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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.

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Abstract

This report contains geological single-hole interpretation of the cored boreholes KLX12A, KLX09G, KLX10B and KLX10C 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.

Three rock units are indicated in KLX12A (RU1–RU3). In general the upper part of borehole KLX12A is dominated by Ävrö granite (501044), the middle part by diorite/gabbro (501033) and the lower part by quartz monzodiorite (501036). Subordinate rock types comprise occurrences of fine-grained granite (511058), fine-grained dioritoid (501030), fine-grained diorite-gabbro (505102), pegmatite (501061) and granite (501058). Twelve possible deformation zones are identified in KLX12A (DZ1–DZ12).

The geological single-hole interpretation shows that one rock unit (RU1) occurs in borehole KLX09G. The borehole is totally dominated by Ävrö granite (501044). Subordinate rock types comprise occurrences of fine-grained granite (511058), fine-grained diorite-gabbro (505102), granite (501058), pegmatite (501061) and fine-grained dioritoid (501030). One possible deformation zone is identified in KLX09G (DZ1).

One rock unit is indicated in KLX10B (RU1). The borehole is dominated by Ävrö granite (501044). Subordinate rock types comprise occurrences of fine-grained granite (511058), fine-grained diorite-gabbro (505102) and granite (501058).Two possible deformation zones are identified in KLX110B (DZ1–DZ2).

One rock unit is indicated in KLX10C (RU1). The borehole is totally dominated by Ävrö granite (501044). Subordinate rock types comprise occurrences of fine-grained dioritoid (501030), fine-grained diorite-gabbro (505102), fine-grained granite (511058), pegmatite (501061) and granite (501058). Seven possible deformation zones are identified in KLX10C (DZ1–DZ7).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålen KLX12A, KLX09G, KLX10B och KLX10C 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.

Tre litologiska enheter (RU1–RU3) har identifierats i KLX12A. Generellt sett domineras övre delen av borrhålet av Ävrögranit (501044), mellersta delen av diorit/gabbro (501033) och den undre delen av kvartsmonzodiorit (501036). Finkornig granit (511058), finkornig dioritoid (501030), finkornig diorit-gabbro (505102), pegmatit (501061) och granit (501058) förekommer som underordnade bergarter. Tolv möjliga deformationszoner har identifierats i KLX12A (DZ1–DZ12).

Den geologiska enhålstolkningen visar att det förekommer en litologisk enhet i borrhål KLX09G (RU1). Borrhålet domineras av Ävrögranit (501044). Finkornig granit (511058), finkornig diorit-gabbro (505102), granit (501058), pegmatit (501061) och finkornig dioritoid (501030) förekommer som underordnade bergarter. En möjlig deformationszon har identifierats i KLX09G (DZ1).

En litologisk enhet har identifierats i KLX10B (RU1) vilken domineras av Ävrögranit (501044). Finkornig granit (511058), finkornig diorit-gabbro (505102) och granit (501058) förekommer som underordnade bergarter. En möjlig deformationszon har identifierats i KLX10B (DZ1).

Den geologiska enhålstolkningen visar att det förekommer en litologisk enhet i borrhål KLX10C (RU1) vilken domineras av Ävrögranit (501044). Finkornig dioritoid (501030), finkornig diorit-gabbro (505102), finkornig granit (511058), pegmatit (501061) och granit (501058) förekommer som underordnade bergarter. Sju möjliga deformationszoner har identifierats i KLX10C (DZ1–DZ7).

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 boreholes KLX12A, KLX09G, KLX10B and KLX10C 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 400-06-056. 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.

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

Activity plan	Number	Version
Geologisk enhålstolkning av KLX12A, KLX09G, KLX10B och KLX10C	AP PS 400-06-056	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

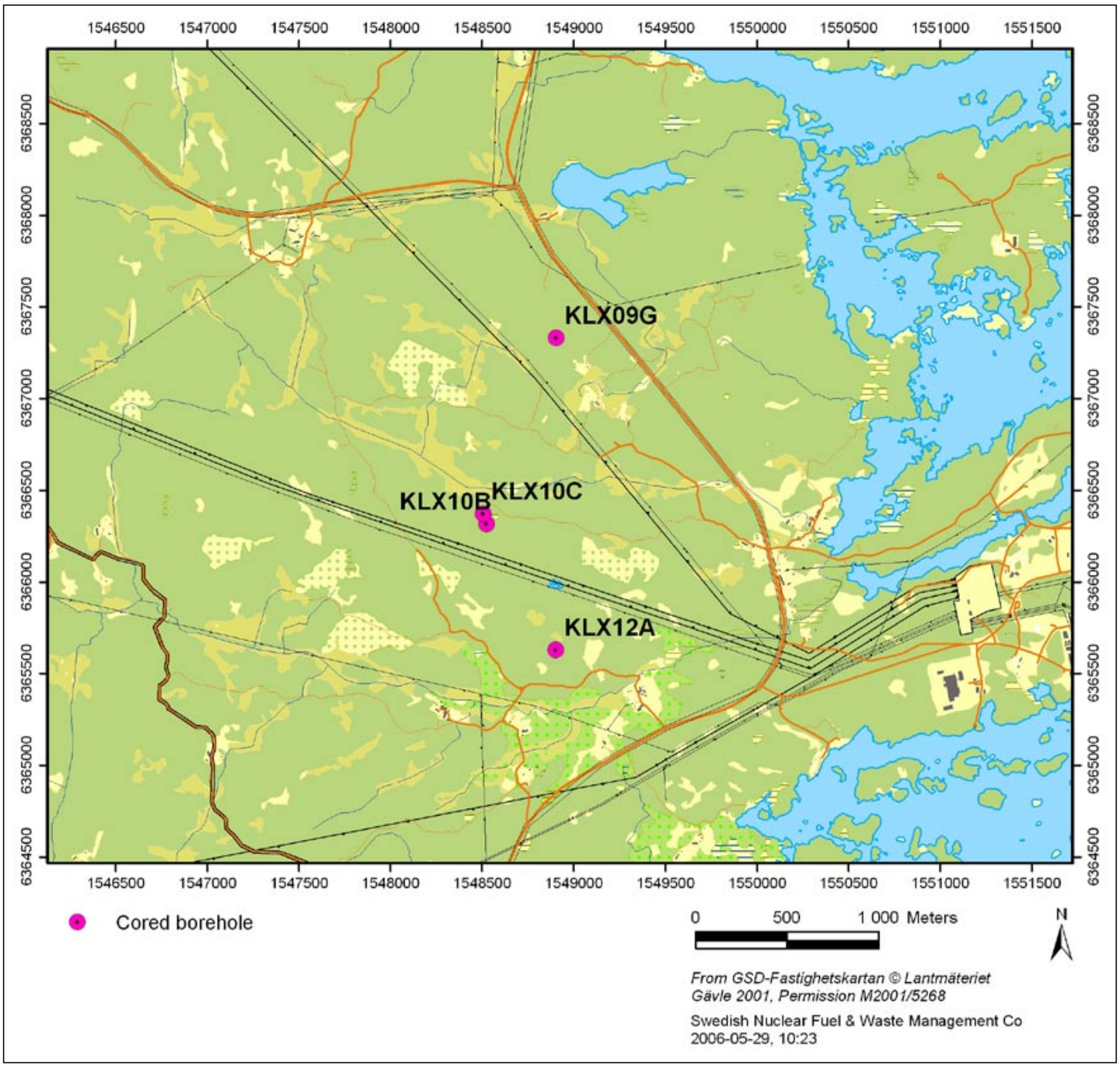


Figure 1-1. *Map showing the position of the cored boreholes KLX12A, KLX09G, KLX10B and KLX10C.*

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 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 KLX12A, KLX09G, KLX10B and KLX10C.

- 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 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.

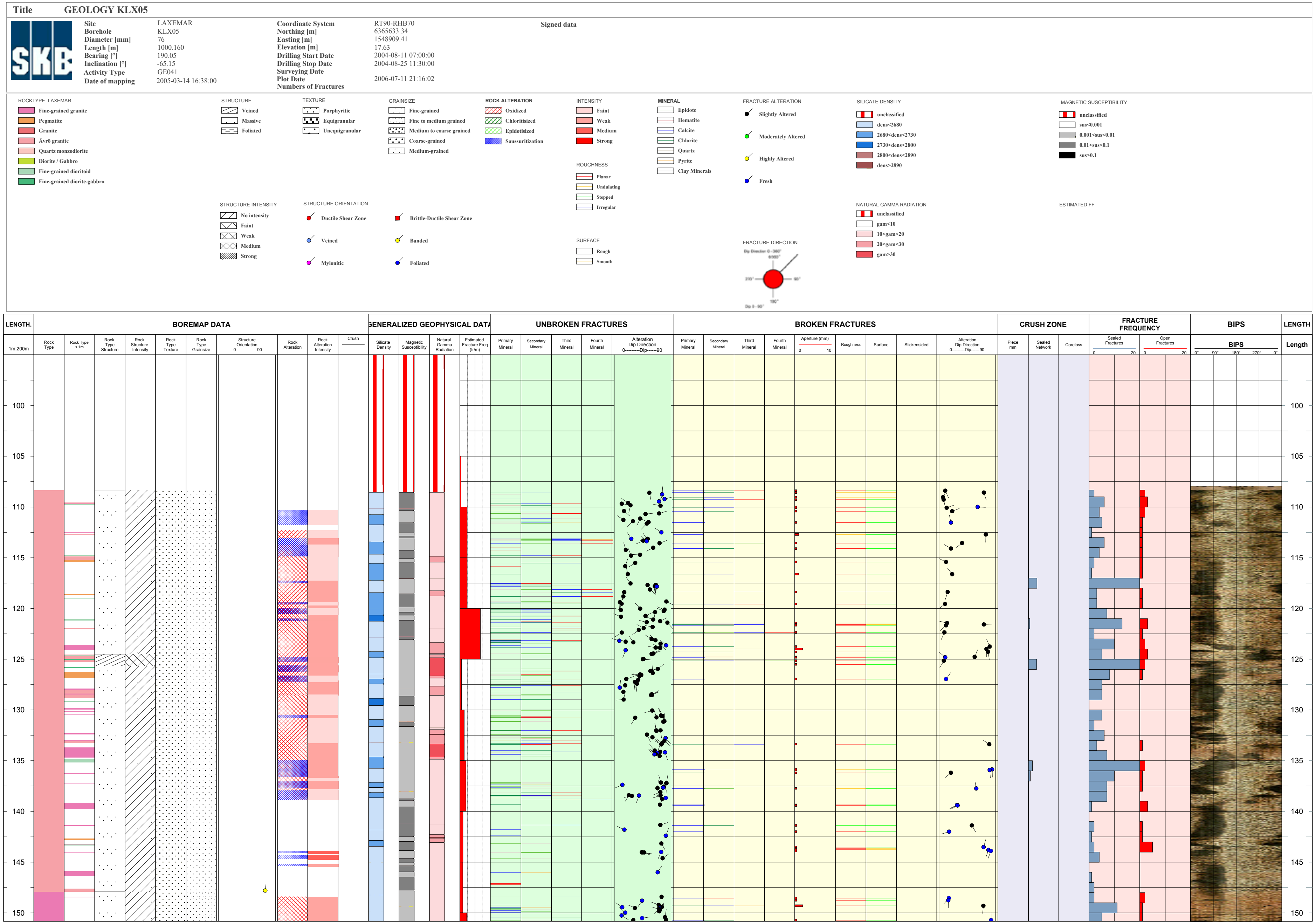


Figure 3-1. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.

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.

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.

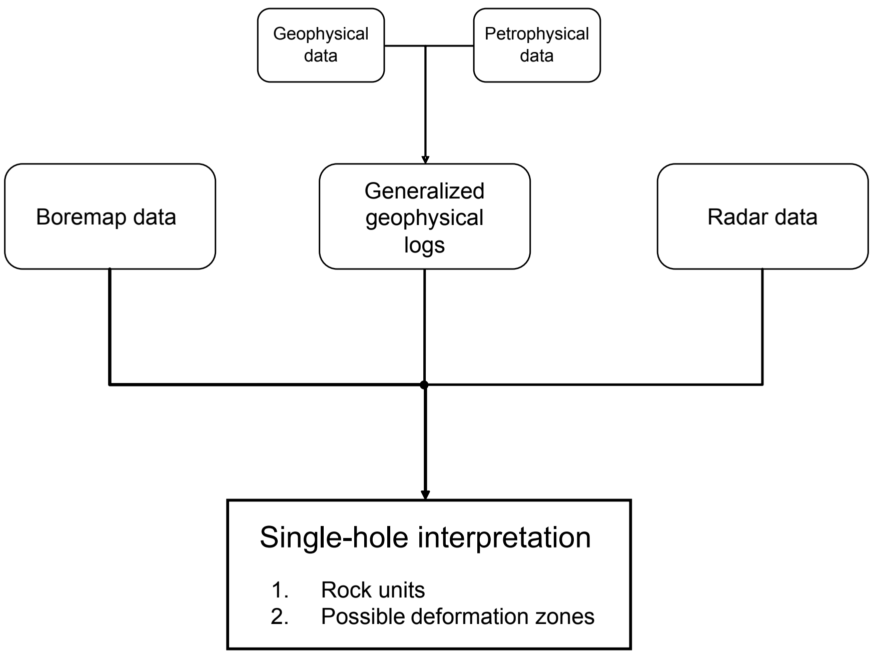


Figure 4-1. *Schematic block-scheme of single-hole interpretation.*

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 boreholes KLX12A, KLX09G, KLX10B and KLX10C (Figures 4-5 to 4-8). 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.

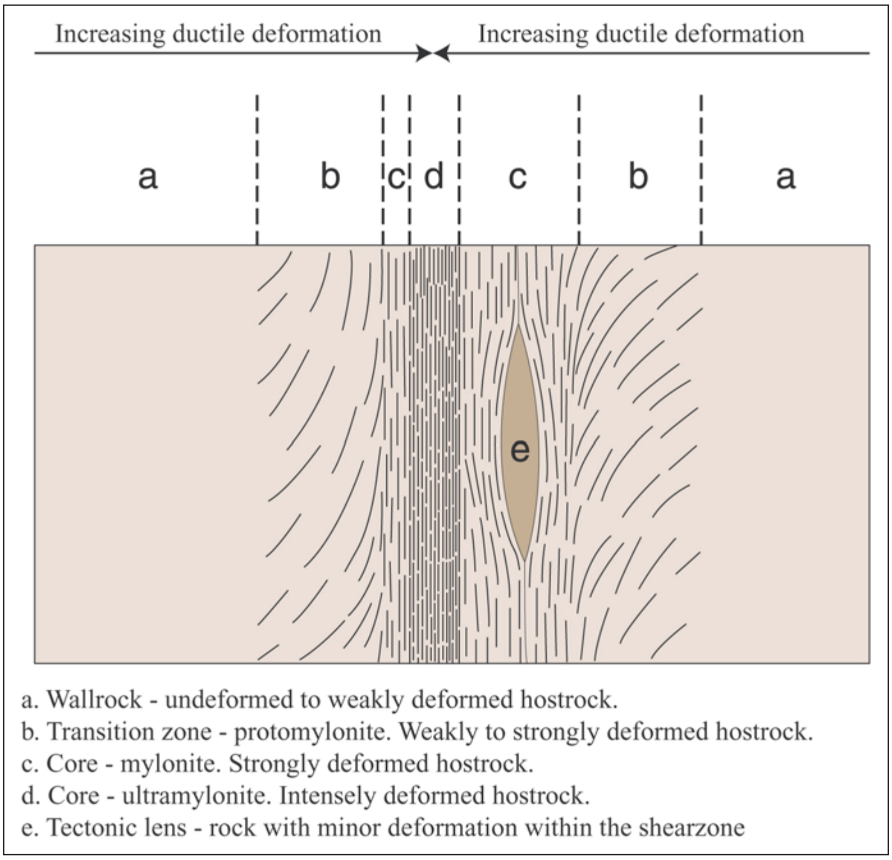


Figure 4-2. *Schematic example of a ductile shear zone. Homogeneous rock which is deformed under low- to medium-grade metamorphic conditions (after /1/).*

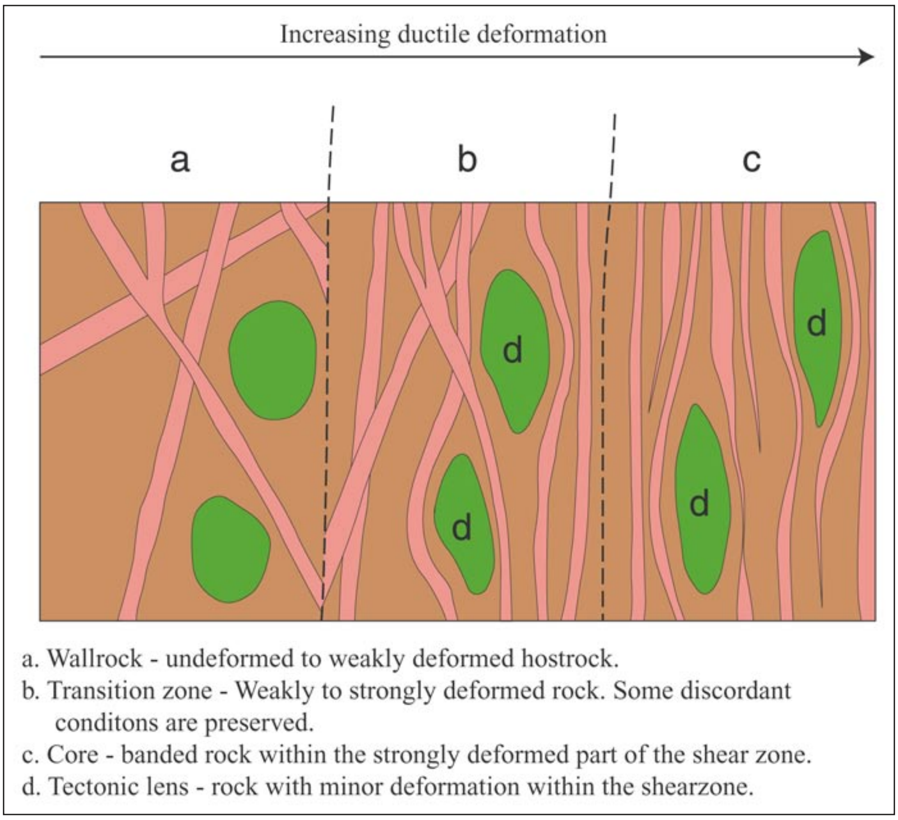


Figure 4-3. *Schematic example of a ductile shear zone. Heterogeneous rock which is deformed under low to high grade metamorphic conditions (after /1/).*

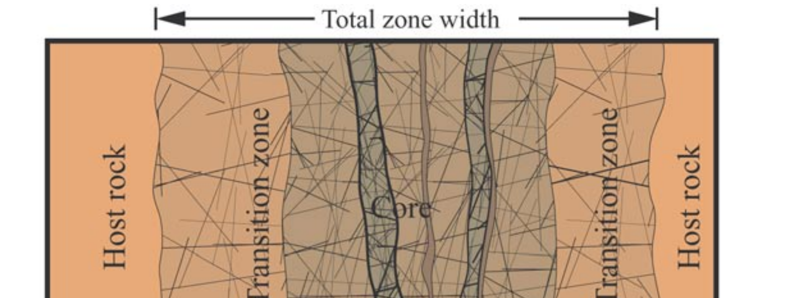


Figure 4-4. *Schematic example of a brittle deformation zone (after /1/).*

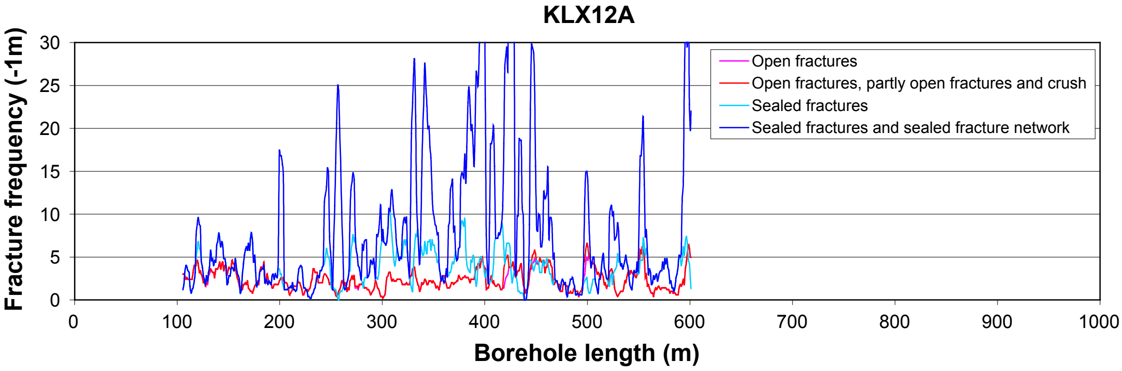


Figure 4-5. Fracture frequency plot for KLX12A. Moving average with a 5 m window and 1 m steps.

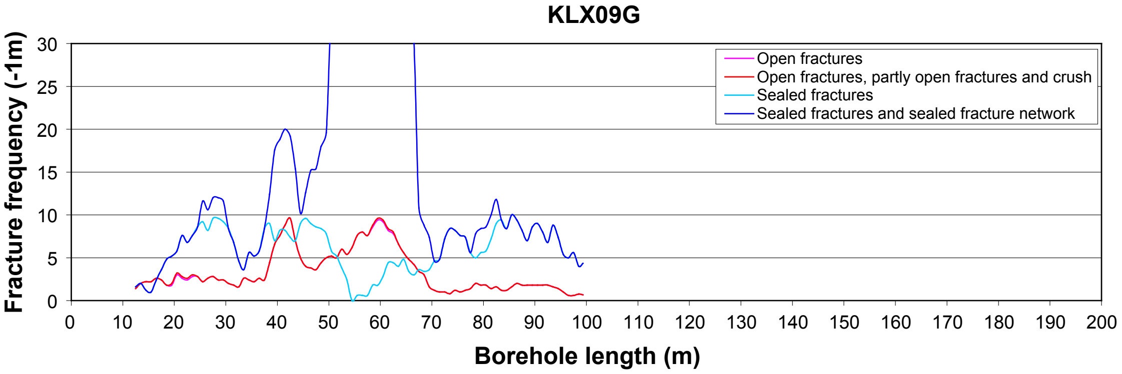


Figure 4-6. Fracture frequency plot for KLX09G. Moving average with a 5 m window and 1 m steps.

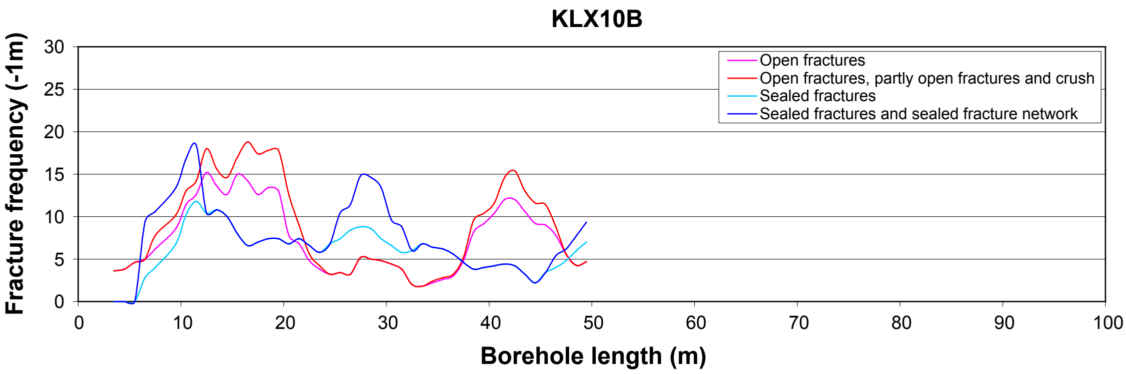


Figure 4-7. Fracture frequency plot for KLX10B. Moving average with a 5 m window and 1 m steps.

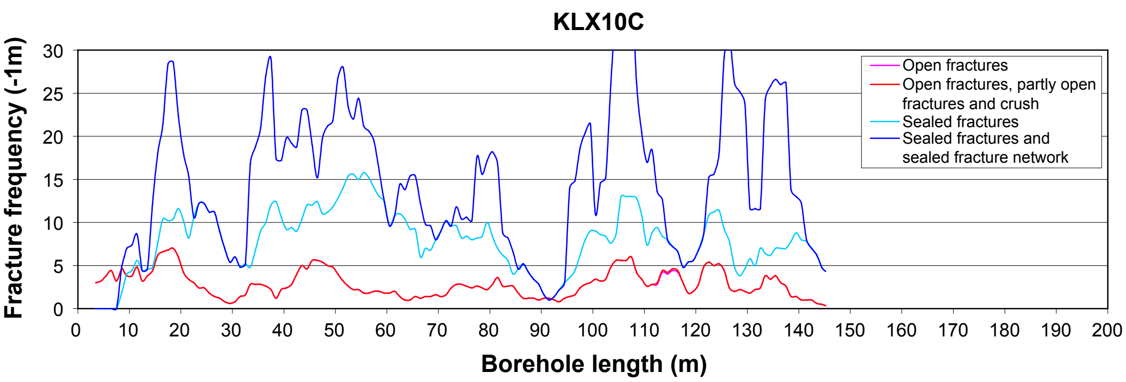


Figure 4-8. Fracture frequency plot for KLX10C. Moving average with a 5 m window and 1 m steps.

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 KLX12A, KLX09G, KLX10B and KLX10C are shown in Figures 4-9 to 4-12. In some cases, alternative orientations for oriented radar reflectors are presented. One of the alternatives is considered to be correct, but due to confidence level 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.

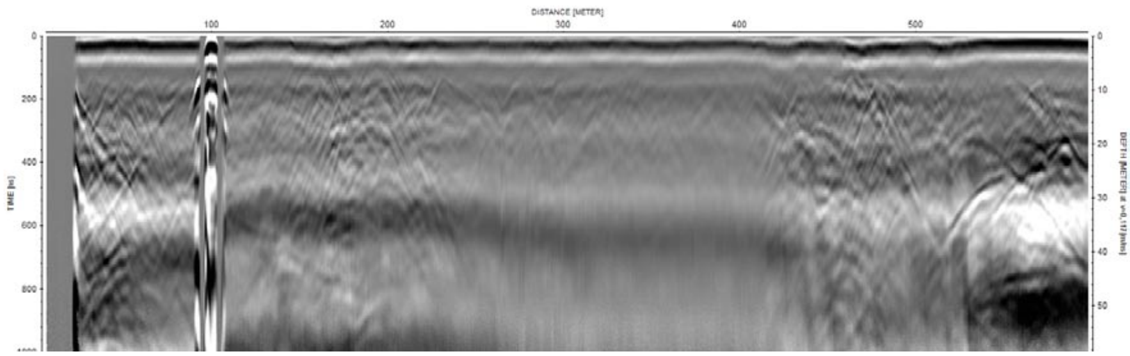


Figure 4-9. *Overview (20 MHz data) of the borehole radar measurement in KLX12A.*

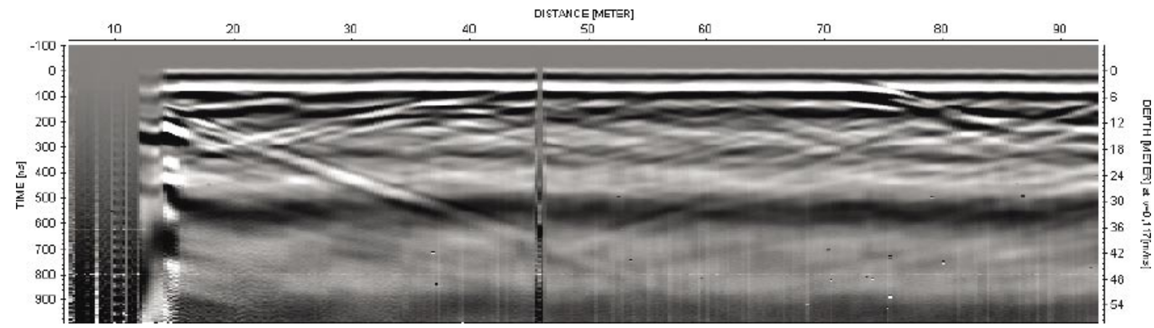


Figure 4-10. *Overview (20 MHz data) of the borehole radar measurement in KLX09G.*

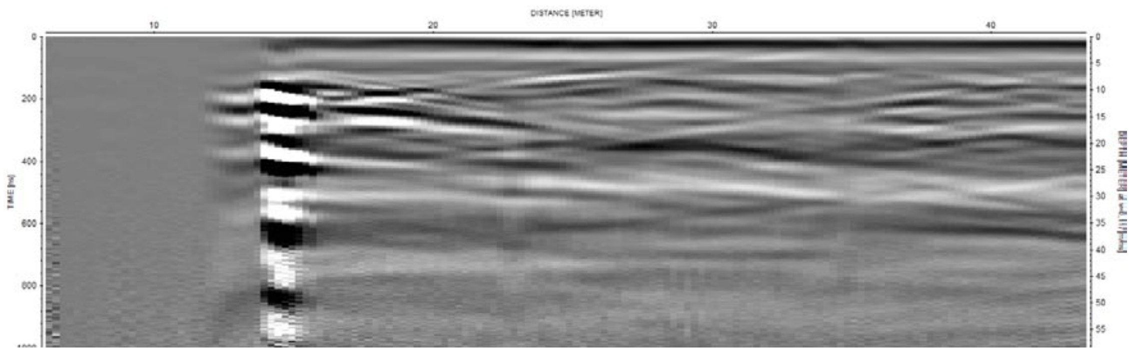


Figure 4-11. *Overview (20 MHz data) of the borehole radar measurement in KLX10B.*

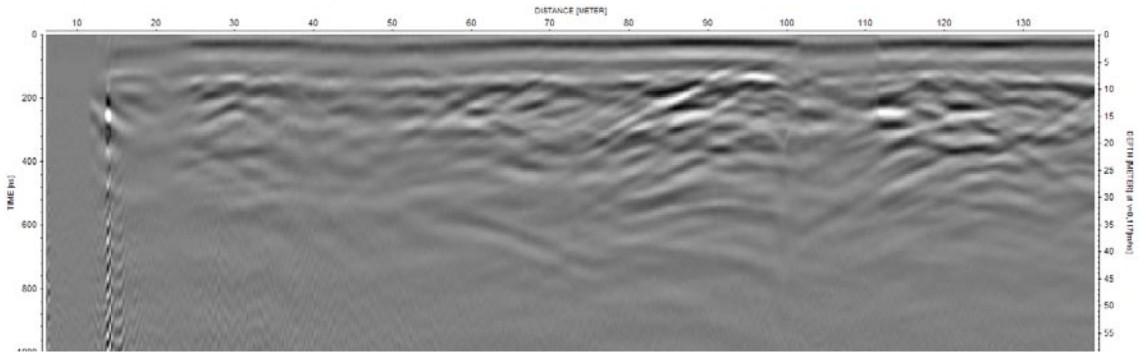


Figure 4-12. *Overview (20 MHz data) of the borehole radar measurement in KLX10C.*

4.2 Nonconformities

There was no BIPS-image available above borehole length 102 m in KLX12A. Geophysical data for boreholes KLX09G, KLX10B and KLX10C was not available during time for the single-hole interpretation meeting.

5 Results

The detailed results of the single-hole interpretations are presented as print-outs from the software WellCad (Appendix 1 for KLX12A, Appendix 2 for KLX09G, Appendix 3 for KLX10B and Appendix 4 for KLX10C).

5.1 KLX12A

Rock units

The borehole can be divided into three rock units (RU1–RU3).

102.01–421.60 m

RU1: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise minor occurrences of fine-grained granite (511058), diorite/gabbro (501033), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030), pegmatite (501061) and granite (501058). Scattered ≤ c. 12 m long sections are foliated. The Ävrö granite has a density in the range 2,720–2,760 kg/m^3, magnetic susceptibility between 0.01 and 0.05 SI, and natural gamma radiation in the range 5–10 µR/h, which is anomalously low for the Ävrö granite. Confidence level = 3.

421.60–527.90 m

RU2: Totally dominated by diorite/gabbro (501033). Subordinate rock types comprise Ävrö granite (501044), particularly in the section c. 517–528 m, and minor occurrences of fine-grained diorite-gabbro (505102), fine-grained granite (511058), granite (501058), fine-grained dioritoid (501030) and pegmatite (501061). The diorite/gabbro in the section 421.60–523.00 m has a density in the range 2,920–3,000 kg/m^3, magnetic susceptibility between 0.04 and 0.13 SI and natural gamma radiation between 1 and 5 µR/h. Confidence level = 3.

527.90–601.05 m

RU3: Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise Ävrö granite (501044), diorite/gabbro (501033), fine-grained granite (511058), granite (501058), fine-grained diorite-gabbro (505102) and pegmatite (501061). The last c. 3 m (598.180–601.050 m) of the rock unit is composed of Ävrö granite. The quartz monzodiorite has a density in the range 2,720–2,770 kg/m^3, magnetic susceptibility between 0.01 and 0.03 SI and natural gamma radiation between 8 and 12 µR/h. The section c. 530–565 shows faint foliation. Confidence level = 3.

Possible deformation zones

Twelve possible deformation zones have been recognised in KLX12A.

182.50–183.20 m

DZ1: Minor low grade ductile shear zone (judged from core). Low resistivity anomaly and decreased magnetic susceptibility. Partly decreased P-wave velocity. One radar reflector close to the deformation zone at 183.9 m with the orientation 029/87 or 208/53. Low radar amplitude along the deformation zone. The host rock is dominated by fine-grained diorite-gabbro (505102). Subordinate rock type is fine-grained granite (511058). Confidence level = 3.

185.40–185.70 m

DZ2: Minor low grade ductile shear zone (judged from core). Low resistivity anomaly and decreased magnetic susceptibility. Partly decreased P-wave velocity. One non-oriented radar reflector close to the deformation zone at 184.8 m with the angle 59° to borehole axis. Low radar amplitude along the deformation zone. The host rock is dominated by fine-grained diorite-gabbro (505102). Confidence level = 3.

270.70–271.05 m

DZ3: Minor low-grade ductile shear zone (judged from core). Low resistivity anomaly and decreased magnetic susceptibility. One radar reflector at 270.9 m with the orientation 351/24 or 085/20. Low radar amplitude at 270–272 m. The host rock is dominated by fine-grained diorite-gabbro (505102). Confidence level = 3.

276.60–277.70 m

DZ4: Minor low grade inhomogeneous ductile shear zone (judged from core). Minor low resistivity anomaly and partly decreased magnetic susceptibility. One non-oriented radar reflector at 277.1 m with the angle 80° to borehole axis. Low radar amplitude along the deformation zone. The host rock is dominated by fine-grained diorite-gabbro (505102). Subordinate rock types are Ävrö granite (501044) and fine-grained granite (511058). Confidence level = 3.

282.00–282.40 m

DZ5: Minor low grade inhomogeneous ductile shear zone (judged from core). Minor low resistivity anomaly and decreased magnetic susceptibility. The host rock is dominated by fine-grained diorite-gabbro (505102). Confidence level = 3.

304.41–305.45 m

DZ6: Minor low grade ductile shear zone (judged from core). Narrow, low resistivity anomaly and decreased magnetic susceptibility. One radar reflector at 305.0 m with the orientation 197/57 or 020/86. The host rock is dominated by fine-grained granite (511058). Low radar amplitude along the deformation zone. Subordinate rock type is Ävrö granite (501044). Confidence level = 3.

329.39–329.85 m

DZ7: Minor low grade brittle shear zone (judged from core). Shear zone is subparallel with core. Narrow, low resistivity anomaly and decreased magnetic susceptibility. One non-oriented radar reflector close to the deformation zone at 330.1 m with the angle 15° to borehole axis. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

366.48.41–366.99 m

DZ8: Minor low grade ductile shear zone (judged from core) in composite dike. Decreased magnetic susceptibility. One non-oriented radar reflector close to the deformation zone at 366.3 m with the angle 75° to borehole axis. The host rock is dominated by fine-grained diorite-gabbro (505102). Confidence level = 3.

428.95–429.40 m

DZ9: Minor low grade ductile shear zone (judged from core) composite dike. Decreased magnetic susceptibility. Low radar amplitude along the deformation zone. The host rock is dominated by fine-grained diorite-gabbro (505102). Confidence level = 3.

445.60–447.55 m

DZ10: Sealed network, inhomogeneously foliated. Low resistivity anomaly. Decreased magnetic susceptibility in the section 446.6–455.6 m, i.e. it continues outside the DZ. One non-oriented radar reflector close to the deformation zone at 447.8 m with the angle 53° to borehole axis. Low radar amplitude along the deformation zone. The host rock is dominated by diorite-gabbro (501033). Subordinate rock type is fine-grained granite (511058). Confidence level = 3.

498.85–499.54 m

DZ11: Minor low grade ductile shear zone (judged from core) composite dike. Low resistivity anomaly and decreased magnetic susceptibility. Decreased P-wave velocity. One non-oriented radar reflector close to the deformation zone at 499.6 m with the angle 73° to borehole axis. The host rock is dominated by fine-grained diorite-gabbro (505102). Subordinate rock type is diorite/gabbro (501033). Confidence level = 3.

596.50–600.80 m

DZ12: Minor low grade inhomogeneous ductile shear zone (judged from core). Partly decreased resistivity. One non-oriented radar reflector at 598.0 m with the angle 66° to borehole axis. The host rock is dominated by Ävrö granite (501044) and quartz monzodiorite (501036). Subordinate rock types are diorite/gabbro (501033), fine-grained granite (511058) and granite (501058). Confidence level = 3.

5.2 KLX09G

Rock units

The borehole contains one rock unit (RU1).

9.31–99.63 m

RU1: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite-gabbro (505102), granite (501058), pegmatite (501061) and fine-grained dioritoid (501030). The Ävrö granite has a density in the range 2,750–2,790 kg/m^3. The major part of the section is foliated. Confidence level = 3.

Possible deformation zones

One possible deformation zone has been recognized in KLX09G.

40.02–67.52 m

DZ1: Characterized by high frequency of open and sealed fractures, with partly large aperture. Increased frequency of sealed network in the lower part. Most intense deformation between 40.38–41.50 m (low grade ductile to brittle ductile shear zone) and 53.40–56.15 m (low grade ductile to brittle ductile shear zone). In the section c 40–44 m there is partly decreased resistivity, decreased P-wave velocity and a caliper anomaly. Three radar reflectors at 41.9 m with the orientation 004/29, at 42.9 m with the orientation 146/68 or 273/25, and at 52.8 m with the orientation 330/16 or 167/77. Five non-oriented radar reflectors with angle to borehole axis between 20° and 49°. Low radar amplitude at 40–41 m and 55–56 m. The host rock is dominated by Ävrö granite (501044). Subordinate rock types are fine-grained diorite-gabbro (505102), granite (501058), fine-grained granite (511058) and pegmatite (501061). Confidence level = 3.

5.3 KLX10B

Rock units

The borehole contains one rock unit (RU1).

8.00–50.24 m

RU1: Dominated by Ävrö granite (501044) with a density in the range 2,730–2,750 kg/m^3. Gamma radiation is in the range 20–25 μR/h. Subordinate rock types comprise fine-grained granite (511058), particularly between 10.35 and 20.35 m, and minor occurrences of fine-grained diorite-gabbro (505102) and granite (501058). The occurrence of fine-grained granite at 10.35–20.35 m coincides with decreased density (2,630 kg/m^3) and the natural gamma radiation is in the range 35–50 μR/h. Confidence level = 3.

Possible deformation zones

Two possible deformation zones have been recognized in KLX10B.

10.35–20.35 m

DZ1: Dominated by fine-grained granite (511058) In the section 19.63–20.35 m, gradually increase degree of foliation. Increased frequency in open fractures, faint red staining. There are no significant anomalies in the geophysical logging data along the section. Two non-oriented radar reflectors at 13.6 m and 16.4 m with the angle to borehole axis 58° and 47°, respectively. The host rock is dominated by fine-grained granite (511058). Subordinate rock types are Ävrö granite (501044) and granite (501058). Confidence level = 3.

39.20–46.60 m

DZ2: Increased frequency of open fractures, partly with large apertures. Low frequency of sealed fractures. Most intense part in between 39.96–40.32 m. At c 40.4 m there is one distinct caliper anomaly that coincides with decreased resistivity and decreased P-wave velocity. One non-oriented radar reflector at 39.9 m with the angle 51° to borehole axis. Two radar reflectors, one at 41.0 m with the orientation 274/72 or 125/15 and one at 43.6 m with the orientation 131/30. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

5.4 KLX10C

Rock units

The borehole contains one rock unit (RU1).

9.00–145.34 m

RU1: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained dioritoid (501030), minor occurrence of fine-grained diorite-gabbro (505102), fine-grained granite (511058), and very sparse occurrence of pegmatite (501061) and granite (501058). Ävrö granite has a density in the range 2,750–2,800 kg/m^3 in the section c 9–60 m, and mainly 2.690–2,730 kg/m^3 in the remaining part of the borehole. Scattered sections are foliated. Confidence level = 2.

Possible deformation zones

Seven possible deformation zones have been recognized in KLX10C.

8.65–9.50 m

DZ1: Brittle deformation zone, red staining. Increased frequency of open fractures. Section is above BIPS image and geophysical logging data, apart from the caliper log that does not show any anomalies. The host rock is dominated by Ävrö granite (501044). Confidence level = 2.

15.90–21.60 m

DZ2: The most intense sections are at 17.18–17.35 m and 18.92–19.60 m. Deformation characterised by medium to strong alteration (chloritization and red staining) and increased frequency of sealed and open fractures. The entire section is characterized by a major decrease in the bulk resistivity, significantly decreased P-wave velocity and magnetic susceptibility and also caliper anomalies. Two very strong and persistent non-oriented radar reflectors at 16.7 m and 19.4 m with the angle to borehole axis 58° and 55°, respectively. Low radar amplitude at 15–21 m. The host rock is dominated by a mixture of fine-grained dioritoid (501030) and Ävrö granite (501044). Subordinate rock types are pegmatite (501061) and fine-grained diorite-gabbro (505102). Confidence level = 3.

35.00–59.30 m

DZ3: Inhomogeneous deformation zone. Characterized by increased alteration (red staining) and increased frequency of sealed network, and partly also open fractures. Partly decreased magnetic susceptibility along the entire section. Decreased P-wave velocity and low resistivity anomalies in the section 42–47 m. Two non-oriented radar reflectors at 41.2 m and 44.3 m with the angle to borehole axis 8° and 6°, respectively. The host rock is dominated by Ävrö granite (501044). Subordinate rock types are fine-grained diorite-gabbro (505102) and fine-grained granite (511058). Confidence level = 3.

79.45–79.70m

DZ4: Characterized by sealed network. Partly decreased P-wave velocity in the interval 79.2–80.7 m, and sharp low resistivity anomaly at c 80.0 m. The host rock is dominated by Ävrö granite (501044). Confidence level = 3.

96.90–97.60 m

DZ5: Characterized by sealed fracture network. The interval 97.17–97.26 m is the most intense section. Red staining. No anomalies in the geophysical logs. The host rock is dominated by Ävrö granite (501044). Subordinate rock type is fine-grained granite (511058). Confidence level = 2.

103.50–110.10 m

DZ6: Inhomogeneous deformation zone. Characterized by sealed fracture network and open fractures. 505102 is foliated. The most intense sections are between 105.50–105.74 m and 106.10–106.27 m depth. Significant decrease in P-wave velocity and in resistivity along the section 105.5–107.1 m, which coincides with decreased magnetic susceptibility, natural gamma radiation and increased density. One strong and persistent radar reflector at 104.7 m with the orientation 193/25 or 060/71. Two non-oriented radar reflectors at 103.9 m and 105.6 m with the angle to borehole axis 78° and 52°, respectively. Low radar amplitude at 105–108 m.The host rock is dominated by Ävrö granite (501044). Subordinate rock types are fine-grained diorite-gabbro (505102) and fine-grained granite (511058). Confidence level = 3.

121.00–140 m

DZ7: Increased frequency of sealed fracture and partly open fractures. Partly also medium red staining. Partly decreased magnetic susceptibility in the section 127.7–140.0 m. Only minor negative anomalies in the P-wave velocity and resistivity logging data along the section of the DZ. Two radar reflectors, one at 125.0 m with the orientation 187/32 and one at 134.52 m with the orientation 060/33 or 114/34. Two non-oriented radar reflectors at 123.4 m and 125.6 m with the angle to borehole axis 29° and 52°, respectively. The host rock is dominated by Ävrö granite (501044). Subordinate rock types are fine-grained dioritoid (501030) and fine-grained granite (511058). Confidence level = 3.

6 Comments

The results from the geological single-hole interpretations of KLX12A, KLX09G, KLX10B and KLX10C are presented in WellCad plots (Appendices 1–4). 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.

/2/ **Rauséus G, Ehrenborg J, 2006.** Oskarshamn site investigation. Boremap mapping of core drilled borehole KLX12A. SKB P-06-242, Svensk Kärnbränslehantering AB.

/3/ **Mattsson K-J, Eklund S, 2006.** Oskarshamn site investigation. Boremap mapping of core drilled MDZ boreholes KLX09G, KLX10B and KLX10C. SKB P-06-236, Svensk Kärnbränslehantering AB.

/4/ **Mattsson H, 2006.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX12A. SKB P-06-253, Svensk Kärnbränslehantering AB.

/5/ **Mattsson H, Keisu M, 2006.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX09G, KLX10B, KLX10C, HLX36 and HLX37. SKB P-06-264, Svensk Kärnbränslehantering AB.

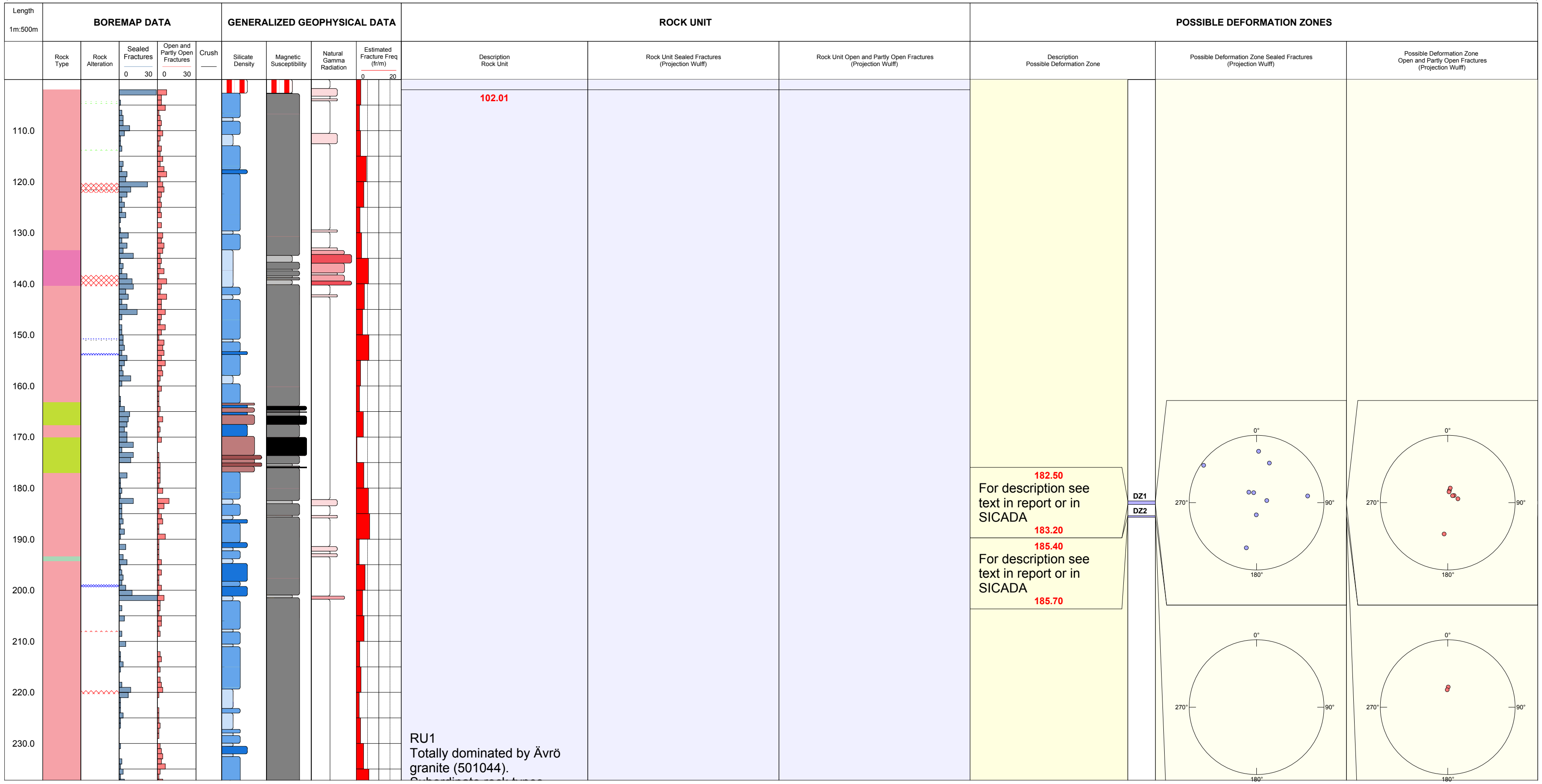
/6/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX09B, KLX09C, KLX09D, KLX09E, KLX09F and KLX09G. SKB P-06-99, Svensk Kärnbränslehantering AB.

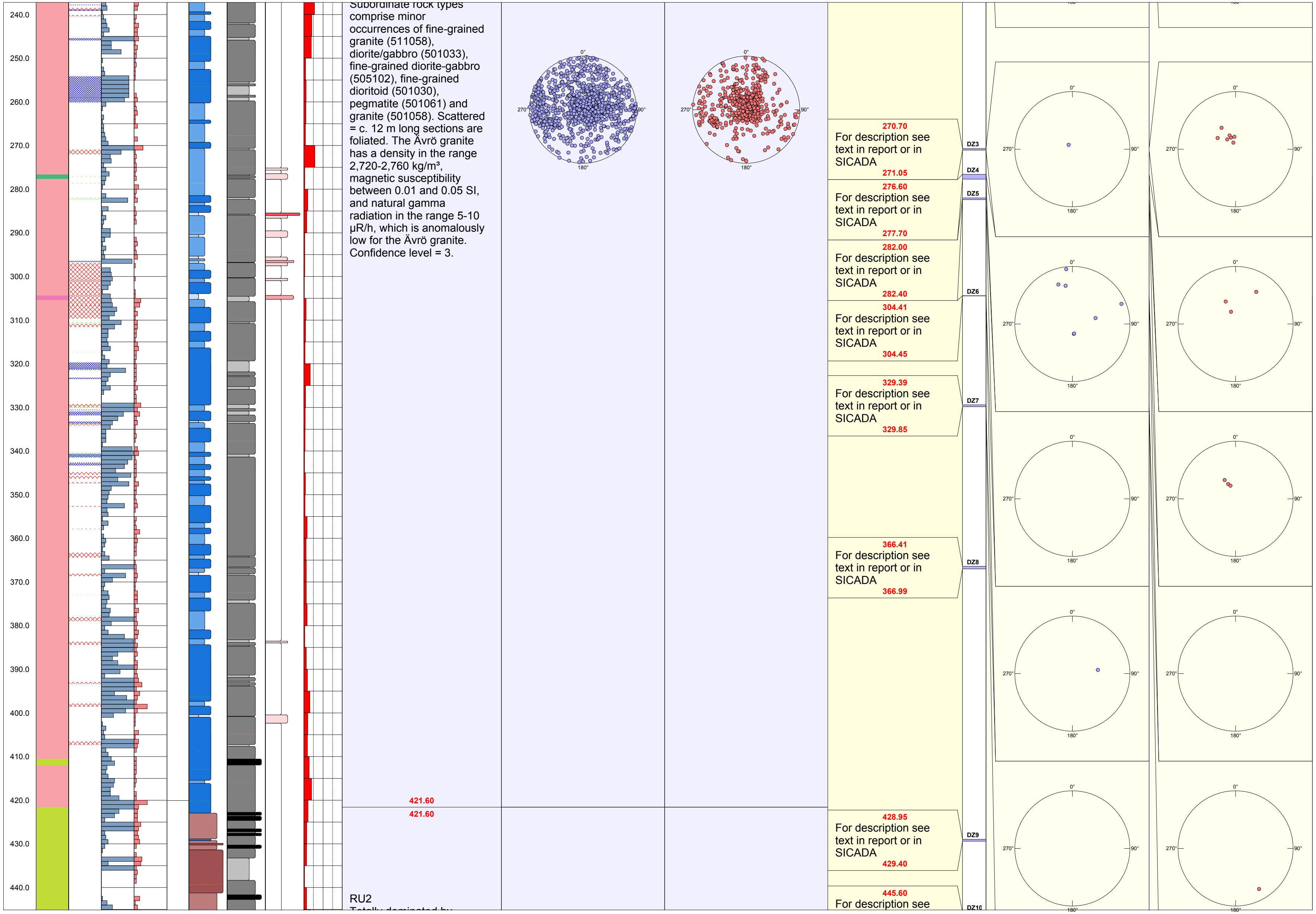
/7/ **Gustafsson J, Gustafsson C, Friborg, J, 2006.** Oskarshamn site investigation. RAMAC and BIPS logging in boreholes KLX10B, KLX10C and KLX12A. SKB P-06-167, Svensk Kärnbränslehantering AB.

Geological single-hole interpretation of KLX12A

Title	SINGLE HOLE INTERPRETATION KLX12A					
Site	LAXEMAR	Inclination [°]	-75.30	Elevation [m.a.s.l.]	17.67	Signed data
Borehole	KLX12A	Date of mapping	2006-04-03 10:15:00	Drilling Start Date	2005-10-19 07:00:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2005-10-27 16:00:00	
Length [m]	602.290	Northing [m]	6365629.96	Surveying Date		
Bearing [°]	315.92	Easting [m]	1548904.49	Plot Date	2007-10-14 22:03:05	

ROCKTYPE LAXEMAR	ROCK ALTERATION	SILICATE DENSITY	SUSCEPTIBILITET	NATURAL GAMMA
Fine-grained granite	Oxidized	unclassified	unclassified	unclassified
Ävrö granite	Chloritisized	dens<2680	0.001<sus<0.01	gam<10
Quartz monzodiorite	Epidotisized	2680<dens<2730	0.01<sus<0.1	10<gam<20
Diorite / Gabbro	Silicification	2730<dens<2800	sus>0.1	20<gam<30
Fine-grained dioritoid	Saussuritization	2800<dens<2890		gam>30
Fine-grained diorite-gabbro		dens>2890		

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370.0
380.0
390.0
400.0
410.0
420.0
430.0
440.0
Subordinate rock types comprise minor occurrences of fine-grained granite (511058), diorite/gabbro (501033), fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030), pegmatite (501061) and granite (501058). Scattered = c. 12 m long sections are foliated. The Ävrö granite has a density in the range 2,720-2,760 kg/m³, magnetic susceptibility between 0.01 and 0.05 SI, and natural gamma radiation in the range 5-10 µR/h, which is anomalously low for the Ävrö granite. Confidence level = 3.
421.60
421.60
RU2
270.70
For description see text in report or in SICADA
271.05
276.60
For description see text in report or in SICADA
277.70
282.00
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282.40
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For description see text in report or in SICADA
304.45
329.39
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329.85
366.41
For description see text in report or in SICADA
366.99
428.95
For description see text in report or in SICADA
429.40
445.60
For description see
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DZ4
DZ5
DZ6
DZ7
DZ8
DZ9
DZ10
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90°
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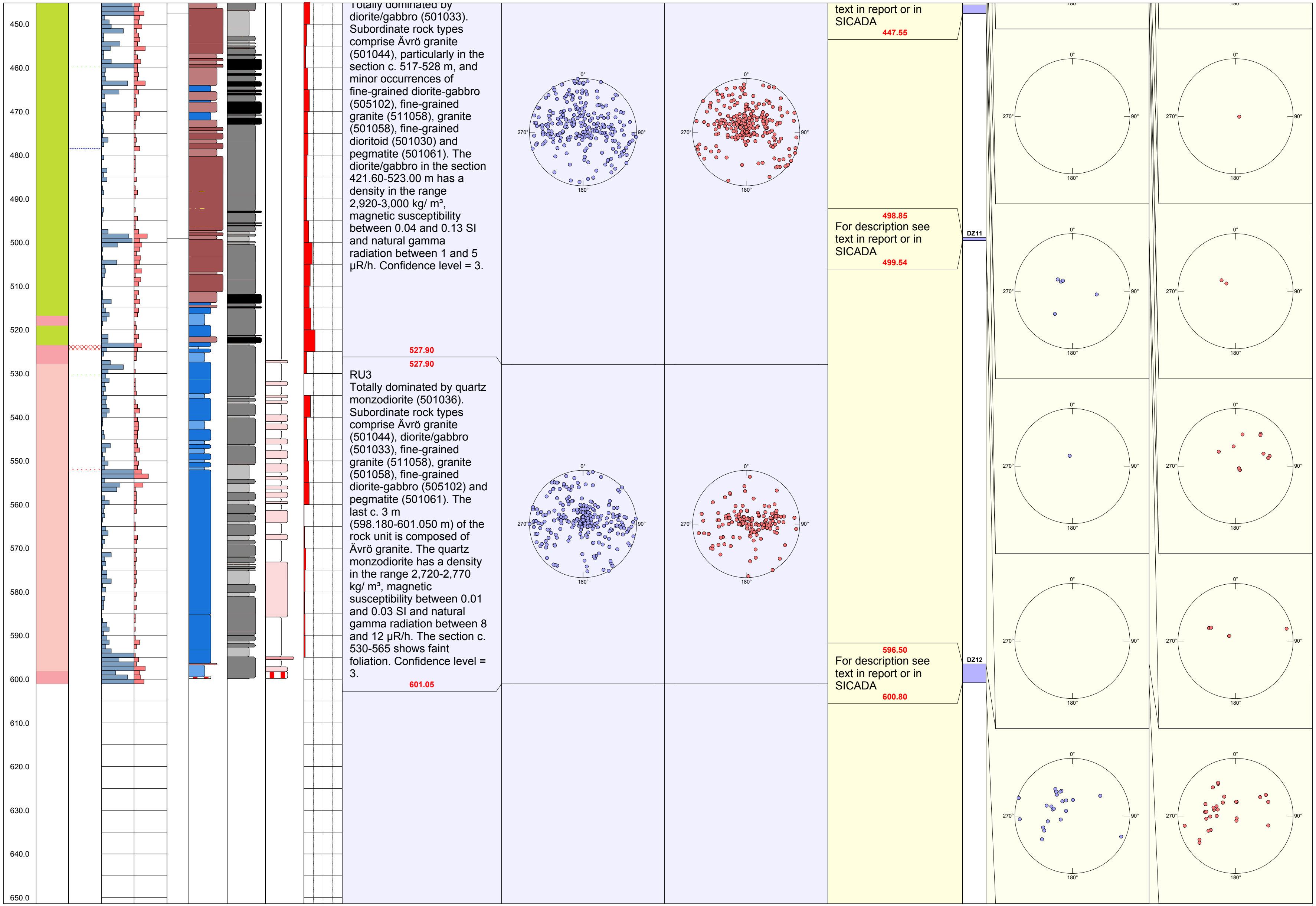
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590.0
600.0
610.0
620.0
630.0
640.0
650.0
Totally dominated by diorite/gabbro (501033). Subordinate rock types comprise Ävrö granite (501044), particularly in the section c. 517-528 m, and minor occurrences of fine-grained diorite-gabbro (505102), fine-grained granite (511058), granite (501058), fine-grained dioritoid (501030) and pegmatite (501061). The diorite/gabbro in the section 421.60-523.00 m has a density in the range 2,920-3,000 kg/ m³, magnetic susceptibility between 0.04 and 0.13 SI and natural gamma radiation between 1 and 5 µR/h. Confidence level = 3.
527.90
527.90
RU3
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise Ävrö granite (501044), diorite/gabbro (501033), fine-grained granite (511058), granite (501058), fine-grained diorite-gabbro (505102) and pegmatite (501061). The last c. 3 m (598.180-601.050 m) of the rock unit is composed of Ävrö granite. The quartz monzodiorite has a density in the range 2,720-2,770 kg/ m³, magnetic susceptibility between 0.01 and 0.03 SI and natural gamma radiation between 8 and 12 µR/h. The section c. 530-565 shows faint foliation. Confidence level = 3.
601.05
text in report or in SICADA
447.55
498.85
For description see text in report or in SICADA
499.54
DZ11
596.50
For description see text in report or in SICADA
600.80
DZ12
0°
90°
180°
270°

Geological single-hole interpretation of KLX09G

Title	SINGLE HOLE INTERPRETATION KLX09G					
Site	LAXEMAR	Inclination [°]	-61.07	Elevation [m.a.s.l.]	19.56	Signed data
Borehole	KLX09G	Date of mapping	2006-04-24 08:56:00	Drilling Start Date	2006-01-27 16:00:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2006-02-03 12:00:00	
Length [m]	100.100	Northing [m]	6367329.27	Surveying Date		
Bearing [°]	85.41	Easting [m]	1548905.82	Plot Date	2007-10-14 22:03:05	

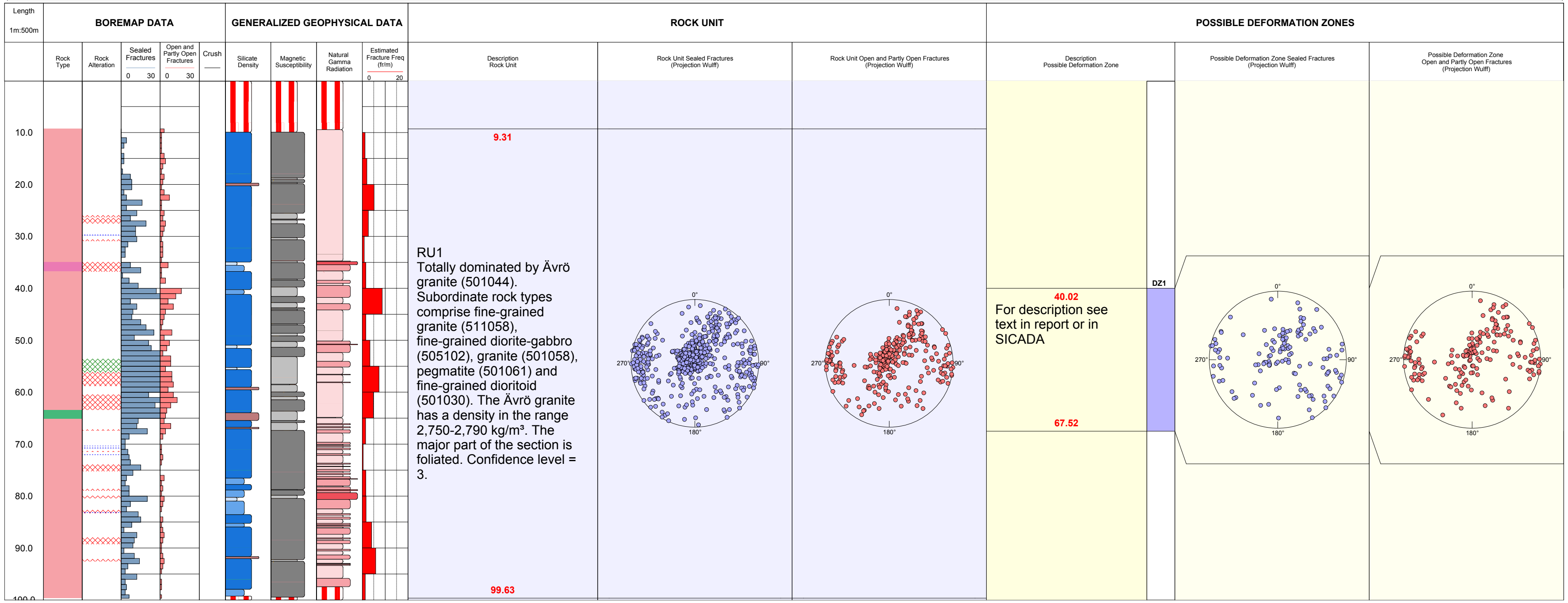
ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Fine-grained diorite-gabbro

ROCK ALTERATION
- Oxidized
- Chloritisized
- Saussuritization

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 3

Geological single-hole interpretation of KLX10B

Title	SINGLE HOLE INTERPRETATION KLX10B					
Site	LAXEMAR	Inclination [°]	-59.96	Elevation [m.a.s.l.]	18.08	Signed data
Borehole	KLX10B	Date of mapping	2006-04-12 17:24:00	Drilling Start Date	2006-02-08 16:35:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2006-02-14 06:55:00	
Length [m]	50.250	Northing [m]	6366315.67	Surveying Date		
Bearing [°]	170.33	Easting [m]	1548525.20	Plot Date	2007-10-14 22:03:05	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite

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
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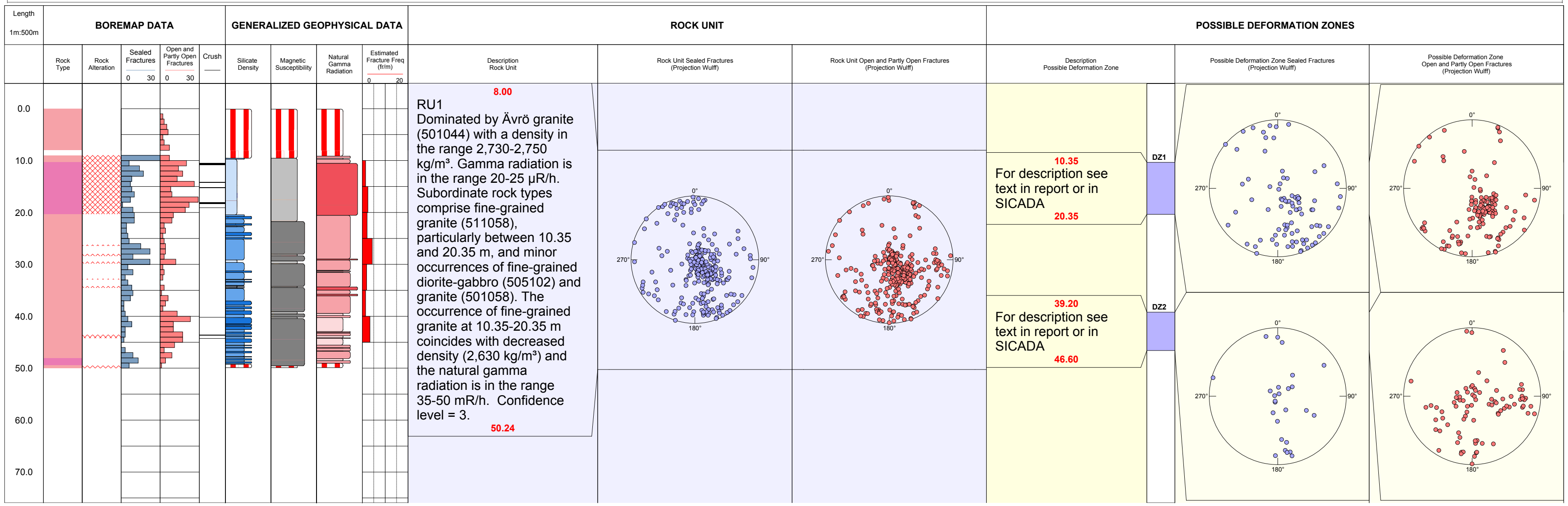
- 10<gam<20
- 20<gam<30
- gam>30



Geological single-hole interpretation of KLX10C

Title	SINGLE HOLE INTERPRETATION KLX10C						
Site	LAXEMAR	Inclination [°]	-60.02	Elevation [m.a.s.l.]	16.87	Signed data	
Borehole	KLX10C	Date of mapping	2006-04-03 13:38:00	Drilling Start Date	2006-02-15 14:38:00		
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2006-02-28 07:22:00		
Length [m]	146.250	Northing [m]	6366371.25	Surveying Date			
Bearing [°]	352.43	Easting [m]	1548506.99	Plot Date	2007-10-14 22:03:05		

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

ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Saussuritization

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

SUSCEPTIBILITET
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- sus<0.001
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NATURAL GAMMA
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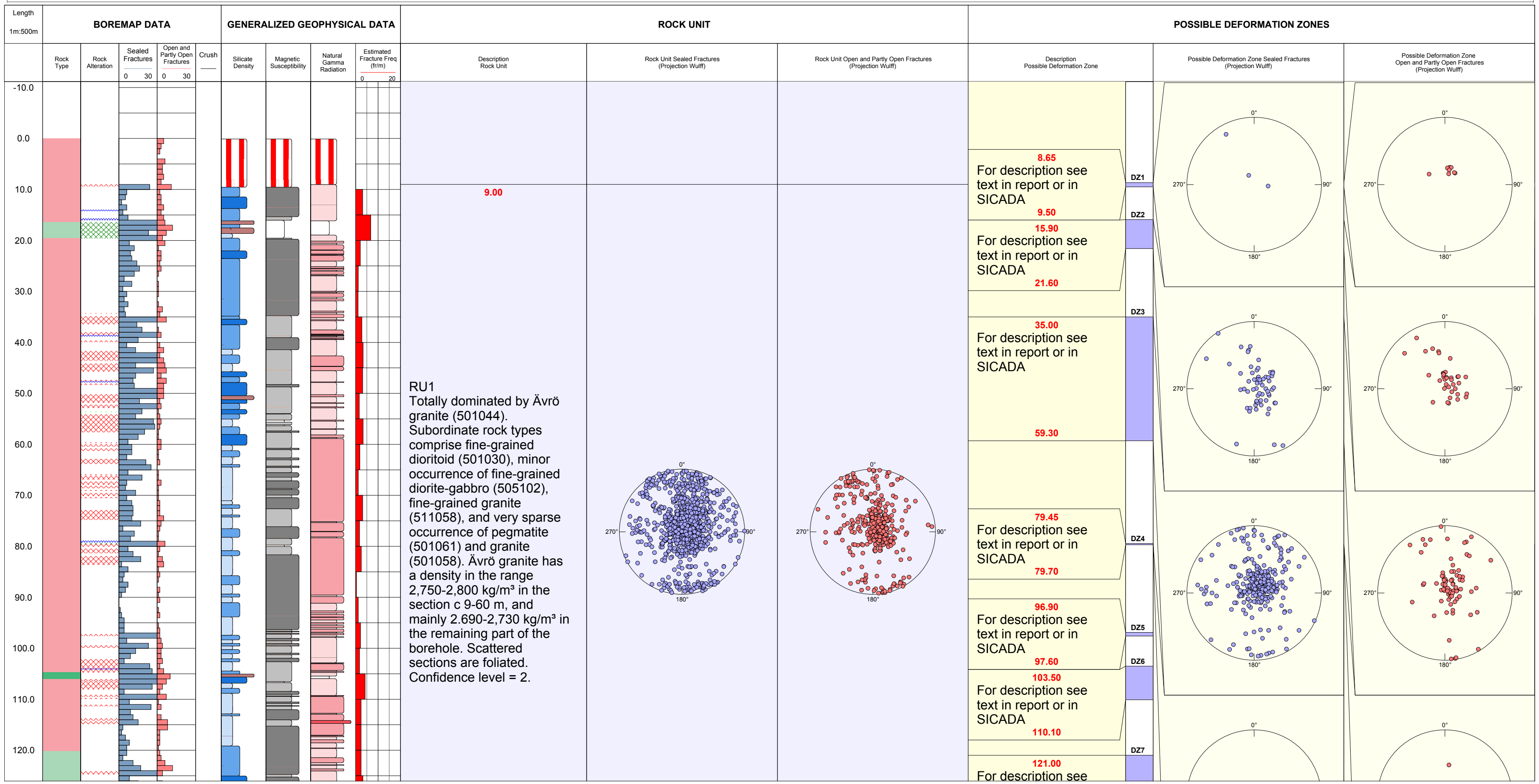

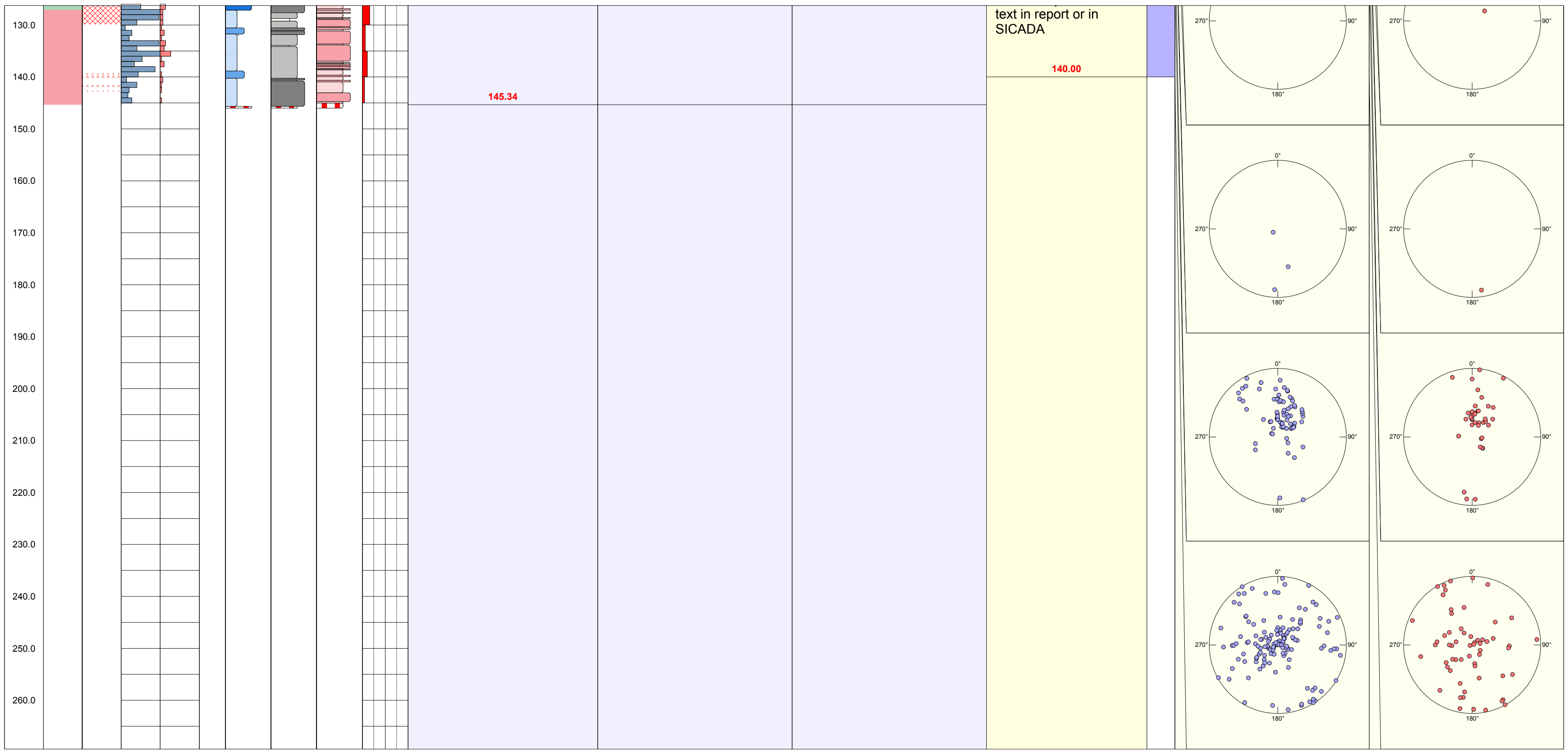

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