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July 2006

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Abstract

This report contains geological single-hole interpretations of the cored borehole KLX05 and the percussion boreholes HLX15, HLX18, HLX19 and HLX32 at Laxemar. Each interpretation combines the geological core mapping, interpreted geophysical logs and borehole radar measurements to identify rock units and possible deformation zones in the boreholes.

Five rock units are indicated in KLX05 (RU1–RU5). One of the units is recurrent in the borehole and the borehole can therefore be subdivided into six separate sections. In general KLX05 is dominated by Ävrö granite (501044), a mixture of Ävrö granite (501044) and diorite to gabbro (501033), and by quartz monzodiorite (501036). Subordinate rock types are fine-grained dioritoid (501030), quartz monzodiorite (501036), Ävrö granite (501044), fine-grained diorite to gabbro (505102), fine-grained granite (511058), granite (501058) and pegmatite (501061). Seven possible deformation zones are identified in KLX05 (DZ1–DZ7).

The percussion borehole HLX15 is dominated by quartz monzodiorite, which constitutes one rock unit (RU1). Subordinate rock types are pegmatite, fine-grained granite and granite. No deformation zone has been identified in HLX15.

The percussion borehole HLX18 is dominated by Ävrö granite (501044) and fine-grained dioritoid (501030). Three rock units are identified in the borehole (RU1–RU3). Subordinate rock types are fine-grained granite (511058), pegmatite (501061), diorite to gabbro (501033) and fine-grained diorite to gabbro (505102). One possible deformation zone is identified in HLX18 (DZ1).

Two rock units are identified in HLX19 (RU1–RU2). The borehole is dominated by Ävrö granite (501044) and fine-grained dioritoid (501030). Subordinate rock types are diorite to gabbro (501033), pegmatite (501061), fine-grained diorite to gabbro (505102) and fine-grained granite (511058). One deformation zone is indicated in HLX19 (DZ1).

One rock unit is identified in HLX32 (RU1). The borehole is totally dominated by quartz monzodiorite (501036). Subordinate rock types are fine-grained granite (511058), fine-grained diorite to gabbro (505102) and pegmatite (501061). Three possible deformation zones are identified in HLX32 (DZ1–DZ3).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålet KLX05 samt hammarborrhålen HLX15, HLX18, HLX19 och HLX32 i Laxemar. Den geologiska enhålstolkningen syftar till att utifrån den geologiska karteringen, tolkade geofysiska loggar och borrhålsradarmätningar identifiera litologiska enheter och möjliga deformationszoner i borrhålen.

Fem litologiska enheter (RU1–RU5) har identifierats i KLX05. Baserat på repetition av en av dessa enheter kan borrhålet delas in i 6 sektioner. Generellt sett domineras borrhålet av Ävrögranit (501044), en blandning mellan Ävrögranit (501044) och diorit till gabbro (501033), samt av kvartsmonzodiorit (501036). Finkornig dioritoid (501030), kvartsmonzodiorit (501036), Ävrö granit (501044), finkornig diorit till gabbro (505102), finkornig granit (511058), granit (501058) och pegmatit (501061) förekommer som underordnade bergarter. Sju möjliga deformationszoner är identifierade i KLX05 (DZ1–DZ7).

I hammarborrhålet HLX15 finns en litologisk enhet (RU1) som domineras av kvarsmonzodiorit. Inslag av pegmatit, finkornig granit och granit förekommer. Ingen deformationszon har identifierats i HLX15.

Hammarborrhålet HLX18 domineras av Ävrö granit (501044) och finkornig dioritoid (501030). Tre litologiska enheter är identifierade i borrhålet (RU1–RU3). Inslag av finkornig granit (511058), pegmatit (501061), diorit till gabbro (501033) and finkornig diorit till gabbro (505102) förekommer i borrhålet. En möjlig deformationszon är identifierad i HLX18 (DZ1).

Två litologiska enheter är identifierade i hammarborrhålet HLX19 (RU1–RU2). Borrhålet domineras av Ävrö granit (501044) och finkornig dioritoid (501030). Inslag av diorit till gabbro (501033), pegmatit (501061), finkornig diorit till gabbro (505102) och finkornig granit (511058) förekommer i borrhålet. En deformationszon är identifierad i HLX19 (DZ1).

HLX32 utgörs av en litologisk enhet (RU1) som domineras av kvartsmonzodiorit (501036). Inslag av finkornig granit (511058), finkornig diorit till gabbro (505102) och pegmatit (501061) förekommer i borrhålet. Tre möjliga deformationszoner är identifierade i HLX32 (DZ1–DZ3).

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 KLX05 and the percussion drilled boreholes HLX15, HLX18, HLX19 and HLX32 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 400-05-046. 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.

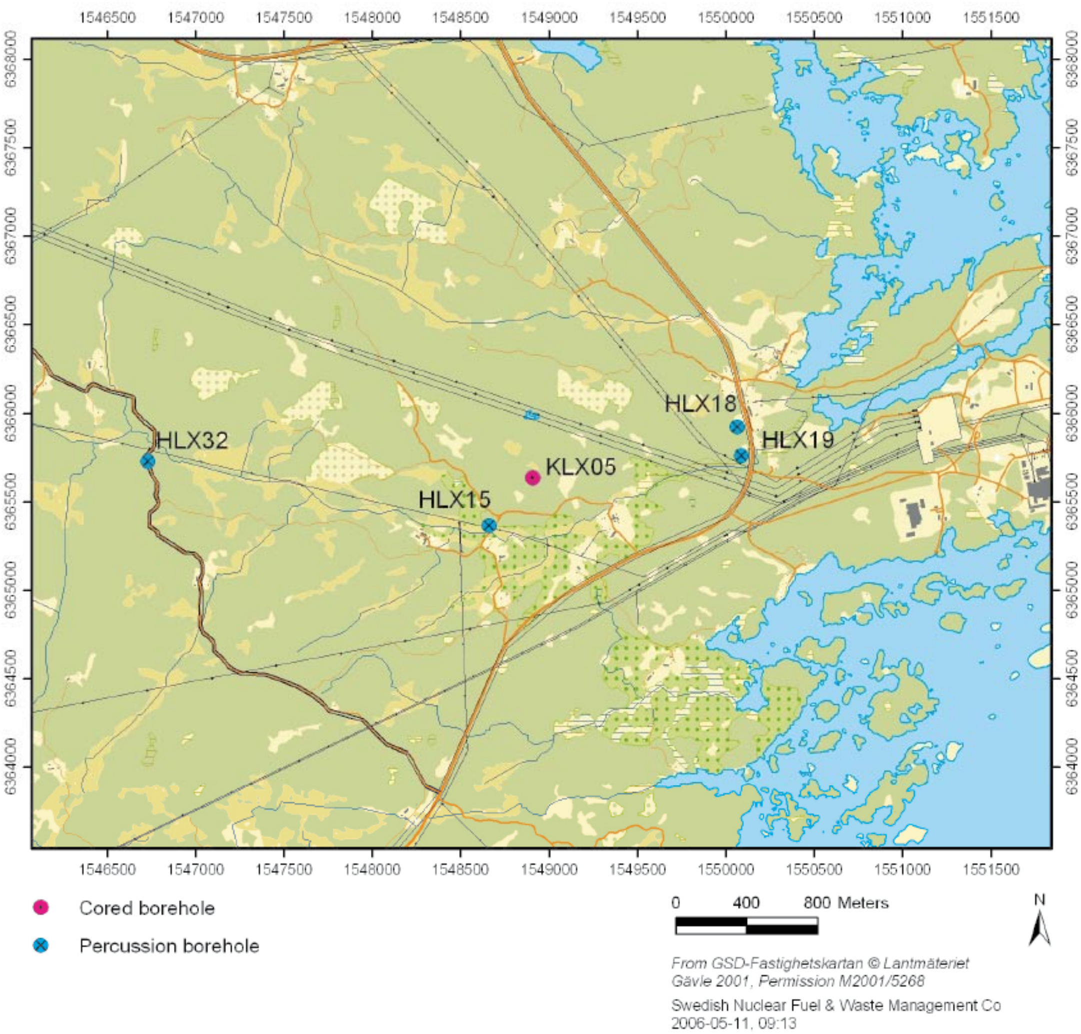

***Figure 1-1.** Map showing the position of the cored borehole KLX05 and the percussion drilled boreholes HLX15, HLX18, HLX19 and HLX32.*

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

Activity plan	Number	Version
Geologisk enhålstolkning av KLX05, HLX15, HLX18, HLX19, och HLX32	AP PS 400-05-046	1.0
Method description	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	1.0

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

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

2 Objective and scope

A geological single-hole interpretation is carried out in order to identify and to describe briefly the characteristics of major rock units and possible deformation zones within a borehole. The work involves an integrated interpretation of data from the geological mapping of the borehole (Boremap), different borehole geophysical logs and borehole radar data. The geological mapping of the cored boreholes involves a documentation of the character of the bedrock in the drill core. This work component is carried out in combination with an inspection of the oriented image of the borehole walls that is obtained with the help of the *B*orehole *I*mage *P*rocessing *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.

3 Equipment

The following data have been used in the single-hole interpretation of the boreholes KLX05, HLX15, HLX18, HLX19 and HLX32:

- Boremap data (including BIPS and geological mapping data) /1, 2 and 3/.
- Generalized geophysical logs and their interpretation /4, 5, 6 and 7/.
- Radar data and their interpretation /8, 9, 10 and 11/.

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

1: Length along the borehole

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

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

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

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

6: Crush zones
    6.1: Piece (mm)
    5.9: Sealed network
    5.10: Core loss

7: Fracture frequency
    6.1: Sealed fractures
    6.2: Open fractures

9: BIPS

The geophysical logs are described below:

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

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

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

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

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

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

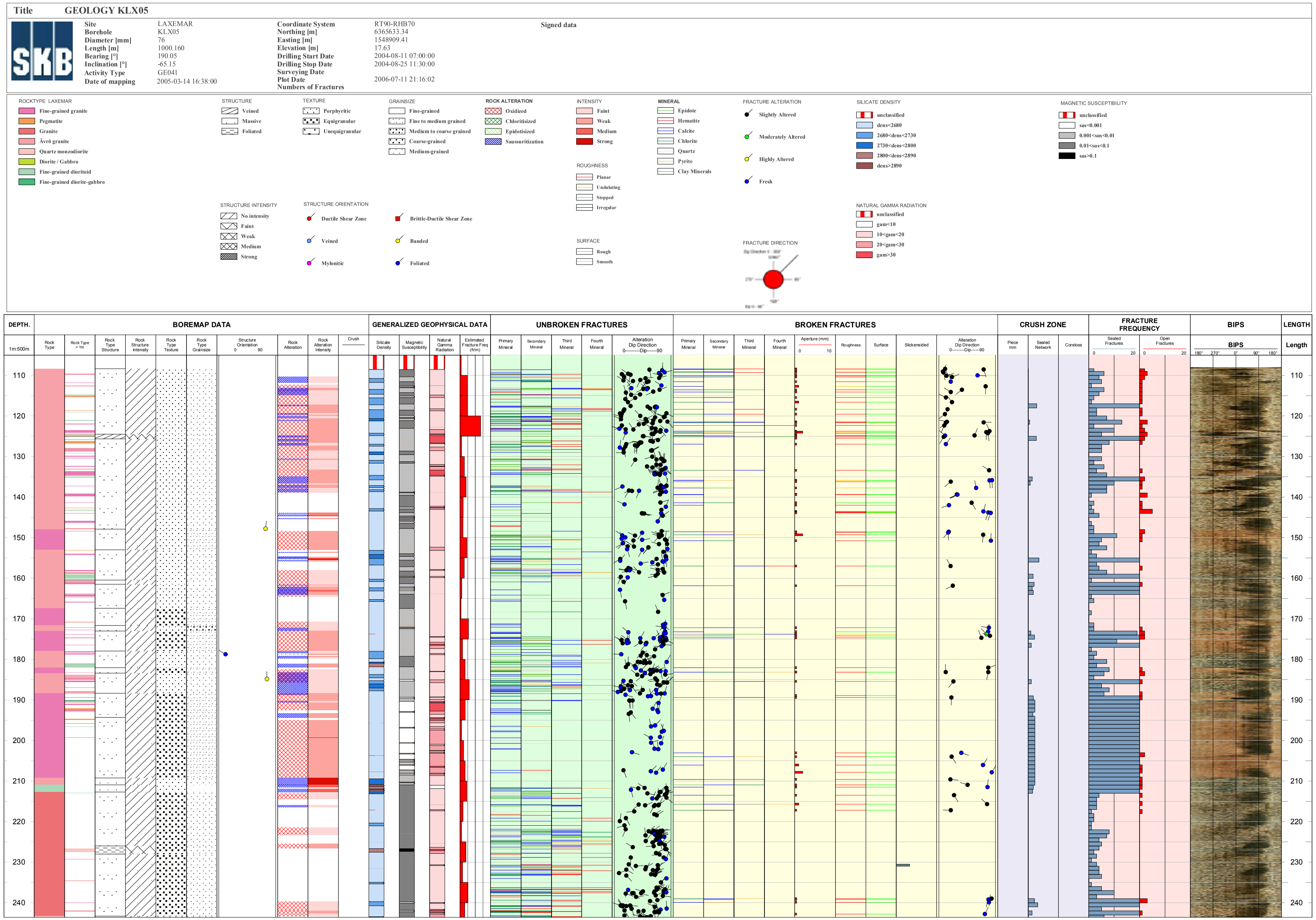

Figure 3-1. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.

4 Execution

4.1 General

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

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

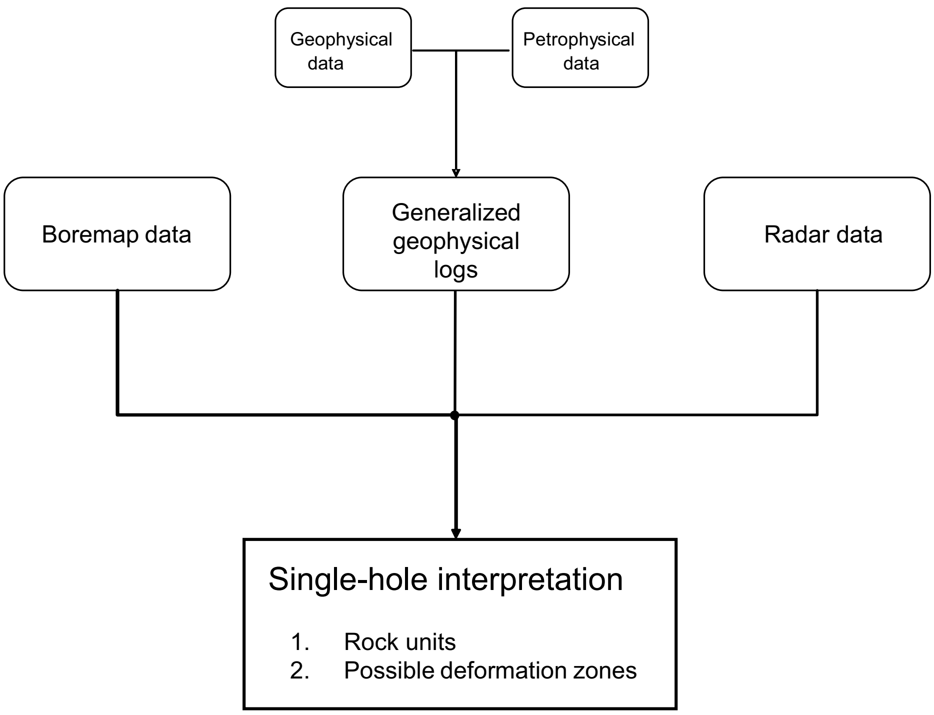

Figure 4-1. *Schematic block-scheme of single-hole interpretation.*

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

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

Deformation zones that are brittle in character have been identified primarily on the basis of the frequency of fractures, according to the recommendations in /12/. Both the transitional part, with a fracture frequency in the range 4–9 fractures/m, and the cored part, with a fracture frequency > 9 fractures/m, have been included in each zone (Figure 4-2). The frequencies of open and sealed fractures have been assessed in the identification procedure, and the character of the zone has been described accordingly. Partly open fractures are included together with open fractures in the brief description of each zone. The presence of bedrock alteration, the occurrence and, locally, inferred orientation of radar reflectors, the resistivity, SPR, P-wave velocity, caliper and magnetic susceptibility logs have all assisted in the identification of the zones.

4.2 Nonconformities

Data from BIPS is missing in the section 150–200 m in HLX19.

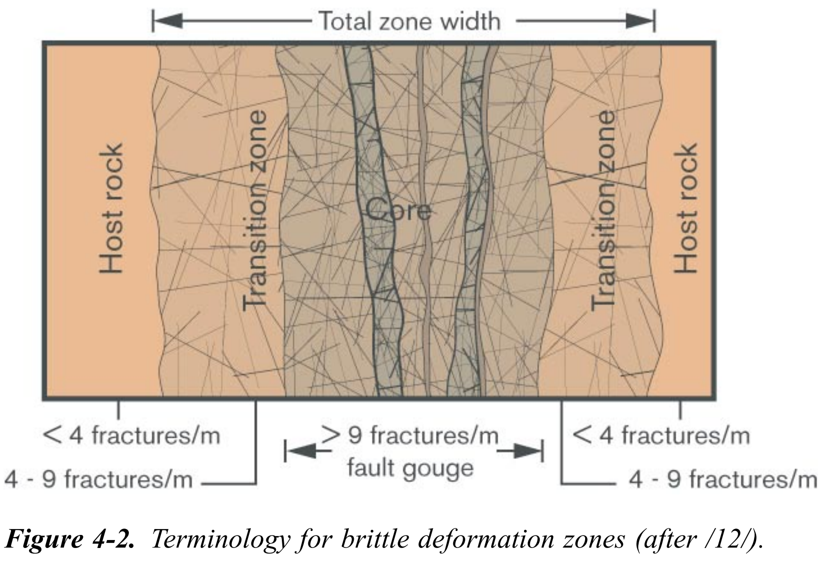

Figure 4-2. *Terminology for brittle deformation zones (after /12/).*

5 Results

The detailed results of the single-hole interpretation are presented as print-outs from the software WellCad (Appendix 1 for KLX05, Appendix 2 for HLX15, Appendix 3 for HLX18, Appendix 4 for HLX19 and Appendix 5 for HLX32). The legend of the WellCad is presented in Chapter 6. In 5.1 to 5.5 all identified rock units and possible deformation zones in KLX05, HLX15, HLX18, HLX19 and HLX32 are presented.

5.1 KLX05

The borehole can be divided into five rock units. One of the units is recurrent in the borehole and the borehole can therefore be subdivided into six separate sections:

RU1: 108.33–210.97 m
Dominated by a mixture of Ävrö granite (501044) and fine-grained granite (511058). Subordinate rock types comprise pegmatite (501061) and fine-grained dioritoid (501030). Confidence: 3.

RU2: 210.97–291.58 m
Completely dominated by granite (501058). Subordinate rock types comprise fine-grained dioritoid (501030), quartz monzodiorite (501036), Ävrö granite (501044), fine-grained diorite to gabbro (505102), and fine-grained granite (511058). Scattered sections are foliated. Section 244–255 m is characterized by very high magnetic susceptibility. Confidence: 3.

RU3: 291.58–473.30 m
Dominated by a mixture of Ävrö granite (501044) and diorite to gabbro (501033). Subordinate rock types comprise fine-grained granite (511058), fine-grained dioritoid (501030), fine-grained diorite to gabbro (505102), granite (501058) and pegmatite (501061). Scattered sections are foliated. The diorite to gabbro section 340–375 m is characterized by very high magnetic susceptibility (> 0.1 SI) and high density (> 2,875 kg/m^3), whereas the diorite to gabbro in section 406–436 m has markedly l ower magnetic susceptibility. Confidence: 3.

RU4: 473.30–691.93 m
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise pegmatite (501061), fine-grained granite (511058), fine-grained dioritoid (501030) and fine-grained diorite to gabbro (505102) Scattered sections are foliated. The pegmatite dykes are characterized by very high natural gamma radiation (70–150 μR/h). Confidence: 3.

RU5: 691.93–752.12 m
Totally dominated by fine-grained granite (511058). Subordinate rock type comprises pegmatite (501061). The rock unit is more or less foliated. The entire section is characterized by low density (> 2,670 kg/m^3), low magnetic susceptibility and high natural gamma radiation (40–50 μR/h). Confidence: 3.

RU4: 752.12–995.22 m
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise pegmatite (501061), fine-grained granite (511058), fine-grained dioritoid (501030) and fine-grained diorite to gabbro (505102). Scattered sections are foliated. The pegmatite dykes are characterized by very high natural gamma radiation (c 100 μR/h). Confidence: 3.

Seven deformation zones have been recognised in KLX05:

DZ1: 100.5–107.5 m (outside mapping section, only in core)
Three radar reflectors occur in the section. One reflector at 100.8 m with the angle 15° to borehole axis, one at 102.3 m with 50° and one at 106.6 m with 56°. Confidence: 1.

DZ2: 261.23–263.00 m
Strongly foliated mixed rocks comprising fine-grained diorite to gabbro (505102) and fine- to medium-grained granite (511058). Slightly increased open fracture frequency and sealed network, weak alteration and one small core loss. One radar reflector at 261.3 m with the angle 35° to borehole axis. One distinct low resistivity anomaly and a corresponding low p-wave velocity anomaly. Confidence: 3.

DZ3: 403.40–406.10 m
Intermediately foliated to protomylonitic Ävrö granite (501044). One radar reflector at 403.7 m with the angle 53° to borehole axis. A slight decrease in p-wave velocity. Confidence: 3.

DZ4: 477.50–478.10 m
Intermediately to strongly foliated quartz monzodiorite (501036). One radar reflector at 478.7 m with the angle 72° to borehole axis. No indications in geophysical data. Confidence: 3.

DZ5: 576.6–577.6 m
Intermediately to strongly foliated quartz monzodiorite (501036). One radar reflector at 576.2 m with the angle 54° to borehole axis. One minor low resistivity anomaly. Confidence: 3.

DZ6: 590.35–590.85 m
Intermediately to strongly foliated quartz monzodiorite (501036). One radar reflector at 590.2 m with the angle 65° to borehole axis. Distinct low resistivity and caliper anomalies and a slightly decreased p-wave velocity. Confidence: 3.

DZ7: 654.40–655.50 m
Inhomogeneous intermediate to strong foliation along the contact between fine- to medium-grained granite (511058) and quartz monzodiorite (501036) overprinted by fractures filled with calcite, pyrite, chlorite and clay minerals. Confidence: 3.

5.2 HLX15

The borehole is composed of one rock unit:

RU1: 12.04–151.32 m
Totally dominated by quartz monzodiorite. Subordinate rock types include pegmatite, fine-grained granite (511058) and granite (501058). Large variations in the silicate density, ranging from 2,650 kg/m^3 up to 2890 kg/m^3. Low density often corresponds to high natural gamma radiation. Confidence: 2.

No deformation zone has been indicated in HLX15.

5.3 HLX18

The borehole can be divided into three different rock units, RU1–RU3:

RU1: 15.15–58.76 m
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058). Weak to medium oxidation. Confidence: 2.

RU2: 58.76–82.38 m
Totally dominated by fine-grained dioritoid (501030). Subordinate rock type comprises pegmatite (501061) and fine-grained granite (511058). Weak to medium oxidation. The section is characterized by high density in the range 2,850–2,900 kg/m^3, large variations in the magnetic susceptibility and low natural gamma radiation (< 10 μR/h). These geophysical properties are typical for diorite to gabbro and do not support the rock type classification. Confidence: 2.

RU3: 82.38–181.22 m
Totally dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained dioritoid (501030), fine-grained granite (511058), pegmatite (501061), diorite to gabbro (501033) and fine-grained diorite to gabbro (505102). Weak to medium oxidation. Confidence: 2.

One possible deformation zone has been identified in HLX18:

DZ1: 16.5–103 m
Scattered 2–10 m wide sections of increased fracture frequency and related fracture zone alterations. 20 radar reflectors have been interpreted. The angles to borehole axis are mainly between 40° and 80°. The section is characterized by minor caliper anomalies, partly low resistivity and several scattered sections of variable magnetic susceptibility. Confidence: 2.

5.4 HLX19

The borehole contains two rock units:

RU1: 12.23–120.23 m
Dominated by Ävrö granite (501044). Subordinate rock types comprise diorite to gabbro (501033), particularly in the section 12.2–53.5 m, pegmatite (501061), fine-grained diorite to gabbro (505102) and fine-grained granite (511058). Weak oxidation. Confidence: 2.

RU2: 120.23–201.40 m (BIPS missing 150–200 m)
Totally dominated by fine-grained dioritoid (501030). No subordinate rock types. The rock type classification below 150 m is based solely on geophysical logs. The section is characterized by high density in the range 2,850–3,000 kg/m^3, and low natural gamma radiation (< 10 μR/h). These geophysical properties are typical for diorite to gabbro and do not support the rock type classification. Confidence: 2.

One deformation zone has been identified in HLX19:

DZ1: 139–153 m
Scattered c 1.5 m wide sections of increased fracture frequency and related fracture zone alterations. No interpretable radar reflectors below 130 m. The section is characterized by distinct caliper anomalies, partly low resistivity and an indicated decrease in p-wave velocity. Confidence: 1.

5.5 HLX32

The borehole contains one rock unit:

RU1: 12.30–161.82 m
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102) and some pegmatite (501061). The whole unit is weakly oxidized. From 127 m down to bottom, the BIPS image is of bad quality. The density is fairly constant in the range of 2,680–2,740 kg/m^3 and the magnetic susceptibility displays large variations between 0.0005–0.015 SI in the section 13–125 m. Beneath 125 m the magnetic susceptibility is fairly constant at c 0.015 SI. The natural gamma radiation is c 20 μR/h, apart from some minor sections with increased natural gamma radiation. Confidence: 2.

Three possible deformation zones have been identified in HLX32:

DZ1: 23–23.50 m
Minor deformation zone. Increased fracture frequency and minor increase of apertures in single fractures, one at least 10 mm wide. Closely related to the lower contact of a small section of fine- to medium-grained granite (511058). Radar reflectors at 23.3 m with the angle 68° to borehole axis and at 23.7 m with the angle 46°. Distinct caliper and low resistivity anomalies. Confidence: 1.

DZ2: 33–37 m
Minor deformation zone. Increased fracture frequency and minor increase of apertures in single fractures. One strong radar reflector at 32.2 m with the angle 57° to borehole axis. Distinct caliper and low resistivity anomalies. Confidence: 1.

DZ3: 104–114 m
The deformation zone is located to a minor section of diorite to gabbro (501033). Increased fracture frequency and increased apertures in single fractures. Radar reflector at 105.3 m with the angle 77° to borehole axis. There is a significant decrease in the resistivity logs in the section 104–125 m and there are minor caliper anomalies in the section. At c 115 m there is a large decrease in the fluid resistivity. Confidence: 1.

6 Comments

The result from the geological single-hole interpretation of KLX05, HLX15, HLX18, HLX19 and HLX32 are presented in WellCad plots (Appendix 1–5). The WellCad plots consist of the following columns:

In data Boremap

1: Depth (length along the borehole)

2: Rock type

3: Rock alteration

4: Sealed fractures

5: Open and partly open fractures

6: Crush zones

In data Geopysics

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

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/4/ **Mattsson H, Keisu M, 2005.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX05. SKB P-05-189, Svensk Kärnbränslehantering AB.

/5/ **Mattsson H, Keisu M, 2004.** Oskarshamn site investigation. Interpretation of geophysical borehole data from HLX17, HLX18 and HLX19. SKB P-04-284, Svensk Kärnbränslehantering AB.

/6/ **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.

/7/ **Mattsson H, 2004.** Oskarshamn site investigation. Interpretation of geophysical borehole data and compilation of petrophysical data from KAV04 (100–1,000 m), KAV04B, HLX13 and HLX15. SKB P-04-217, 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/ **Gustafsson J, Gustafsson C, 2005.** Oskarshamn site investigation. RAMAC and BIPS logging in boreholes KLX05 and HLX32. SKB P-05-82, Svensk Kärnbränslehantering AB.

/10/ **Gustafsson J, Gustafsson C, 2004.** Oskarshamn site investigation. RAMAC and BIPS logging in boreholes HLX17, HLX18 and HLX19. SKB P-04-279, Svensk Kärnbränslehantering AB.

/11/ **Gustafsson, J, Gustafsson C, 2004.** Oskarshamn site investigation. RAMAC and BIPS logging in boreholes KAV04A, KAV04B, HLX13 and HLX15, Oskarshamn site investigation. SKB P-04-195, Svensk Kärnbränslehantering AB.

/12/ **Munier R, Stenberg L, Stanfors R, Milnes A G, Hermanson J, Triumf CA, 2003.** Geological site descriptive model. A strategy for the model development during site investigations. SKB report R-03-07, Svensk Kärnbränslehantering AB.

Geological single-hole interpretation of KLX05

Appendix 1

Title	SINGLE HOLE INTERPRETATION KLX05						
Site	LAXEMAR	Inclination [°]	-65.15	Elevation [m.a.s.l.]	17.56	Signed data	
Borehole	KLX05	Date of mapping	2005-03-14 16:38:00	Drilling Start Date	2004-08-11 07:00:00		
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-08-25 11:30:00		
Length [m]	1000.160	Northing [m]	6365632.52	Surveying Date			
Bearing [°]	190.05	Easting [m]	1548909.46	Plot Date	2006-07-13 21:14:56		

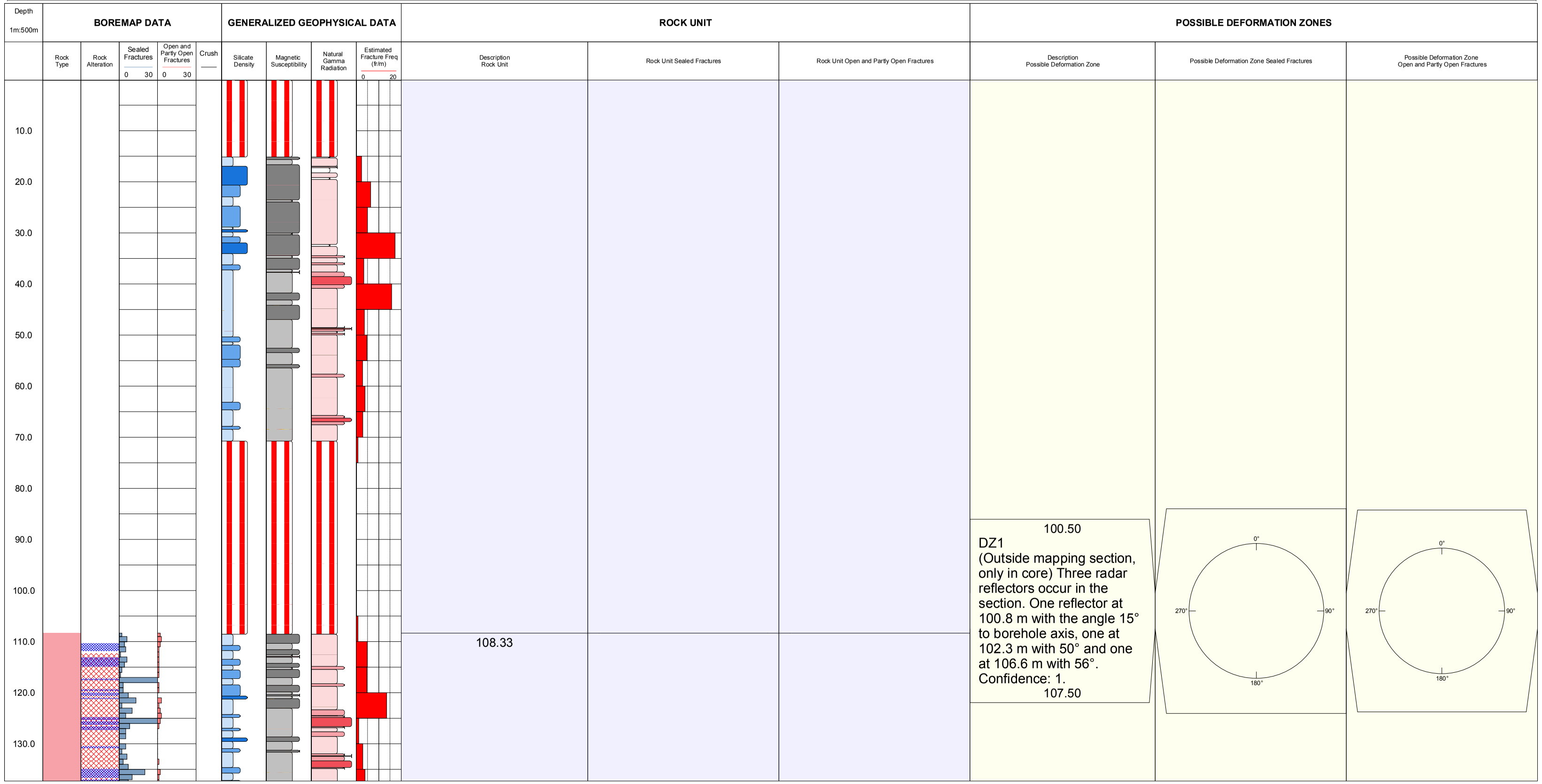
ROCKTYPE LAXEMAR
- Fine-grained granite
- Pegmatite
- Granite
- Ävrö granite
- Quartz monzodiorite
- Diorite / Gabbro
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

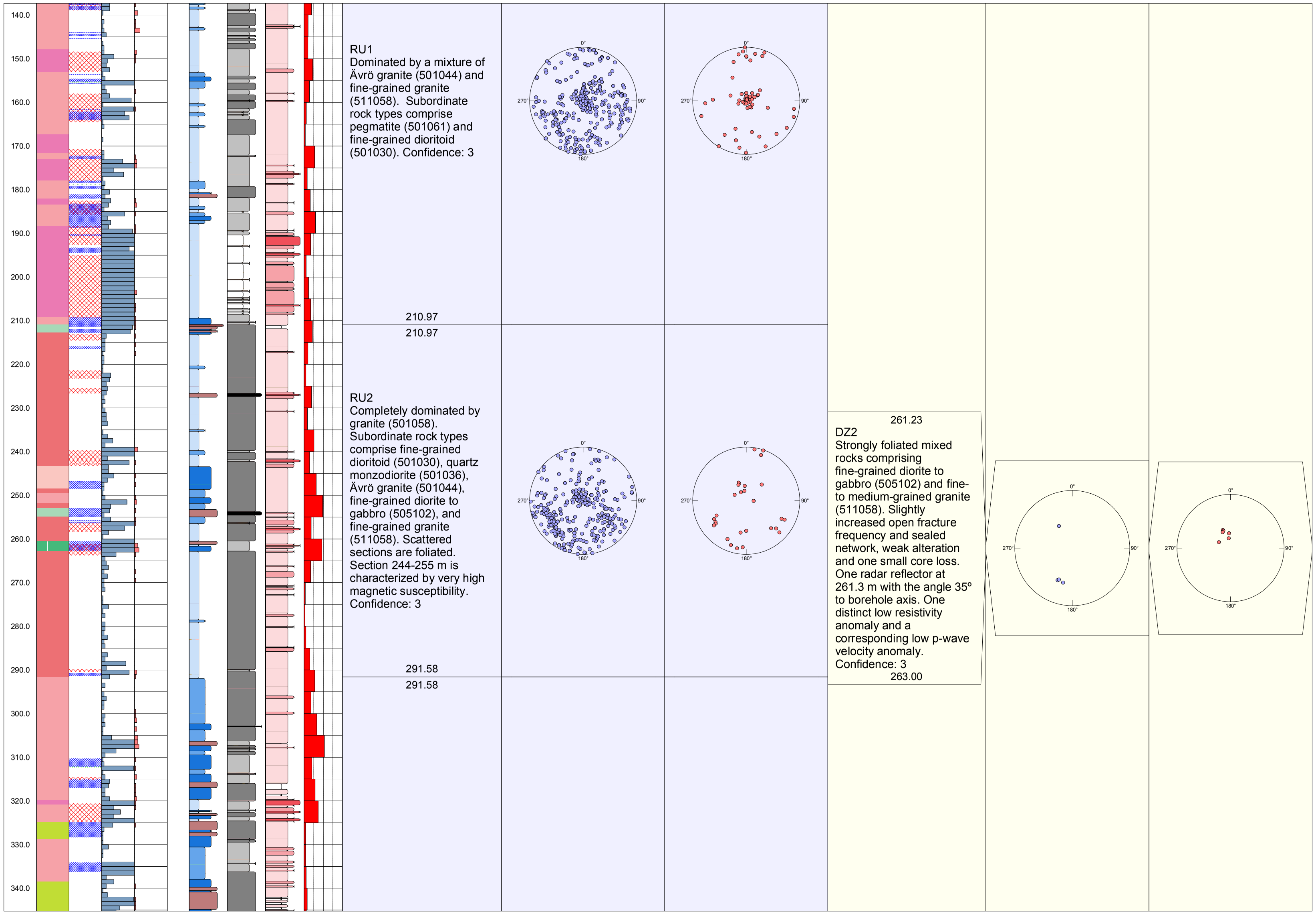
ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Saussuritization

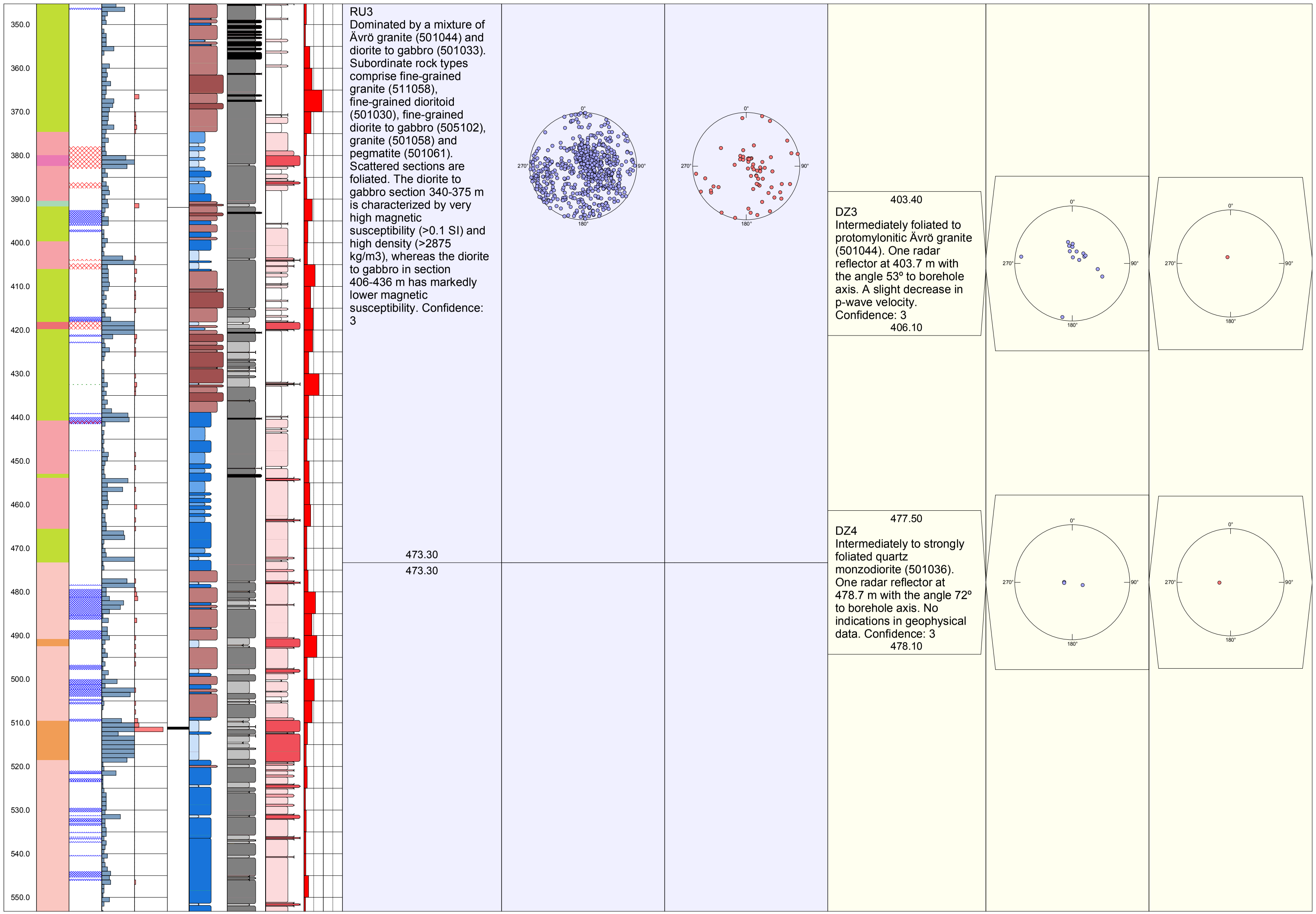
SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2730<dens<2800
- 2800<dens<2890
- dens>2890

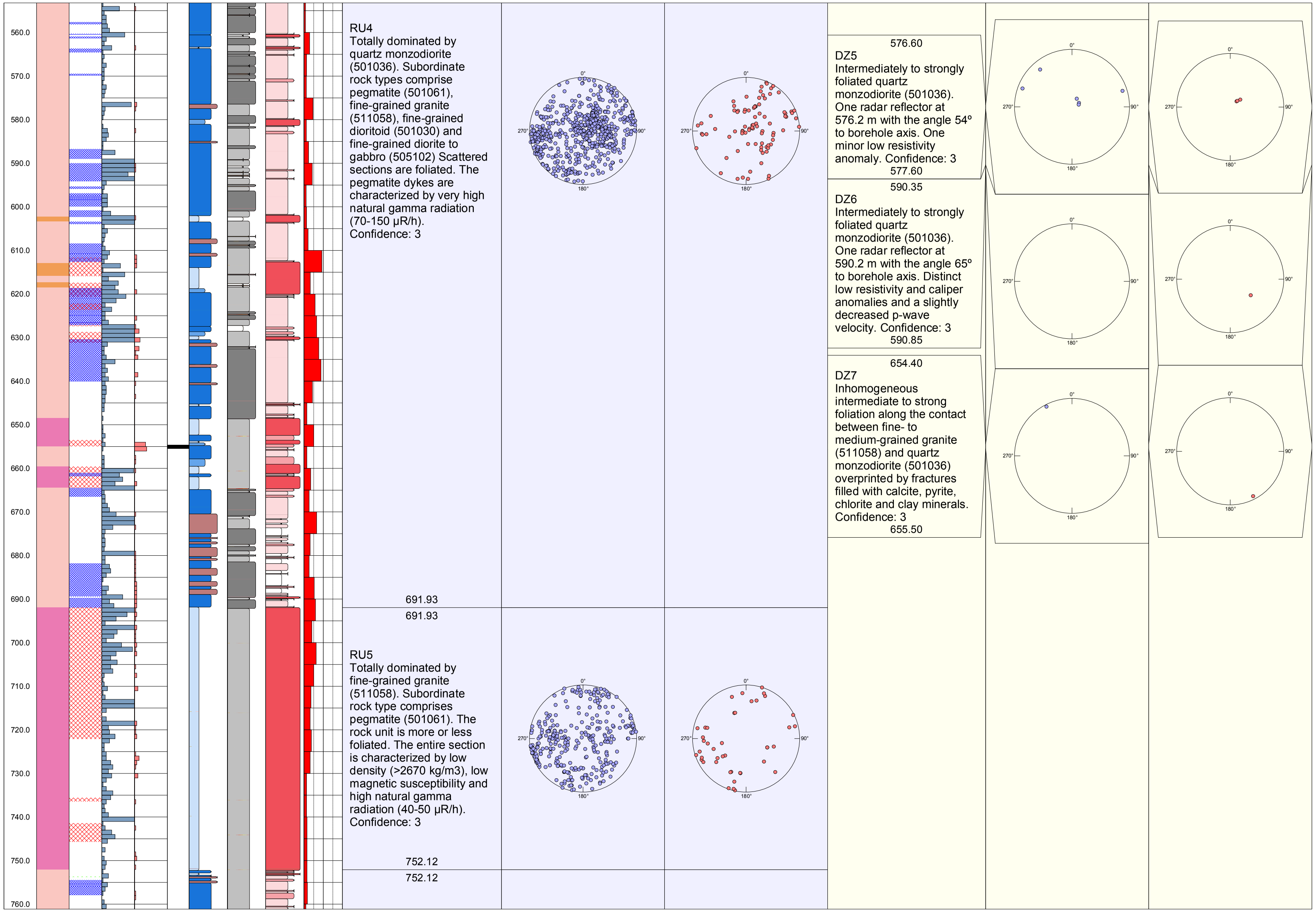
SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1
- sus>0.1

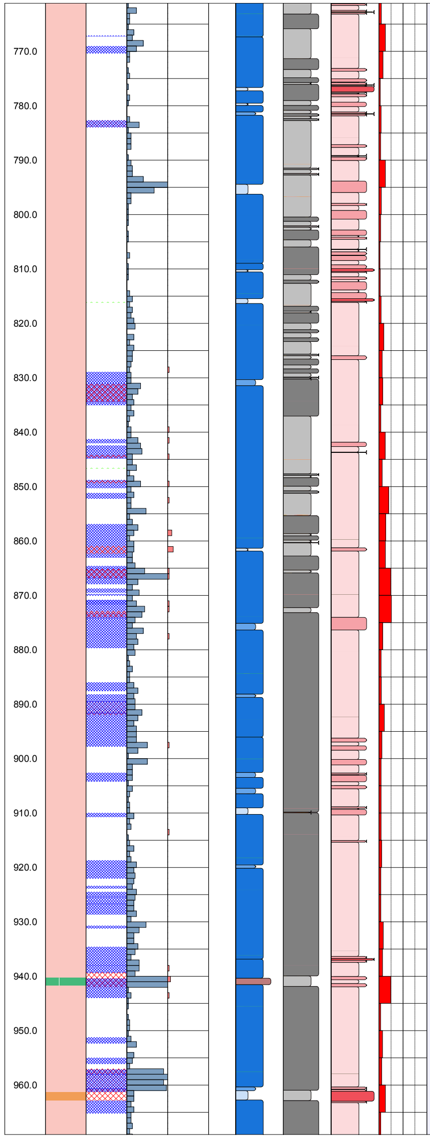
NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30



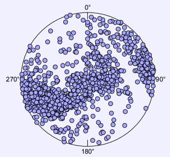

140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
230.0
240.0
250.0
260.0
270.0
280.0
290.0
300.0
310.0
320.0
330.0
340.0
RU1
Dominated by a mixture of Ävrö granite (501044) and fine-grained granite (511058). Subordinate rock types comprise pegmatite (501061) and fine-grained dioritoid (501030). Confidence: 3
210.97
210.97
RU2
Completely dominated by granite (501058). Subordinate rock types comprise fine-grained dioritoid (501030), quartz monzodiorite (501036), Ävrö granite (501044), fine-grained diorite to gabbro (505102), and fine-grained granite (511058). Scattered sections are foliated. Section 244-255 m is characterized by very high magnetic susceptibility. Confidence: 3
291.58
291.58
261.23
DZ2
Strongly foliated mixed rocks comprising fine-grained diorite to gabbro (505102) and fine- to medium-grained granite (511058). Slightly increased open fracture frequency and sealed network, weak alteration and one small core loss. One radar reflector at 261.3 m with the angle 35º to borehole axis. One distinct low resistivity anomaly and a corresponding low p-wave velocity anomaly. Confidence: 3
263.00
0°
90°
180°
270°

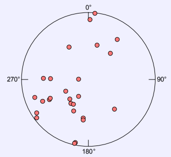

350.0
360.0
370.0
380.0
390.0
400.0
410.0
420.0
430.0
440.0
450.0
460.0
470.0
480.0
490.0
500.0
510.0
520.0
530.0
540.0
550.0
RU3
Dominated by a mixture of Ävrö granite (501044) and diorite to gabbro (501033). Subordinate rock types comprise fine-grained granite (511058), fine-grained dioritoid (501030), fine-grained diorite to gabbro (505102), granite (501058) and pegmatite (501061). Scattered sections are foliated. The diorite to gabbro section 340-375 m is characterized by very high magnetic susceptibility (>0.1 SI) and high density (>2875 kg/m3), whereas the diorite to gabbro in section 406-436 m has markedly lower magnetic susceptibility. Confidence: 3
473.30
473.30
0°
90°
180°
270°
403.40
DZ3
Intermediately foliated to protomylonitic Ävrö granite (501044). One radar reflector at 403.7 m with the angle 53º to borehole axis. A slight decrease in p-wave velocity. Confidence: 3
406.10
477.50
DZ4
Intermediately to strongly foliated quartz monzodiorite (501036). One radar reflector at 478.7 m with the angle 72º to borehole axis. No indications in geophysical data. Confidence: 3
478.10

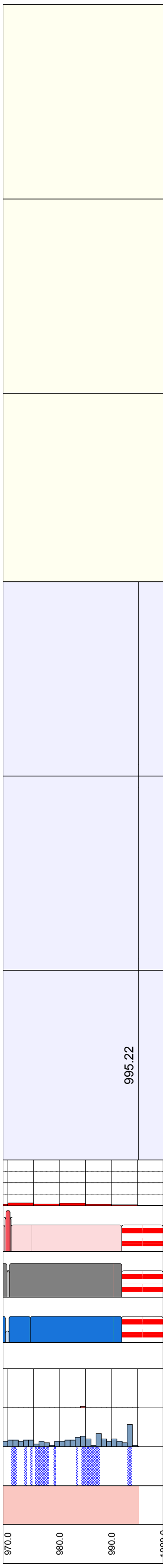

560.0
570.0
580.0
590.0
600.0
610.0
620.0
630.0
640.0
650.0
660.0
670.0
680.0
690.0
700.0
710.0
720.0
730.0
740.0
750.0
760.0
RU4
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise pegmatite (501061), fine-grained granite (511058), fine-grained dioritoid (501030) and fine-grained diorite to gabbro (505102) Scattered sections are foliated. The pegmatite dykes are characterized by very high natural gamma radiation (70-150 µR/h). Confidence: 3
691.93
691.93
RU5
Totally dominated by fine-grained granite (511058). Subordinate rock type comprises pegmatite (501061). The rock unit is more or less foliated. The entire section is characterized by low density (>2670 kg/m3), low magnetic susceptibility and high natural gamma radiation (40-50 µR/h). Confidence: 3
752.12
752.12
576.60
DZ5
Intermediately to strongly foliated quartz monzodiorite (501036). One radar reflector at 576.2 m with the angle 54º to borehole axis. One minor low resistivity anomaly. Confidence: 3
577.60
590.35
DZ6
Intermediately to strongly foliated quartz monzodiorite (501036). One radar reflector at 590.2 m with the angle 65º to borehole axis. Distinct low resistivity and caliper anomalies and a slightly decreased p-wave velocity. Confidence: 3
590.85
654.40
DZ7
Inhomogeneous intermediate to strong foliation along the contact between fine- to medium-grained granite (511058) and quartz monzodiorite (501036) overprinted by fractures filled with calcite, pyrite, chlorite and clay minerals. Confidence: 3
655.50
0°
90°
180°
270°



RU4
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise pegmatite (501061), fine-grained granite (511058), fine-grained dioritoid (501030) and fine-grained diorite to gabbro (505102). Scattered sections are foliated. The pegmatite dykes are characterized by very high natural gamma radiation (c. 100 µR/h).
Confidence: 3






995.22
970.0
980.0
990.0

Geological single-hole interpretation of HLX15

Appendix 2

Title	SINGLE HOLE INTERPRETATION HLX15					
Site	LAXEMAR	Inclination [°]	-58.36	Elevation [m.a.s.l.]	4.81	Signed data
Borehole	HLX15	Date of mapping	2004-07-29 12:12:00	Drilling Start Date	2004-04-27 07:00:00	
Diameter [mm]	137	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-04-29 09:30:00	
Length [m]	151.900	Northing [m]	6365361.98	Surveying Date		
Bearing [°]	184.65	Easting [m]	1548664.02	Plot Date	2006-08-15 21:14:45	

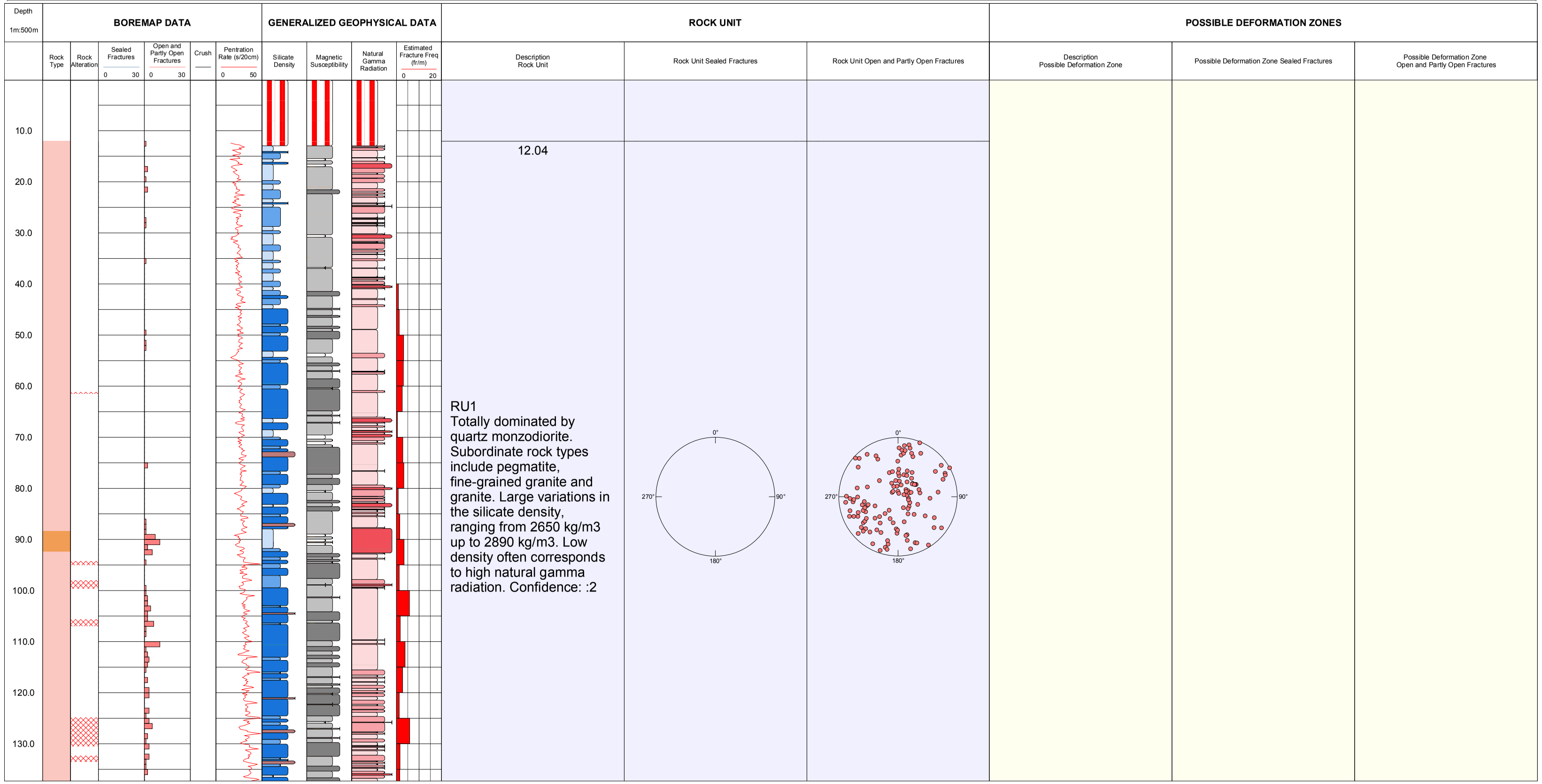
ROCKTYPE LAXEMAR
- Pegmatite
- Quartz monzodiorite

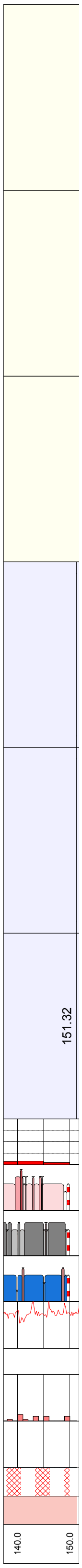
ROCK ALTERATION
- Oxidized

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




151.32
140.0
150.0

Geological single-hole interpretation of HLX18

Title	SINGLE HOLE INTERPRETATION HLX18					
Site	LAXEMAR	Inclination [°]	-57.59	Elevation [m.a.s.l.]	4.04	Signed data
Borehole	HLX18	Date of mapping	2005-03-15 17:14:00	Drilling Start Date	2004-07-01 12:00:00	
Diameter [mm]	139	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-07-06 17:30:00	
Length [m]	181.200	Northing [m]	6365919.12	Surveying Date		
Bearing [°]	135.91	Easting [m]	1550067.64	Plot Date	2006-08-15 21:14:45	

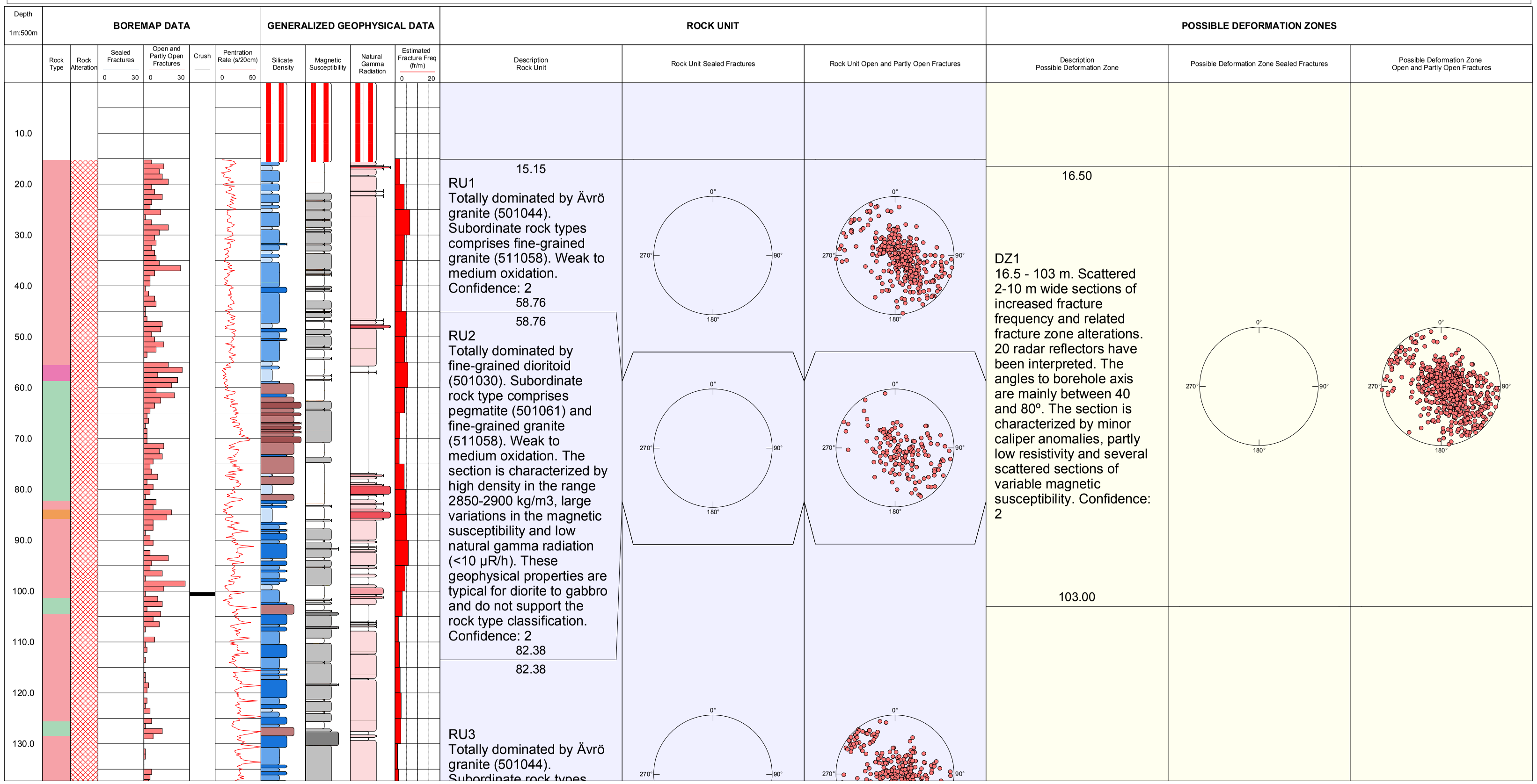
ROCKTYPE LAXEMAR
- Fine-grained granite
- Pegmatite
- Ävrö granite
- Fine-grained dioritoid

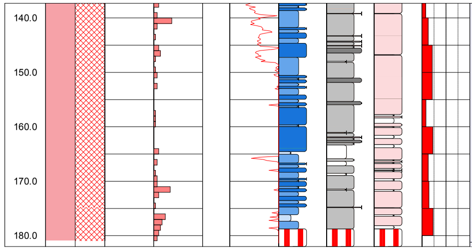
ROCK ALTERATION
- Oxidized

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

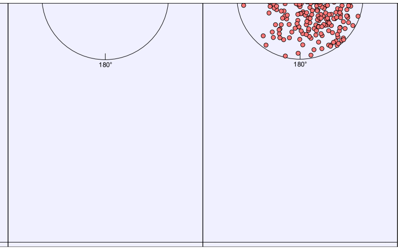
NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30





Subordinate rock types comprise fine-grained dioritoid (501030), fine-grained granite (511058), pegmatite (501061), diorite to gabbro (501033) and fine-grained diorite to gabbro (505102). Weak to medium oxidation. Confidence: 2

181.20



Geological single-hole interpretation of HLX19

Appendix 4

Title SINGLE HOLE INTERPRETATION HLX19

SKB

Site	LAXEMAR	**Inclination [°]**	-57.89	**Elevation [m.a.s.l.]**	5.95	**Signed data**
Borehole	HLX19	**Date of mapping**	2005-04-05 17:14:00	**Drilling Start Date**	2004-08-10 13:30:00	
Diameter [mm]	137	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2004-08-12 20:15:00	
Length [m]	202.200	**Northing [m]**	6365757.88	**Surveying Date**		
Bearing [°]	130.04	**Easting [m]**	1550090.87	**Plot Date**	2006-08-15 21:14:45	

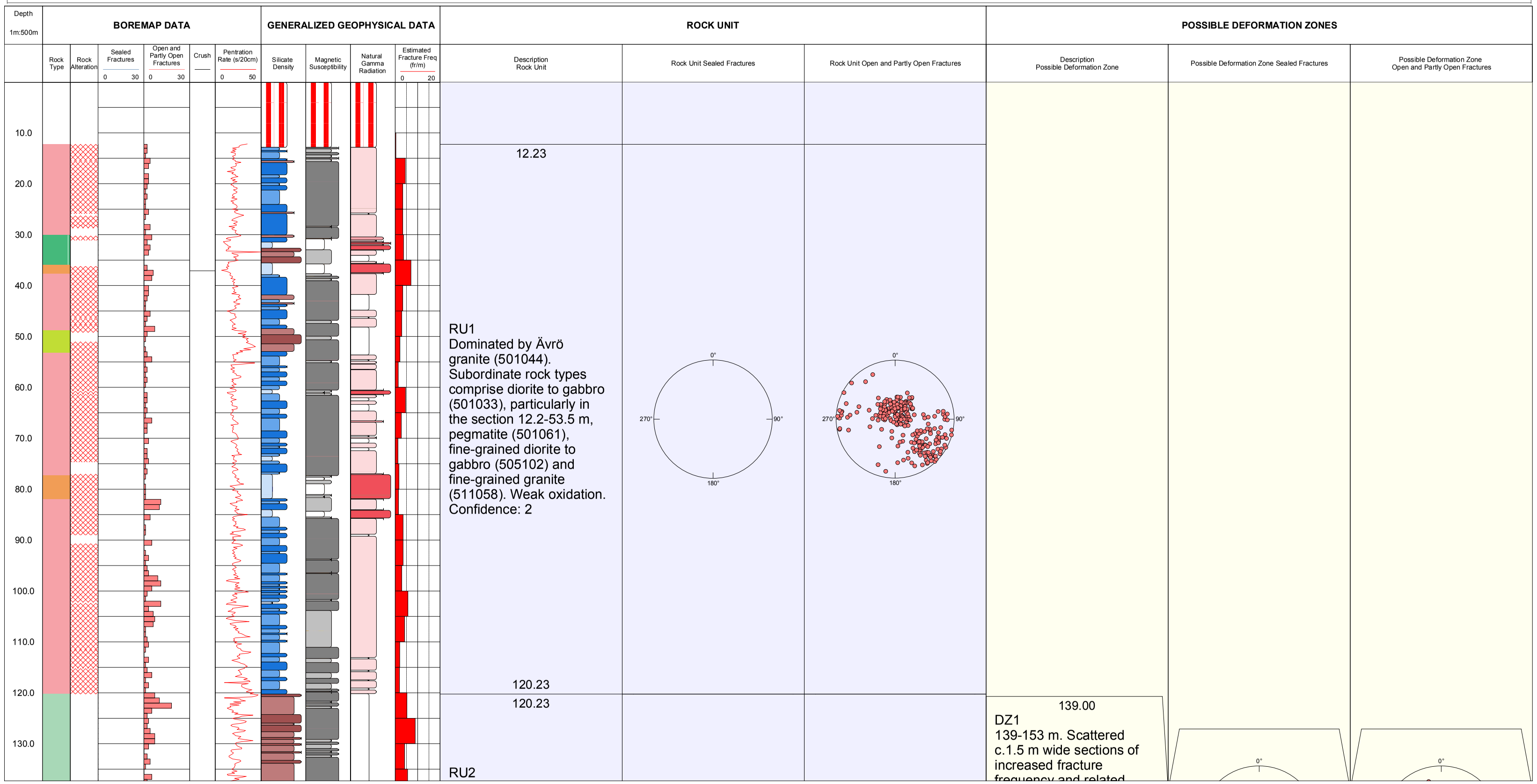
ROCKTYPE LAXEMAR
- Pegmatite
- Ävrö granite
- Diorite / Gabbro
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

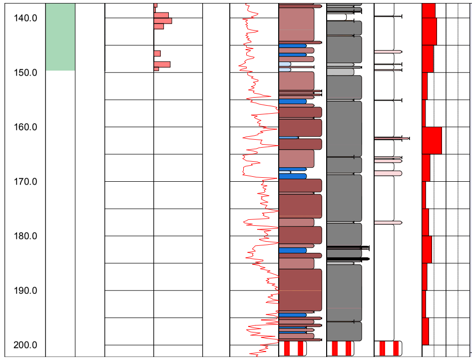
ROCK ALTERATION
- Oxidized

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

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

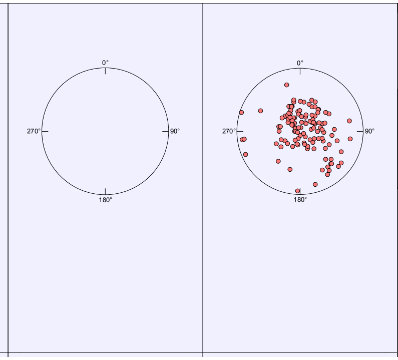
NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30





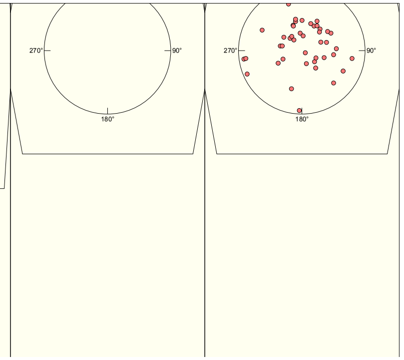
Totally dominated by fine-grained dioritoid (501030). No subordinate rock types. The rock type classification below 150 m is based solely on geophysical logs. The section is characterized by high density in the range 2850-3000 kg/m3, and low natural gamma radiation (<10 µR/h). These geophysical properties are typical for diorite to gabbro and do not support the rock type classification. Confidence: 2

201.40



frequency and related fracture zone alterations. No interpretable radar reflectors below 130 m. The section is characterized by distinct caliper anomalies, partly low resistivity and an indicated decrease in p-wave velocity. Confidence: 1

153.00



Geological single-hole interpretation of HLX32

Title	SINGLE HOLE INTERPRETATION HLX32					
Site	LAXEMAR	Inclination [°]	-58.66	Elevation [m.a.s.l.]	10.84	Signed data
Borehole	HLX32	Date of mapping	2005-04-12 17:36:00	Drilling Start Date	2005-01-04 12:00:00	
Diameter [mm]	140	Coordinate System	RT90-RHB70	Drilling Stop Date	2005-01-11 12:30:00	
Length [m]	162.600	Northing [m]	6365725.79	Surveying Date		
Bearing [°]	28.59	Easting [m]	1546734.36	Plot Date	2006-08-15 21:14:45	

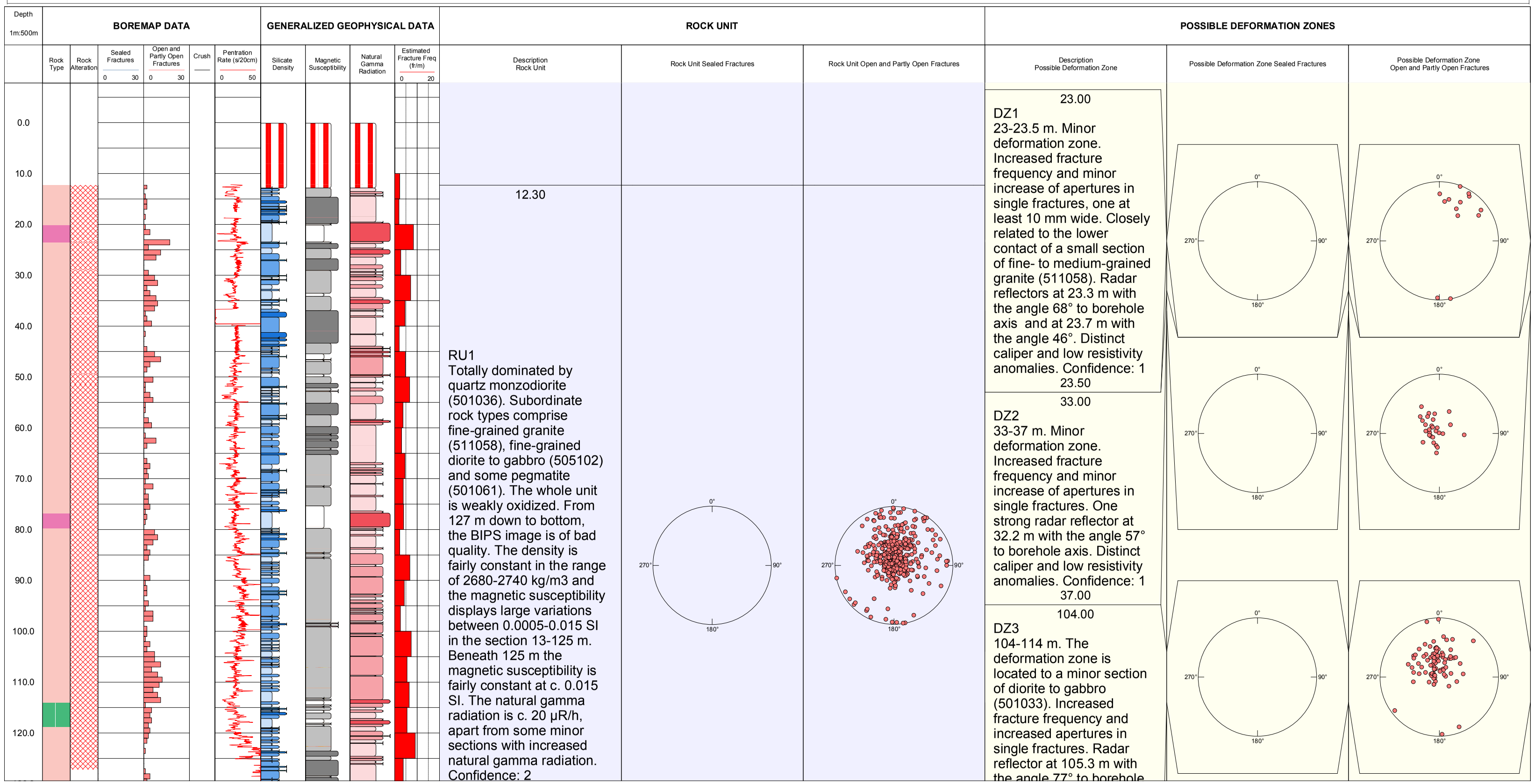
ROCKTYPE LAXEMAR
- Fine-grained granite
- Quartz monzodiorite
- Fine-grained diorite-gabbro

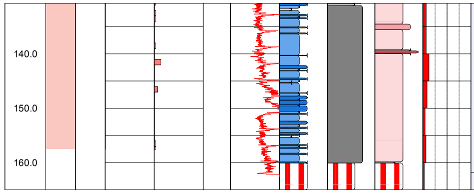
ROCK ALTERATION
- Oxidized

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

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





161.82

axis. There is a significant decrease in the resistivity logs in the section 104-125 m and there are minor caliper anomalies in the section. At c. 115 m there is a large decrease in the fluid resistivity. Confidence: 1

114.00