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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 KLX10 and the percussion boreholes HLX20 and HLX36 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.

Seven rock units are indicated in KLX10 (RU1–RU7). However, the borehole can be divided into nine separate sections due to the repetition of RU3 (RU3a, RU3b and RU3c). In general KLX10 is dominated by Ävrö granite (501044), and a mixture of Ävrö granite (501044) and diorite/gabbro (501033). A section in the central part of the borehole contains fine-grained dioritoid (501030) and the lower part of the borehole is dominated by quartz monzodiorite (501036). Subordinate rock types comprise sparse occurrences of fine-grained diorite-gabbro (505102), fine-grained granite (511058), fine-grained dioritoid (501030), granite (501058) and some pegmatite (501061). Nine possible deformation zones are identified in KLX10 (DZ1–DZ9).

The percussion borehole HLX20 is dominated by Ävrö granite (501044). The borehole is divided into two rock units (RU1–RU2) due to differences in the density. Subordinate rock types comprise fine-grained diorite-gabbro (505102), fine-grained granite (511058) and pegmatite (501061). One possible deformation zone is identified in HLX20 (DZ1).

Two rock units are indicated in percussion borehole HLX36 (RU1–RU2). The upper part of the borehole is dominated by quartz monzodiorite (501036) and the lower part by dolerite (501027). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite-gabbro (505102) and quartz monzodiorite (501036). One possible deformation zone is identified in HLX36 (DZ1).

# Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhål KLX10 och hammarborrhålen HLX20 och HLX36 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 KLX10. Baserat på repetition av enheten RU3 (RU3a, RU3b och RU3c) kan borrhålet delas in i nio sektioner. Generellt sett domineras borrhålet av Ävrögranit (501044) och en blandning mellan Ävrögranit (501044) och diorit/gabbro (501033). En sektion i den centrala delen av borrhålet består av finkornig dioritoid (501030) och nedre delen av borrhålet domineras av kvartsmonzodiorit (501036). Finkornig diorit-gabbro (505102), finkornig granit (511058), finkornig dioritoid (501030), granit (501058) och pegmatit (501061) förekommer som underordnade bergarter. Nio möjliga deformationszoner har identifierats i KLX10 (DZ1–DZ9).

Hammarborrhål HLX20 domineras av Ävrögranit (501044). Borrhålet kan delas in i två litologiska enheter (RU1–RU2) baserat på skillnader i densitet. Finkornig diorit-gabbro (505102), finkornig granit (511058) och pegmatit (501061) förekommer som underordnade bergarter. En möjlig deformationszon har identifierats i HLX20 (DZ1).

I hammarborrhål HLX36 finns två litologiska enheter (RU1–RU2). Övre delen av borrhålet domineras av kvartsmonzodiorit (501036) medan den nedre delen domineras av diabas (501027). Finkornig granit (511058), finkornig diorit-gabbro (505102) och kvartsmonzodiorit (501036) förekommer som underordnade bergarter. En möjlig deformationszon har identifierats i HLX36 (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 interpretation of the cored borehole KLX10 and the percussion boreholes HLX20 and HLX36 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 400-06-018. 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.

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

| Activity Plan | Number | Version |
|---|---|---|
| Geologisk enhålstolkning av KLX10, HLX20 och HLX36 | AP PS 400-06-018 | 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 |

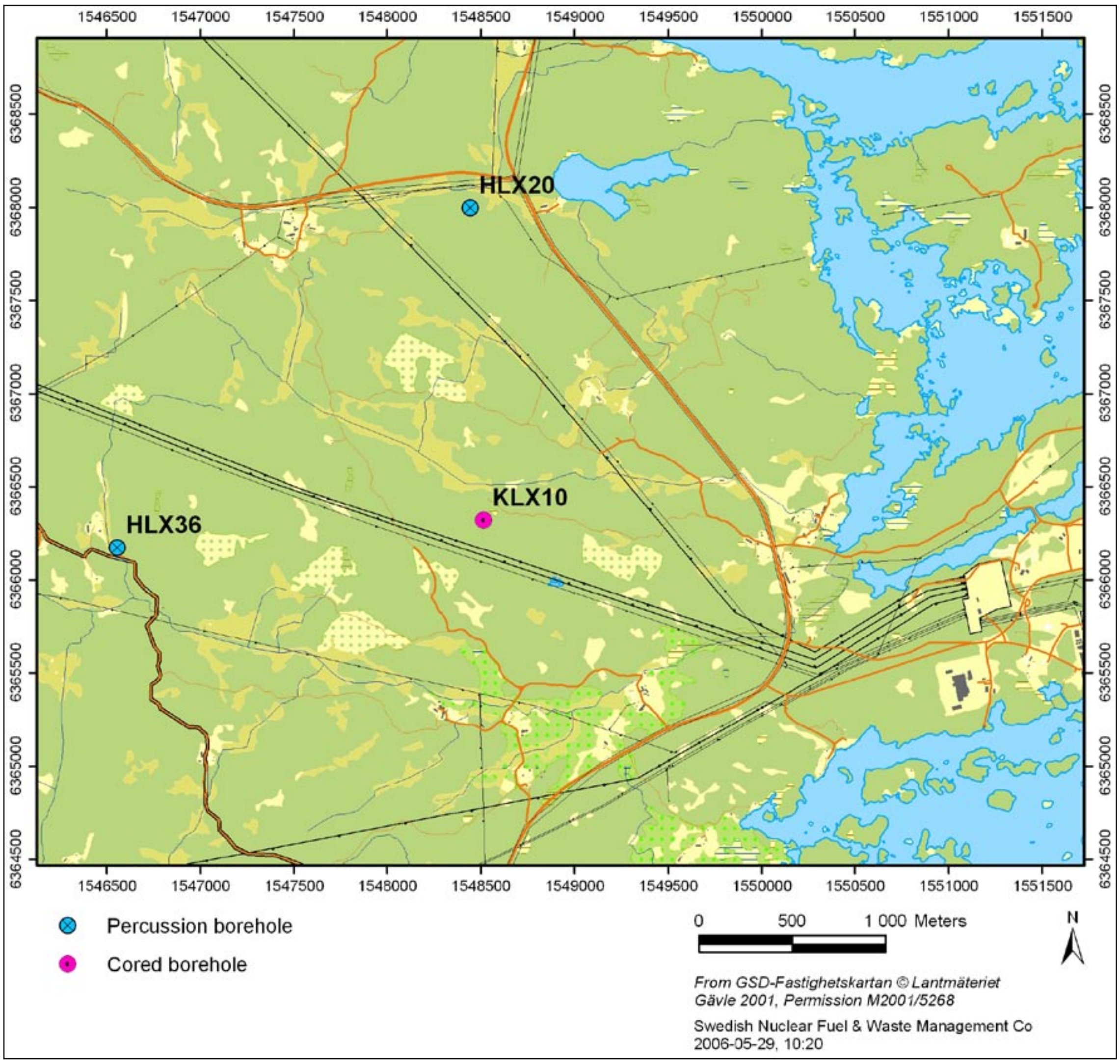

***Figure 1-1.*** *Map showing the position of the cored borehole KLX10 and the percussion boreholes HLX20 and HLX36.*

# 2 Objective and scope

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

# 3 Data used for the geological single-hole interpretation

The following data have been used in the single-hole interpretation of the borehole KLX10, HLX20 and HLX36:

- Boremap data (including BIPS and geological mapping data) /1, 2, 3/.
- Generalized geophysical logs and their interpretation /4, 5/.
- Radar data and their interpretation /6, 7, 8/.

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 < 1m
  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.

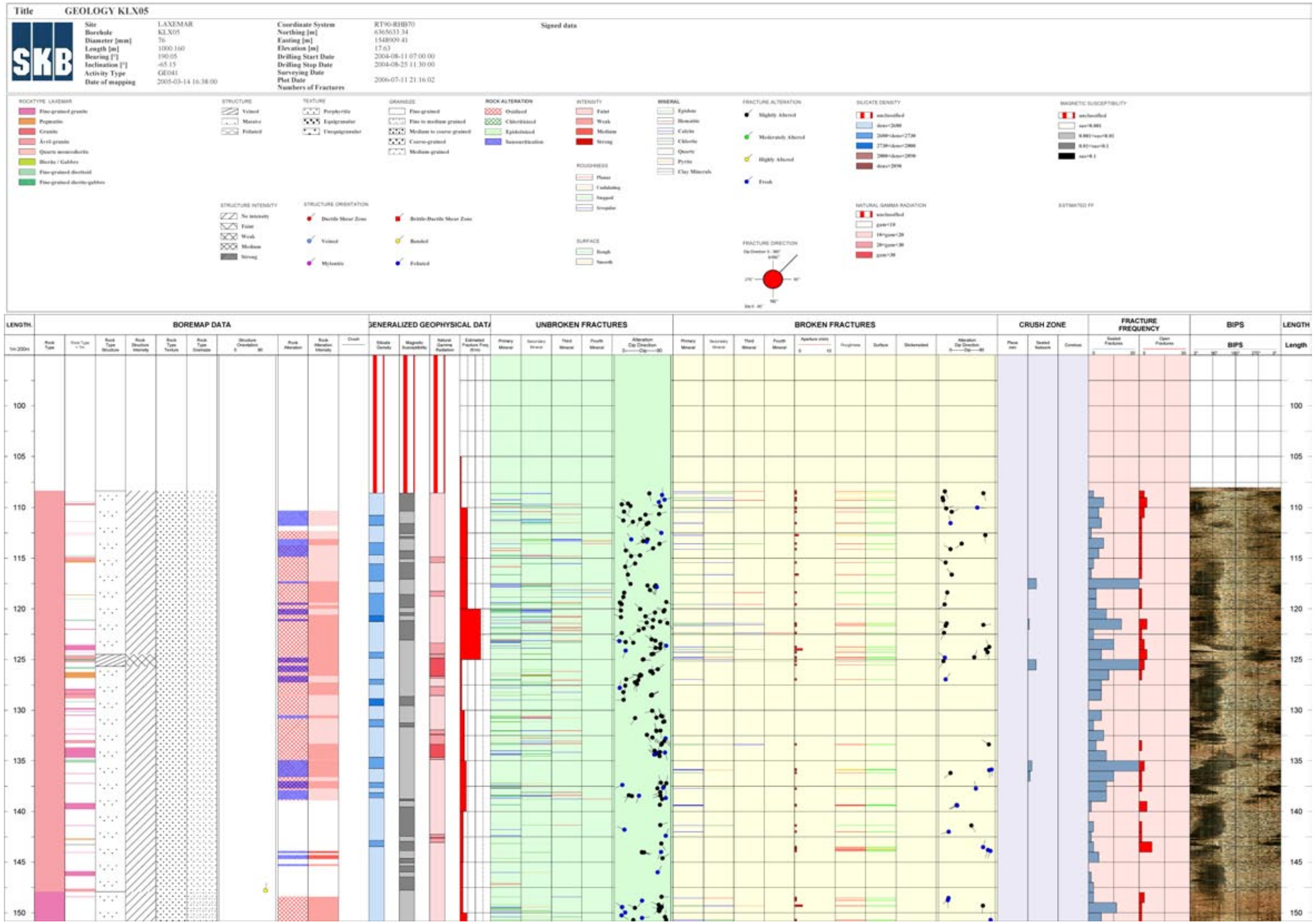

*Figure 3-1. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.*

# 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.

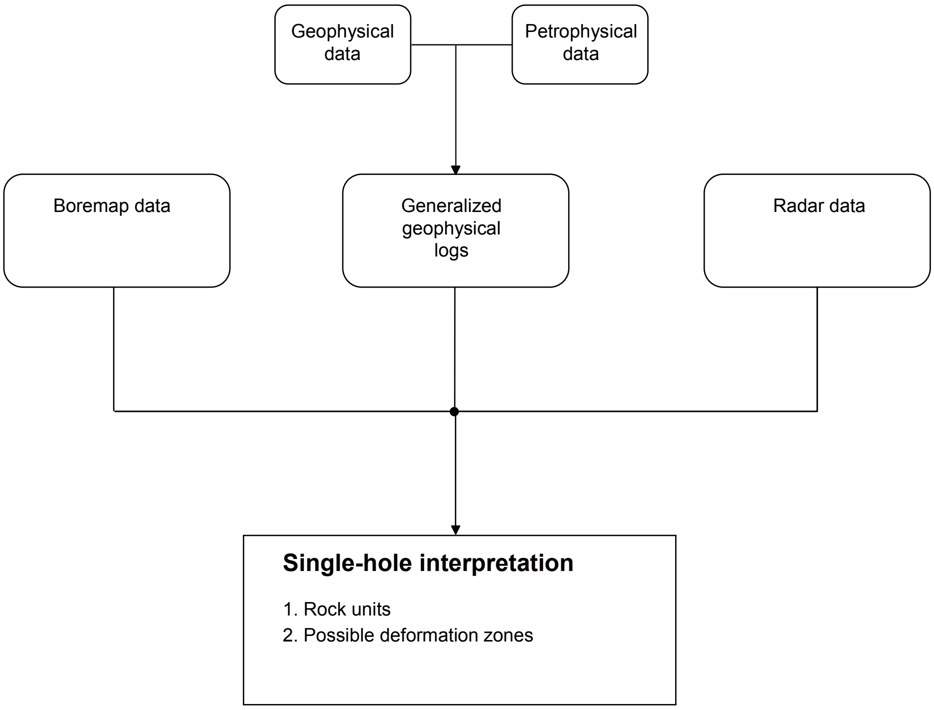

***Figure 4-1.*** *Schematic block-scheme of single-hole interpretation.*

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.

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

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 KLX10 (Figure 4-3). 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 this diagram.

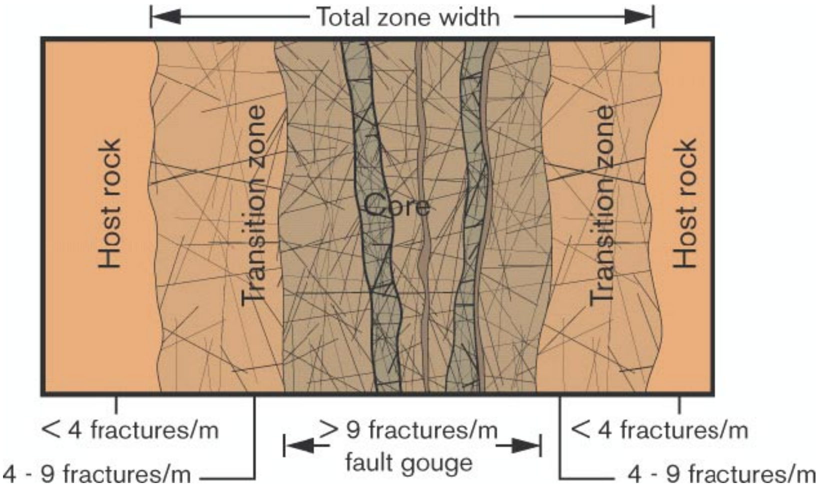

***Figure 4-2.*** *Terminology for brittle deformation zones (after /9/).*

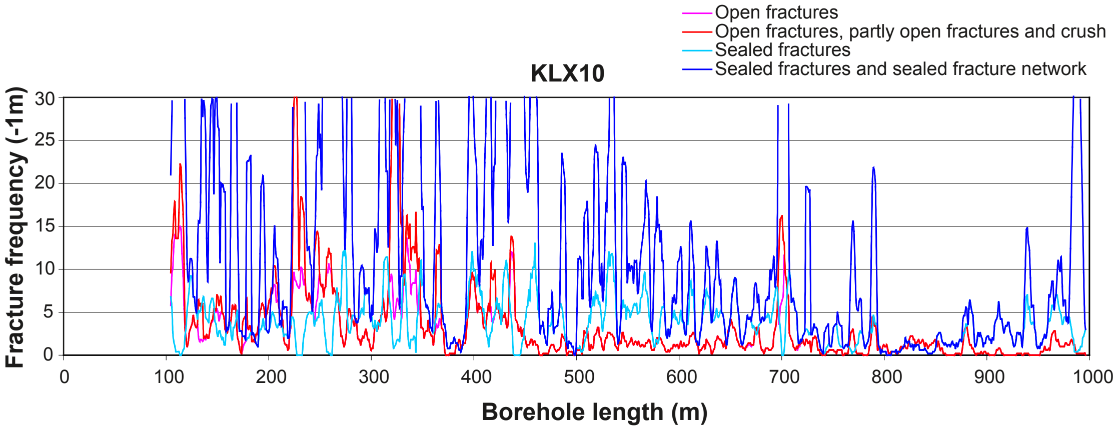

***Figure 4-3.*** *Fracture frequency plot for KLX10. Moving average with a 5 m window and 1 m steps.*

The occurrence and orientation of radar anomalies within the possible deformation zones are used during the identification of possible deformation zones. Overview of the borehole radar measurement in KLX10 and HLX36 are shown in Figures 4-4 and 4-5.

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.

## 4.2 Nonconformities

Percussion borehole HLX20 was logged with BIPS down to about 118 m. Below 118 m the geological mapping is based on drill cuttings.

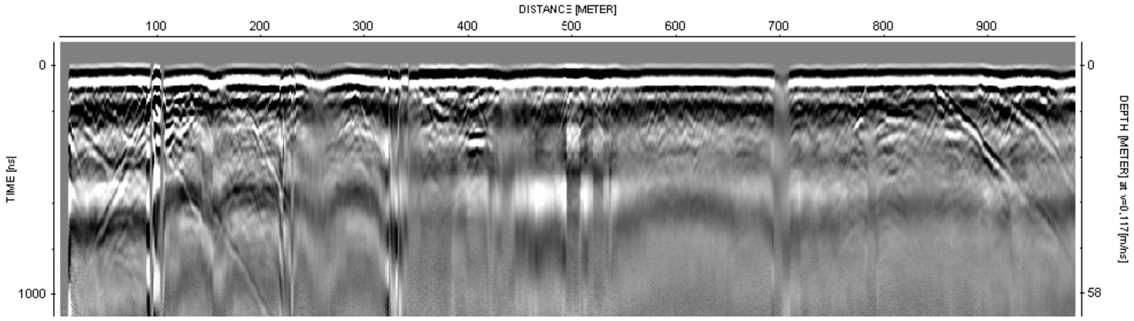

***Figure 4-4.*** *Overview (20 MHz data) of the borehole radar measurement in KLX10.*

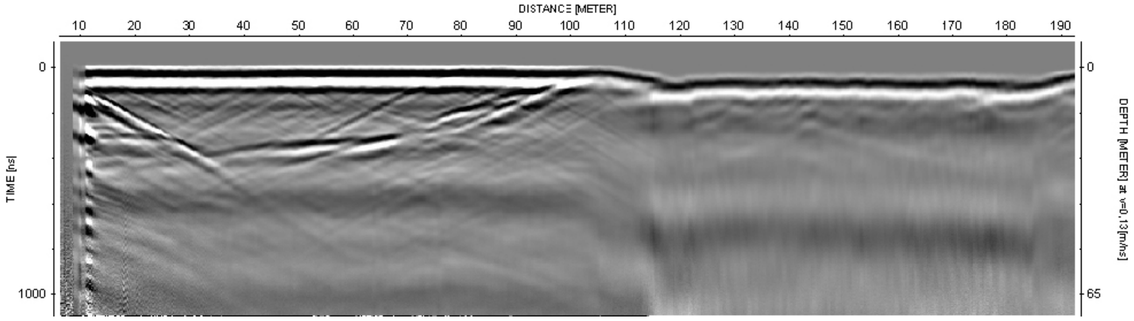

***Figure 4-5.*** *Overview (20 MHz data) of the borehole radar measurement in HLX36.*

# 5 Results

The detailed results of the single-hole interpretation are presented as print-outs from the software WellCad (Appendix 1 for KLX10, Appendix 2 for HLX20 and Appendix 3 for HLX36).

## 5.1 KLX10

### Rock units

The borehole can be divided into seven rock units (RU1–RU7). However, due to the repetition of RU3 (RU3a, RU3b and RU3c) can the borehole be divided into nine separate sections.

#### *101.86–328.84 m*

RU1: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058) in up to 10 m long sections and sparse occurrences of fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030) and very sparse occurrences of granite (501058). Scattered up to c. 26 m long sections are foliated. In the sections 150.2–161.4 and 320.3–323.5 m the Ävrö granite (501044) is vuggy in character. The Ävrö granite has a density in the range 2,700–2,730 kg/m$^3$ in the section 100–142 m and 2,650–2,680 kg/m$^3$ in the remaining part of the rock unit. Confidence level = 3.

#### *328.84–348.83 m*

RU2: Mixture of Ävrö granite (501044) and fine-grained diorite-gabbro (505102). The fine-grained diorite-gabbro (505102) constitutes c. 4 m long sections at the top and bottom of the rock unit. In the sections 333.2–333.3, 333.8–334.4 and 336.8–337.6 m the Ävrö granite (501044) is vuggy in character. Subordinate rock type comprises fine-grained dioritoid (501030). Confidence level = 3.

#### *348.83–395.99 m*

RU3a: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise sparse occurrences of fine-grained granite (511058) and fine-grained dioritoid (501030). The section c. 370–382 is foliated. Scattered minor sections are also foliated. Confidence level = 3.

#### *395.99–432.20 m*

RU4: Totally dominated by fine-grained dioritoid (501030). Subordinate rock types comprise Ävrö granite (501044) and fine-grained granite (511058). The section 406–410 m is foliated. Confidence level = 3.

#### *432.20–767.75 m*

RU3b: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise < 1 m long sections of fine-grained granite (511058) and fine-grained diorite-gabbro (505102). Scattered up to 4 m long sections are foliated. Confidence level = 3.

### *767.75–791.95 m*

RU5: Mixture of Ävrö granite (501044) and fine-grained diorite-gabbro (505102). Subordinate rock types comprise < 1 m long sections of fine-grained granite (511058) and granite (501058). The major part of the rock unit is foliated. Confidence level = 3.

### *791.95–857.08 m*

RU3c: Totally dominated by Ävrö granite (501044). Subordinate rock types comprise < 1 m long sections of fine-grained granite (511058) and fine-grained diorite-gabbro (505102). Scattered sections are foliated, in particular the section 792–817 m. One very strong and persistent non-oriented radar reflector occurs at 824.9 m with the angle 18° to borehole axis. Confidence level = 3.

### *857.08–980.95 m*

RU6: Mixture of Ävrö granite (501044) and diorite/gabbro (501033). The mixture is most accentuated in the section 902–981 m. Ävrö granite (501044) dominates in the upper part of the section. Subordinate rock types comprise fine-grained granite (511058), and very sparse occurrences of granite (501058) and pegmatite (501061). Scattered up to 9 m long sections are foliated. A very strong and persistent radar reflector occurs at 868.8 m with the orientation 353/84. Confidence level = 3.

### *980.95–996.49 m*

RU7: Totally dominated by quartz monzodiorite (501036). Subordinate rock type comprises fine-grained granite (511058). The section c. 990–998 meter is foliated. Confidence level = 3.

## Possible deformation zones

Nine possible deformation zones have been recognised in KLX10.

### *103.0–116.3 m*

DZ1: Deformation zone in Ävrö granite (501044) with subordinate fine-grained granite (511058) and very sparse granite (501058). Inhomogeneous brittle deformation zone characterized by increased frequency of sealed and open fractures and weak to medium red staining. Some of the open fractures have large apertures. One open fracture with gauge. Crush zones at 106.61–106.65 and 114.97–115.08 m. Low electric resistivity, P-wave velocity and magnetic susceptibility. Several caliper anomalies. Two non-oriented radar reflectors occur with intersection angle 53° and 58° to borehole axis, respectively. Low radar amplitude occurs in the interval 105–115 m. Confidence level = 3.

### *150–161.5 m*

DZ2: Deformation zone in Ävrö granite (501044) with subordinate fine-grained granite (511058). The deformation zone is mainly characterized by vuggy character of the Ävrö granite (dissolution of quartz). Crush zone at 151.8–151.95. Very low electric resistivity, low P-wave velocity and magnetic susceptibility. One caliper anomaly, low density and elevated natural gamma radiation. Four non-oriented radar reflectors occur with intersection angle between 42 and 58° to borehole axis. Low radar amplitude occurs in the interval 145–165 m, i.e. partly outside the deformation zone. Confidence level = 2.

### *176–176.7 m*

DZ3: Minor deformation zone in Ävrö granite (501044) and fine-grained dioritoid (501030) characterized by crush. Low electric resistivity and magnetic susceptibility. Minor caliper anomaly. One non-oriented radar reflector occurs at 176.3 m with the angle 75° to borehole axis. Confidence level = 3.

### *188–208 m*

DZ4: Deformation zone in Ävrö granite (501044) with very subordinate occurrence of fine-grained granite (511058). Increased frequency of open fractures and a crush zone at 206.66–206.73. Several fractures are parallel with the drill core, some of which have large apertures. These fractures partly contain idiomorphic calcite crystals. Low electric resistivity and P-wave velocity. Several caliper anomalies. Four non-oriented radar reflectors occur with intersection angle between 44 and 56° to borehole axis. One oriented radar reflector occurs at 192.2 m with the orientation 050/43 or 246/36. Confidence level = 3.

### *224–232.7 m*

DZ5: Deformation zone in Ävrö granite (501044) with subordinate fine-grained granite (511058). Increased frequency of sealed and open fractures. Some of the open fractures are parallel with the drill core and have large apertures. Crush zones at 224.99–225.22, 226.14–226.40, 227.60–228.05 and 232.18–232.59. Weak red staining. Low electric resistivity and magnetic susceptibility and low P-wave velocity in the uppermost part. Several caliper anomalies. One non-oriented radar reflector at 229.8 m with the angle 59° to borehole axis. Confidence level = 3.

### *245–263 m*

DZ6: Deformation zone Ävrö granite (501044) with subordinate fine-grained granite (511058), fine-grained dioritoid (501030) and granite (501058). Increased frequency of sealed and open fractures including sealed network. Crush zones at 245.60–246.78 and 258.62–258.66. Weak red staining. Very low electric resistivity and low P-wave velocity and magnetic susceptibility. Several caliper anomalies. Four non-oriented radar reflectors occur with intersection angle between 52 and 71° to borehole axis. Low radar amplitude occurs in the interval 240–280 m, i.e. partly outside the deformation zone. Confidence level = 3.

### *318–349 m*

DZ7: Deformation zone dominated by Ävrö granite (501044) with subordinate fine-grained diorite-gabbro (505102) and fine-grained dioritoid (501030). Increased frequency of sealed and open fractures. Some of the latter have large apertures. Crushed zones at 319.95–321.31, 322.57–323.49, 324.14–324.19, 324.72–325.52, 328.04–328.84, 335.98–336.05, 339.71–339.93, 341.74–341.79, 344.61–344.69, and 345.01–345.09. Weak to medium red staining. The Ävrö granite is locally vuggy in character (dissolution of quartz). Eight non-oriented radar reflectors occur with intersection angle between 52 and 86° to borehole axis. One oriented radar reflector occurs at 327.7 m with the orientation 261/80 or 079/83. Low radar amplitude occurs in the interval 320–350 m. Very low electric resistivity, low P-wave velocity and magnetic susceptibility. Some major caliper anomalies. Anomaly in temperature gradient. Confidence level = 3.

### *435–439.2 m*

DZ8: Deformation zone dominated by Ävrö granite (501044) with subordinate fine-grained granite (511058). Increased frequency of sealed and open fractures. Some of the latter have large apertures. Crush zone at 436.35–436.44. Weak red staining. Low electric resistivity, P-wave velocity and magnetic susceptibility. One non-oriented radar reflector occurs at 438.6 m with the angle 56° to borehole axis. Low radar amplitude occurs in the interval 435–440 m, i.e. partly outside the deformation zone. Confidence level = 3.

### *694.4–706.4 m*

DZ9: Deformation zone dominated by Ävrö granite (501044) with subordinate fine-grained granite (511058). Increased frequency of sealed and open fractures. A few of the latter have large apertures. Crush zone at 698.32–700.26. Weak to medium red staining. Very low electric resistivity, low P-wave velocity, magnetic susceptibility and density. One caliper anomaly and an anomaly in temperature gradient. Three non-oriented radar reflectors occur with intersection angle between 53 and 56° to borehole axis. One oriented radar reflector occurs at 701.1 m with the orientation 274/46. Low radar amplitude occurs in the interval 695–715 m, i.e. partly outside the deformation zone. Confidence level = 3.

## 5.2 HLX20

### Rock units

The borehole can be divided into two rock units (RU1–RU2).

### *9.12–110 m*

RU1: Totally dominated by Ävrö granite (501044) with density in the range 2,680–2,730 kg/m$^3$. Gamma radiation is in the range 10–20 μR/h. Subordinate rock types comprise fine-grained diorite-gabbro (505102), fine-grained granite (511058) and pegmatite (501061). Confidence level = 2.

### *110–202 m*

RU2: Totally dominated by Ävrö granite (501044) with density ≤ 2,680 kg/m$^3$. Gamma radiation is in the range 20–30 μR/h. Subordinate rock types comprise fine-grained diorite-gabbro (505102) and fine-grained granite (511058). Confidence level = 1.

### Possible deformation zones

One possible deformation zone has been recognised in HLX20.

### *90–170 m*

DZ1: High frequency of open fractures, red staining. Low electric resistivity, low magnetic susceptibility, low P-wave velocity and several caliper anomalies. The most prominent geophysical anomalies are found in the interval 113 to 136 m. Nineteen non-oriented radar reflectors occur in the section with angles in the interval 23–86° to borehole axis. Dominated by Ävrö granite (501044), with subordinate occurrence of fine-grained granite (511058). Confidence level = 2.

## 5.3 HLX36

### Rock units

The borehole can be divided into two rock units (RU1–RU2).

#### *6.22–112.00 m*

RU1: Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058) and a minor section of fine-grained diorite-gabbro (505102). Confidence level = 2.

#### *112.00–193.71 m*

RU2: Totally dominated by dolerite (501027). Subordinate rock type comprises quartz monzodiorite (501036) between 191.3 and 193.7 m. Confidence level = 2.

### Possible deformation zones

One possible deformation zone has been recognized in HLX36:

#### *110.8–191.36 m*

DZ1: High frequency of open fractures. Very low electric resistivity and low magnetic susceptibility. Caliper anomalies along the entire zone, the most prominent ones at the margins. Nine non-oriented radar reflectors occur in the section with angles in the interval 31–68° to borehole axis and one non-oriented with the angle 36°. Two of them are very strong and persistent and occur at 110.8 m (44°) and at 112.7 m (31°), i.e. at the margin of the deformation zone. Very low radar amplitude in the interval 110–190 m. The host rock is totally dominated by dolerite (501027). Subordinate rock type is quartz monzodiorite (501036). Confidence level = 2.

# 6 Comments

The result from the geological single-hole interpretations of KLX10, HLX20 and HLX36 are presented in WellCad plots (Appendices 1–3). The WellCad plots consist 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/ **Dahlin P, Ehrenborg J, 2006.** Oskarshamn site investigation. Boremap mapping of core drilled borehole KLX10, SKB P-06-51, Svensk Kärnbränslehantering AB.

/2/ **Sigurdsson O, 2006.** Oskarshamn site investigation. Simplified Boremap mapping of percussion borehole HLX20 on lineament EW002. SKB P-05-163, 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, 2006.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements and petrophysical data from KLX10. SKB P-06-162, Svensk Kärnbränslehantering AB.

/5/ **Mattsson H, Keisu M, 2005.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX07A, KLX07B, HLX20, HLX32, HLX34 and HLX35. SKB P-05-259, Svensk Kärnbränslehantering AB.

/6/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC and BIPS logging in boreholes KLX10 and HLX31. SKB P-06-50, Svensk Kärnbränslehantering AB.

/7/ **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.

/8/ **Gustafsson J, Gustafsson C, 2005.** Oskarshamn site investigation. RAMAC directional logging in borehole KLX05 and RAMAC and BIPS logging in borehole HLX20. SKB P-05-161, Svensk Kärnbränslehantering AB.

/9/ **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.

# Appendix 1

## Geological single-hole interpretation of KLX10

| | | | | | |
|---|---|---|---|---|---|
| **Title** | SINGLE HOLE INTERPRETATION KLX10 | | | | |
| **Site** | LAXEMAR | **Inclination [°]** | -85.18 | **Elevation [m.a.s.l.]** | 18.21 |
| **Borehole** | KLX10 | **Date of mapping** | 2005-11-29 09:18:00 | **Drilling Start Date** | 2005-05-24 12:30:00 |
| **Diameter [mm]** | 76 | **Coordinate System** | RT90-RHB70 | **Drilling Stop Date** | 2005-06-01 16:45:00 |
| **Length [m]** | 1001.200 | **Northing [m]** | 6366318.57 | **Surveying Date** | |
| **Bearing [°]** | 250.80 | **Easting [m]** | 1548515.28 | **Plot Date** | 2007-10-14 22:03:05 |

**Signed data**

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

**ROCK ALTERATION**
- ▨ Oxidized
- ▨ Chloritisized
- ▨ Epidotisized
- ▨ Sericitisized
- ▨ Quartz dissolution
- ▨ Argillization
- ▨ 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**
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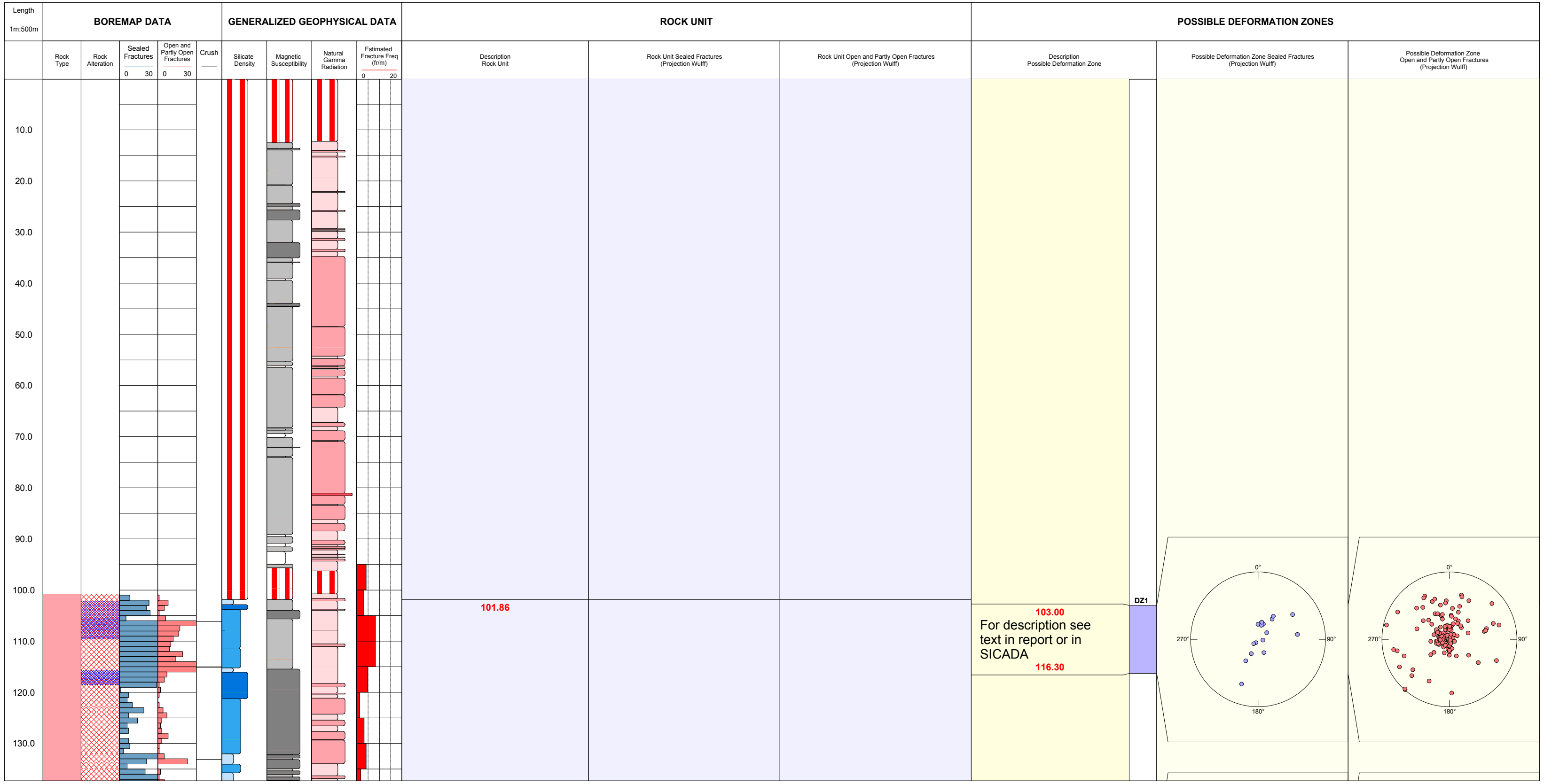
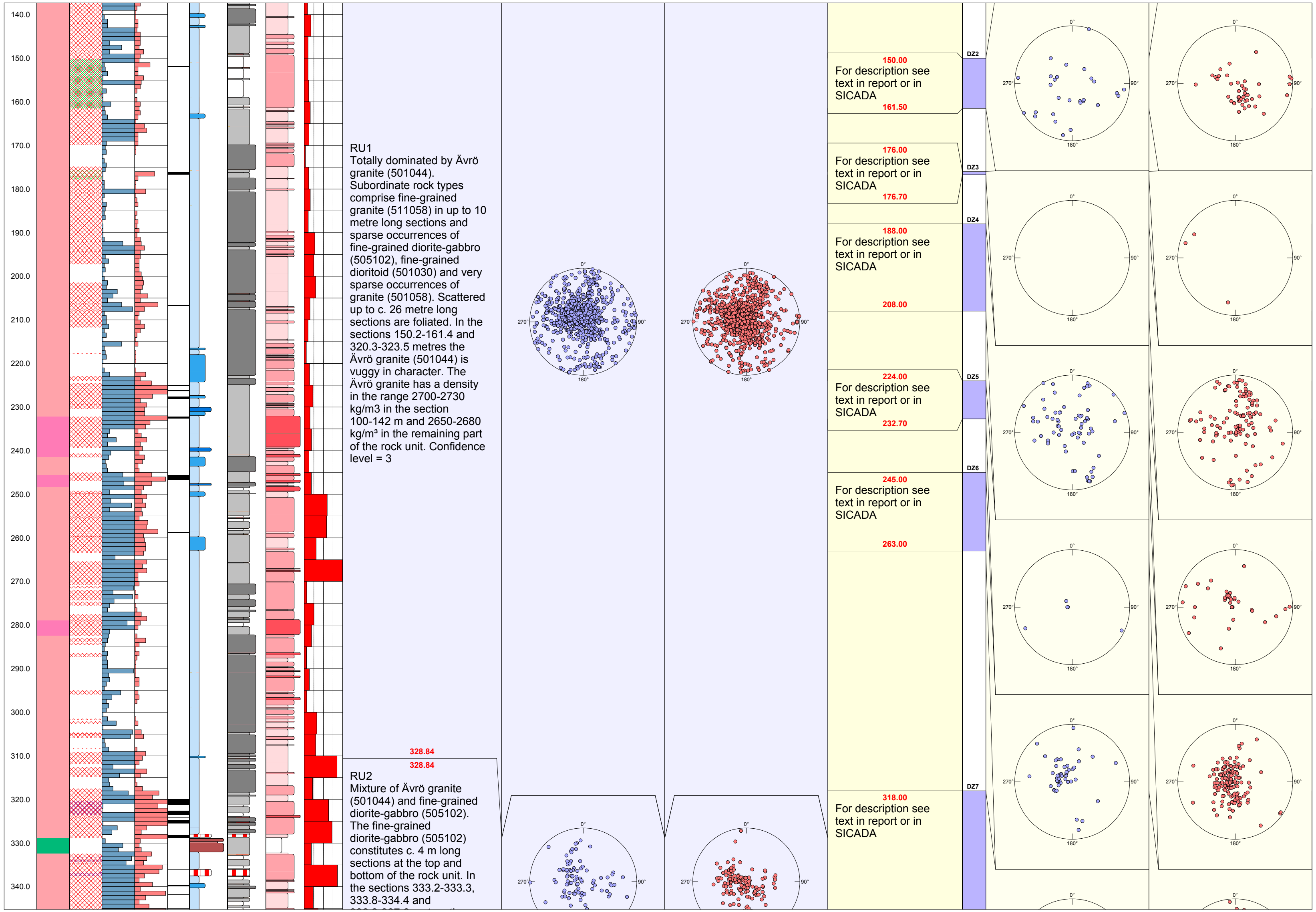
- ▨ gam<10
- ▨ 10<gam<20
- ▨ 20<gam<30
- ▨ gam>30





RU1
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058) in up to 10 metre long sections and sparse occurrences of fine-grained diorite-gabbro (505102), fine-grained dioritoid (501030) and very sparse occurrences of granite (501058). Scattered up to c. 26 metre long sections are foliated. In the sections 150.2-161.4 and 320.3-323.5 metres the Ävrö granite (501044) is vuggy in character. The Ävrö granite has a density in the range 2700-2730 kg/m3 in the section 100-142 m and 2650-2680 kg/m³ in the remaining part of the rock unit. Confidence level = 3

RU2
Mixture of Ävrö granite (501044) and fine-grained diorite-gabbro (505102). The fine-grained diorite-gabbro (505102) constitutes c. 4 m long sections at the top and bottom of the rock unit. In the sections 333.2-333.3, 333.8-334.4 and

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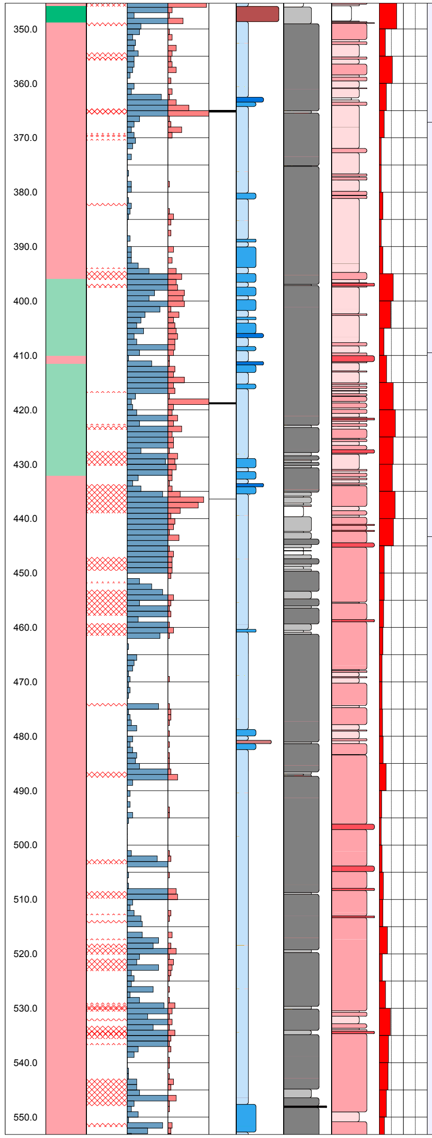


336.8-337.6 metres the Ävrö granite (501044) is vuggy in character. Subordinate rock type comprises fine-grained dioritoid (501030). Confidence level = 3

348.83

348.83

RU3a
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise sparse occurrences of fine-grained granite (511058) and fine-grained dioritoid (501030). The section c. 370-382 is foliated. Scattered minor sections are also foliated. Confidence level = 3

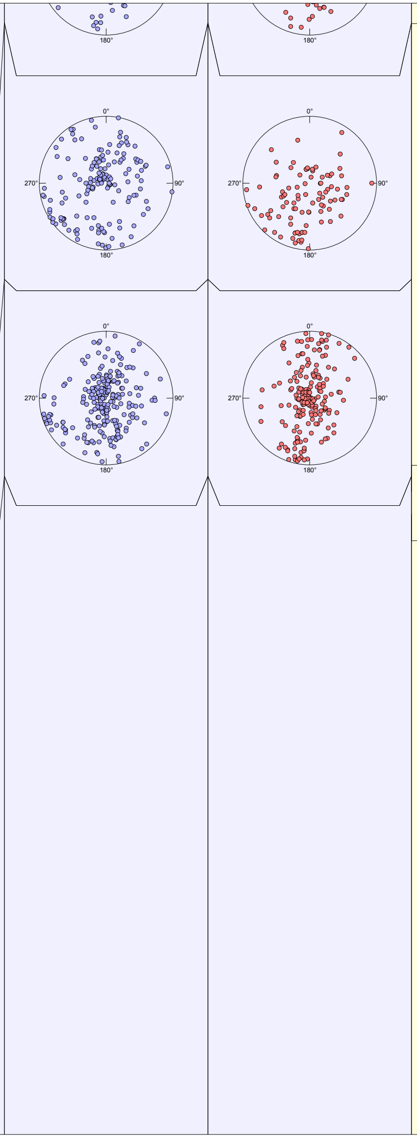
395.99

395.99

RU4
Totally dominated by fine-grained dioritoid (501030). Subordinate rock types comprise Ävrö granite (501044) and fine-grained granite (511058). The section 406-410 metres is foliated. Confidence level = 3

432.20

432.20



349.00

435.00
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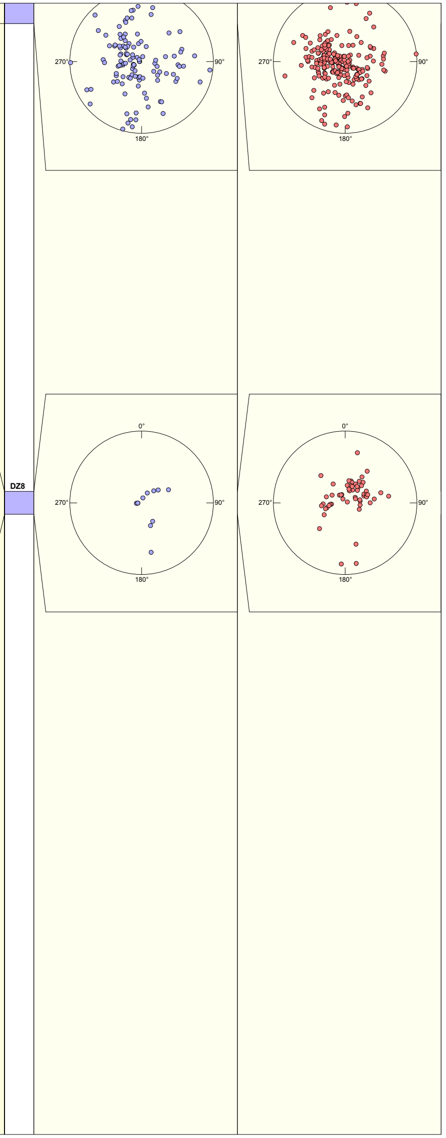
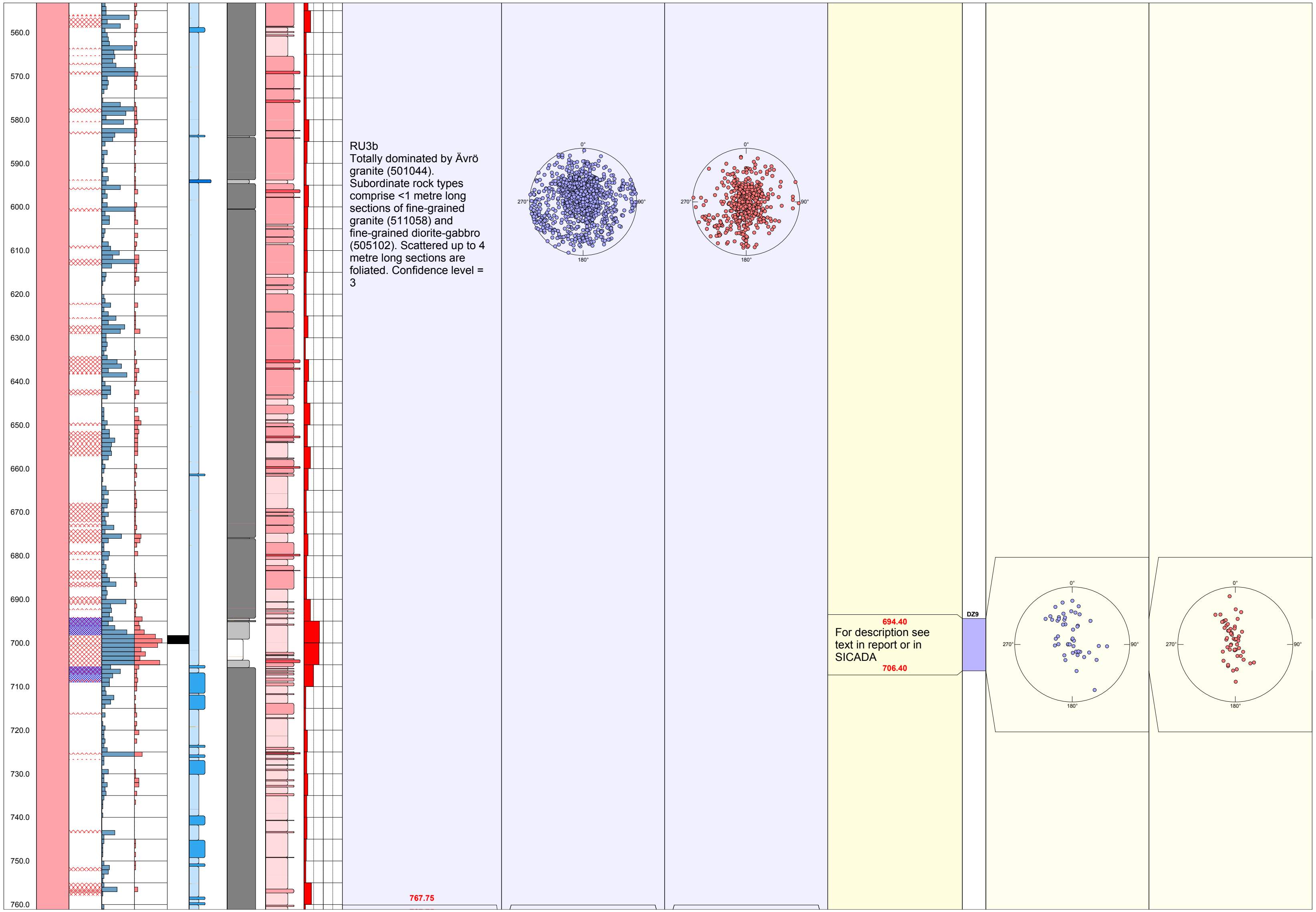
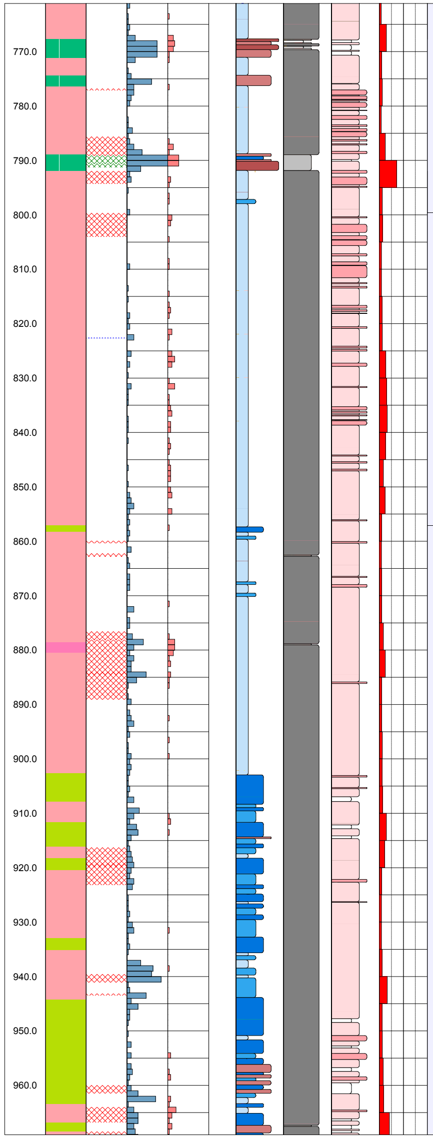
439.20





RU3b
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise <1 metre long sections of fine-grained granite (511058) and fine-grained diorite-gabbro (505102). Scattered up to 4 metre long sections are foliated. Confidence level = 3

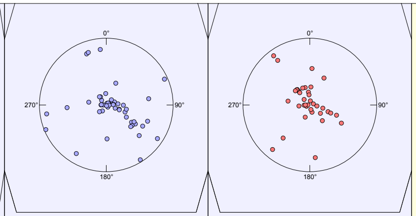
For description see text in report or in SICADA



**767.75**

RU5
Mixture of Ävrö granite (501044) and fine-grained diorite-gabbro (505102). Subordinate rock types comprise <1 metre long sections of fine-grained granite (511058) and granite (501058). The major part of the rock unit is foliated. Confidence level = 3

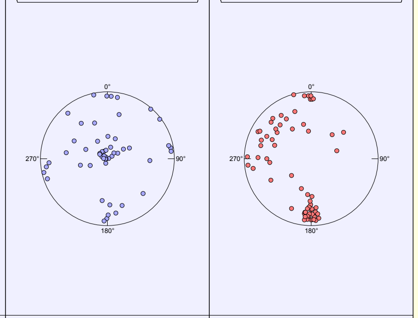
**791.95**



**791.95**

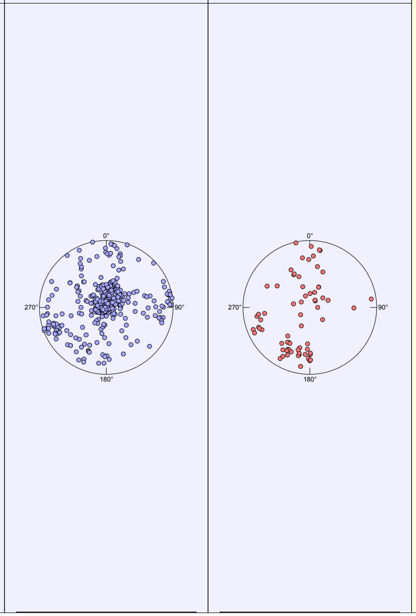
RU3c
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise <1 metre long sections of fine-grained granite (511058) and fine-grained diorite-gabbro (505102). Scattered sections are foliated, in particular the section 792-817 metres. One very strong and persistent non-oriented radar reflector occurs at 824.9 m with the angle 18º to borehole axis. Confidence level = 3

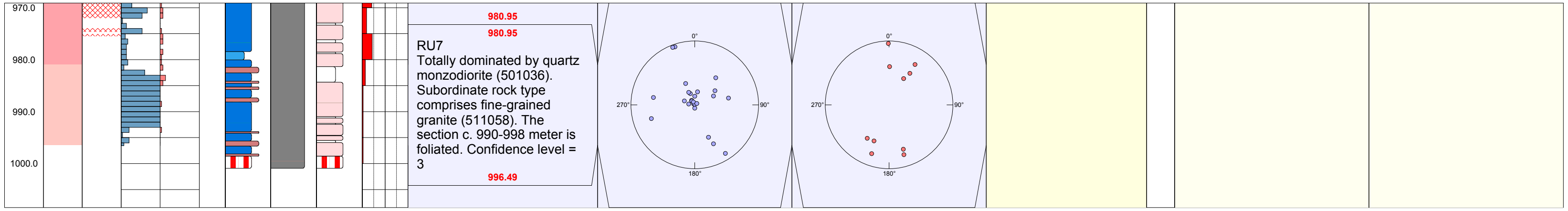
**857.08**



**857.08**

RU6
Mixture of Ävrö granite (501044) and diorite/gabbro (501033). The mixture is most accentuated in the section 902-981 metres. Ävrö granite (501044) dominates in the upper part of the section. Subordinate rock types comprise fine-grained granite (511058), and very sparse occurrences of granite (501058) and pegmatite (501061). Scattered up to 9 metre long sections are foliated. A very strong and persistent radar reflector occurs at 868.8 m with the orientation 353/84. Confidence level = 3





RU7
Totally dominated by quartz monzodiorite (501036). Subordinate rock type comprises fine-grained granite (511058). The section c. 990-998 meter is foliated. Confidence level = 3

# Appendix 2

# Geological single-hole interpretation of HLX20

| | | | | | | |
|---|---|---|---|---|---|---|
| **Title** | **SINGLE HOLE INTERPRETATION HLX20** | | | | | |
| **Site** | LAXEMAR | **Inclination [°]** | -60.37 | **Elevation [m.a.s.l.]** | 11.18 | **Signed data** |
| **Borehole** | HLX20 | **Date of mapping** | 2005-06-27 13:10:00 | **Drilling Start Date** | 2004-06-15 09:30:00 | |
| **Diameter [mm]** | 138 | **Coordinate System** | RT90-RHB70 | **Drilling Stop Date** | 2004-06-21 12:00:00 | |
| **Length [m]** | 202.200 | **Northing [m]** | 6367996.26 | **Surveying Date** | | |
| **Bearing [°]** | 0.41 | **Easting [m]** | 1548446.09 | **Plot Date** | 2007-10-15 22:03:14 | |

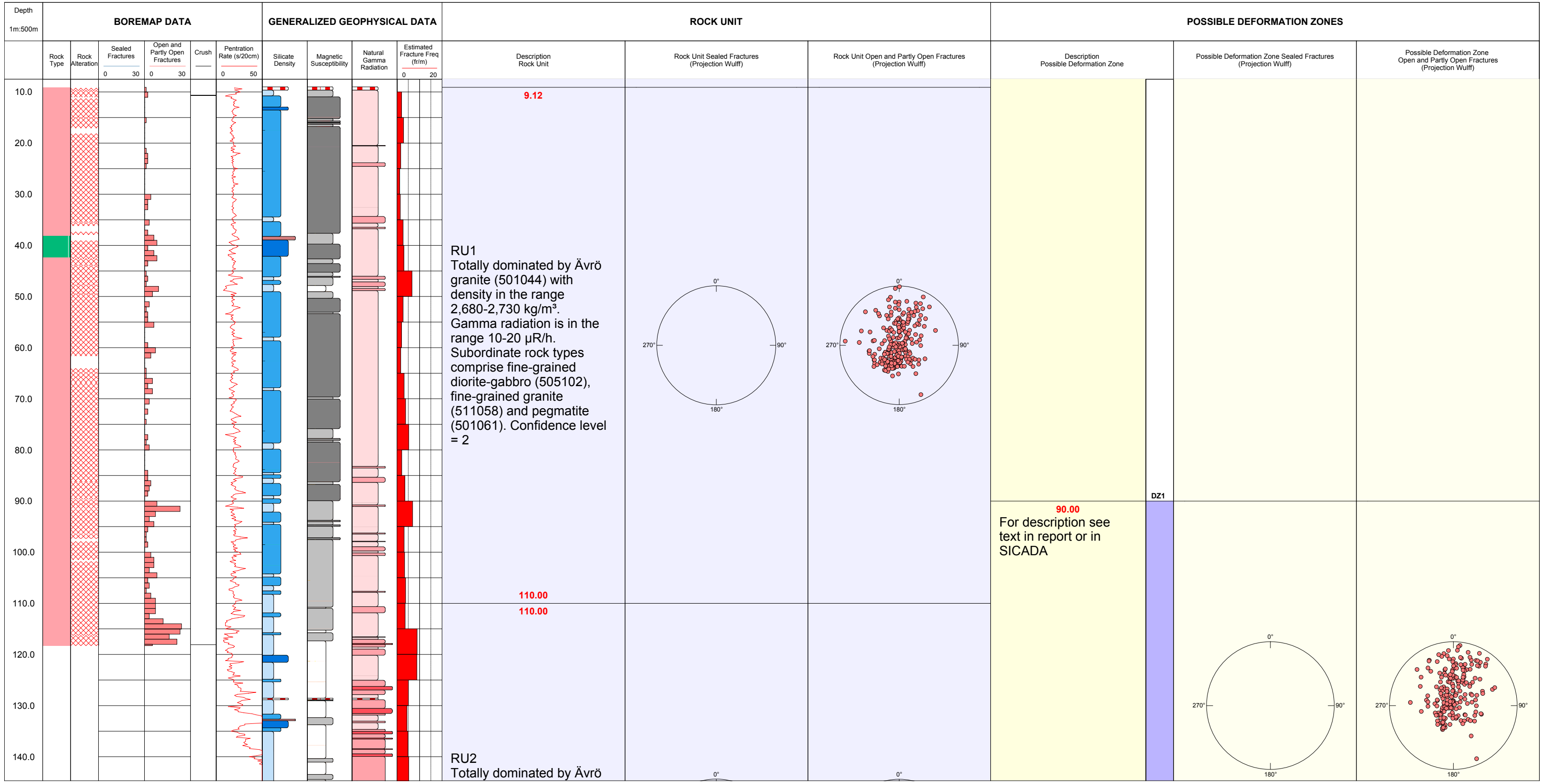
**ROCKTYPE LAXEMAR**
- 🟥 Ävrö granite
- 🟩 Fine-grained diorite-gabbro

**ROCK ALTERATION**
- ▨ Oxidized

**SILICATE DENSITY**
- ▨ unclassified
- ▭ dens<2680
- 🟦 2680<dens<2730
- 🟦 2730<dens<2800
- 🟥 2800<dens<2890

**SUSCEPTIBILITET**
- ▨ unclassified
- ▭ sus<0.001
- ▭ 0.001<sus<0.01
- ■ 0.01<sus<0.1

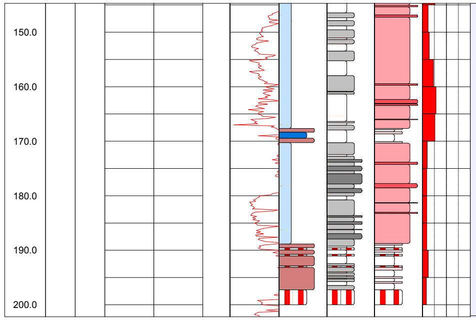
**NATURAL GAMMA**
- ▨ unclassified
- ▭ gam<10
- ▭ 10<gam<20
- 🟥 20<gam<30
- 🟥 gam>30



RU1
Totally dominated by Ävrö granite (501044) with density in the range 2,680-2,730 kg/m³. Gamma radiation is in the range 10-20 μR/h. Subordinate rock types comprise fine-grained diorite-gabbro (505102), fine-grained granite (511058) and pegmatite (501061). Confidence level = 2

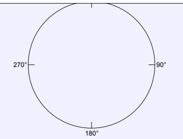
For description see text in report or in SICADA

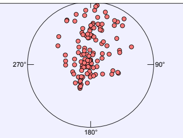
RU2
Totally dominated by Ävrö



granite (501044) with density =2,680 kg/m³. Gamma radiation is in the range 20-30 µR/h. Subordinate rock types comprise fine-grained diorite-gabbro (505102) and fine-grained granite (511058). Confidence level = 1

202.00





170.00

# Geological single-hole interpretation of HLX36

**Title** SINGLE HOLE INTERPRETATION HLX36

| | | | | | | |
|---|---|---|---|---|---|---|
| **Site** | LAXEMAR | **Inclination [°]** | -59.01 | **Elevation [m.a.s.l.]** | 15.56 | **Signed data** |
| **Borehole** | HLX36 | **Date of mapping** | 2006-01-10 12:54:00 | **Drilling Start Date** | 2005-09-20 07:00:00 | |
| **Diameter [mm]** | 140 | **Coordinate System** | RT90-RHB70 | **Drilling Stop Date** | 2005-09-22 07:00:00 | |
| **Length [m]** | 199.800 | **Northing [m]** | 6366172.94 | **Surveying Date** | | |
| **Bearing [°]** | 270.61 | **Easting [m]** | 1546558.45 | **Plot Date** | 2007-10-15 22:03:14 | |

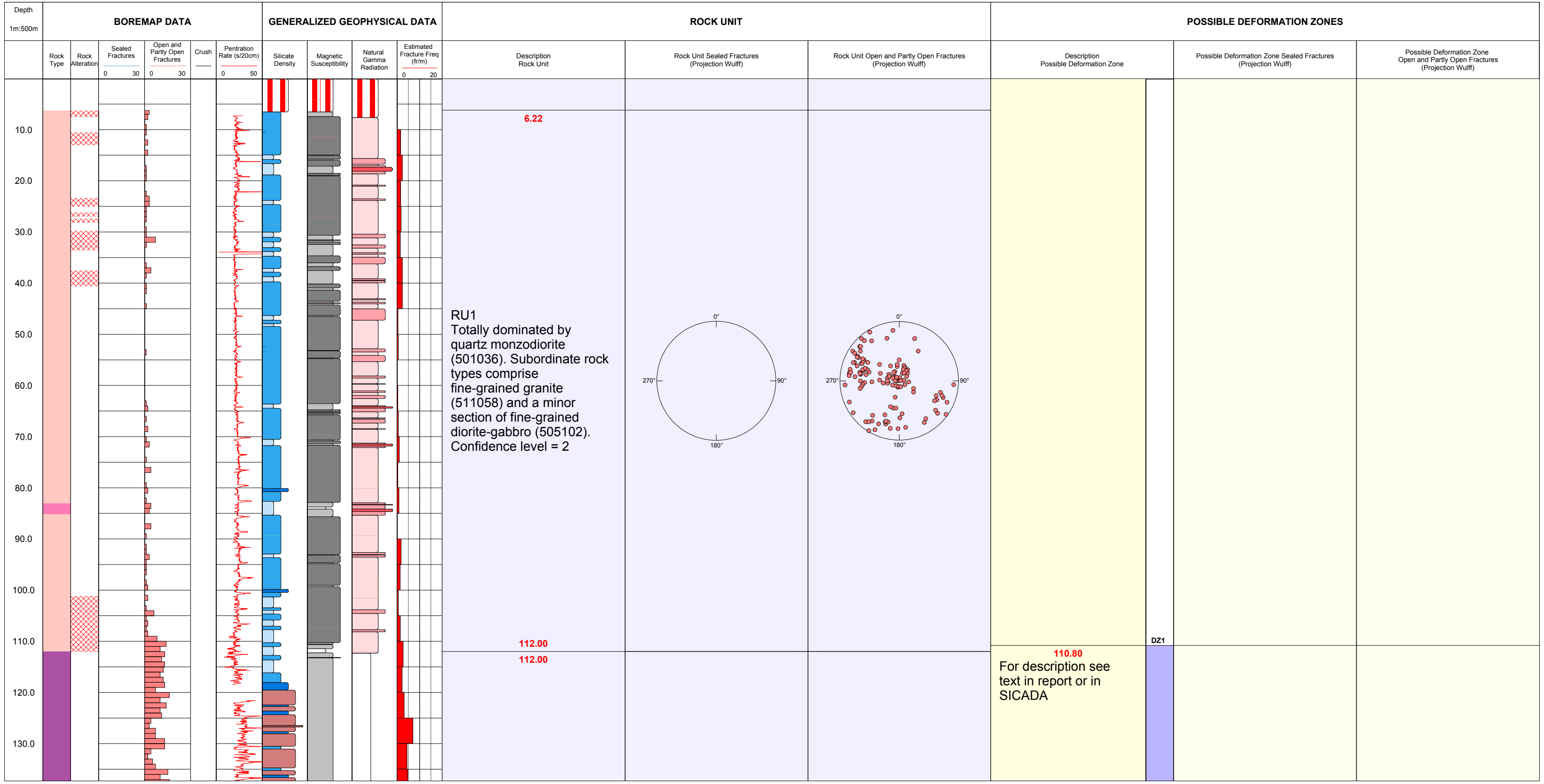
**ROCKTYPE LAXEMAR**
- 🟪 Dolerite
- 🟥 Fine-grained granite
- 🟧 Quartz monzodiorite

**ROCK ALTERATION**
- ▨ Oxidized

**SILICATE DENSITY**
- ▥ unclassified
- 🟦 dens<2680
- 🟦 2680<dens<2730
- 🟦 2730<dens<2800
- 🟥 2800<dens<2890
- 🟥 dens>2890

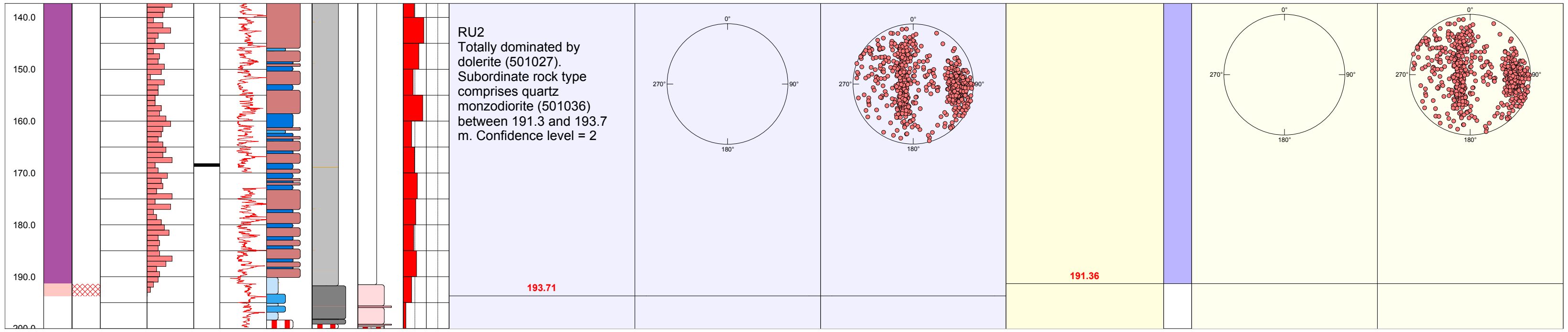
**SUSCEPTIBILITET**
- ▥ unclassified
- ☐ sus<0.001
- ⬜ 0.001<sus<0.01
- ⬛ 0.01<sus<0.1

**NATURAL GAMMA**
- ▥ unclassified
- ☐ gam<10
- 🟥 10<gam<20
- 🟥 20<gam<30
- 🟥 gam>30



RU1
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058) and a minor section of fine-grained diorite-gabbro (505102). Confidence level = 2

For description see text in report or in SICADA



RU2
Totally dominated by dolerite (501027). Subordinate rock type comprises quartz monzodiorite (501036) between 191.3 and 193.7 m. Confidence level = 2