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Äspö Hard Rock Laboratory

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July 2013

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

Update notice

The original report, dated July 2013, was found to contain factual errors which have been corrected in this updated version. The corrected factual errors are presented below.

Updated 2014-02

Location	Original text	Corrected text
Page 11, first paragraph, first point.	(Carlsten et al. 2013)	(Carlsten and Stråhle 2013)
Page 23, first reference.	Carlsten et al. 2013	Carlsten S, Stråhle A, 2013. Äspö Hard Rock Laboratory. Boremap mapping of cored drilled boreholes KA3011A01 and KA3065A01. SKB P-13-28. Svensk Kärnbränslehantering AB.

Abstract

This report contains geological single-hole interpretation of the cored boreholes KA3011A01 and KA3065A01 which have been drilled underground from the Äspö tunnel. 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 borehole KA3011A01 is dominated by Ävrö granodiorite (501056). In the lower half of the borehole the Ävrö granodiorite is intermingled with Äspö diorite (501037). A section with fine-grained granite (511058) occurs in the upper part of the borehole. Subordinate rock types comprise occurrences of pegmatite (501061) and fine-grained diorite-gabbro (505102). One possible deformation zone is identified in KA3011A01 (DZ1).

The geological single-hole interpretation shows that the borehole KA3065A01 is dominated by Äspö diorite (501037). Two sections with Ävrö granodiorite (501056) occurs in the upper part of the borehole, separated by a section with fine-grained diorite-gabbro (505102). Fine-grained granite (511058) occurs in the end of the borehole. Subordinate rock types comprise occurrences of pegmatite (501061) and sparse occurrences of breccia (508002) and mylonite (508004). No possible deformation zone is identified in KA3065A01.

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålen KA3011A01 och KA3065A01 vilka har borrats under jord från Äspötunneln. Den geologiska enhålstolkningen syftar till att utifrån den geologiska karteringen, tolkade geofysiska loggar och borrhålsradarmätningar identifiera olika bergenheters fördelning i borrhålen samt möjliga deformationszoners läge och utbredning.

Den geologiska enhålstolkningen visar att kärnborrhålet KA3011A01 domineras av Ävrögranodiorit (501056). I nedre delen av borrhålet är Ävrögranodioriten uppblandad med Äspödiorit (501037). En sektion med finkornig granit (511058) återfinns i borrhålets översta del. Underordnade bergarter utgörs av pegmatit (501061) och finkornig diorit-gabbro (505102). En möjlig deformationszon har identifierats i KA3011A01 (DZ1).

Den geologiska enhålstolkningen visar att kärnborrhålet KA3065A01 domineras av Äspödiorit (501037). Två sektioner med Ävrögranodiorit (501056) förekommer i översta delen av borrhålet, åtskilda sinsemellan av en sektion med finkorning diorit-gabbro (505102). Finkornig granit (511058) återfinns i borrhålets nedre del. Underordnade bergarter utgörs av pegmatit (501061) och mindre delar med breccia (508002) och mylonit (508004). Möjliga deformationszoner har inte identifierats i KA3065A01.

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 modelling 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 the cored boreholes KA3011A01 and KA3065A01, which is one of the activities performed within the work of upgrading the geological model of the Äspö HRL (Figure 1-1). The boreholes have been drilled underground from the Äspö tunnel for the expansion of the Äspö HRL. The work was carried out in accordance with activity plan AP TD TUDP002-11-085. The controlling documents for performing this activity are listed in Table 1-1. Rock type nomenclature (Table 1-2) that has been used is in accordance with method instruction SKB MD 132.004. The activity plan, method description and method instruction are SKB's internal controlling documents.

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

Activity plan	Number	Version
Äspö utbyggnad, DP1-karaktärisering – geologisk enhålstolkning av KA3011A01 och KA3065A01	AP TD TUDP002-11-085	1.0
Method description	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	3.0

Table 1-2. Rock type nomenclature for the Äspö SDM.

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
Ävrö granodiorite	501056	Granite to granodiorite, sparsely porphyritic to porphyritic
Ävrö quartz monzodiorite	501046	Quartz monzonite to quartz monzodiorite, generally porphyritic
Äspö diorite	501037	Quartz monzodiorite to granodiorite, 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
Gabbroid-dioritoid	508107	Mafic rock undifferentiated
Mylonite	508004	Mylonite
Sulphide mineralization	509010	Sulphide mineralization
Sandstone	506007	Sandstone
Quartz-dominated hydrothermal vein/segregation	508021	Quartz-dominated hydrothermal vein/segregation
Hybrid rock	505105	Hybrid rock
Breccia	508002	Breccia
Felsic volcanic rock	503076	Felsic volcanic rock

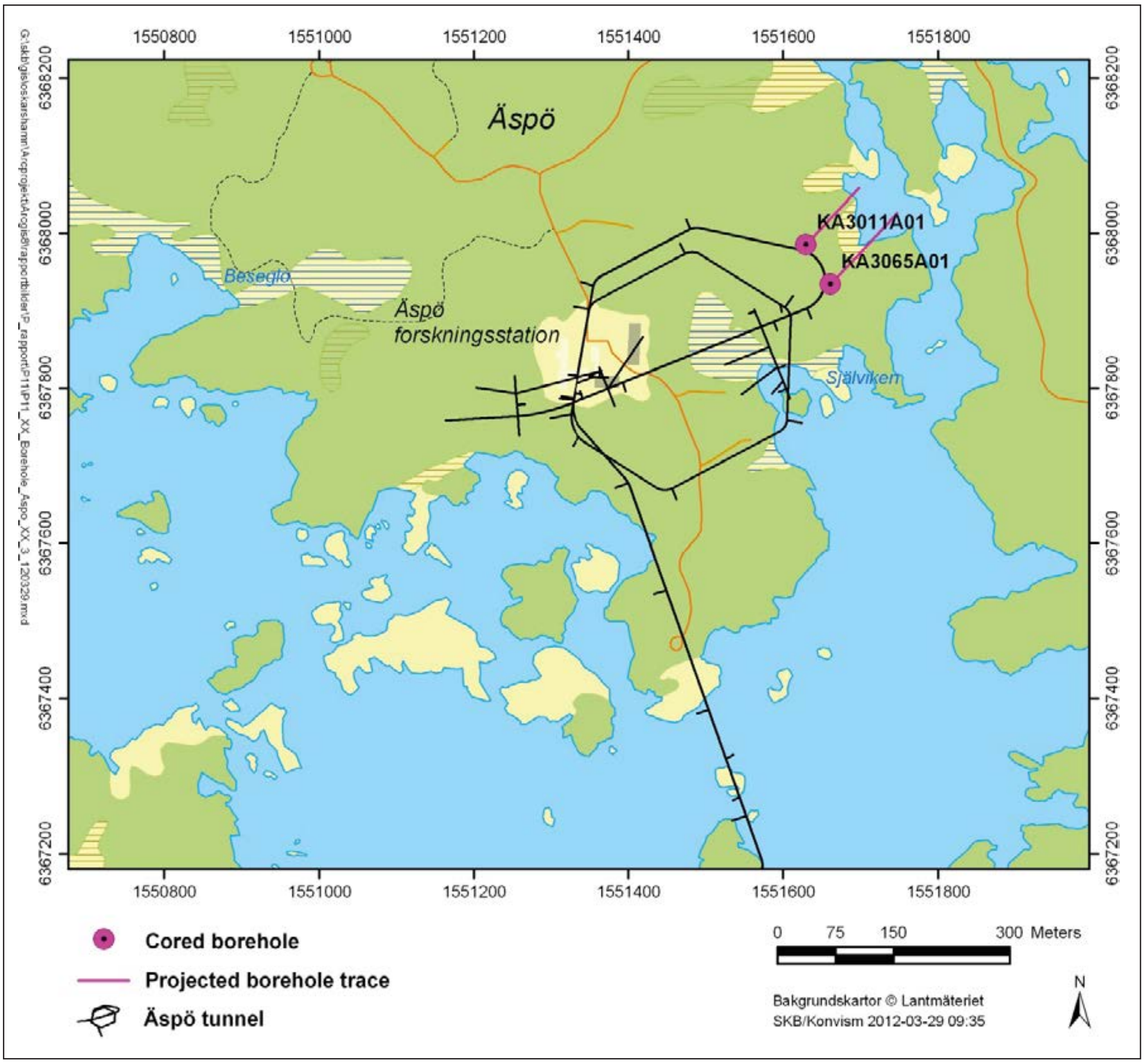


Figure 1-1. *Map showing the position of the cored boreholes KA3011A01 and KA3065A01.*

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 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 WellCad plots (Appendix 1 and Appendix 2) and described in this report. The work reported here concerns stage 1 in the geological single-hole interpretation, as defined in the method description SKB MD 810.003.

3 Data used for the geological single-hole interpretation

The following data have been used in the single-hole interpretation of boreholes KA3011A01 and KA3065A01:

- Boremap data from geological mapping (Carlsten and Stråhle 2013).
- Generalized geophysical logs and their interpretation (Mattsson 2013).
- Radar data and their interpretation (Gustafsson 2013).

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 seven main columns and several subordinate columns. Note that Figure 3-1 only serves as an example and that minor differences in the content of the columns between different boreholes might occur. The columns in Figure 3-1 include:

1: BH Length: Length along the borehole

2: Rock type
  2.1: Rock type
  2.2: Occurrence, Rock type < 1m
  2.3: Rock type structure
  2.4: Rock type texture
  2.5: Rock type grain size
  2.6: Structure orientation
  2.7: Rock alteration
  2.8: Rock alteration intensity

3: Fracture frequency
  3.1: Open total
  3.2: Sealed total
  3.3: Fracture orientation open/sealed
  3.4: Fracture orientation broken/unbroken
  3.5: Total fractures
  3.6: RQD

4: Fracture alteration orientation
  4.1: Open alteration
  4.2: Sealed alteration
  4.3: Surface

5: Crush zones and core loss
  5.1: Crush zone
  5.2: Piece length (mm)
  5.3: Core loss

6: Generalized geophysical data
  6.1: Silicate density
  6.2: Magnetic susceptibility
  6.3: Natural gamma radiation
  6.4: Estimated fracture frequency (fr/m)

7: Geophysics
  7.1: Magnetic susceptibility
  7.2: Sonic
  7.3: Radar directional primary/radar dipole 1
  7.4: Radar directional alternative

The geophysical logs are described below:

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

Magnetic susceptibility: The bedrock 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 bedrock 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 fine-grained granite or pegmatite.

Estimated fracture frequency: This parameter provides an estimate of the fracture frequency along 5 m sections, calculated from short, long and lateral resistivity (only KAS04), SPR, P-wave velocity and caliper data. 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.

Separate diagrams with moving averages for open fractures alone, sealed fractures alone, and total number of open and sealed fractures were available during the interpretation process.

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 or alpha angles of radar anomalies within the possible deformation zones are commented upon in the text that describes these zones.

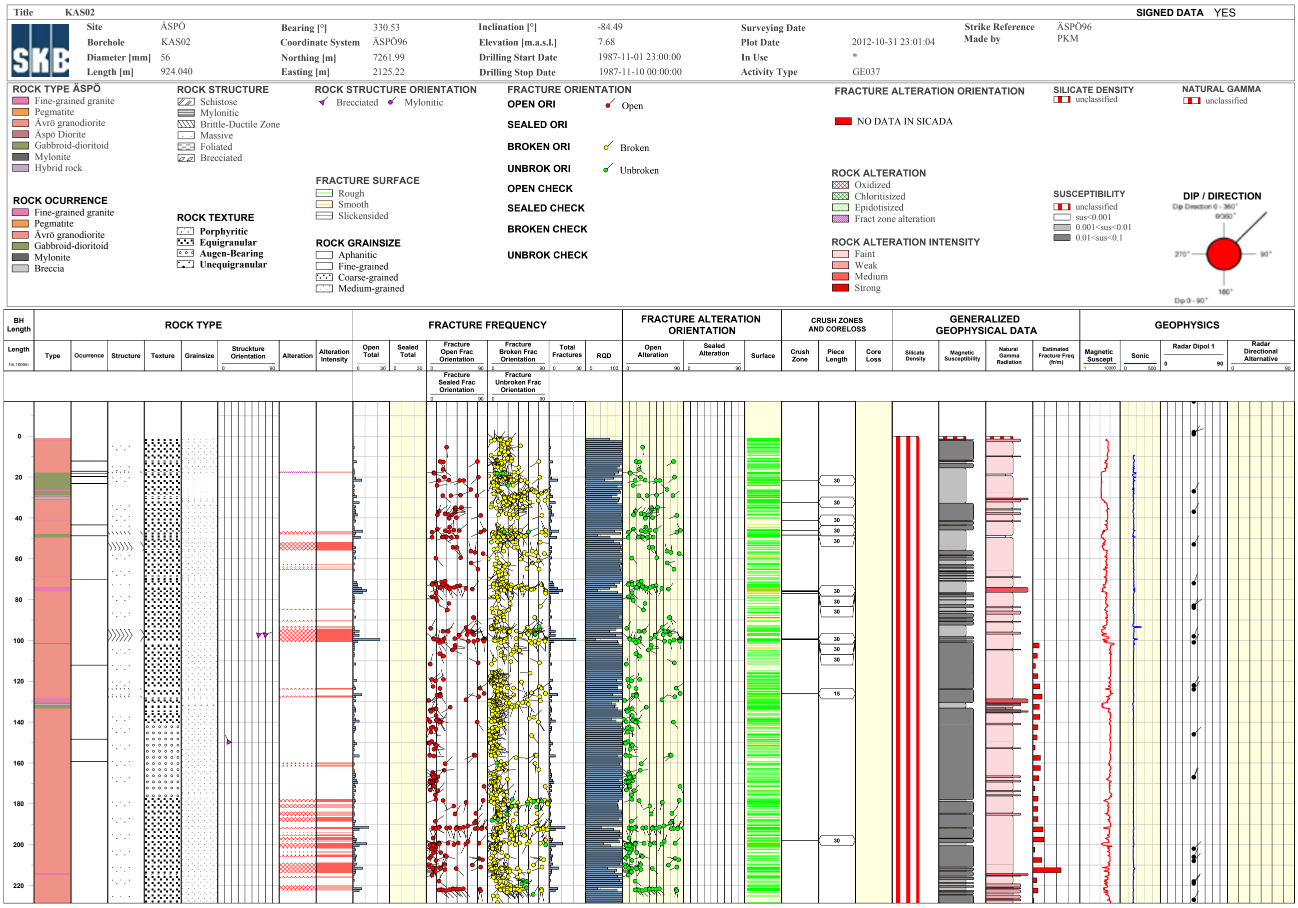


Figure 3-1. Example of WellCad plot (from borehole KAS02) used as a basis for the geological single-hole interpretation.

4 Execution

4.1 General

The geological single-hole interpretation has been carried out by a group of geoscientists consisting of geologists and geophysicists. All data to be used (see Chapter 3) are visualized side by side in a borehole document made with 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 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.

Following definition of rock units and deformation zones, with their respective confidence estimates, the drillcores 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.

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 fault rocks and frequency of fractures, respectively, according to the recommendations in Munier et al. (2003). Both the damaged zone and the core 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 and geophysical data, if available, have all assisted in the identification of primarily the brittle structures. Hydrogeological data have been treated separately and have not been considered in the definition of possible deformation zones.

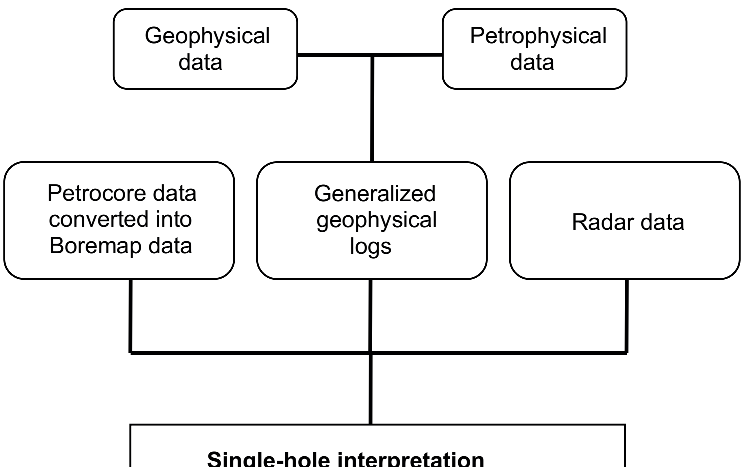


***Figure 4-1.** Schematic block-scheme of single-hole interpretation*

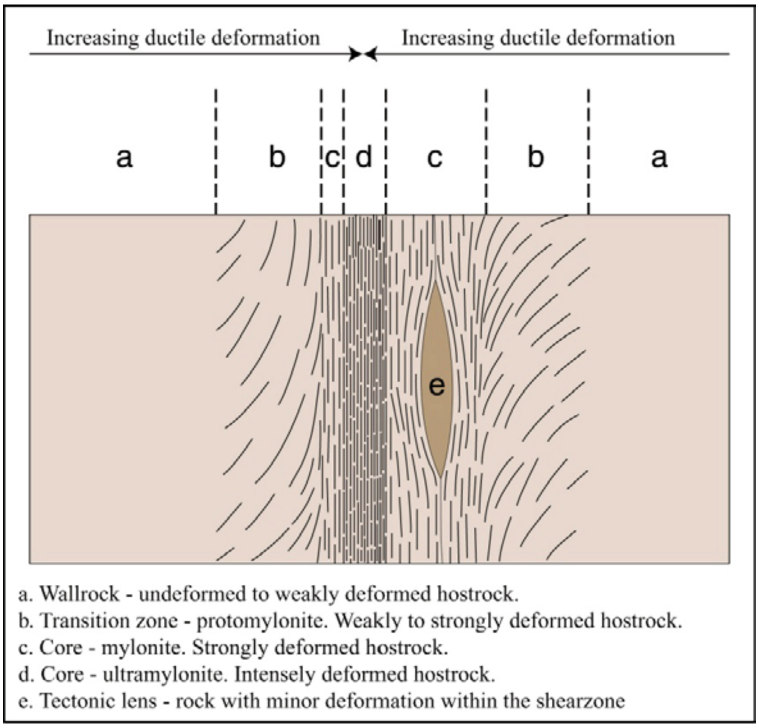


Figure 4-2. *Schematic example of a ductile shear zone. Homogeneous rock which is deformed under low- to medium-grade metamorphic conditions after Munier et al. (2003).*

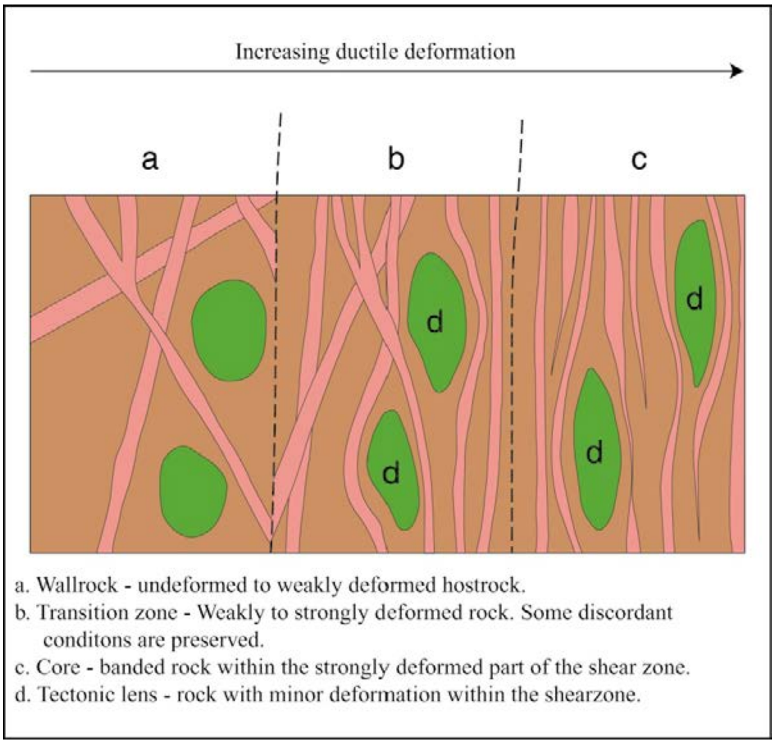


Figure 4-3. *Schematic example of a ductile shear zone. Heterogeneous rock which is deformed under low- to high-grade metamorphic conditions after Munier et al. (2003).*

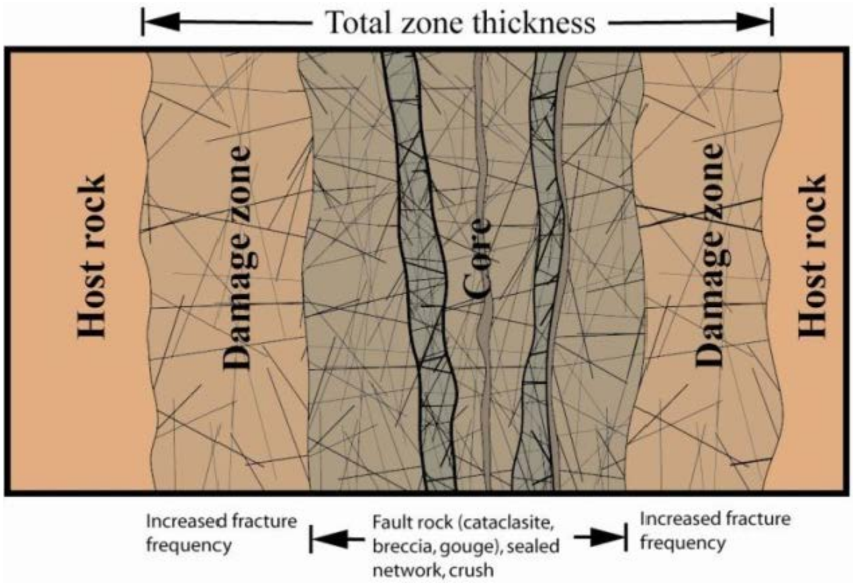


Figure 4-4. *Schematic example of a brittle deformation zone modified from Munier et al. (2003).*

Since the frequency of fractures is of key importance for the definition of the possible deformation zones, moving average plots for this parameter are shown for the cored borehole KA3011A01 (Figure 4-5) and borehole KA3065A01 (Figure 4-6). A 5 m window and 1 m steps have been used in the calculation procedure. The moving averages for open fractures alone, the sealed fractures alone, and the total number of open and sealed fractures are shown in diagrams.

The occurrence and orientation of radar anomalies have been adapted to the DZ afterwards. Overview of the borehole radar measurement in KA3011A01 is shown in Figure 4-7 and for KA3065A01 in Figure 4-8. A conductive environment causes attenuation of the radar wave, which in turn decreases the penetration. The effect of attenuation can be observed at 83–87 m in KA3011A01 and at 72–76 m in KA3065A01. The effect of attenuation varies between the different antenna frequencies (20 MHz and 60 MHz directional antenna). 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. Strike is related to Äspö96 north.

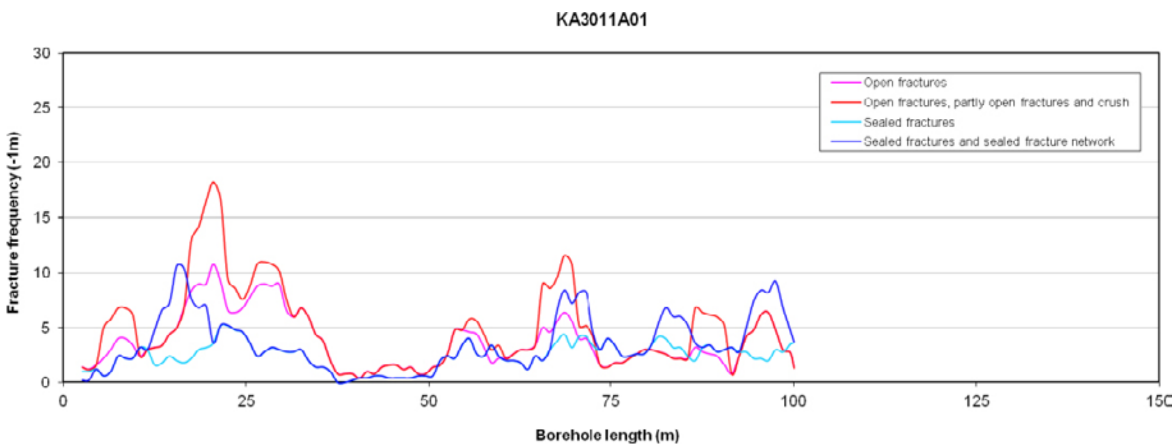


Figure 4-5. *Fracture frequency plot for KA3011A01. Moving average with a 5 m window and 1 m steps.*

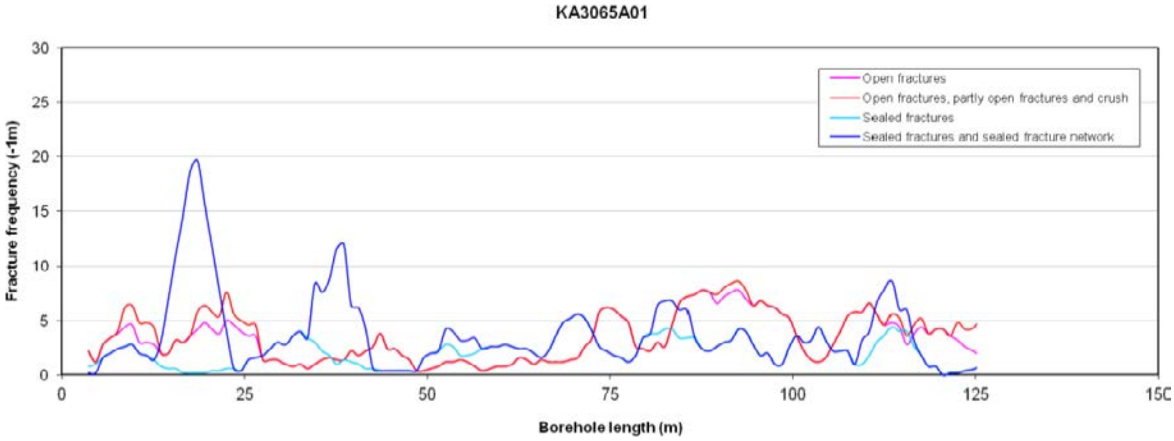


Figure 4-6. *Fracture frequency plot for KA3065A01. Moving average with a 5 m window and 1 m steps.*

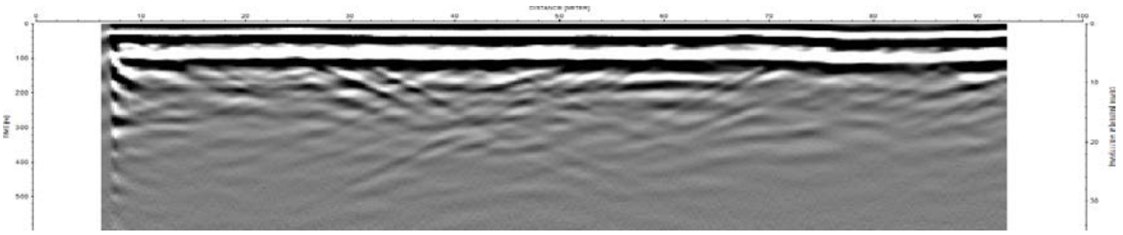


Figure 4-7. *Overview (20 MHz data) of the borehole radar measurement in KA3011A01.*

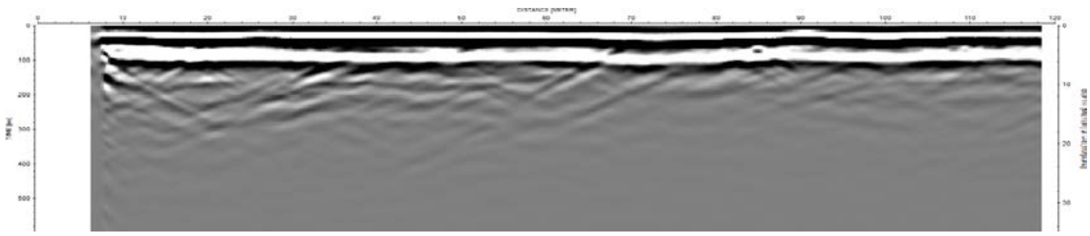


Figure 4-8. *Overview (20 MHz data) of the borehole radar measurement in KA3065A01.*

4.2 Nonconformities

Results from the borehole radar logging were not available during the time for the single-hole interpretation.

The density logging data of KA3011A01 are not of the standard to be desired. The logging data were calibrated with reference to laboratory measurements on six core samples (Mattsson 2013). The statistical analysis of the calibration shows a fairly poor correlation between sample and logging data, and in addition the absolute accuracy is estimated at only c. 58 kg/m^3. Hence, the density logging data from KA3011A01 should be treated with caution.

5 Results

The detailed result of the geological single-hole interpretation is presented as print-out from the software WellCad (Appendix 1 for KA3011A01 and Appendix 2 for KA3065A01). Orientations are related to Äspö96 north.

5.1 KA3011A01

5.1.1 Rock units in KA3011A01

The borehole consists of four rock units (RU1–RU4). However, due to repetition of RU1 (RU1a, RU1b and RU1c) the borehole can be divided into six sections.

0.000–14.309 m

RU1a: Dominated by Ävrö granodiorite (501056). Subordinate rock types comprise fine-grained granite (511058) and minor occurrence of pegmatite (501061). The Ävrö granodiorite (501056) has a density in the range 2,680–2,700 kg/m^3. Confidence level = 3.

14.309–28.041 m

RU2: Dominated by fine-grained granite (511058), but Ävrö granodiorite (501056) constitutes an important lithological component. The contacts between the fine-grained granite (511058) and the Ävrö granodiorite (501056) have the following orientation: 286°/51°, 264°/73°, 114°/71°, 286°/64°, 281°/69°, 299°/53°. Subordinate rock types comprise fine-grained diorite-gabbro (505102) and very sparse occurrence of pegmatite (501061). Confidence level = 3.

28.041–58.012 m

RU1b: Totally dominated by Ävrö granodiorite (501056). Subordinate rock types comprise minor occurrence of Äspö diorite (501037) and fine-grained granite (511058), and very sparse occurrence of pegmatite (501061). The Ävrö granodiorite (501056) has a density in the range 2,680–2,710 kg/m^3. Confidence level = 3.

58.012–63.110 m

RU3: Dominated by Äspö diorite (501037). Subordinate rock types comprise Ävrö granodiorite (501056), fine-grained granite (511058) and pegmatite (501061). The Äspö diorite (501037) has a density in the range 2,720–2,740 kg/m^3. Confidence level = 3.

63.110–83.827 m

RU1c: The density log indicates that the rock unit is dominated by Ävrö granodiorite (501056). Furthermore, the density log indicates that Äspö diorite (501037) is intermingled with the Ävrö granodiorite (501056). Subordinate rock types comprise fine-grained granite (511058) and sparse occurrence of pegmatite (501061). The Ävrö granodiorite (501056) has a density in the range 2,660–2,710 kg/m^3. Confidence level = 2.

83.827–100.060 m

RU4: The density log indicates that the rock unit is dominated by Ävrö granodiorite (501056), intermingled with Äspö diorite (501037), but fine-grained granite (511058) also constitutes an important lithological component. Subordinate rock type comprises sparse occurrence of pegmatite (501061). The Ävrö granodiorite (501056) has a density in the range 2,680–2,720 kg/m^3. Confidence level = 2.

5.1.2 Possible deformation zones in KA3011A01

One possible deformation zone has been recognized in KA3011A01 (DZ1).

13.90–35.00 m

DZ1: Brittle deformation zone divided in a core and damage zones.

13.90–18.75 m

Damage zone: Characterized by varying intensity of sealed fractures/network, varying degree of oxidation, one crush at 13.928–14.259 m and foliation of varying intensity. Pyrite impregnation occurs at c. 16 m. The damage zone is mainly characterized by minor anomalies of decreased resistivity and magnetic susceptibility; however, there is a significant decrease in resistivity and partly decreased p-wave velocity at c. 14.0 m. One oriented radar reflector of medium strength occurs at 16.25 m with the angle 61° to borehole axis and the orientation 163°/82°. The host rock is dominated by almost equal amounts of fine-grained granite (511057) and Ävrö granodiorite (501056). Subordinate rock types comprise fine-grained diorite-gabbro (505102) and very sparse occurrence of pegmatite (501061). Confidence level = 3.

18.75–20.10 m

Core: Characterized by increased frequency of open fractures, oxidation, one crush at 19.216–19.370 m and documentation of a brittle-ductile shear zone. The geophysical anomalies include a significant decrease in p-wave velocity, resistivity and magnetic susceptibility, and a caliper anomaly. The host rock is totally dominated by Ävrö granodiorite (501056). Subordinate rock type comprises fine-grained granite (511057). Confidence level = 3.

20.10–35.00 m

Damage zone: Characterized by slightly increased frequency of open fractures, oxidation, four crush at 20.731–20.742 m, 21.388–21.440 m, 26.569–26.600 m and 27.990–28.083 m and foliation of varying intensity. In the damage zone there are two 0.5 – 1.5 m long intervals with decreased p-wave velocity, resistivity and magnetic susceptibility. At borehole length c. 35 m there is a significant decrease in the fluid temperature data, which indicates in- or outflow of water. One oriented radar reflector of medium strength occurs at 20.44 m with the angle 56° to borehole axis and the orientation 285°/89°. The host rock is slightly dominated by Ävrö granodiorite (501056), but fine-grained granite (511057) constitutes an important lithological component. Subordinate rock type comprises sparse occurrence of fine-grained diorite-gabbro (505102). Confidence level = 3.

5.2 KA3065A01

5.2.1 Rock units in KA3065A01

The borehole consists of four rock units (RU1–RU4). However, due to repetition of RU1 (RU1a and RU1b) and RU3 (RU3a and RU3b) the borehole can be divided into six sections.

0.000–14.246 m

RU1a: Totally dominated by Ävrö granodiorite (501056). Subordinate rock types comprise fine-grained granite (511058) and very sparse occurrences of pegmatite (501061) and breccia (508002). The Ävrö granodiorite (501056) has a density in the range 2,680–2,710 kg/m^3. Confidence level = 3.

14.246–20.828 m

RU2: Dominated by fine-grained diorite-gabbro (505102). Subordinate rock type comprises fine-grained granite (511058). Confidence level = 3.

20.828–32.500 m

RU1b: Totally dominated by Ävrö granodiorite (501056). Subordinate rock types comprise fine-grained granite (511058), and sparse occurrence of pegmatite (501061) and very sparse occurrence of breccia (508002). The Ävrö granodiorite (501056) has a density in the range 2,680–2,710 kg/m^3. Confidence level = 3.

32.500–85.644 m

RU3a: Dominated by Äspö diorite (501037). Subordinate rock types comprise fine-grained diorite-gabbro (505102), fine-grained granite (511058), pegmatite (501061) and mylonite (508004). The Äspö diorite (501037) has a density in the range 2,720–2,780 kg/m^3. Confidence level = 3.

85.644–93.681 m

RU4: Dominated by fine-grained granite (511058). Subordinate rock types comprise mylonite (508004) and Äspö diorite (501037). Confidence level = 3.

93.681–125.222 m

RU3b: Dominated by Äspö diorite (501037). Subordinate rock types comprise fine-grained granite (511058), pegmatite (501061) and very sparse occurrence of dm-thick mylonite (508004). The rock unit is characterized by scattered occurrences of epidote cataclasites, in total 1.174 m. The Äspö diorite (501037) has a density in the range 2,710–2,780 kg/m^3. Confidence level = 3.

5.2.2 Possible deformation zones in KA3065A01

No possible deformation zone has been recognized in KA3065A01.

6 Comments

The results from the geological single-hole interpretation of KA3011A01 and KA3065A01 are presented in WellCAD plots (Appendix 1 and Appendix 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.
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).

References

SKB's (Svensk Kärnbränslehantering AB) publications can be found at www.skb.se/publications.

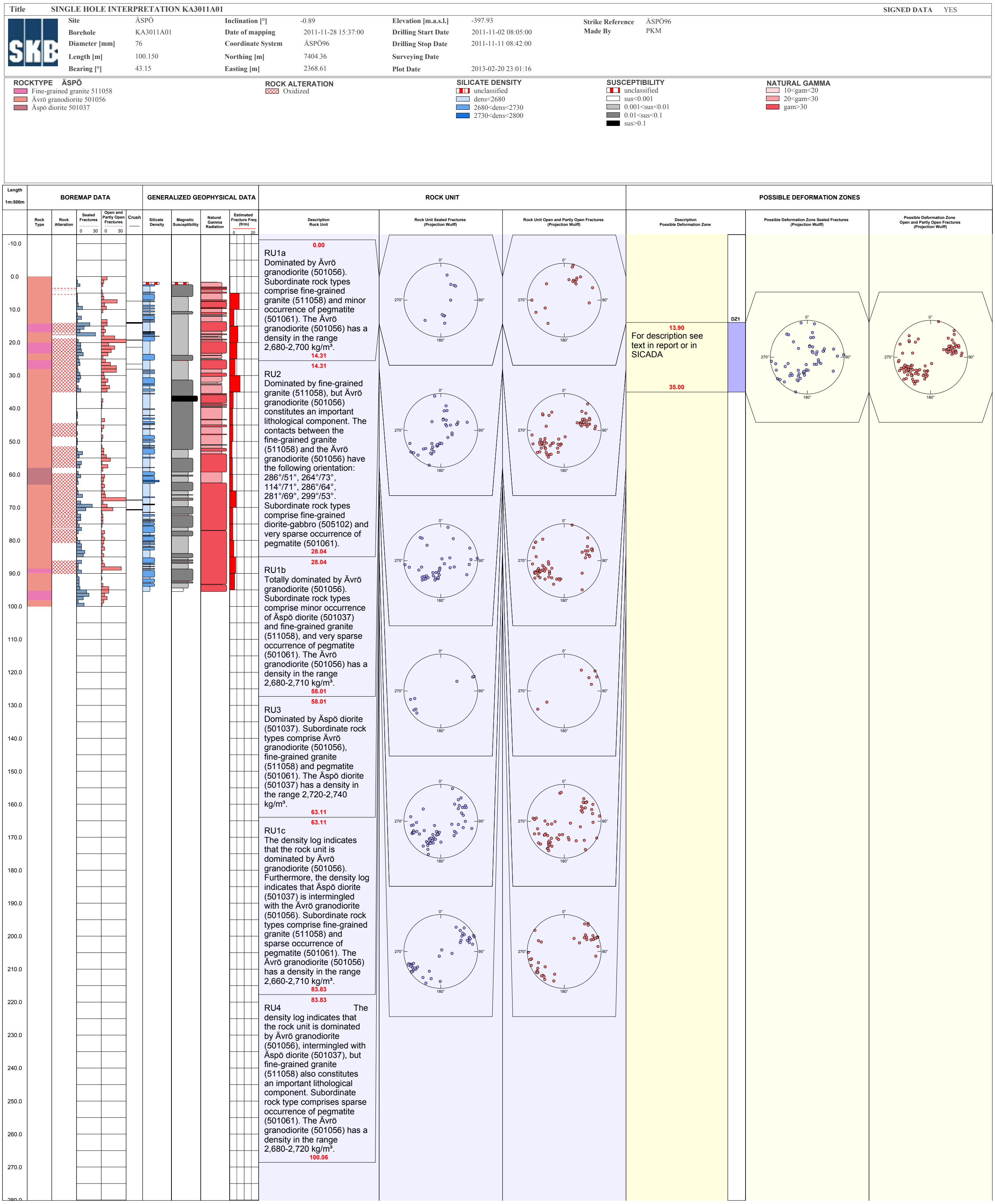
Carlsten S, Stråhle A, 2013. Äspö Hard Rock Laboratory. Boremap mapping of cored drilled boreholes KA3011A01 and KA3065A01. SKB P-13-28. Svensk Kärnbränslehantering AB.

Gustafsson C, 2013. Äspö Hard Rock Laboratory. BIPS and radar in KA3011A01 and KA3065A01. SKB P-13-18, Svensk Kärnbränslehantering AB.

Mattson H, 2013. Äspö Hard Rock Laboratory. Interpretation of geophysical borehole measurements and petrophysical measurements from KA3011A01 and KA3065A01. SKB P-13-23, Svensk Kärnbränslehantering AB.

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.

Geological single-hole interpretation of KA3011A01



Geological single-hole interpretation of KA3065A01