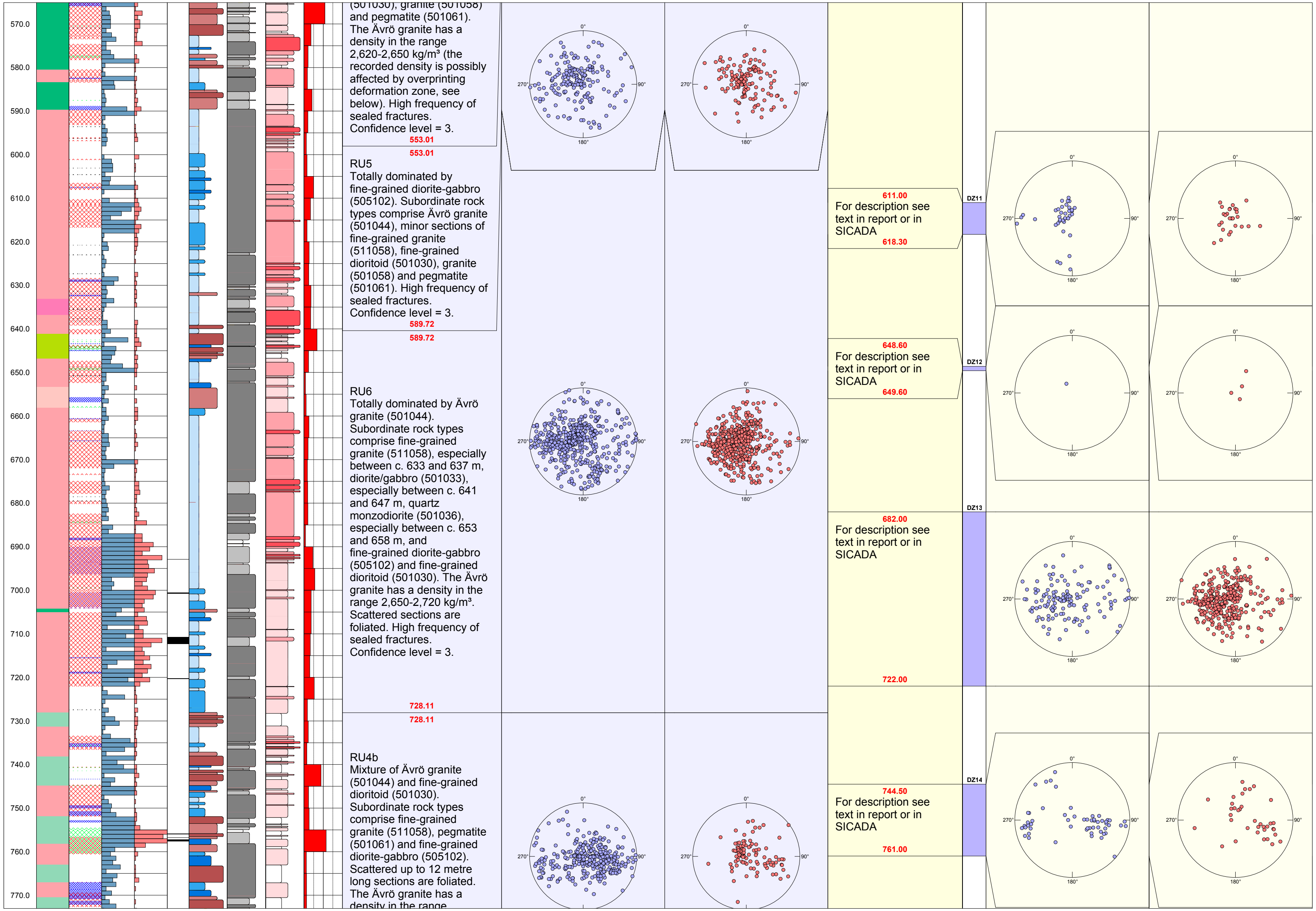


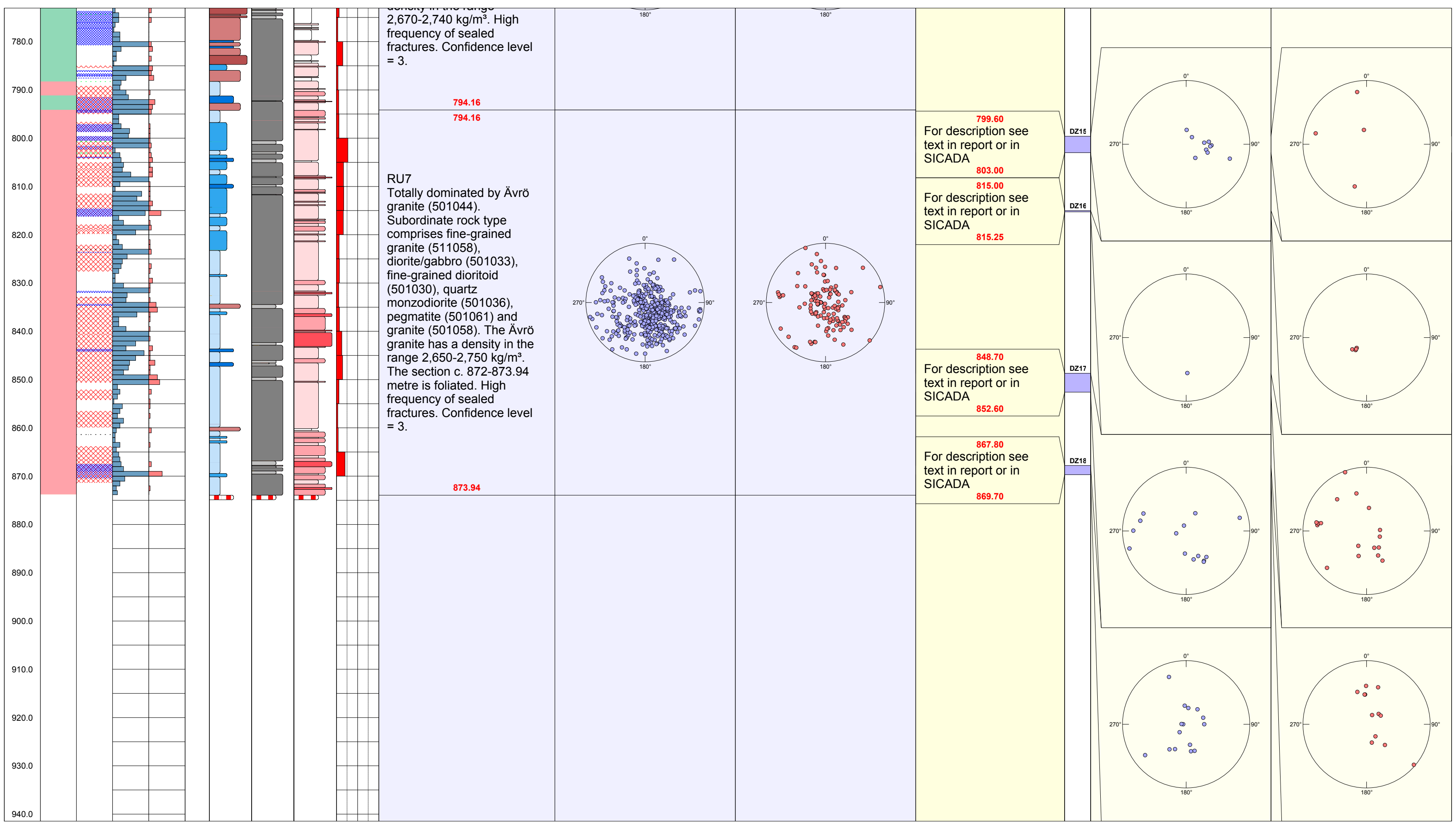
440.00
For description see text in report or in SICADA
446.00
DZ8

492.40
For description see text in report or in SICADA
509.00
DZ9

520.00
For description see text in report or in SICADA
554.00
DZ10




570.0
580.0
590.0
600.0
610.0
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
(501030), granite (501058) and pegmatite (501061). The Ävrö granite has a density in the range 2,620-2,650 kg/m³ (the recorded density is possibly affected by overprinting deformation zone, see below). High frequency of sealed fractures. Confidence level = 3.
553.01
553.01
RU5
Totally dominated by fine-grained diorite-gabbro (505102). Subordinate rock types comprise Ävrö granite (501044), minor sections of fine-grained granite (511058), fine-grained dioritoid (501030), granite (501058) and pegmatite (501061). High frequency of sealed fractures. Confidence level = 3.
589.72
589.72
RU6
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), especially between c. 633 and 637 m, diorite/gabbro (501033), especially between c. 641 and 647 m, quartz monzodiorite (501036), especially between c. 653 and 658 m, and fine-grained diorite-gabbro (505102) and fine-grained dioritoid (501030). The Ävrö granite has a density in the range 2,650-2,720 kg/m³. Scattered sections are foliated. High frequency of sealed fractures. Confidence level = 3.
728.11
728.11
RU4b
Mixture of Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types comprise fine-grained granite (511058), pegmatite (501061) and fine-grained diorite-gabbro (505102). Scattered up to 12 metre long sections are foliated. The Ävrö granite has a range density in the range
611.00
For description see text in report or in SICADA
618.30
DZ11
648.60
For description see text in report or in SICADA
649.60
DZ12
682.00
For description see text in report or in SICADA
722.00
DZ13
744.50
For description see text in report or in SICADA
761.00
DZ14
0°
90°
180°
270°


2,670-2,740 kg/m³. High frequency of sealed fractures. Confidence level = 3.
794.16
794.16
RU7
Totally dominated by Ävrö granite (501044). Subordinate rock type comprises fine-grained granite (511058), diorite/gabbro (501033), fine-grained dioritoid (501030), quartz monzodiorite (501036), pegmatite (501061) and granite (501058). The Ävrö granite has a density in the range 2,650-2,750 kg/m³. The section c. 872-873.94 metre is foliated. High frequency of sealed fractures. Confidence level = 3.
873.94
799.60
For description see text in report or in SICADA
803.00
DZ15
815.00
For description see text in report or in SICADA
815.25
DZ16
848.70
For description see text in report or in SICADA
852.60
DZ17
867.80
For description see text in report or in SICADA
869.70
DZ18

Appendix 2

Geological single-hole interpretation of HLX37

Title	SINGLE HOLE INTERPRETATION HLX37					
Site	LAXEMAR	Inclination [°]	-59.24	Elevation [m.a.s.l.]	15.19	Signed data
Borehole	HLX37	Date of mapping	2006-01-31 10:30:00	Drilling Start Date	2005-09-26 09:00:00	
Diameter [mm]	139	Coordinate System	RT90-RHB70	Drilling Stop Date	2005-09-28 12:00:00	
Length [m]	199.800	Northing [m]	6366183.66	Surveying Date		
Bearing [°]	86.18	Easting [m]	1546406.21	Plot Date	2007-10-15 22:03:14	

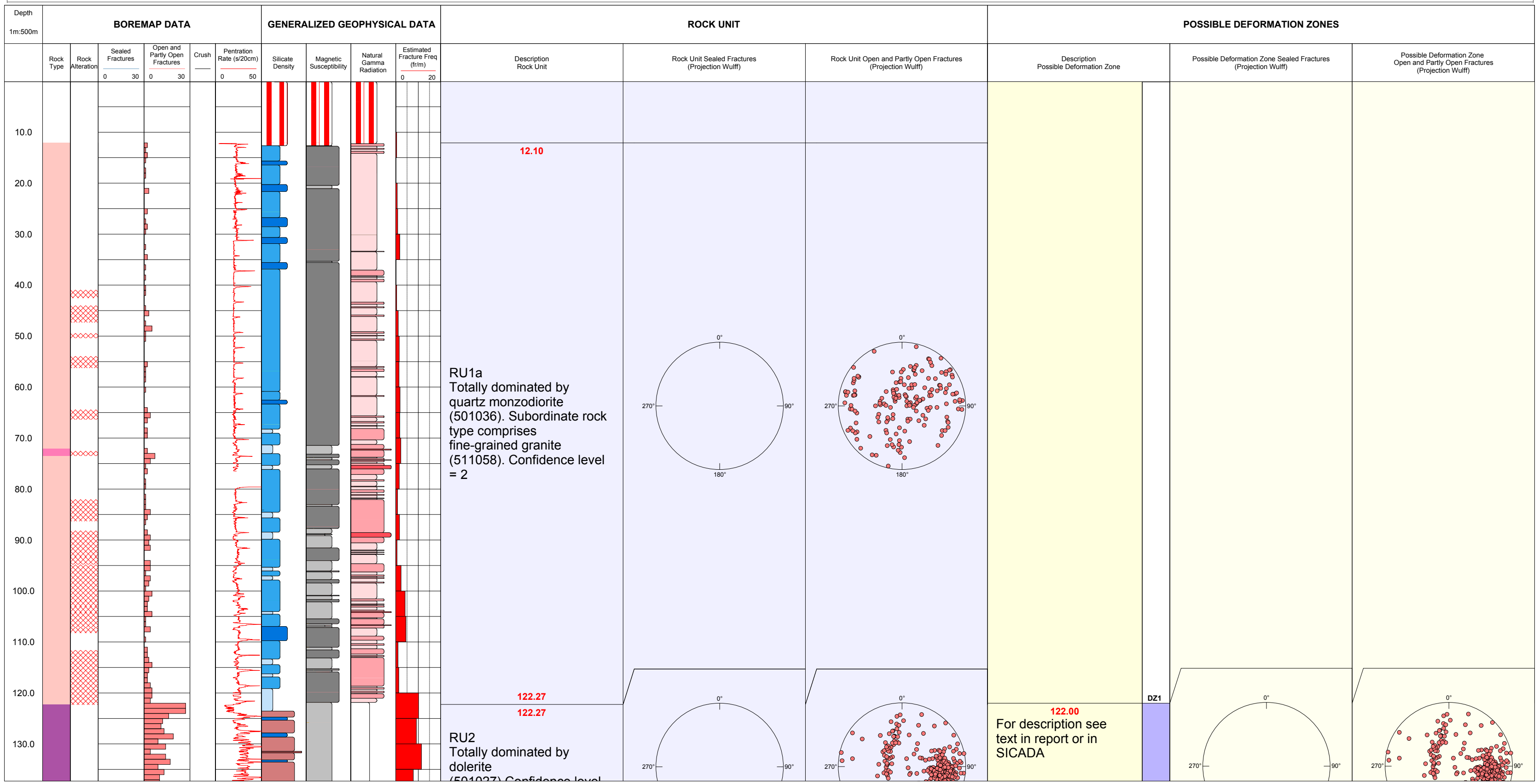
ROCKTYPE LAXEMAR
- Dolerite
- Fine-grained granite
- Quartz monzodiorite

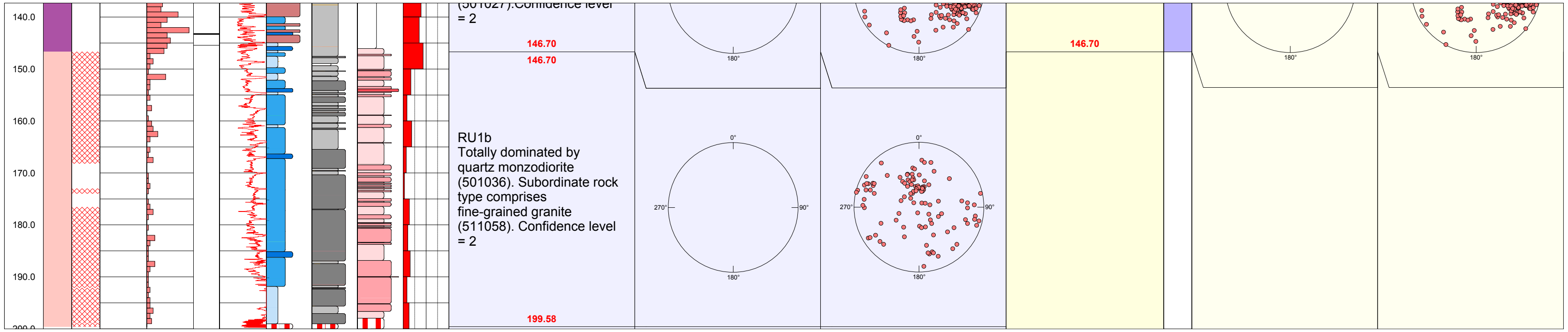
ROCK ALTERATION
- Oxidized

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




140.0
150.0
160.0
170.0
180.0
190.0
(501027).Confidence level
= 2
146.70
146.70
RU1b
Totally dominated by
quartz monzodiorite
(501036). Subordinate rock
type comprises
fine-grained granite
(511058). Confidence level
= 2
199.58
0°
90°
180°
270°
146.70