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

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Abstract

This report contains geological single-hole interpretation of the cored borehole KLX19A and the percussion borehole HLX38 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.

The geological single-hole interpretation shows that two rock units (RU1–RU2) occur in KLX19A. However, the borehole can be divided into five separate sections due to the repetition of RU1 (RU1a, RU1b and RU1c) and RU2 (RU2a and RU2b). In general, borehole KLX19A is dominated by quartz monzodiorite (501036) and, to a lesser extent, dolerite (501027). Subordinate rock types comprise occurrences of fine-grained granite (511058), pegmatite (501061), fine-grained diorite-gabbro (505102), granite (501058), Ävrö granite (501044) and fine-grained dioritoid (501030). Ten possible deformation zones are identified in KLX19A (DZ1–DZ10).

One rock unit (RU1) occurs in HLX38. In general, the percussion borehole HLX38 is dominated by quartz monzodiorite (501036). Subordinate rock types comprise occurrences of fine-grained granite (511058) and sparse occurrences of dolerite (501027) and fine-grained diorite-gabbro (505102). Three possible deformation zones are identified in HLX38 (DZ1–DZ3).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålet KLX19A och hammarborrhålet HLX38 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.

Den geologiska enhålstolkningen visar att KLX19A kan delas in i två litologiska enheter (RU1–RU2). Baserat på repetition av enheterna RU1 (RU1a, RU1b och RU1c) och RU2 (RU2a och RU2b) kan borrhålet delas in i fem sektioner. Generellt sett domineras borrhålet av kvartsmonzodiorit (501036) och, i mindre omfattning, av diabas (501027). Finkornig granit (511058), pegmatit (501061), finkornig diorit-gabbro (505102), granit (501058), Ävrögranit (501044) och finkornig dioritoid (501030) förekommer som underordnade bergarter. Tio möjliga deformationszoner har identifierats i KLX19A (DZ1–DZ10).

En litologisk enhet (RU1) förekommer i hammarborrhålet HLX38. Borrhålet domineras av kvartsmonzodiorit (501036). Finkornig granit (511058) och mindre förekomster av diabas (501027) och finkornig diorit-gabbro (505102) utgör underordnade bergarter. Tre möjliga deformationszoner har identifierats i HLX38 (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 v. 3.0, SKB internal controlling document).

This document reports the results gained by the geological single-hole interpretation of boreholes KLX19A and HLX38 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 400-06-146. 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.

Original data from the reported activity are stored in the primary database Sicada, where they are traceable by the Activity Plan number (AP PS 400-06-146). Only data in SKB´s databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major data revisions entail a revision of the P-report. Minor data revisions are normally presented as supplements, available at www.skb.se.

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

Activity plan	Number	Version
Geologisk enhålstolkning av KLX19A och HLX38	AP PS 400-06-146	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

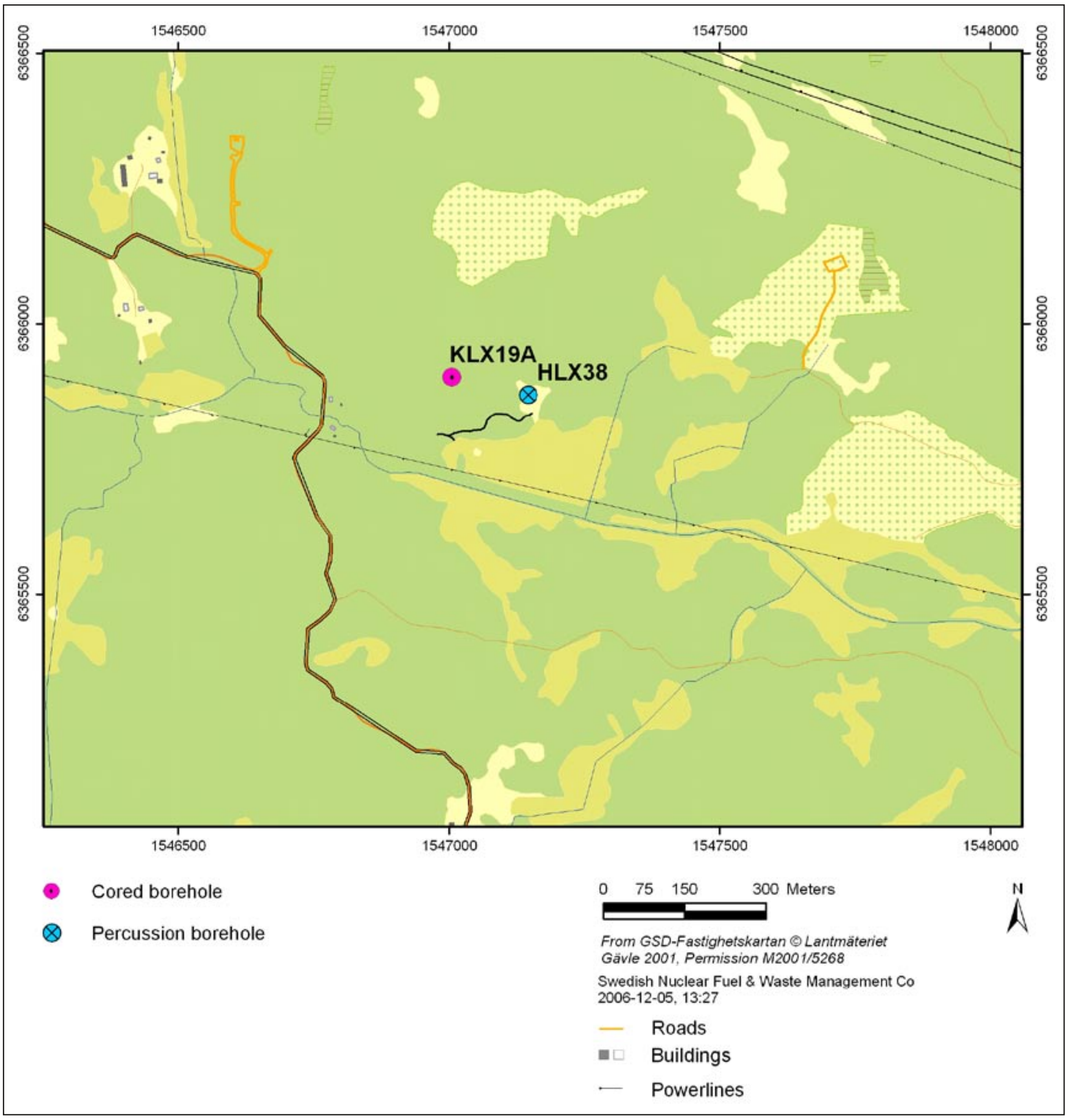


Figure 1-1. *Map showing the position of the cored borehole KLX19A and the percussion drilled borehole HLX38.*

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. The work reported here concerns stage 1 in the single-hole interpretation, as defined in the method description.

3 Data used for the geological single-hole interpretation

The following data have been used in the single-hole interpretation of boreholes KLX19A and HLX38:

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

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

1: Length along the borehole

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

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

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

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

6: Crush zones
   6.1: Piece (mm)
   6.2: Sealed network
   6.3: Core loss

7: Fracture frequency
   7.1: Sealed fractures
   7.2: Open fractures

8: BIPS

9: Length along the borehole

The geophysical logs are described below:

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

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

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

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

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

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

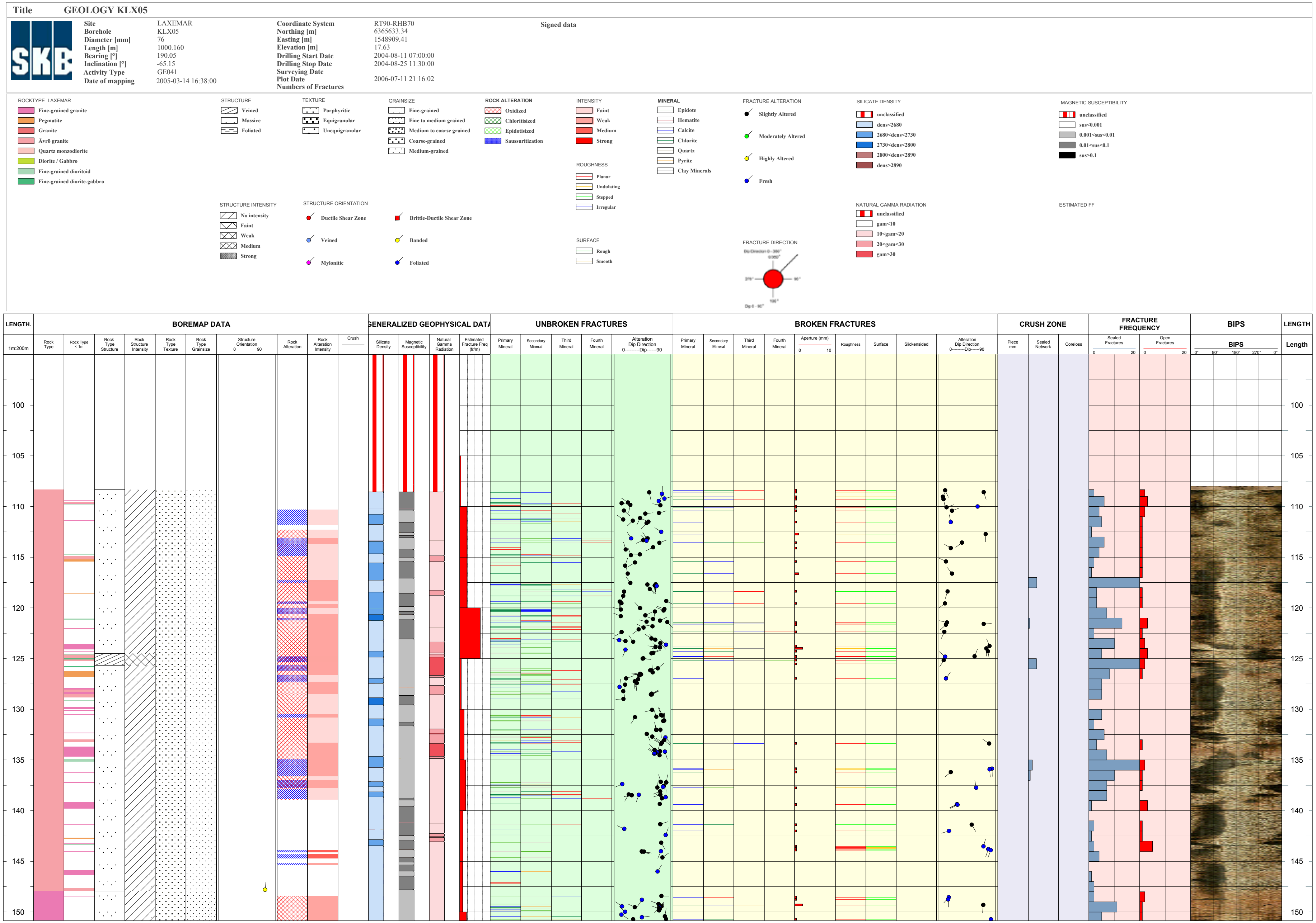


Figure 3-1. Example of WellCad plot (from borehole KLX05 in Laxemar) used as a basis for the single-hole interpretation.

4 Execution

4.1 General

The geological single-hole interpretation has been carried out by a group of geoscientists consisting of both geologists and geophysicists. All data to be used (see Chapter 3) are visualized side by side in a borehole document extracted from the software WellCad. The working procedure is summarized in Figure 4-1 and in the text below.

The first step in the working procedure is to study all types of data (rock type, rock alteration, silicate density, natural gamma radiation, etc) related to the character of the rock type and to merge sections of similar rock types, or sections where one rock type is very dominant, into rock units (minimum length of c. 5 m). Each rock unit is defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. This includes a brief description of the rock types affected by the possible deformation zone. The confidence in the interpretation of a rock unit is made on the following basis: 3 = high, 2 = medium and 1 = low.

The second step in the working procedure is to identify possible deformation zones by visual inspection of the results of the geological mapping (fracture frequency, fracture mineral, aperture, alteration, etc) in combination with the geophysical logging and radar data. The section of each identified possible deformation zone is defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. The confidence in the interpretation of a possible deformation zone is made on the following basis: 3 = high, 2 = medium and 1 = low.

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

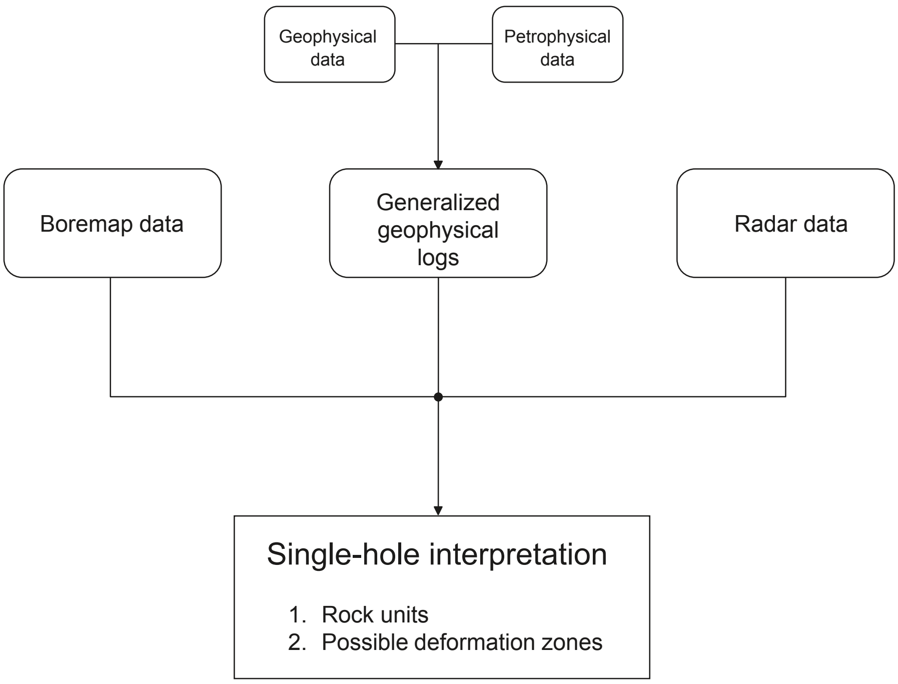


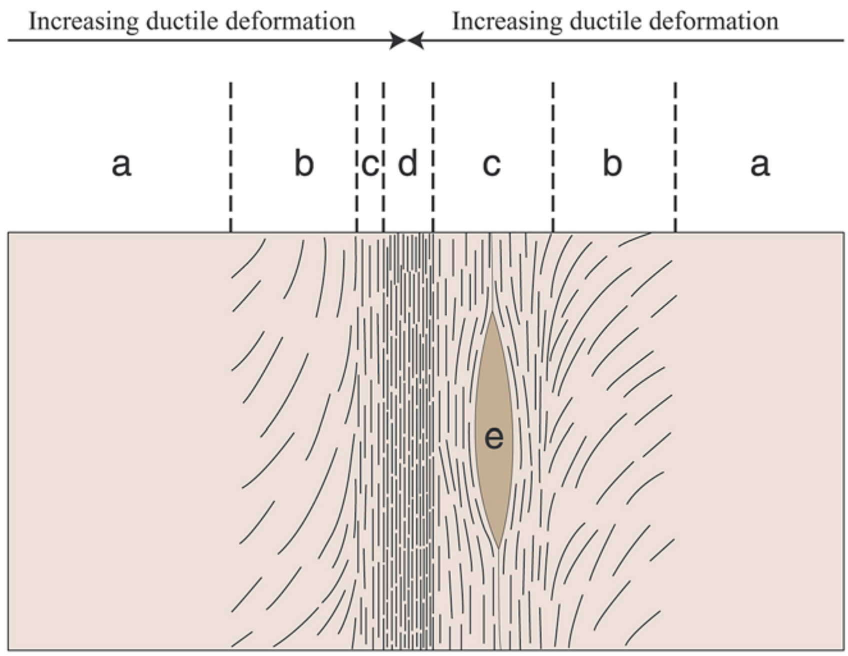
Figure 4-1. *Schematic block-scheme of single-hole interpretation.*

Possible deformation zones that are ductile or brittle in character have been identified primarily on the basis of occurrence of protomylonitic to mylonitic foliation and the frequency of fractures, respectively, according to the recommendations in /1/. Both the transitional parts and the core part have been included in each zone (Figures 4-2 to 4-4). The fracture/m values in Figure 4-4 may serve only as examples. The frequencies of open and sealed fractures have been assessed in the identification procedure, and the character of the zone has been described accordingly. Partly open fractures are included together with open fractures in the brief description of each zone. The presence of bedrock alteration, the occurrence and, locally, inferred orientation of radar reflectors, the resistivity, SPR, P-wave velocity, caliper and magnetic susceptibility logs have all assisted in the identification of primarily the brittle structures.

Since the frequency of fractures is of key importance for the definition of the possible deformation zones, a moving average plot for this parameter is shown for the cored borehole KLX19A (Figure 4-5). A 5 m window and 1 m steps have been used in the calculation procedure. The moving averages for open fractures alone, the total number of open fractures (open, partly open and crush), the sealed fractures alone, and the total number of sealed fractures (sealed and sealed fracture network) are shown in a diagram.

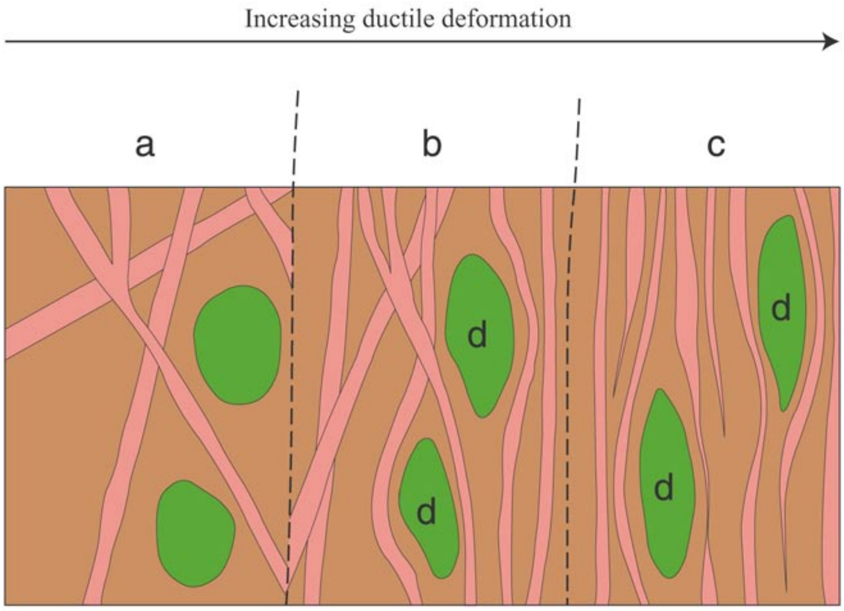
The occurrence and orientation of radar anomalies within these possible deformation zones are used during the identification of zones. Overview of the borehole radar measurement in KLX19A is shown in Figure 4-6 and for HLX38 in Figure 4-7. In some cases, alternative orientations for oriented radar reflectors are presented. One of the alternatives is considered to be correct, but due to uncertainty in the interpretation of radar data, a decision concerning which of the alternatives that represent the true orientation cannot be made.

Orientations from directional radar are presented as strike/dip using the right-hand-rule method, e.g. 040/80 corresponds to a strike of N40°E and a dip of 80° to the SE.



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

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



a. Wallrock - undeformed to weakly deformed hostrock.
b. Transition zone - Weakly to strongly deformed rock. Some discordant conditons are preserved.
c. Core - banded rock within the strongly deformed part of the shear zone.
d. Tectonic lens - rock with minor deformation within the shearzone.

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

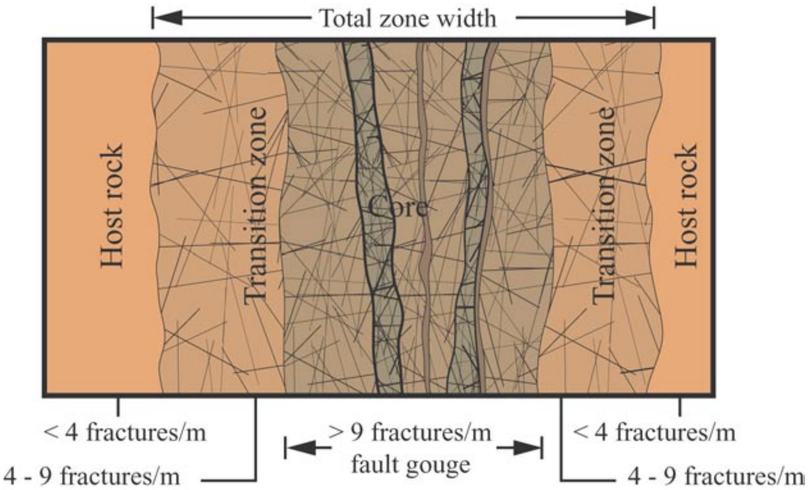


Figure 4-4. *Schematic example of a brittle deformation zone (after /1/).*

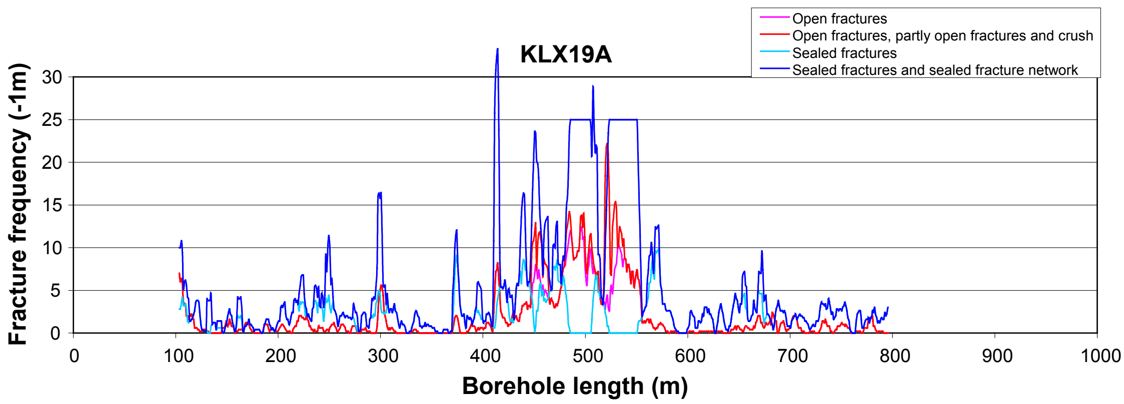


Figure 4-5. *Fracture frequency plot for KLX19A. Moving average with a 5 m window and 1 m steps.*

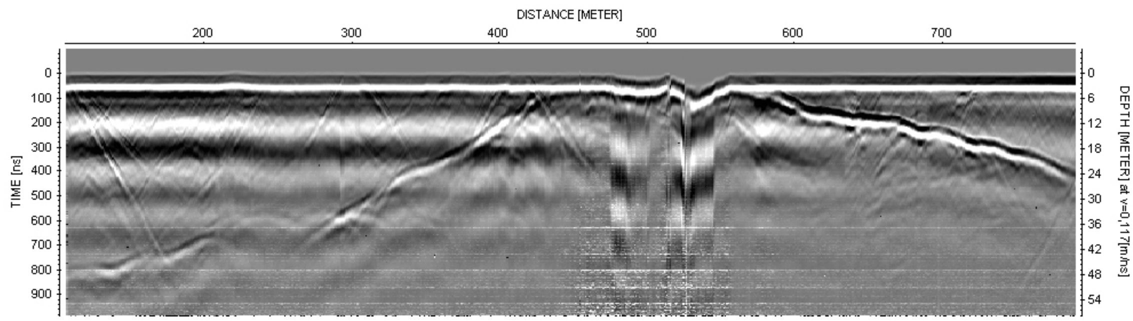


Figure 4-6. *Overview (20 MHz data) of the borehole radar measurement in KLX19A.*

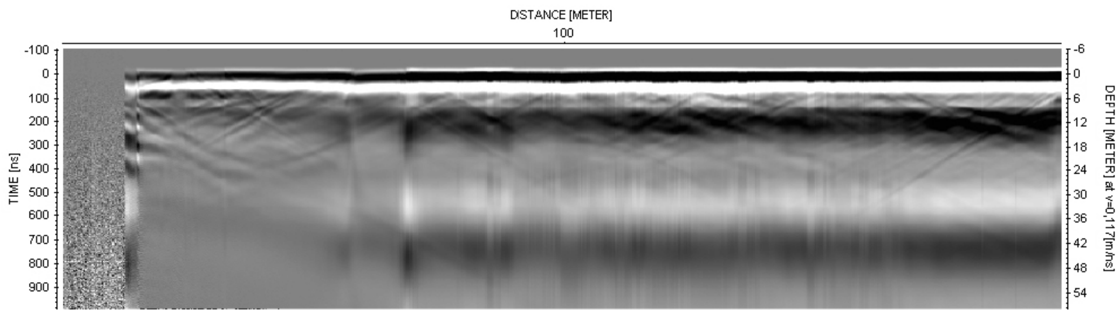


Figure 4-7. *Overview (20 MHz data) of the borehole radar measurement in HLX38.*

4.2 Nonconformities

Borehole KLX19A was shielded by a perforated metal plate along the section 520.43–522.41 m. The metal plate was present during geophysical, BIPS and borehole radar logging.

There are no density data or caliper 1D data in the interval 64.0–125.0 m in HLX38.

5 Results

The detailed result of the single-hole interpretation is presented as print-out from the software WellCad (Appendix 1 for KLX19A and Appendix 2 for HLX38).

5.1 KLX19A

Rock units

The borehole consists of two rock units (RU1 and RU2). Due to repetition of RU1 (RU1a, RU1b and RU1c) and RU2 (RU2a and RU2b) the borehole can be divided into five sections.

100.42–482.60 m

RU1a: Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058), pegmatite (501061) and sparse occurrence of fine-grained diorite-gabbro (505102), granite (501058) and Ävrö granite (501044). Scattered ≤ c. 55 m long sections are characterized by faint to mainly weak foliation, particularly the section c. 360–415 m. The quartz monzodiorite (501036) has a density in the range 2,750–2,785 kg/m^3, and a magnetic susceptibility in the range 0.020–0.030 SI. Confidence level = 3.

482.60–507.68 m

RU2a: Totally dominated by dolerite (501027). The dolerite (501027) has a density in the range 2,830–2,900 kg/m^3 and a magnetic susceptibility in the range 0.012–0.014 SI. The density is highly variable along the section which presumably is caused by the intense fracturing, see DZ5 below. The dolerite is indicated by two very strong radar reflectors which are more or less parallel to the borehole axis. The orientation of the reflector at 494.5 m is 067/39 or 082/47, and the reflector at 507.1 m is oriented 070/37 or 079/42. The first orientation for both reflectors agrees best with the radar reflector at 543.9 m in RU2b, see below. The reflectors can be traced along the borehole. Confidence level = 3.

507.68–520.44 m

RU1b: Totally dominated by quartz monzodiorite (501036). Subordinate rock type comprises fine-grained granite (511058). The quartz monzodiorite (501036) has a density in the range 2,750–2,785 kg/m^3, and a magnetic susceptibility in the range 0.020–0.030 SI. Confidence level = 3.

520.44–552.21 m

RU2b: Totally dominated by dolerite (501027). The dolerite (501027) has a density in the range 2,830–2,900 kg/m^3, and a magnetic susceptibility in the range 0.007–0.010 SI. The density is highly variable along the section which presumably is caused by the intense fracturing, see DZ7 below. The dolerite is indicated by a very strong radar reflector which can be observed along the borehole from the borehole intersection length to the bottom of the borehole. The orientation of the reflector at 543.9 m is 065/31. Confidence level = 3.

552.21–795.97 m

RU1c: Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058), pegmatite (501061), fine-grained diorite-gabbro (505102), granite (501058) and sparse occurrence of fine-grained dioritoid (501030). Scattered ≤ c. 27 m long sections are characterized by faint to mainly weak foliation, particularly the section c. 573–600 m. The quartz monzodiorite (501036) has a density in the range 2,750–2,785 kg/m^3, and a magnetic susceptibility in the range 0.020–0.030 SI. Confidence level = 3.

Possible deformation zones

Ten possible deformation zones have been recognised in KLX19A.

100.42–105.76 m

DZ1: Brittle deformation zone characterized by increased frequency of open and sealed fractures, core loss and faint to medium saussuritization and red staining. Distinctly decreased resistivity, P-wave velocity, magnetic susceptibility, density and caliper anomalies in the interval 104.5–105.5 m. One oriented radar reflector occurs at 103.1 m (111/41 or 110/75) and two non-oriented radar reflectors occur at 103.1 m and 104.8 m with the angle 29° and 57° to borehole axis, respectively. The oriented reflector can be observed to a distance of 16 m outside the borehole, and the upper non-oriented, which exhibits strong character, to a distance of 14 m outside the borehole. Low radar amplitude occurs at 102–105 m. The host rock is totally dominated by quartz monzodiorite (501036), and very sparse occurrence of fine-grained granite (511058). Confidence level = 3.

298.35–304.20 m

DZ2: Brittle deformation zone characterized by increased frequency of open and sealed fractures, faint to weak red staining and saussuritization, core loss and a c. 0.5 dm long sealed breccia in the bottom of the section. Large apertures in open fractures. Distinctly decreased resistivity and P-wave velocity in the interval c. 299–301 m. The entire section is characterized by decreased magnetic susceptibility, increased borehole diameter (caliper) and increased natural gamma radiation. One oriented radar reflector occurs at 299.3 m (277/71 or 050/11) and one non-oriented radar reflector occurs at 301.9 m with the angle 37° to borehole axis. The oriented reflector exhibits strong character and can be observed to a distance of 12 m outside the borehole. The non-oriented, which also exhibits a strong character, can be observed to a distance of 18 m outside the borehole. Low radar amplitude occurs at c. 300 m. The host rock is totally dominated by quartz monzodiorite (501036), and very sparse occurrence of fine-grained granite (511058). Confidence level = 3.

412.15–416.90 m

DZ3: Brittle deformation zone characterized by increased frequency of open and sealed fractures, large apertures, weak to medium epidotization and red staining, calcite-healed breccia, slickensides and foliation of medium intensity. Decreased resistivity and P-wave velocity at c. 412–415 m. This interval is also characterized by decreased density and increased natural gamma radiation in combination with decreased magnetic susceptibility, which usually indicates the occurrence of fine-grained granite. One oriented radar reflector occurs at 413.1 m (235/75) and two non-oriented radar reflectors occur at 413.4 m and 416.0 m with the angle 50° and 40° to borehole axis, respectively. The oriented reflector can be observed to a distance of 18 m outside the borehole, and the non-oriented reflectors to a distance of 6 m and 4 m outside the borehole, respectively. The host rock is totally dominated by quartz monzodiorite (501036). Confidence level = 3.

437.00–464.10 m

DZ4: Brittle to brittle-ductile deformation zone characterized by increased frequency of open and sealed fractures, four crush zones, weak to medium red staining and epidotization, breccia, ductile and brittle-ductile shear zones and gouge. The most intensely deformed sections (cores) are 448.0–457.20 m and 461.40–464.0 m. The ductile to brittle-ductile deformation is concentrated to the most intensely deformed sections. The section is characterized by a slight but general decrease in resistivity. In the section c. 449–451 m there is a large distinct decrease in the resistivity and P-wave velocity, in combination with caliper anomalies. In the interval c. 460–461 there is a distinct decrease in the P-wave velocity. Two oriented radar reflectors occur at 456.3 m (049/85) and at 457.2 m (057/53 or 068/78). Eight non-oriented radar reflectors occur with an angle between 13° and 53° to borehole axis. The oriented reflectors can be observed to a distance of 8 m and 30 m outside the borehole, respectively. The latter exhibits a strong character in the radar map. Low radar amplitude occurs at 432–442 m. The host rock is dominated by quartz monzodiorite (501036). Subordinate rock types are pegmatite (501061) and fine-grained granite (511058). Confidence level = 3.

482.60–507.68 m

DZ5: Brittle deformation zone characterized by increased frequency of open and sealed fractures, apertures, six crush zones, core loss and slickensides. The entire section is characterized by a large general decrease in the bulk resistivity and several caliper anomalies. There is also partly decreased P-wave velocity. The magnetic susceptibility is c. 0.012–0.014 SI. Two oriented radar reflectors occur at 494.5 m (039/67 or 047/82) and at 507.1 m (037/70 or 042/79). Both reflectors are very strong and probably indicate the dolerite. Also, reflector 58 at 470.7 m (044/59 or 057/82) probably indicates the upper contact of the same dolerite, even if it is interpreted to intersect above the dolerite section. One non-oriented radar reflector occurs at 501.5 m with the angle 51° to borehole axis. The oriented reflectors can be observed along almost the entire borehole length. The non-oriented reflector can be observed to a distance of 10 m outside the borehole. Extremely low radar amplitude occurs at 481–510 m. The host rock is dominated by dolerite (501027). Confidence level = 3.

508.40–510.00 m

DZ6: Brittle deformation zone characterized by increased frequency of open and sealed fractures and medium red staining and saussuritization. No significant geophysical anomalies. Two non-oriented radar reflectors occur at 508.5 m with the angle 50° and 30° to borehole axis, respectively. The host rock is dominated by quartz monzodiorite (501036) with subordinate fine-grained granite (511058). Confidence level = 3.

520.44–552.21 m

DZ7: Brittle deformation zone characterized by increased frequency of open and sealed fractures, five crush zones, core loss and slickensides. The entire section is characterized by a large general decrease in the bulk resistivity and several caliper anomalies. There is also partly decreased P-wave velocity. The caliper anomalies and decreased P-wave velocity anomalies are mainly concentrated to the interval c. 520–537 m. The magnetic susceptibility is c. 0.007–0.010 SI. One oriented radar reflector occurs at 543.9 m (031/65). The oriented reflector, which exhibits a strong character, can be observed to a distance of 15 m outside the borehole, from the borehole intersection along the borehole down to the bottom of the borehole. The oriented reflector probably indicates the dolerite. Three non-oriented radar reflectors occur with an angle between 49° and 59° to borehole axis. A fourth non-oriented very strong radar reflector has the angle 7° to borehole axis. It can be observed to a distance of 23 m outside the borehole and is probably a part of the dolerite. Extremely low radar amplitude occurs at 517–552 m. The host rock is dominated by dolerite (501027). Confidence level = 3.

552.21–553.10 m

DZ8: Minor low-grade ductile to brittle-ductile shear zone. Weak saussuritization and faint epidotization and red staining. The interval is characterized by decreased density, magnetic susceptibility, resistivity and partly decreased P-wave velocity. The host rock is dominated by quartz monzodiorite (501036) with subordinate fine-grained granite. Confidence level = 3.

691.50–693.64 m

DZ9: Low-grade ductile shear zone in composite intrusion. Faint red staining. The section is characterized by decreased magnetic susceptibility and slightly decreased resistivity. The host rock is dominated by a mixture of fine-grained diorite-gabbro (505102) and fine-grained granite (511058) which most likely explains the large gradients in the density and natural gamma radiation data. Confidence level = 3.

705.21–706.60 m

DZ10: Low-grade ductile shear zone in composite intrusion. The host rock is dominated by a mixture of fine-grained diorite-gabbro (505102) and fine-grained granite (511058) which most likely explains the large gradients in the density and natural gamma radiation data. One non-oriented radar reflector occurs at 706.2 m with the angle 31° to borehole axis. Confidence level = 3.

5.2 HLX38

Rock units

The borehole consists of one rock unit (RU1).

9.31–99.63 m

RU1: Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058), and sparse occurrences of dolerite (501027) and fine-grained diorite-gabbro (505102). The quartz monzodiorite (501036) has a density in the range 2,710–2,750 kg/m^3. The section 62–101 m is dominated by significantly decreased magnetic susceptibility in the range 0.0002–0.001 SI. Despite the low magnetic susceptibility, there are no anomalies in the resistivity and sonic data and the natural gamma radiation. The major part of the section is foliated. Confidence level = 3.

Possible deformation zones

Three possible deformation zones have been recognised in HLX38.

23.4–26.5 m

DZ1: Brittle deformation zone characterized by slightly increased frequency of open fractures and red staining. The section is characterized by decreased resistivity, P-wave velocity and minor caliper anomalies. Two non-oriented radar reflectors occur at 24.6 m and 26.4 m with the angle 46° and 80° to borehole axis, respectively. Both reflectors exhibits a weak character in the radar map. Low radar amplitude occurs at 23–33 m. The host rock is dominated by quartz monzodiorite (501036) with subordinate occurrence of dolerite. Confidence level = 1.

30.3–32.0 m

DZ2: Brittle deformation zone characterized by slightly increased frequency of open fractures and crush in fine-grained granite (511058). The section is characterized by decreased resistivity, P-wave velocity, and a distinct caliper anomaly. The density and magnetic susceptibility data display decreased levels. One non-oriented radar reflector occurs at 30.2 m with the angle 90° to borehole axis. The reflector exhibits a medium character in the radar map and can be observed to a distance of 14 m outside the borehole. Low radar amplitude occurs at 23–33 m. Host rock is dominated by quartz monzodiorite. (501036). Confidence level=2.

64.3–66.8 m

DZ3: Brittle deformation zone characterized by a crush zone. The section is characterized by decreased resistivity, P-wave velocity and decreased magnetic susceptibility. Two non-oriented radar reflectors occur at 65.2 m and 65.3 m with the angle 41° and 50° to borehole axis, respectively. The latter reflector is prominent and can be obeserved to a distance of 15 m outside the borehole. Low radar amplitude occurs at 61–67 m, i.e. partly above DZ3. Host rock is dominated by quartz monzodiorite. (501036) with subordinate fine-grained granite and fine-grained diorite-gabbro. Confidence level = 2.

6 Comments

The results from the geological single-hole interpretation of KLX19A and HLX38 are presented in a WellCad plot (Appendices 1–2). The WellCad plot consists of the following columns:

In data Boremap	1: Depth (Length along the borehole)
	2: Rock type
	3: Rock alteration
	4: Frequency of sealed fractures
	5: Frequency of open and partly open fractures
	6: Crush zones
In data Geophysics	7: Silicate density
	8: Magnetic susceptibility
	9: Natural gamma radiation
	10: Estimated fracture frequency
Interpretations	11: Description: Rock unit
	12: Stereogram for sealed fractures in rock unit (blue symbols)
	13: Stereogram for open and partly open fractures in rock unit (red symbols)
	14: Description: Possible deformation zone
	15: Stereogram for sealed fractures in possible deformation zone (blue symbols)
	16: Stereogram for open and partly open fractures in possible deformation zone (red symbols)

7 References

/1/ **Munier R, Stenberg L, Stanfors R, Milnes A G, Hermanson J, Triumf C A, 2003.** Geological site descriptive model. A strategy for the model development during site investigations. SKB R-03-07, Svensk Kärnbränslehantering AB.

/2/ **Mattsson K-J, Dahlin P, Ehrenborg J, 2006.** Oskarshamn site investigation. Boremap mapping of telescopic drilled borehole KLX19A. SKB P-07-210, Svensk Kärnbränslehantering AB.

/3/ **Sigurdsson O, 2007.** Oskarshamn site investigation. Simplified boremap mapping of percussion boreholes HLX38 on lineament NS059, HLX39, HLX40 and HLX41 on lineament EW900, HLX42 on lineament NE107 and HLX43 on lineament NS001. SKB P-06-266, Svensk Kärnbränslehantering AB.

/4/ **Mattsson H, Keisu M, 2006.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX18A, KLX20A, KLX11B, KLX09B, KLX09D, KLX09F, HLX38, HLX39, HLX40, HLX41 and interpretation of petrophysical data from KLX20A. SKB P-06-292, Svensk Kärnbränslehantering AB.

/5/ **Mattsson H, Keisu M, 2007.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements from KLX19A, KLX28A and KLX29A. SKB P-07-21, Svensk Kärnbränslehantering AB.

/6/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX11B, KLX11C, KLX11D, KLX11E, KLX11F, KLX18A, KLX20A, HLX38 and HLX40 and BIPS and deviation logging in KLX19A. SKB P-06-159, Svensk Kärnbränslehantering AB.

/7/ **Gustafsson J, Gustafsson C, 2007.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX19A, KLX28A and KLX29A. SKB P-07-13, Svensk Kärnbränslehantering AB.

Geological single-hole interpretation of KLX19A

Title	SINGLE HOLE INTERPRETATION KLX19A					
Site	LAXEMAR	Inclination [°]	-57.54	Elevation [m.a.s.l.]	16.80	Signed data
Borehole	KLX19A	Date of mapping	2006-10-16 08:57:00	Drilling Start Date	2006-05-10 16:30:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2006-05-22 12:00:00	
Length [m]	800.070	Northing [m]	6365900.60	Surveying Date		
Bearing [°]	197.13	Easting [m]	1547004.67	Plot Date	2007-10-14 22:03:05	

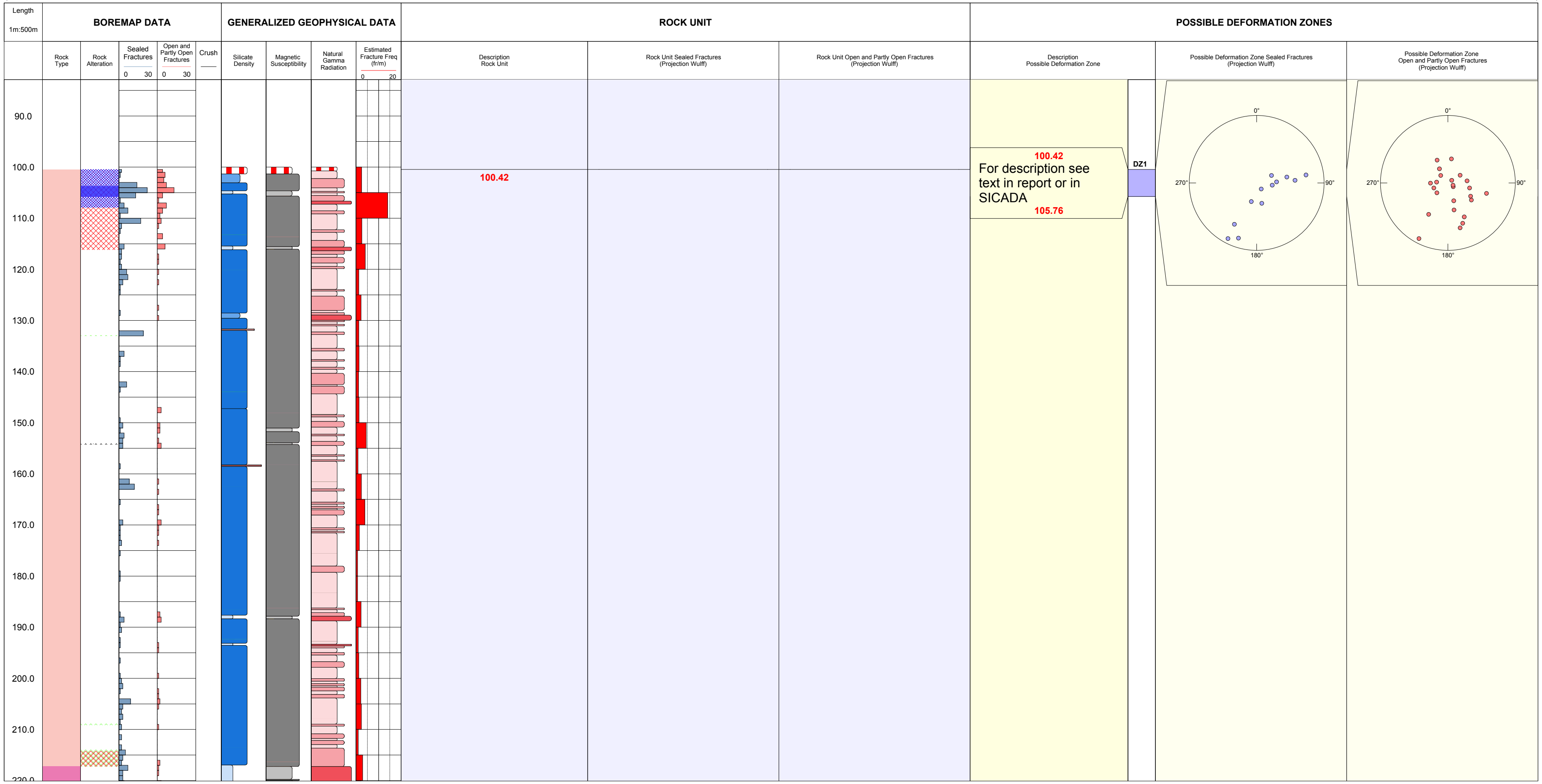
ROCKTYPE LAXEMAR
- Dolerite
- Fine-grained granite
- Pegmatite
- Quartz monzodiorite
- Fine-grained diorite-gabbro

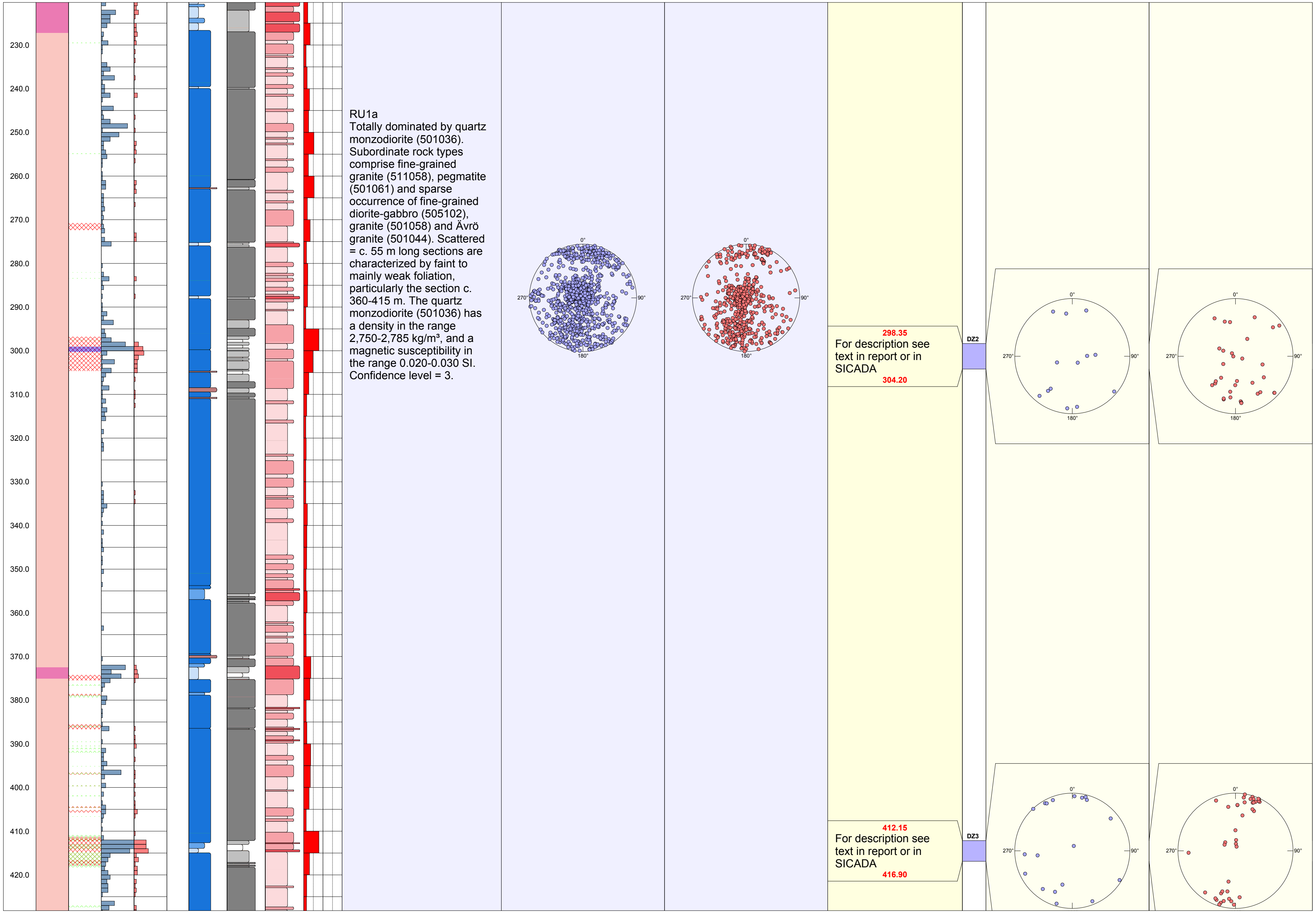
ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Silicification
- Argillization
- Carbonatization
- Saussuritization

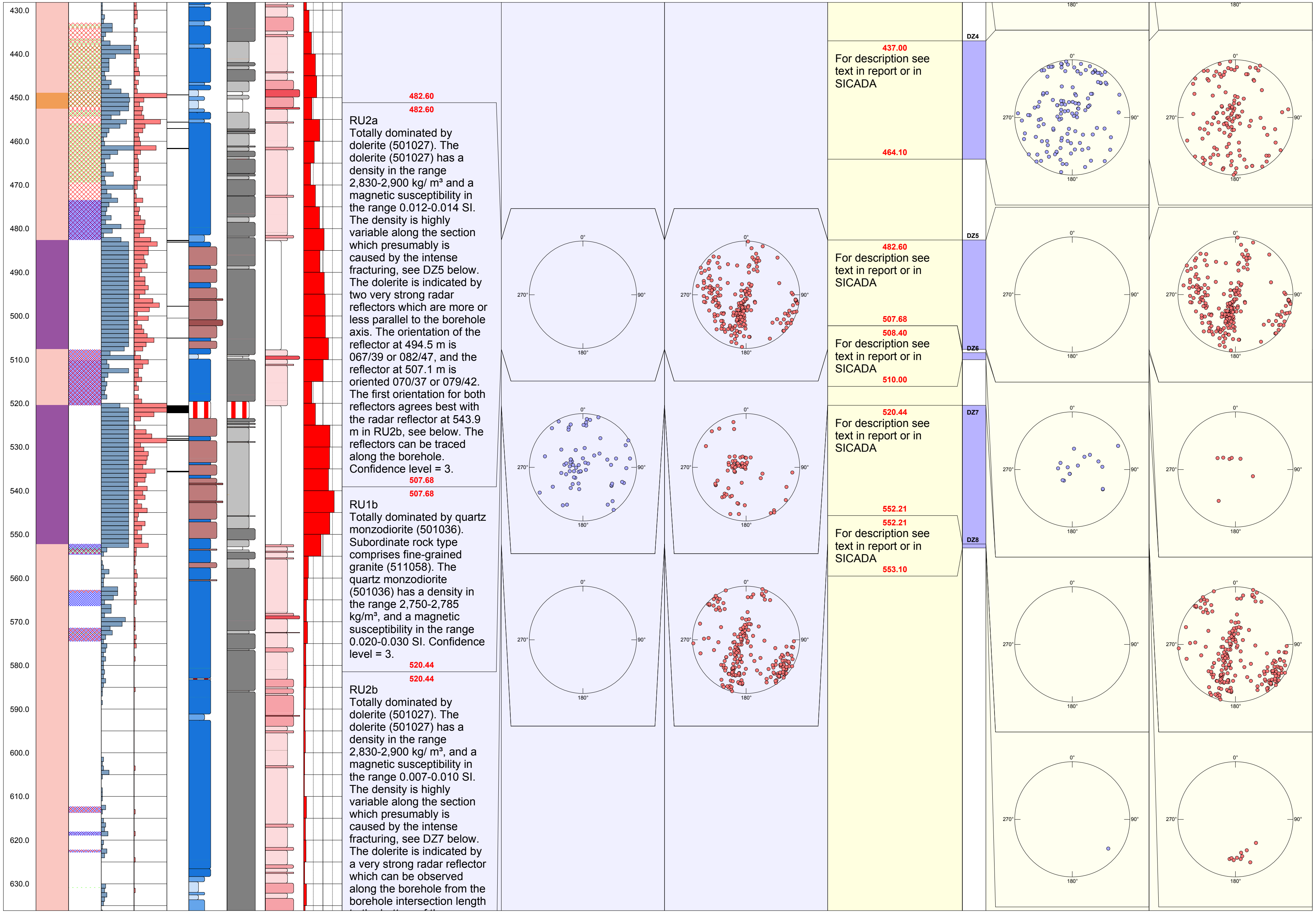
SILICATE DENSITY
- unclassified
- dens<2680
- 2680<dens<2730
- 2730<dens<2800
- 2800<dens<2890
- dens>2890

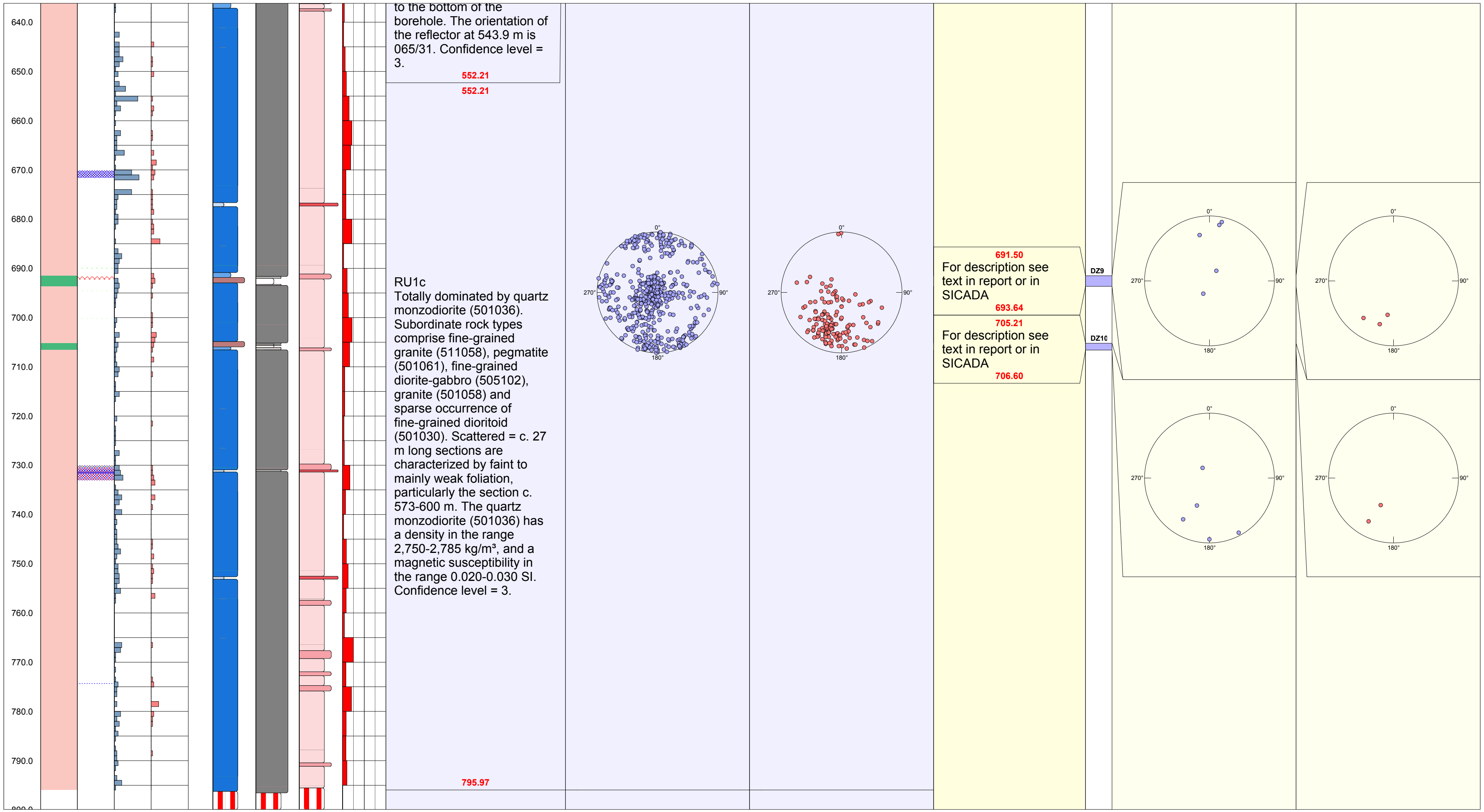
SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

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




230.0
240.0
250.0
260.0
270.0
280.0
290.0
300.0
310.0
320.0
330.0
340.0
350.0
360.0
370.0
380.0
390.0
400.0
410.0
420.0
RU1a
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058), pegmatite (501061) and sparse occurrence of fine-grained diorite-gabbro (505102), granite (501058) and Ävrö granite (501044). Scattered = c. 55 m long sections are characterized by faint to mainly weak foliation, particularly the section c. 360-415 m. The quartz monzodiorite (501036) has a density in the range 2,750-2,785 kg/m³, and a magnetic susceptibility in the the range 0.020-0.030 SI. Confidence level = 3.
298.35
For description see text in report or in SICADA
304.20
DZ2
412.15
For description see text in report or in SICADA
416.90
DZ3
0°
90°
180°
270°


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
560.0
570.0
580.0
590.0
600.0
610.0
620.0
630.0
482.60
482.60
RU2a
Totally dominated by dolerite (501027). The dolerite (501027) has a density in the range 2,830-2,900 kg/ m³ and a magnetic susceptibility in the range 0.012-0.014 SI. The density is highly variable along the section which presumably is caused by the intense fracturing, see DZ5 below. The dolerite is indicated by two very strong radar reflectors which are more or less parallel to the borehole axis. The orientation of the reflector at 494.5 m is 067/39 or 082/47, and the reflector at 507.1 m is oriented 070/37 or 079/42. The first orientation for both reflectors agrees best with the radar reflector at 543.9 m in RU2b, see below. The reflectors can be traced along the borehole. Confidence level = 3.
507.68
507.68
RU1b
Totally dominated by quartz monzodiorite (501036). Subordinate rock type comprises fine-grained granite (511058). The quartz monzodiorite (501036) has a density in the range 2,750-2,785 kg/m³, and a magnetic susceptibility in the range 0.020-0.030 SI. Confidence level = 3.
520.44
520.44
RU2b
Totally dominated by dolerite (501027). The dolerite (501027) has a density in the range 2,830-2,900 kg/ m³, and a magnetic susceptibility in the range 0.007-0.010 SI. The density is highly variable along the section which presumably is caused by the intense fracturing, see DZ7 below. The dolerite is indicated by a very strong radar reflector which can be observed along the borehole from the borehole intersection length
437.00
For description see text in report or in SICADA
464.10
482.60
For description see text in report or in SICADA
507.68
508.40
For description see text in report or in SICADA
510.00
520.44
For description see text in report or in SICADA
552.21
552.21
For description see text in report or in SICADA
553.10
DZ4
DZ5
DZ6
DZ7
DZ8
0°
90°
180°
270°



640.0
650.0
660.0
670.0
680.0
690.0
700.0
710.0
720.0
730.0
740.0
750.0
760.0
770.0
780.0
790.0
to the bottom of the borehole. The orientation of the reflector at 543.9 m is 065/31. Confidence level = 3.
552.21
552.21
RU1c
Totally dominated by quartz monzodiorite (501036). Subordinate rock types comprise fine-grained granite (511058), pegmatite (501061), fine-grained diorite-gabbro (505102), granite (501058) and sparse occurrence of fine-grained dioritoid (501030). Scattered = c. 27 m long sections are characterized by faint to mainly weak foliation, particularly the section c. 573-600 m. The quartz monzodiorite (501036) has a density in the range 2,750-2,785 kg/m³, and a magnetic susceptibility in the range 0.020-0.030 SI. Confidence level = 3.
795.97
0°
90°
180°
270°
691.50
For description see text in report or in SICADA
693.64
705.21
For description see text in report or in SICADA
706.60
DZ9
DZ10

Appendix 2

Geological single-hole interpretation of HLX38

Title SINGLE HOLE INTERPRETATION HLX38

Site	LAXEMAR	**Inclination [°]**	-59.45	**Elevation [m.a.s.l.]**	11.53	**Signed data**
Borehole	HLX38	**Date of mapping**	2006-05-22 17:06:00	**Drilling Start Date**	2006-04-10 07:00:00	
Diameter [mm]	139	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2006-04-24 16:00:00	
Length [m]	199.500	**Northing [m]**	6365868.86	**Surveying Date**		
Bearing [°]	110.04	**Easting [m]**	1547146.08	**Plot Date**	2007-10-15 22:03:14	

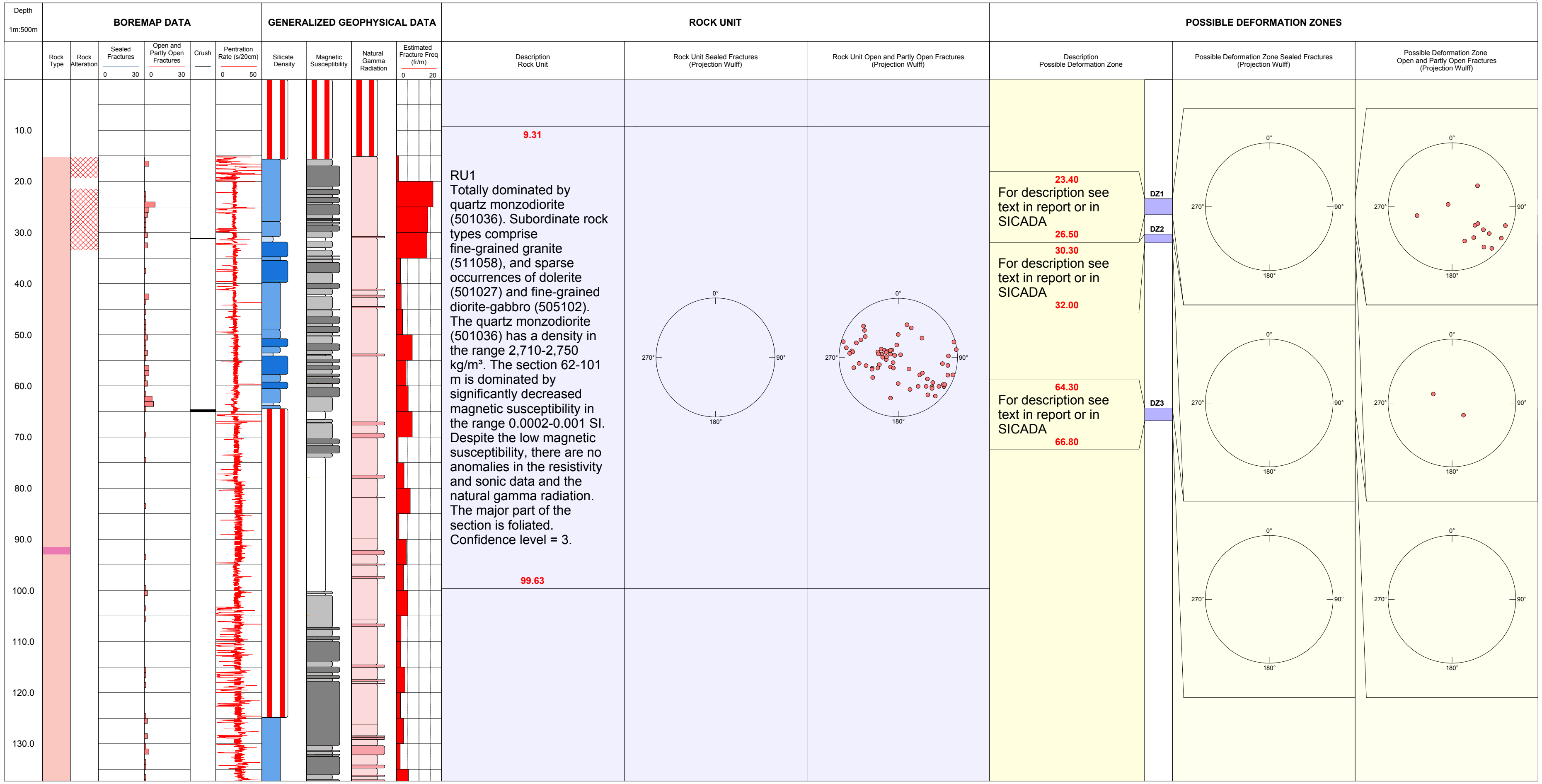
ROCKTYPE LAXEMAR
- Fine-grained granite
- Quartz monzodiorite

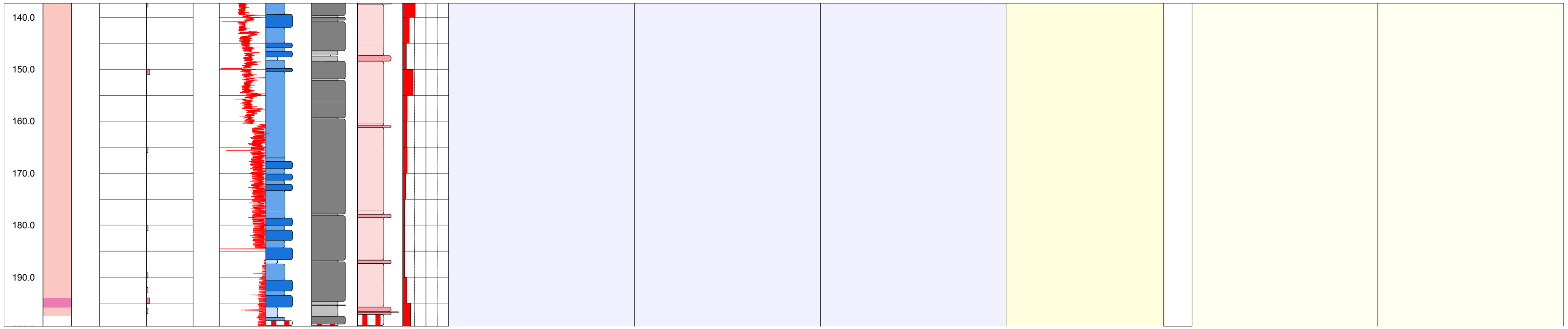
ROCK ALTERATION
- Oxidized

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




140.0
150.0
160.0
170.0
180.0
190.0