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Oskarshamn site investigation

Geological single-hole interpretation of KLX06, HLX13, HLX17 and HLX28

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

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

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

Abstract

This report contains geological single-hole interpretations of the cored borehole KLX06 and the percussion boreholes HLX13, HLX17 and HLX28 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 KLX06 (RU1–RU5). Some of the units are recurrent in the borehole and the borehole can therefore be subdivided into seven separate units. In general KLX06 is dominated by Ävrö granite (501044), a mixture of Ävrö granite (501044), granite (501058) and fine-grained diorite to gabbro (505102), and by granite (501058). Subordinate rock types are fine-grained granite (511058), fine-grained diorite to gabbro (505102), pegmatite (501061), fine-grained dioritoid (501030) and granite (501058). Two possible deformation zones are identified in KLX06 (DZ1-DZ2).

The percussion borehole HLX13 is dominated by Ävrö granite (501044) and dolerite (501027). Three rock units are interpreted in the borehole (RU1–RU3). Subordinate rock types are fine-grained granite (511058) and fine-grained diorite-gabbro (505102). One possible deformation zone is identified in HLX13 (DZ1).

One rock unit is interpreted in HLX17 (RU1). The borehole is totally dominated by Ävrö granite (501044). Subordinate rock types are fine-grained granite (511058), fine-grained diorite to gabbro (505102), diorite to gabbro (501033) and pegmatite (501061). No deformation zone is indicated in HLX17.

One rock unit is identified in HLX28 (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). One possible deformation zone is identified in HLX28 (DZ1).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhål KLX06 samt hammarborrhålen HLX13, HLX17 och HLX28 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.

Fem litologiska enheter (RU1–RU5) har identifierats i KLX06. Baserat på repetition av vissa enheter kan borrhålet delas in i 7 sektioner. Generellt sett domineras borrhålet av Ävrögranit, en blandning mellan Ävrögranit, granit och finkornig diorit till gabbro och slutligen av granit. Finkornig granit, finkornig diorit till gabbro, pegmatit, finkornig dioritoid och granit förekommer som underordnade bergarter. Två möjliga deformationszoner har identifierats i KLX06 (DZ1–DZ2).

Hammarborrhålet HLX13 domineras av Ävrö granit och diabas. Tre litologiska enheter har identifierats i borrhålet (RU1–RU3). Inslag av finkornig granit och finkornig diorit till gabbro förekommer. En möjlig deformationszon har identifierats i HLX13 (DZ1).

En litologisk enhet finns i hammarborrhål HLX17 (RU1), vilken domineras av Ävrö granit. Inslag av finkornig diorit till gabbro, diorit till gabbro och pegmatit förekommer. Inga deformationszoner har identifierats i HLX17.

I HLX28 finns en litologisk enhet (RU1) som domineras av kvartsmonzodiorit. Inslag av finkornig granit, finkornig diorit till gabbro och pegmatit förekommer. En möjlig deformationszon har identifierats i HLX28 (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 KLX06 and the percussion drilled boreholes HLX13, HLX17 and HLX28 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 400-05-017. 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.

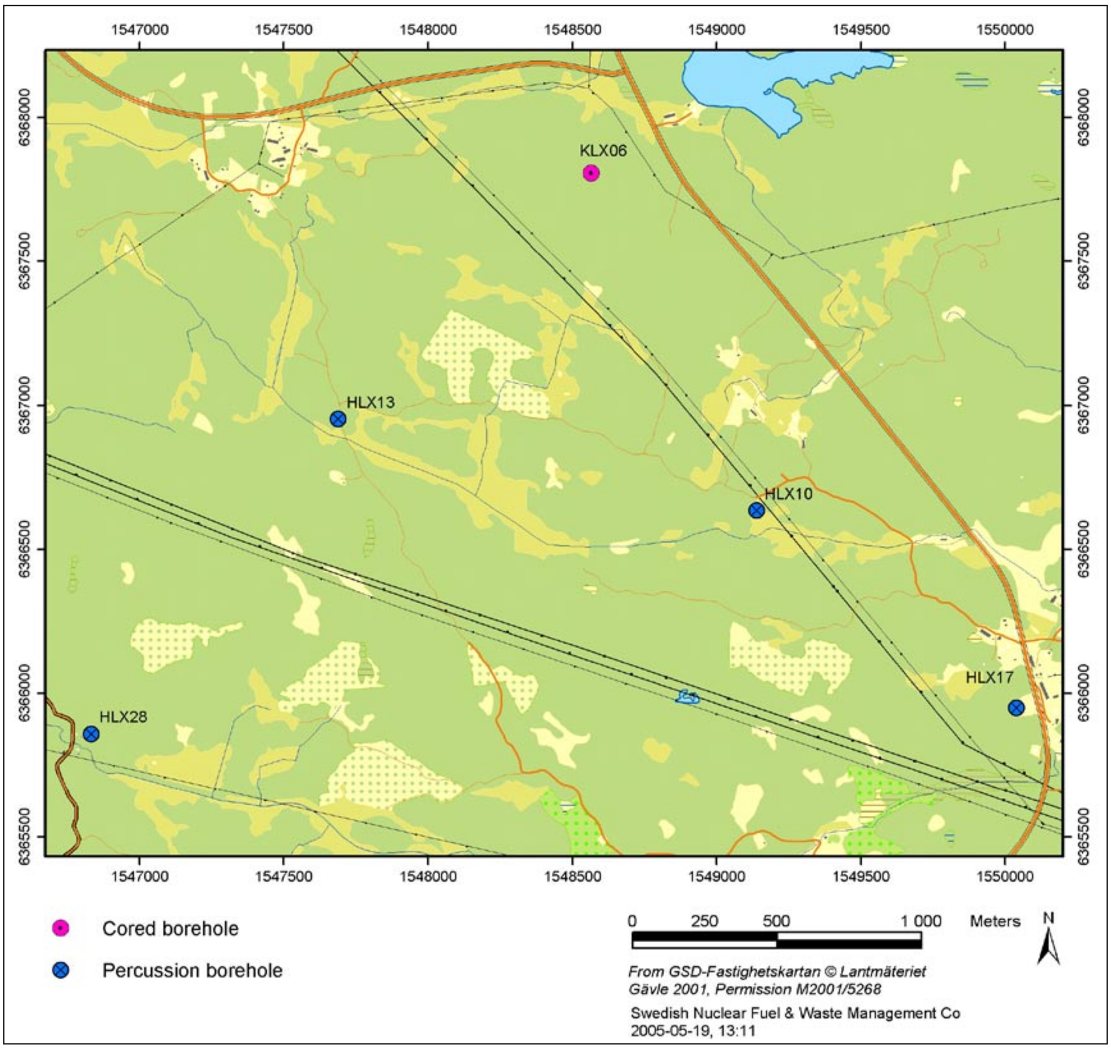

Figure 1-1. *Map showing the position of the cored borehole KLX06 and the percussion drilled boreholes HLX13, HLX17 and HLX28.*

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

Activity plan	Number	Version
Geologisk enhålstolkning av KLX06, HLX10, HLX13, HLX17 och HLX28	AP PS 400-05-017	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 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 single-hole interpretation

The following data have been used in the single-hole interpretation of the boreholes KLX06, HLX13, HLX17 and HLX28:

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

The reflection seismic measurements were not carried out in the borehole but on the ground surface. The reflectors used in this report correspond to those that were predicted to intersect the borehole /10/.

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.

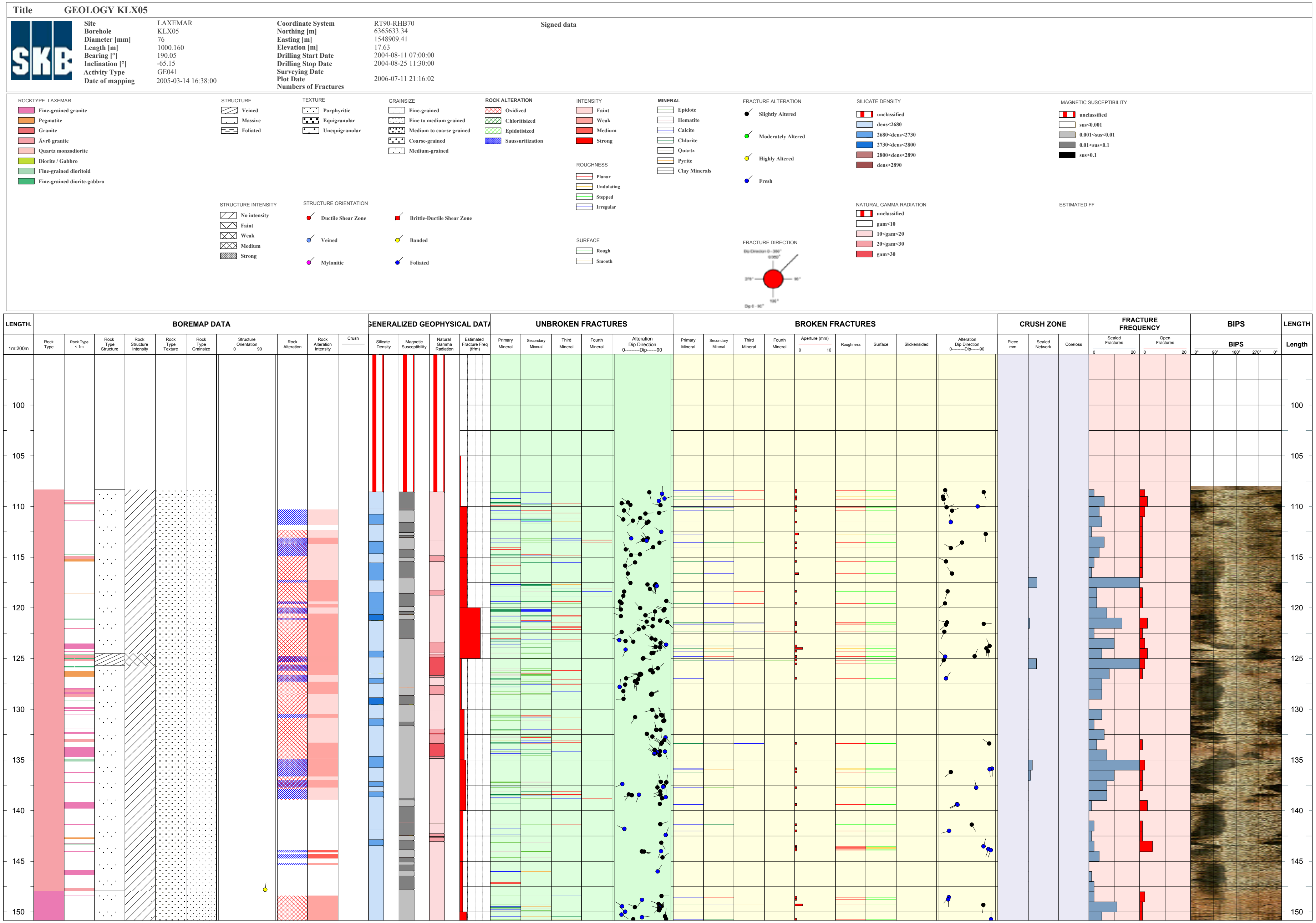

Figure 3-1. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.

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. 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.

Deformation zones that are brittle in character have been identified primarily on the basis of the frequency of fractures, according to the recommendations in /11/. 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.

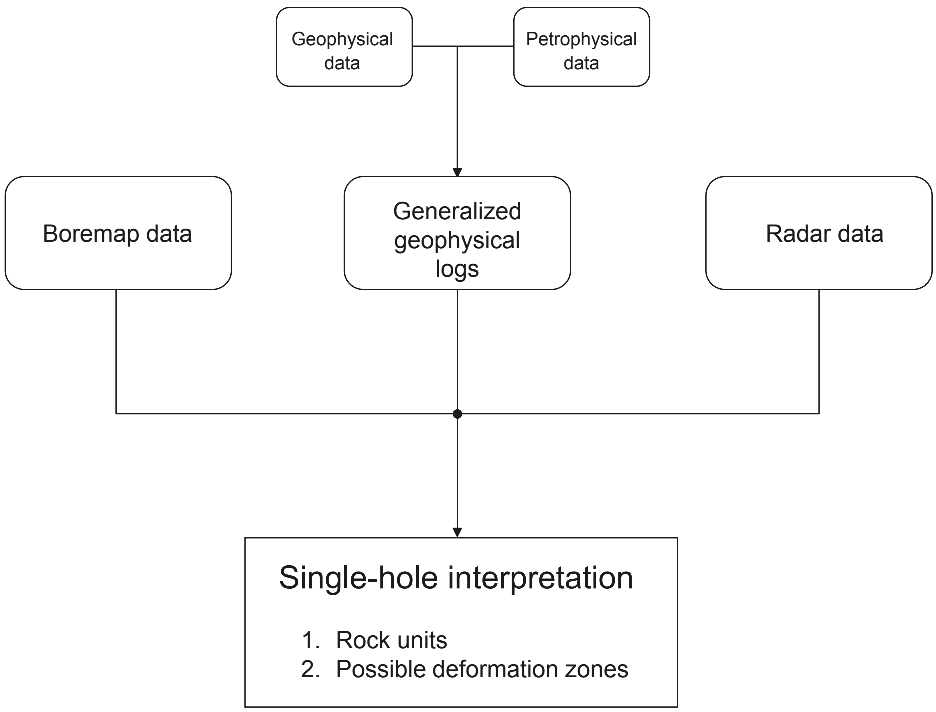

***Figure 4-1.** Schematic block-scheme of single-hole interpretation.*

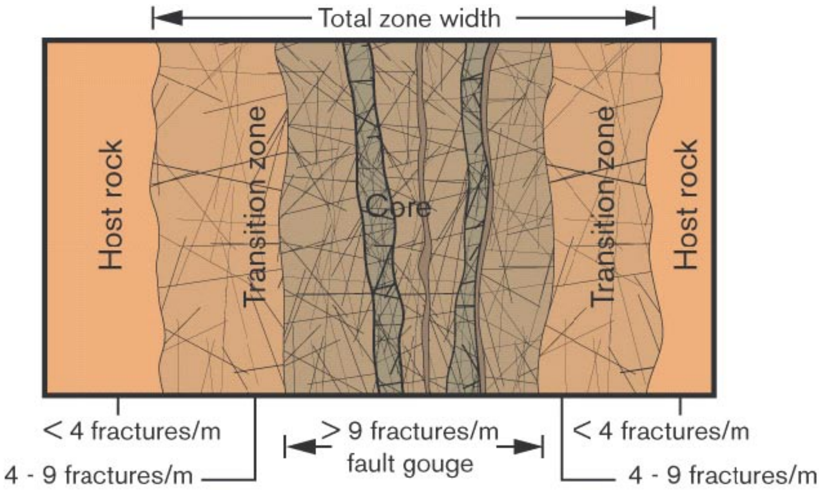

Figure 4-2. *Terminology for brittle deformation zones (after /11/).*

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.

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 dip/strike using the right-hand rule.

4.2 Nonconformities

Percussion drilled borehole HLX10 was not included in the single-hole interpretation due to lack of geological mapping and geophysical borehole data.

5 Results

The detailed results of the single-hole interpretation are presented as print-outs from the software WellCad (Appendix 1 for KLX06, Appendix 2 for HLX13, Appendix 3 for HLX17 and Appendix 4 for HLX28). The legend of the WellCad is presented in Chapter 6. In 5.1 to 5.4 all identified rock units and possible deformation zones in KLX06, HLX13, HLX17 and HLX28 are presented.

5.1 KLX06

The borehole can be divided into five rock units. Some of the units are recurrent in the borehole and the borehole can therefore be subdivided into seven separate units:

RU1: 101.43–202.60 m
Dominated by Ävrö granite (501044). The section 135–165 m is dominated by fine-grained diorite to gabbro (505102). Subordinate rock types comprise fine-grained granite (511058) and some pegmatite (501061). Large variations in the density log along the entire section. The section 135–165 m is characterized by high density (2,840–2,870 kg/m^3) and low natural gamma radiation. Confidence: 3.

RU2: 202.60–373.78 m
Mixture of granite (501058), that dominates in the upper part of the section, and Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102), pegmatite (501061), fine-grained dioritoid (501030) and granite (501058). There is a decrease in magnetic susceptibility towards the end of the section. Confidence: 3.

RU3: 373.78–591.42 m
Mixture of Ävrö granite (501044), fine-grained diorite to gabbro (505102) and granite (501058). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102), pegmatite (501061) and granite (501058). The major part of the section is foliated. Major fluctuations in the density, magnetic susceptibility and natural gamma radiation logs along the entire section. Confidence: 3.

RU1: 591.42–843.28 m
Dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102), pegmatite (501061) and some granite (501058). The major part of the section is foliated. The section 634–660 m is characterized by high density (2,850–2,890 kg/m^3), low magnetic susceptibility and low natural gamma radiation. Confidence: 3.

RU4: 843.28–911.32 m
Dominated by granite (501058). Subordinate rock types comprise Ävrö granite (501044, fine-grained diorite to gabbro (505102), fine-grained granite (511058) and pegmatite (501061). The section is characterized by granite density (2,670 kg/m^3); clearly lower density than for the major part of the borehole. Confidence: 3.

RU5: 911.32–943.60 m
Totally dominated by fine-grained granite (511058). Subordinate rock types comprise of granite (501058), pegmatite (501061) and fine-grained diorite to gabbro (505102). The entire section is characterized by low density (2,670 kg/m^3), low magnetic susceptibility and very high natural gamma radiation (50 µR/h). Confidence: 2.

RU3: 943.60–994.9 m
Mixture of Ävrö granite (501044), fine-grained diorite to gabbro (505102) and granite (501058). Subordinate rock types comprise fine-grained granite (511058) and pegmatite (501061). The section is characterized by large variations in the density, ranging from 2,660 kg/m^3 up to 2,890 kg/m^3. Confidence: 2.

Two deformation zones have been recognised in KLX06:

DZ1: 200–260 m
Inhomogeneous deformation zone characterized by increased frequency of sealed and open fractures, weak to faint alteration (oxidation), scattered minor crush zones. Partly low resistivity, p-wave velocity, density and magnetic susceptibility. Numerous caliper anomalies. The sections 200–207 m and 226–243 m are the most intensely deformed parts and are characterized by several strong anomalies in all geophysical loggings. 14 radar reflectors are interpreted, three of which are oriented. The strongest reflector (33) at 205 m has the orientation 22/302 (alternative orientation is 65/083), at 240.5 m the orientation is 33/299 (alternative orientation is 75/091), and at 259.6 m the orientation is 52/316. An interpreted seismic reflector (C1) from surface reflection seismic measurements (orientation 70/090) coincides with this section in the borehole. Confidence = 3.

DZ2: 297–425 (445) m
Inhomogeneous deformation zone characterized by increased frequency of sealed and open fractures, weak to medium alteration, dominated by oxidation, but sections of saussuritization also occur. The section ca 390–400 m is strongly altered to laumontite and the section 384–386 m is clay altered. Scattered minor crush zones. The section 365–395 m is characterized by strong, protomylonitic to mylonitic foliation. Partly low resistivity, p-wave velocity, density and magnetic susceptibility. Numerous caliper anomalies. The sections 307–315 m and 380–400 m are characterized by several strong anomalies in all geophysical loggings. 23 radar reflectors occur within the section. Four of them are oriented at 308.5 m the orientation is 20/283, at 357.5 m it is 49/286, at 365.9 m it is 62/092, and at 420.3 m the orientation is 30/353. An interpreted seismic reflector (C1) from surface reflection seismic measurements (orientation 70/090) coincides with this section in the borehole. Confidence = 3.

5.2 HLX13

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

RU1: 12.11–75.06 m
Dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058) and fine-grained diorite to gabbro (505102). Confidence: 2.

RU2: 75.06–107.74 m
Dominated by dolerite (501027). Confidence: 2.

RU3: 107.74–199.72 m
Dominated by Ävrö granite (501044). Subordinate rock types comprise diorite to gabbro (505102). Confidence: 2.

One possible deformation zone has been identified in HLX13:

DZ1: 75–108 m
Characterized by increased fracturing in diorite to gabbro. Confidence: 2.

5.3 HLX17

The borehole contains one rock unit:

RU1: 9.10–203.20 m
Dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102), diorite to gabbro (501033) and pegmatite (501061). Alteration is normally weak and fracture frequency low. Confidence: 2.

No deformation zone has been identified in HLX17.

5.4 HLX28

The borehole contains one rock unit:

RU1: 6.10–143.84 m
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102) and pegmatite (501061). The density is c. 2,750 kg/m^3 along the entire borehole. Fluctuations in the geophysical logs occur when they crosscut subordinate rocks. Confidence: 2.

One possible deformation zone has been identified in HLX28:

DZ1: 75–89 m
Characterized by increased fracture frequency, weak to strong alteration (oxidation) and aperture up to at least 10 mm. Increased penetration rate. Several distinct anomalies in all geophysical loggings. Five radar reflectors with intersection angle 24°, 53°, 61°, 48° and 57° to borehole axis. Confidence: 2.

6 Comments

The result from the geological single-hole interpretation of KLX06, HLX13, HLX17 and HLX28 are presented in WellCad plots (Appendix 1–4). 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 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)

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Appendix 1

Geological single-hole interpretation of KLX06

Title	SINGLE HOLE INTERPRETATION KLX06					
Site	LAXEMAR	Inclination [°]	-65.22	Elevation [m.a.s.l.]	17.61	Signed data
Borehole	KLX06	Date of mapping	2005-01-11 11:53:00	Drilling Start Date	2004-08-03 10:30:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-08-10 11:30:00	
Length [m]	994.940	Northing [m]	6367805.82	Surveying Date		
Bearing [°]	328.81	Easting [m]	1548566.93	Plot Date	2006-07-13 21:14:56	

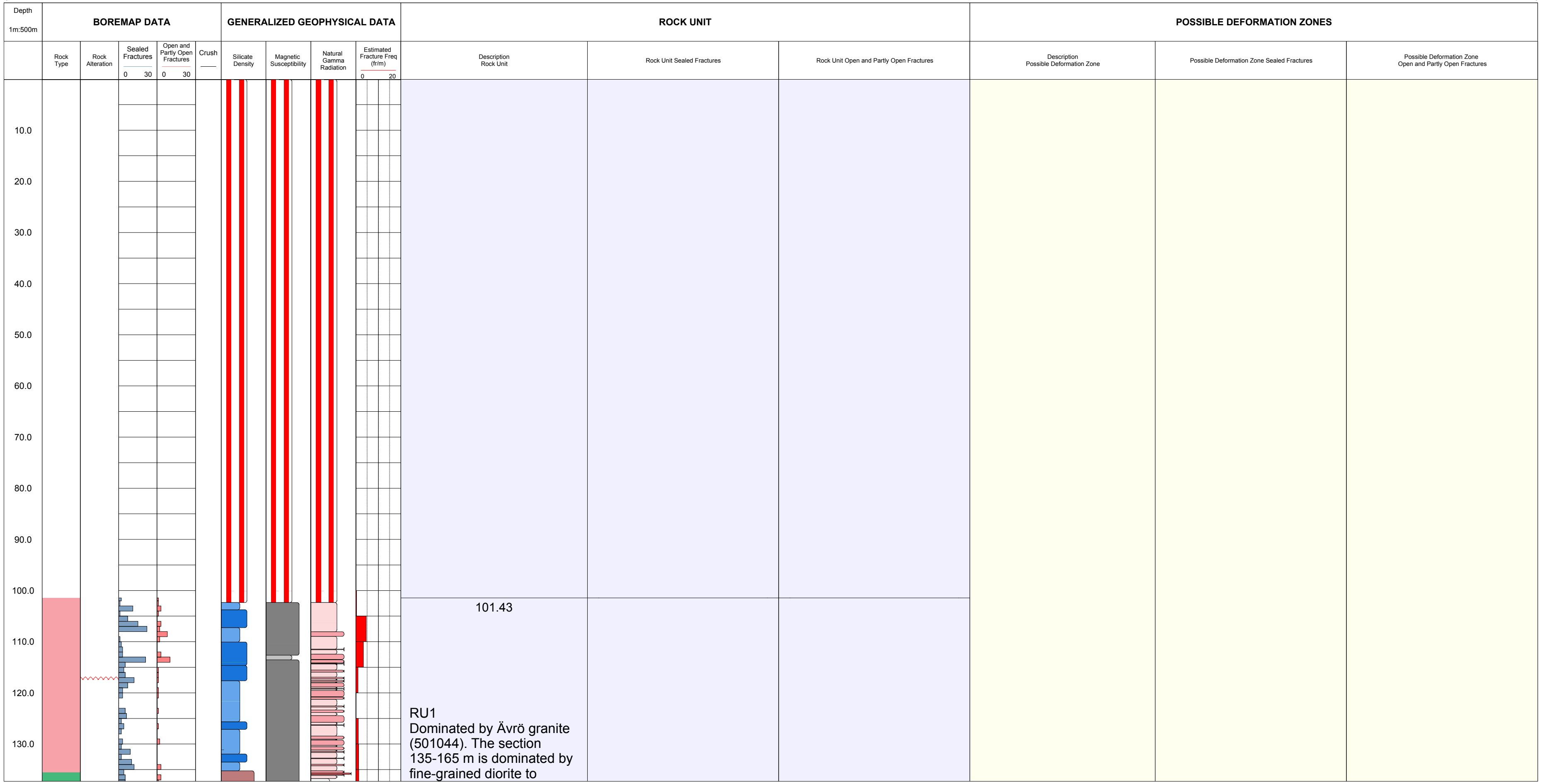
ROCKTYPE LAXEMAR
- Fine-grained granite
- Granite
- Ävrö granite
- Fine-grained diorite-gabbro

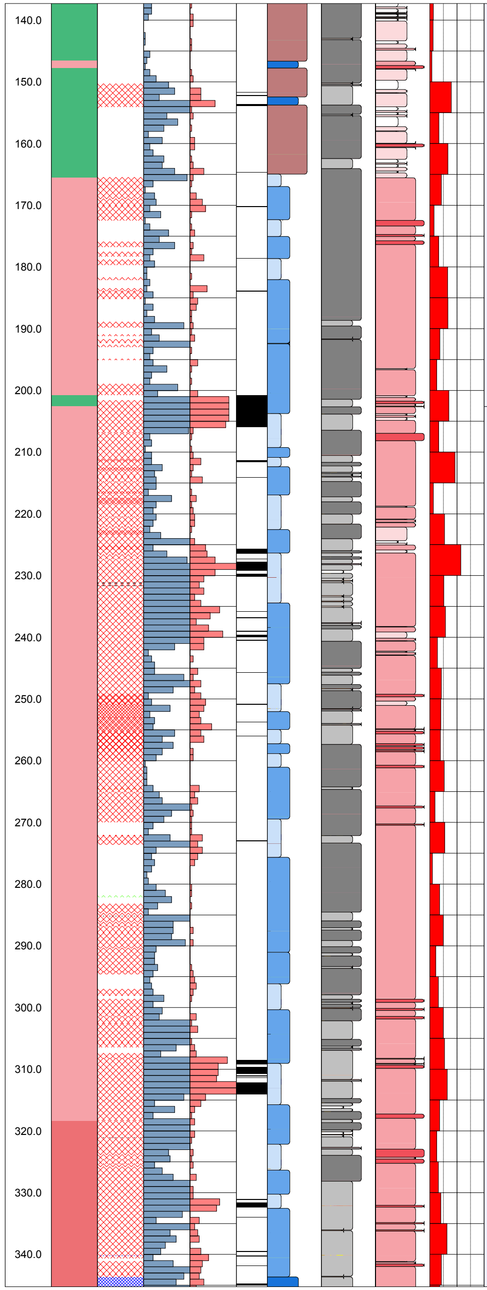
ROCK ALTERATION
- Oxidized
- Epidotisized
- Sericitisized
- Quartz dissolution
- Silicification
- Argillization
- Saussuritization
- Laumontitization

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

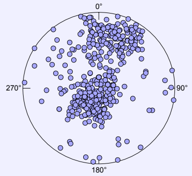
NATURAL GAMMA
- unclassified
- gam<10
- 10<gam<20
- 20<gam<30
- gam>30

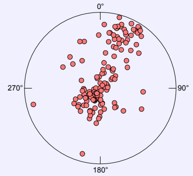




gabbro (505102). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102) and some pegmatite (501061). Large variations in the density log along the entire section. The section 135-165 m is characterized by high density (2840-2870 kg/m3) and low natural gamma radiation. Confidence: 3.

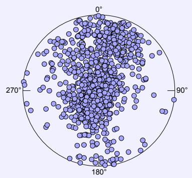
202.60

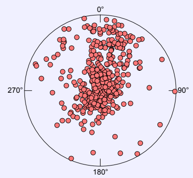




202.60

RU2
Mixture of granite (501058), that dominates in the upper part of the section, and Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102), pegmatite (501061), fine-grained dioritoid (501030) and granite (501058). There is a decrease in magnetic susceptibility towards the end of the section. Confidence: 3.

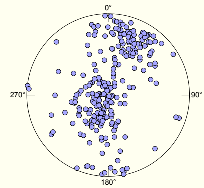


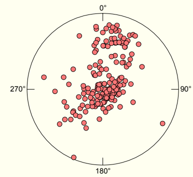


200.00

DZ1
Inhomogeneous deformation zone characterized by increased frequency of sealed and open fractures, weak to faint alteration (oxidation), scattered minor crush zones. Partly low resistivity, p-wave velocity, density and magnetic susceptibility. Numerous caliper anomalies. The sections 200-207m and 226-243 m are the most intensely deformed parts and are characterized by several strong anomalies in all geophysical loggings. 14 radar reflectors are interpreted, three of which are oriented. The strongest reflector (33) at 205 m has the orientation 22/302 (alternative orientation is 65/083), at 240.5 m the orientation is 33/299 (alternative orientation is 75/091), and at 259.6 m the orientation is 52/316. An interpreted seismic reflector (C1) from surface reflection seismic measurements (orientation 70/090) coincides with this section in the borehole. Confidence: 3

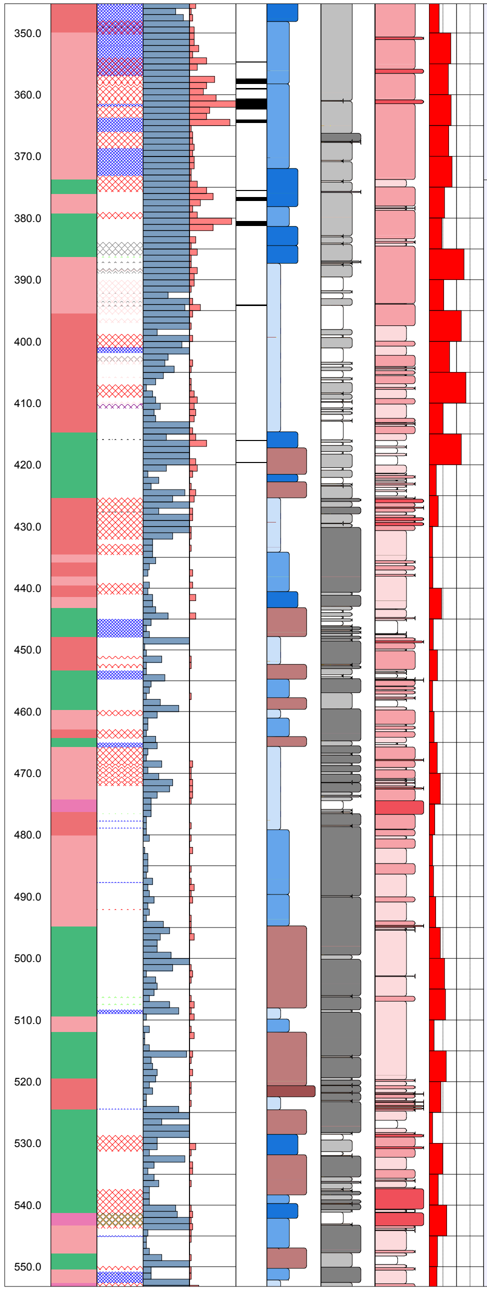
260.00





297.00

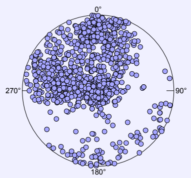
DZ2
Inhomogeneous deformation zone characterized by increased frequency of sealed and open fractures, weak to medium alteration, dominated by oxidation, but sections of saussuritization also occur. The section ca 390-400 m is strongly altered to laumontite and the section 384-386 is clay altered. Scattered minor crush zones. The section 365-395 m is

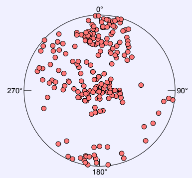


373.78

373.78

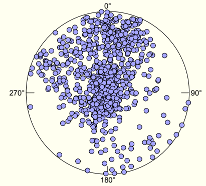
RU3
Mixture of Ävrö granite (501044), fine-grained diorite to gabbro (505102) and granite (501058). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102), pegmatite (501061) and granite (501058). The major part of the section is foliated. Major fluctuations in the density, magnetic susceptibility and natural gamma radiation logs along the entire section. Confidence: 3.

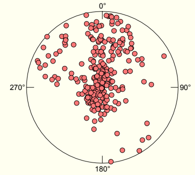


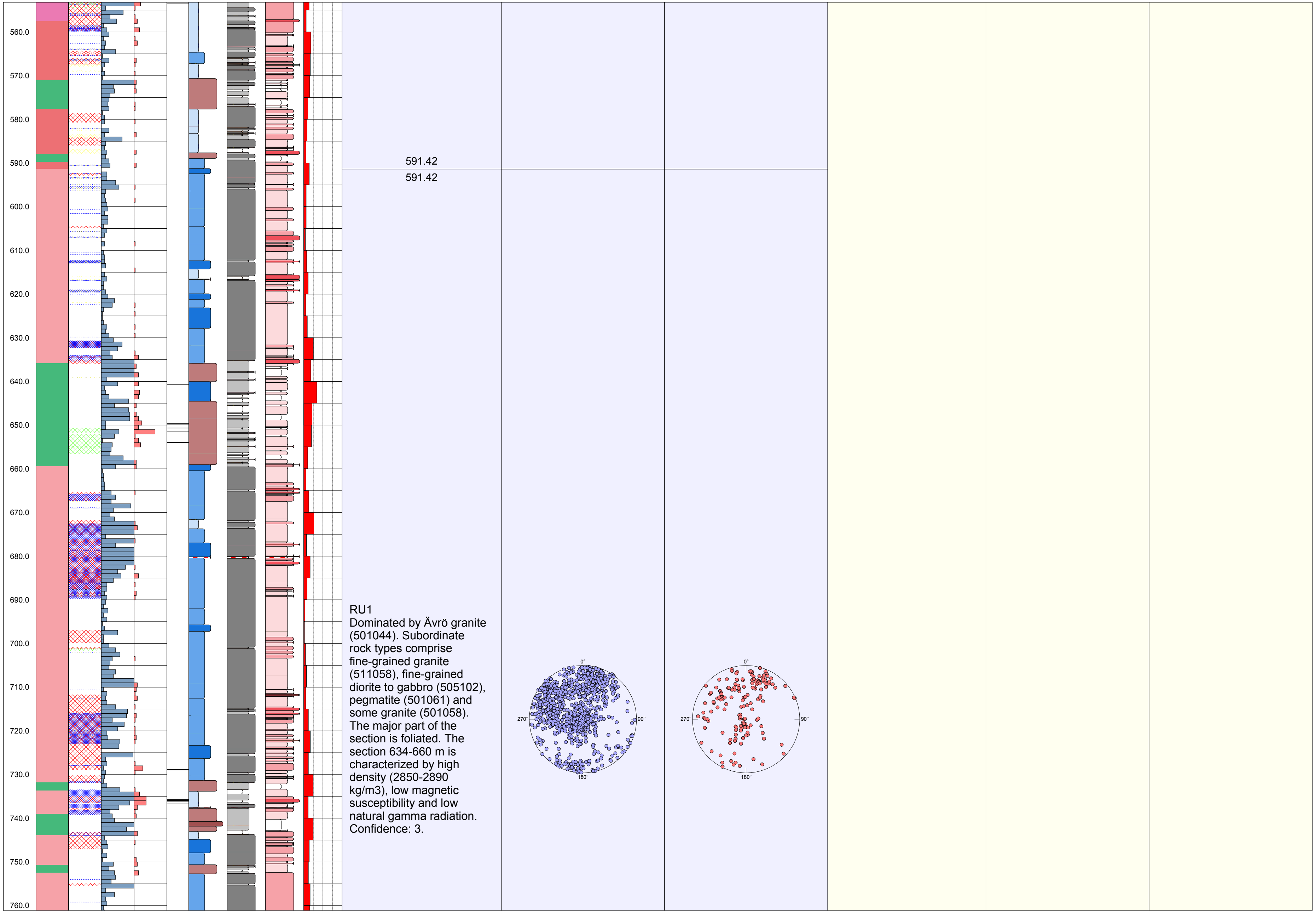


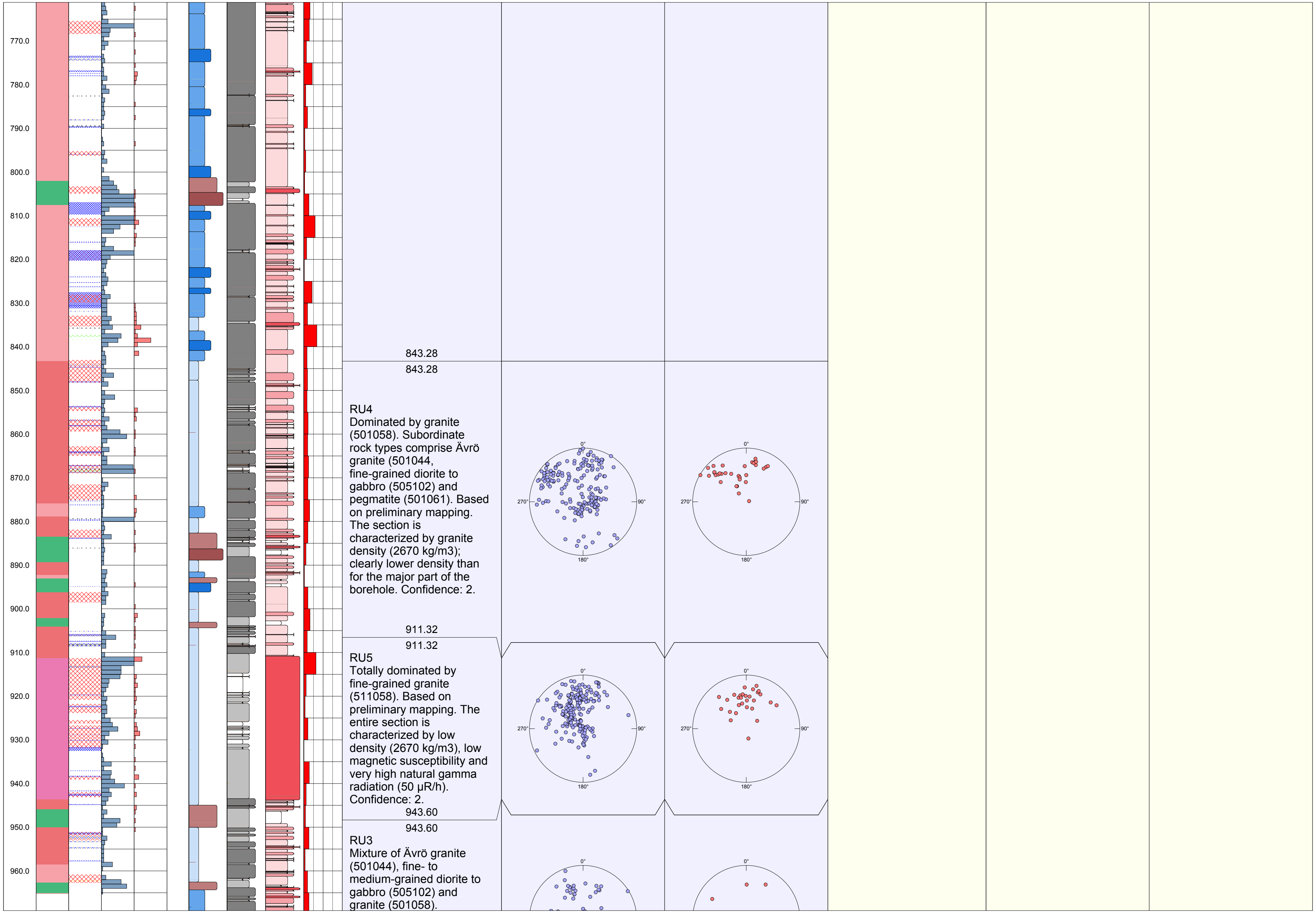
characterized by strong, protomylonitic to mylonitic foliation. Partly low resistivity, p-wave velocity, density and magnetic susceptibility. Numerous caliper anomalies. The sections 307-315 m and 380-400 m are characterized by several strong anomalies in all geophysical loggings. 23 radar reflectors occur within the section. Four of them are oriented at 308.5 m the orientation is 20/283, at 357.5 m it is 49/286, at 365.9 m it is 62/092, and at 420.3 m the orientation is 30/353. An interpreted seismic reflector (C1) from surface reflection seismic measurements (orientation 70/090) coincides with this section in the borehole. Confidence: 3.

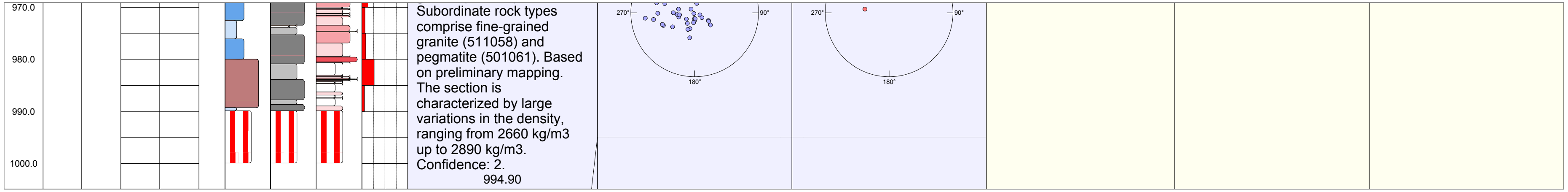
425.00






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
591.42
591.42
RU1
Dominated by Ävrö granite (501044). Subordinate rock types comprise fine-grained granite (511058), fine-grained diorite to gabbro (505102), pegmatite (501061) and some granite (501058). The major part of the section is foliated. The section 634-660 m is characterized by high density (2850-2890 kg/m3), low magnetic susceptibility and low natural gamma radiation. Confidence: 3.
0°
90°
180°
270°
0°
90°
180°
270°


770.0
780.0
790.0
800.0
810.0
820.0
830.0
840.0
850.0
860.0
870.0
880.0
890.0
900.0
910.0
920.0
930.0
940.0
950.0
960.0
843.28
843.28
RU4
Dominated by granite (501058). Subordinate rock types comprise Ävrö granite (501044, fine-grained diorite to gabbro (505102) and pegmatite (501061). Based on preliminary mapping. The section is characterized by granite density (2670 kg/m3); clearly lower density than for the major part of the borehole. Confidence: 2.
911.32
911.32
RU5
Totally dominated by fine-grained granite (511058). Based on preliminary mapping. The entire section is characterized by low density (2670 kg/m3), low magnetic susceptibility and very high natural gamma radiation (50 µR/h). Confidence: 2.
943.60
943.60
RU3
Mixture of Ävrö granite (501044), fine- to medium-grained diorite to gabbro (505102) and granite (501058).
0°
90°
180°
270°


970.0
980.0
990.0
1000.0
Subordinate rock types comprise fine-grained granite (511058) and pegmatite (501061). Based on preliminary mapping. The section is characterized by large variations in the density, ranging from 2660 kg/m3 up to 2890 kg/m3. Confidence: 2.
994.90
270°
90°
180°
270°
90°
180°

Appendix 2

Geological single-hole interpretation of HLX13

Title	SINGLE HOLE INTERPRETATION HLX13					
Site	LAXEMAR	Inclination [°]	-58.06	Elevation [m.a.s.l.]	17.39	Signed data
Borehole	HLX13	Date of mapping	2004-09-13 16:49:00	Drilling Start Date	2004-02-24 12:00:00	
Diameter [mm]	140	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-02-26 18:50:00	
Length [m]	200.200	Northing [m]	6366953.00	Surveying Date		
Bearing [°]	184.18	Easting [m]	1547690.42	Plot Date	2007-10-15 22:03:14	

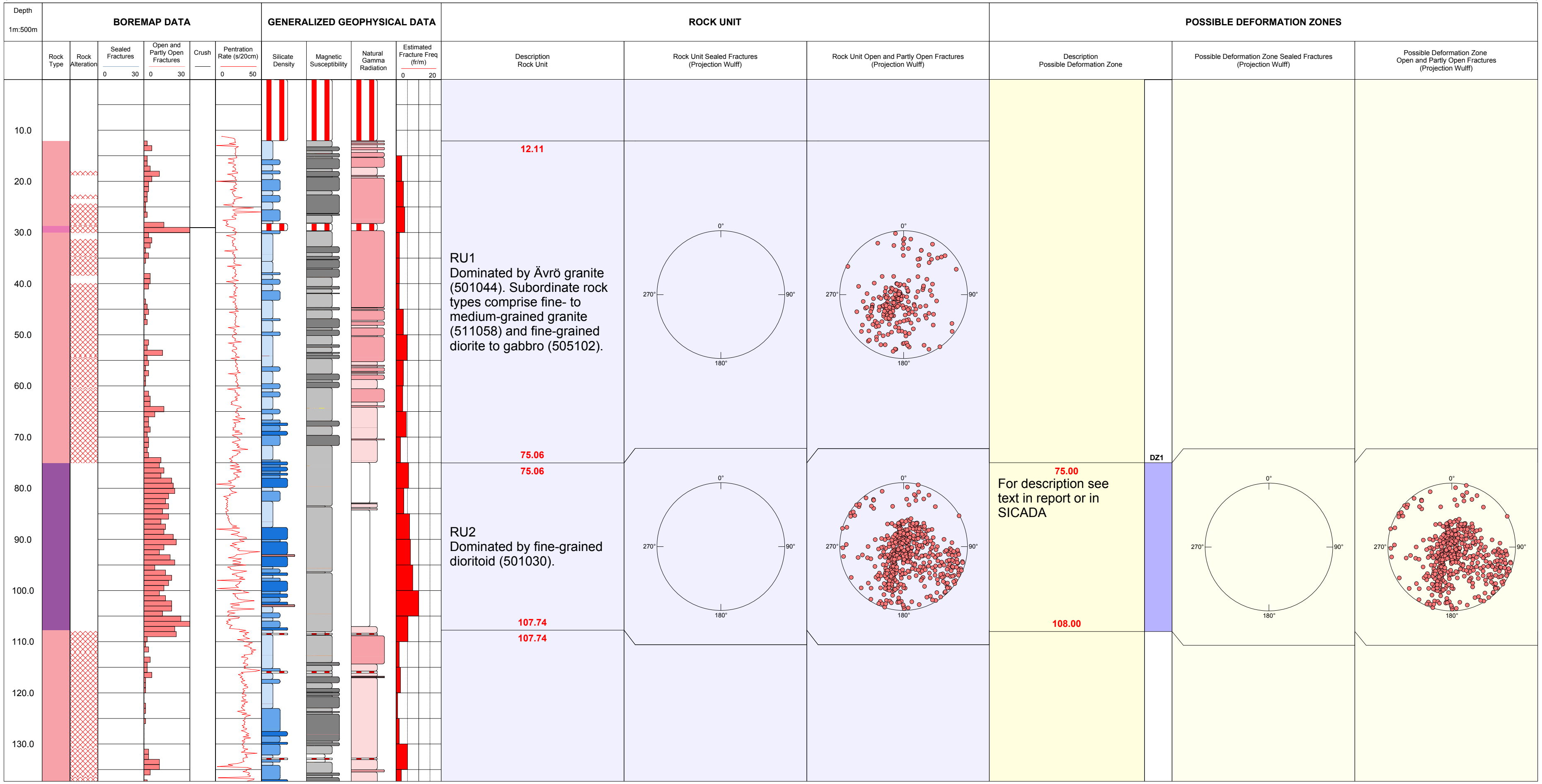
ROCKTYPE LAXEMAR
- Dolerite
- Fine-grained granite
- Ävrö granite
- Fine-grained dioritoid

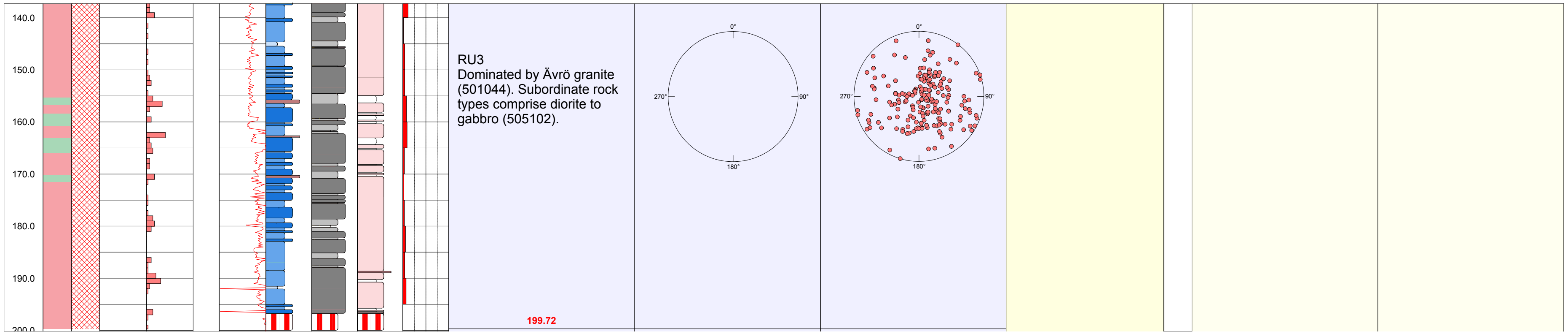
ROCK ALTERATION
- Oxidized

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




140.0
150.0
160.0
170.0
180.0
190.0
200.0
RU3
Dominated by Ävrö granite (501044). Subordinate rock types comprise diorite to gabbro (505102).
199.72
0°
90°
180°
270°
0°
90°
180°
270°

Geological single-hole interpretation of HLX17

Title	SINGLE HOLE INTERPRETATION HLX17					
Site	LAXEMAR	Inclination [°]	-59.48	Elevation [m.a.s.l.]	3.35	Signed data
Borehole	HLX17	Date of mapping	2004-10-12 10:45:00	Drilling Start Date	2004-06-28 14:30:00	
Diameter [mm]	139	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-07-01 09:00:00	
Length [m]	202.200	Northing [m]	6365951.51	Surveying Date		
Bearing [°]	310.94	Easting [m]	1550040.75	Plot Date	2007-10-15 22:03:14	

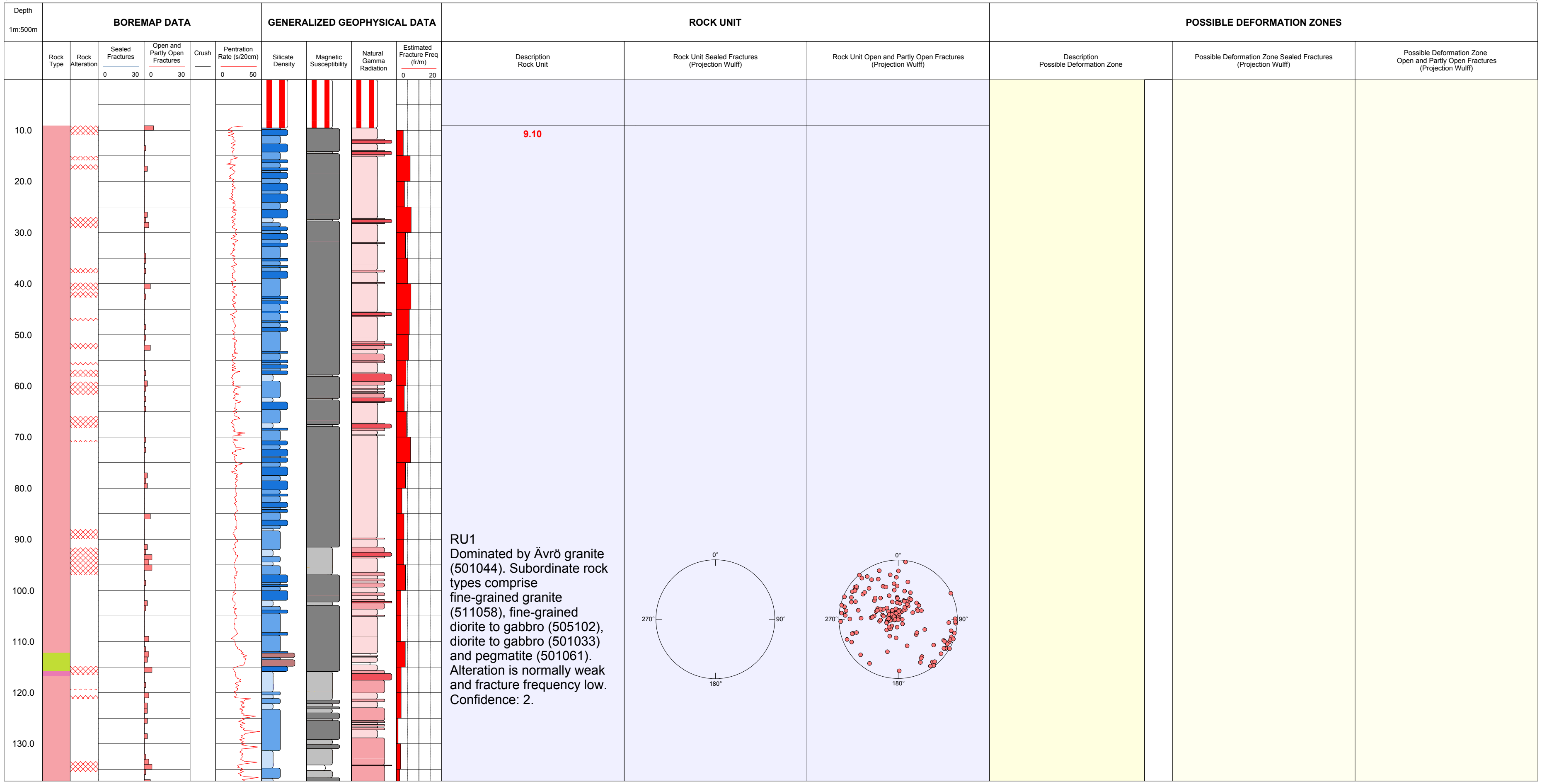
ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Diorite / Gabbro

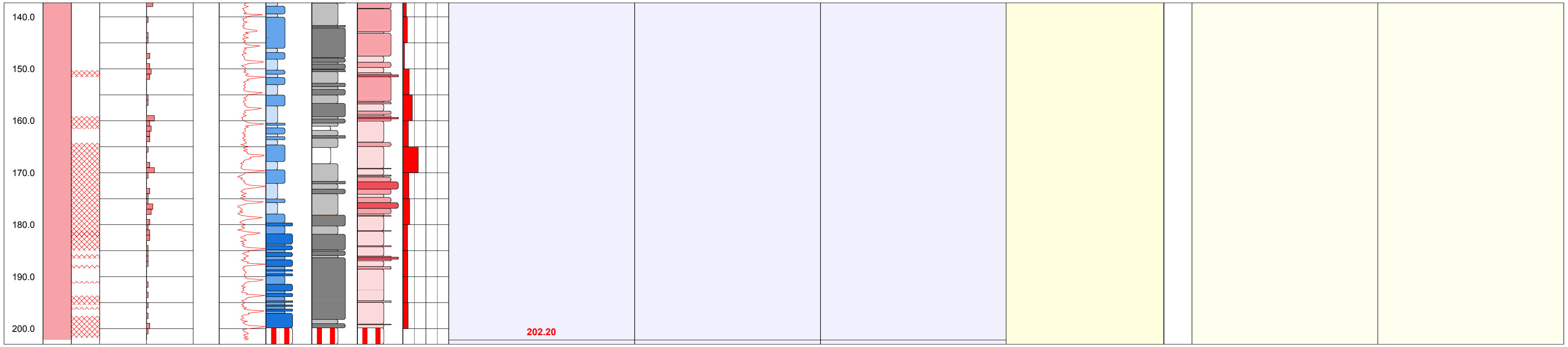
ROCK ALTERATION
- Oxidized

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




140.0
150.0
160.0
170.0
180.0
190.0
200.0
202.20

Geological single-hole interpretation of HLX28

Title	SINGLE HOLE INTERPRETATION HLX28					
Site	LAXEMAR	Inclination [°]	-59.48	Elevation [m.a.s.l.]	13.42	Signed data
Borehole	HLX28	Date of mapping	2004-12-09 15:39:00	Drilling Start Date	2004-09-29 13:40:00	
Diameter [mm]	136	Coordinate System	RT90-RHB70	Drilling Stop Date	2004-10-02 07:30:00	
Length [m]	154.200	Northing [m]	6365861.70	Surveying Date		
Bearing [°]	201.38	Easting [m]	1546834.47	Plot Date	2007-10-15 22:03:14	

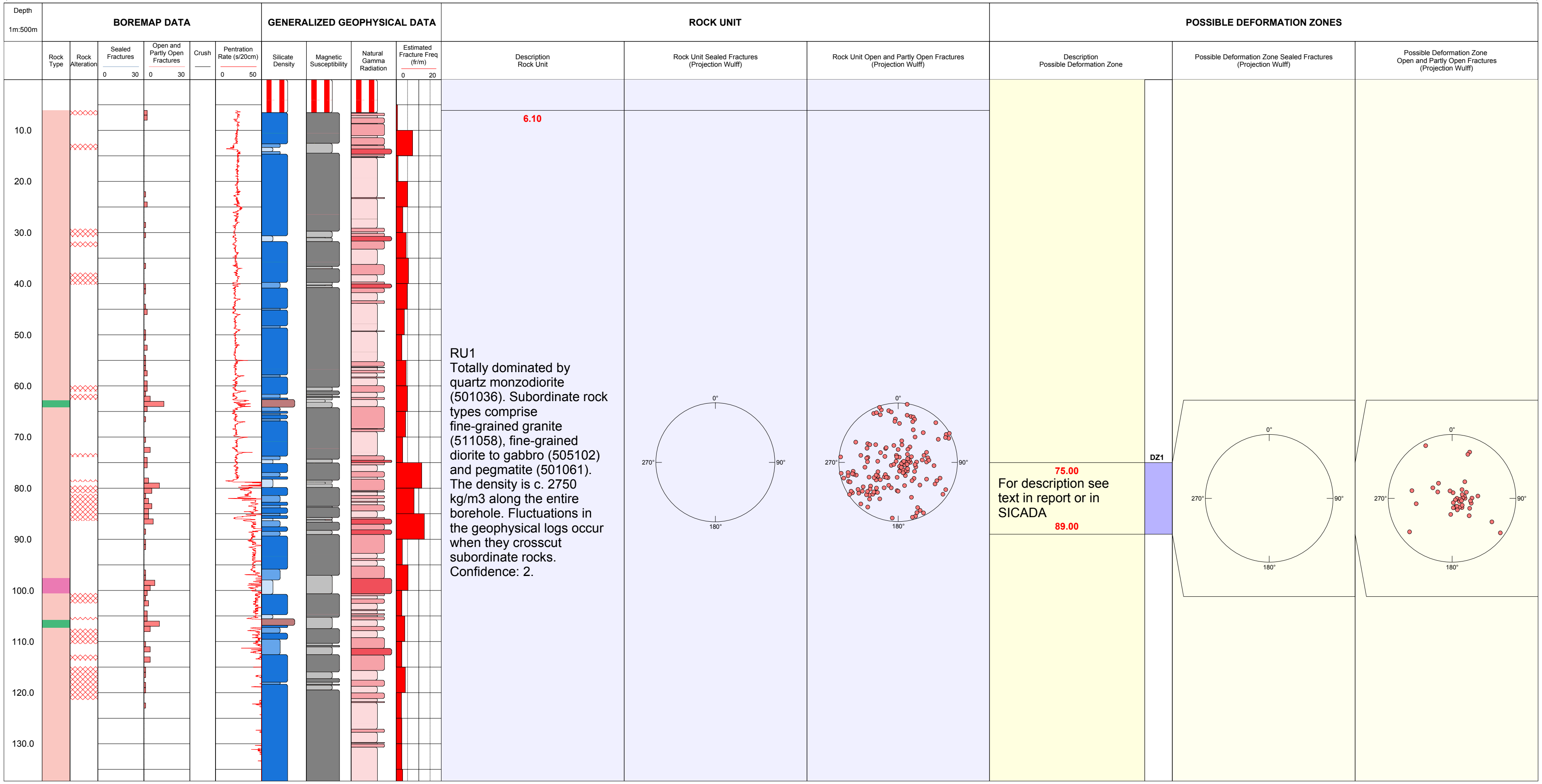
ROCKTYPE LAXEMAR
- Fine-grained granite
- Quartz monzodiorite
- Fine-grained diorite-gabbro

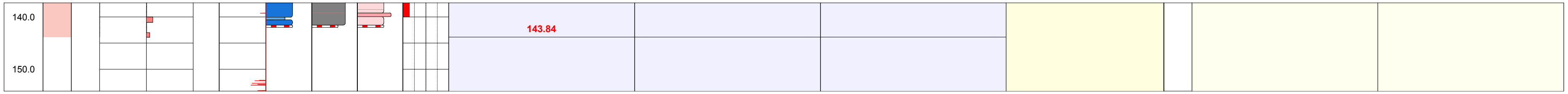
ROCK ALTERATION
- Oxidized

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

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

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




140.0
150.0
143.84