P-09-33

Site investigation SFR

Geological single-hole interpretation of KFR102B and KFR103

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April 2009

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Abstract

This report presents the geological single-hole interpretations of the cored boreholes KFR102B and KFR103 at SFR. The interpretation combines the geological mapping, generalized geophysical logs, borehole radar measurements and subsequently hydrogeological logs to identify where rock units and possible deformation zones occur in the boreholes. A brief description of each rock unit and possible deformation zone is provided.

Borehole KFR102B has been divided into four different rock units, RU1–RU4. The predominant rock type in RU1–RU3 is a weekly to strongly foliated metagranite-granodiorite (101057), whereas RU4 mainly consists of pegmatitic granite (101061), fine- to medium-grained granite (111058) and metagranite-granodiorite (101057). Four possible deformation zones of brittle character have been interpreted in KFR102B (DZ1–DZ4), one with a medium degree of confidence and the other three with a high degree of confidence.

Borehole KFR103 has been divided into five different rock units, RU1–RU5, of which RU3 and RU4 occur in two and three separate length intervals, respectively. A moderately foliated metagranite-granodiorite (101057) predominates RU1 and RU3, whereas RU2 and RU5 mainly consist of pegmatitic granite (101061), and RU4 is dominated by felsic to intermediate metavolcanic rock (103076). Three possible deformation zones of brittle character have been interpreted in KFR103, all three with a high degree of confidence.

Sammanfattning

Denna rapport presenterar den geologiska enhålstolkningen från kärnborrhålen KFR102B och KFR103 i anslutning till SFR. Tolkningen kombinerar den geologiska karteringen, generaliserade geofysiska loggar, data från borrhålsradar och därefter hydrogeologisk data för att identifiera litologiska enheter och möjliga deformationszoner i borrhålen. En översiktlig beskrivning av varje litologisk enhet och möjlig deformationszon presenteras.

Kärnborrhål KFR102B har delats upp i fyra litologiska enheter, RU1–RU4. Den dominerande bergarten i RU1–RU3 är en medel till starkt folierad metagranit-granodiorit (101057), medan RU4 huvudsakligen består av pegmatitisk granit (101061), fin- till medelkornig granit (111058) och metagranit-granodiorit (101057). Fyra möjliga deformationszoner av spröd karaktär har tolkats i KFR102B (DZ1–DZ4), en med medelhög grad av tillförlitlighet och de andra tre med en hög grad av tillförlitlighet.

Kärnborrhål KFR103 har delats upp i fem litologiska enheter, RU1–RU5, av vilka RU3 och RU4 förekommer i två respektive tre separata längdintervall. En medelmåttigt folierad metagranit-granodiorit (101057) dominerar RU1 och RU3, medan RU2 och RU5 huvudsakligen består av pegmatitisk granit (101061). RU4 domineras av en felsisk till intermediär metavulkanisk bergart (103076). Tre möjliga deformationszoner av spröd karaktär har tolkats i KFR103 (DZ1–DZ3), alla tre med en hög grad av tillförlitlighet.

Contents

1 Introduction

During 2008, SKB has initiated an investigation programme for the future expansion of the final repository for low and intermediate-level radioactive waste, SFR. An essential part in this project is the drilling of three percussion and six core drilled boreholes. Each borehole should be thoroughly documented by means of geological mapping by the so-called Boremap system, as well as geophysical and radar borehole measurements. After storage in the SKB database Sicada, the data needs to be integrated and synthesized before they can be used for modelling in the 3D-CAD Rock Visualization System (RVS). This procedure follows SKB's established methodology of geological single-hole interpretation, which is based on an integrated series of different logs and accompanying descriptive documents. However, a difference in the methodology compared to that applied during the site investigation program (i.e. SKB MD 810.003) is the incorporation of hydrogeological borehole data in the interpretation process.

This document outlines the results of the geological single-hole interpretation of boreholes KFR102B and KFR103. The horizontal projections of the boreholes are shown in Figure 1-1.

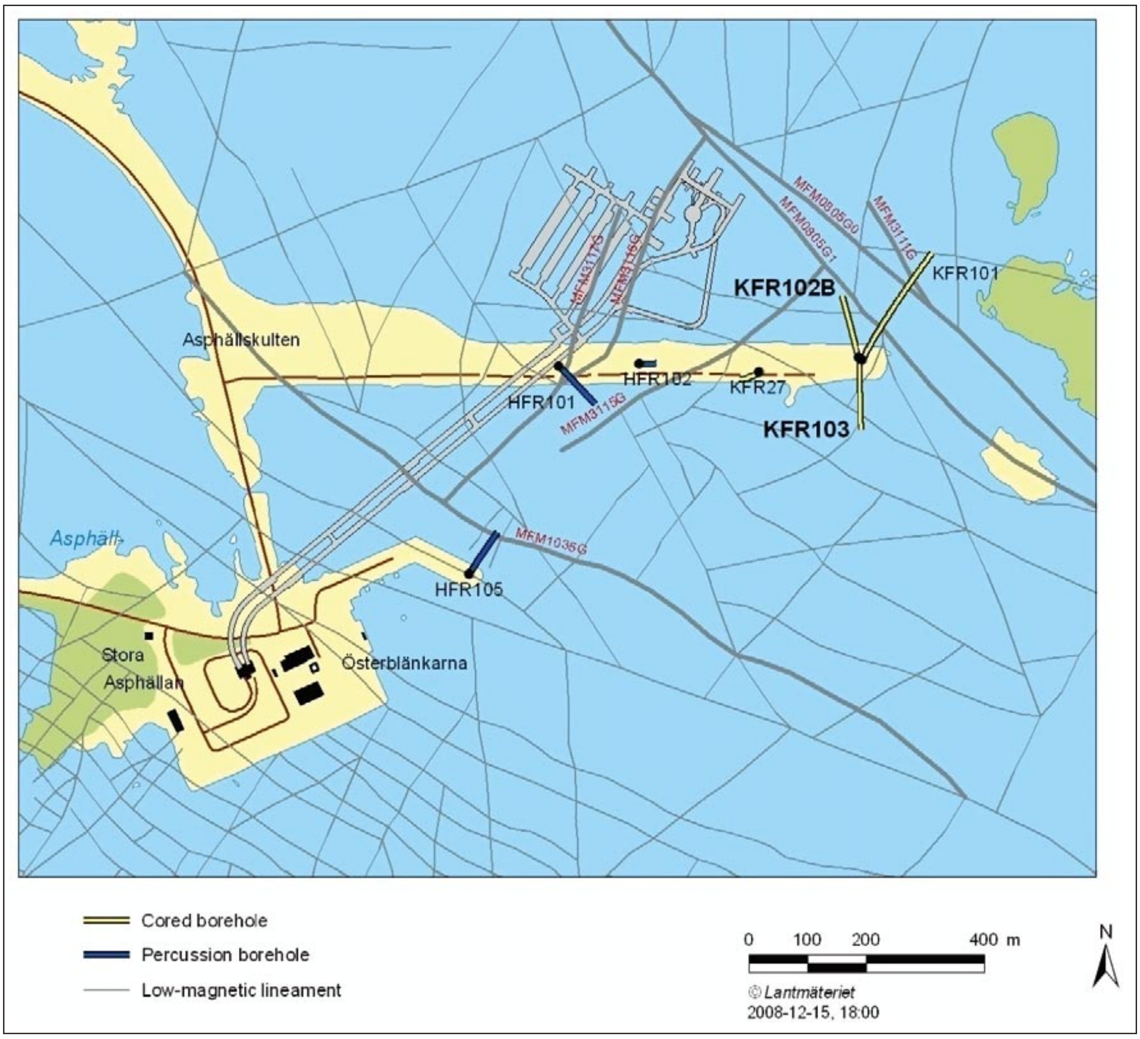

Figure 1-1. Map showing position and horizontal projection of the cored boreholes KFR102B and KFR103 relative to SFR and other boreholes in the drilling programme.

The work was carried out in accordance with activity plan AP SFR-08-009. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

Original data from the reported activity are stored in the primary database Sicada. 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 associated 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 hammarborrhål HFR101, HFR102, HFR105 samt kärnborrhål KFR27, KFR101, KFR102A, KFR102B, KFR103 och KFR104	AP SFR-08-009	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	3.0

2 Objective and scope

A geological single-hole interpretation is carried out in order to identify and to describe the general 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 a drill core. Hydrogeological borehole data was used to identify flow anomalies and transmissive sections of the boreholes.

The result from the geological single-hole interpretation is presented in a WellCAD plot. A detailed description of the technique is provided in the Method Description (SKB MD 810.003). 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 for the single-hole interpretation of the boreholes KFR102B and KFR103.

- Boremap data (including BIPS-image and geological mapping /Döse et al. 2009/.
- Generalized geophysical logs and their interpretation /Mattsson and Keisu 2009/.
- Borehole flow logging data and their interpretation /Kristiansson and Väisäsvaara 2009/.

The geological mapping of the boreholes involves documentation of the drill core in combination with inspection of the oriented image of the borehole walls, obtained by a Borehole Image Processing System (BIPS).

The basis for the geological single-hole interpretation was a WellCAD plot consisting of parameters from the geological mapping, as well as geophysical and hydrogeological data. The latter was included after that the geological single-hole interpretation was performed, i.e. the rock units and the possible deformation zones were defined. Moreover, it should be noted that no borehole radar loggings were performed in the two boreholes. An example of a WellCAD plot used during geological single-hole interpretation is shown in Figure 3-1. The plot consists of eight main columns and several subordinate columns. These include:

1: Length along the borehole

2: Rock type
- 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

3: Geophysics
- 3.1: Silicate density
- 3.2: Natural gamma radiation
- 3.3: Magnetic susceptibility
- 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: Width
- 4.6: Alteration, dip direction

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

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

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

8: Hydrogeology
  8.1: Transmissivity flow anomalies
  8.2: Transmissivity 5-m sections

The use of the geophysical and hydrogeological parameters during the single-hole interpretation is as follows:

Silicate density: Indicates the density of the rock after subtraction of the magnetic component of the rock. It provides general information on the mineral composition of the rock and serves as a support for rock classification.

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 (111058) or pegmatitic granite (101061).

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

Transmissivity: The transmissivity from flow logging is related to the transmissivity of individual fractures and to the connectivity of the water-bearing fracture network.

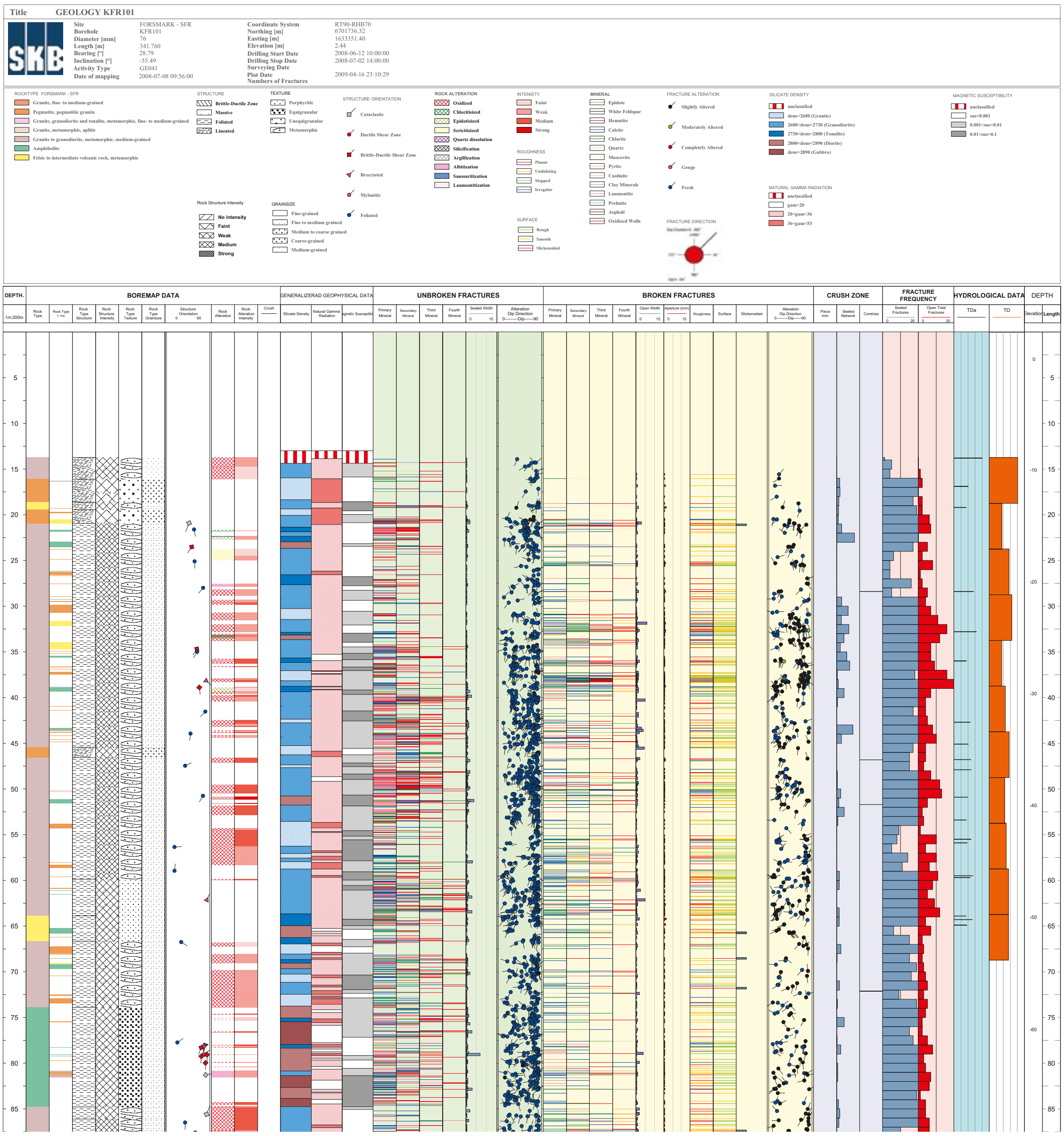

Figure 3-1. *Example of WellCAD plot (from borehole KFR101) used as basis for the geological single-hole interpretation.*

4 Execution

4.1 Geological single-hole interpretation

The geological single-hole interpretation has been carried out by a group of geoscientists, consisting of geologists, geophysicists and hydrogeologists. Several of them previously participated in the development of the source material. All data to be used (see Chapter 3) are presented 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 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. A minimum length of about 5 m was used for the single-hole interpretations during the site investigation. This minimum length was generally also used during this work, but not consistently, since the SFR model volume is considerably less. 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 confidence in the interpretation of a rock unit is assigned according to three classes: 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, alteration, etc.) in combination with available geophysical 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. This includes a brief description of the rock types affected by the possible deformation zone. Mineral fillings registered in at least 10% of the open/sealed fractures in the interval or eight individual fractures are noted. The confidence in the interpretation of a possible deformation zone is assigned according to three classes: 3 = high, 2 = medium and 1 = low.

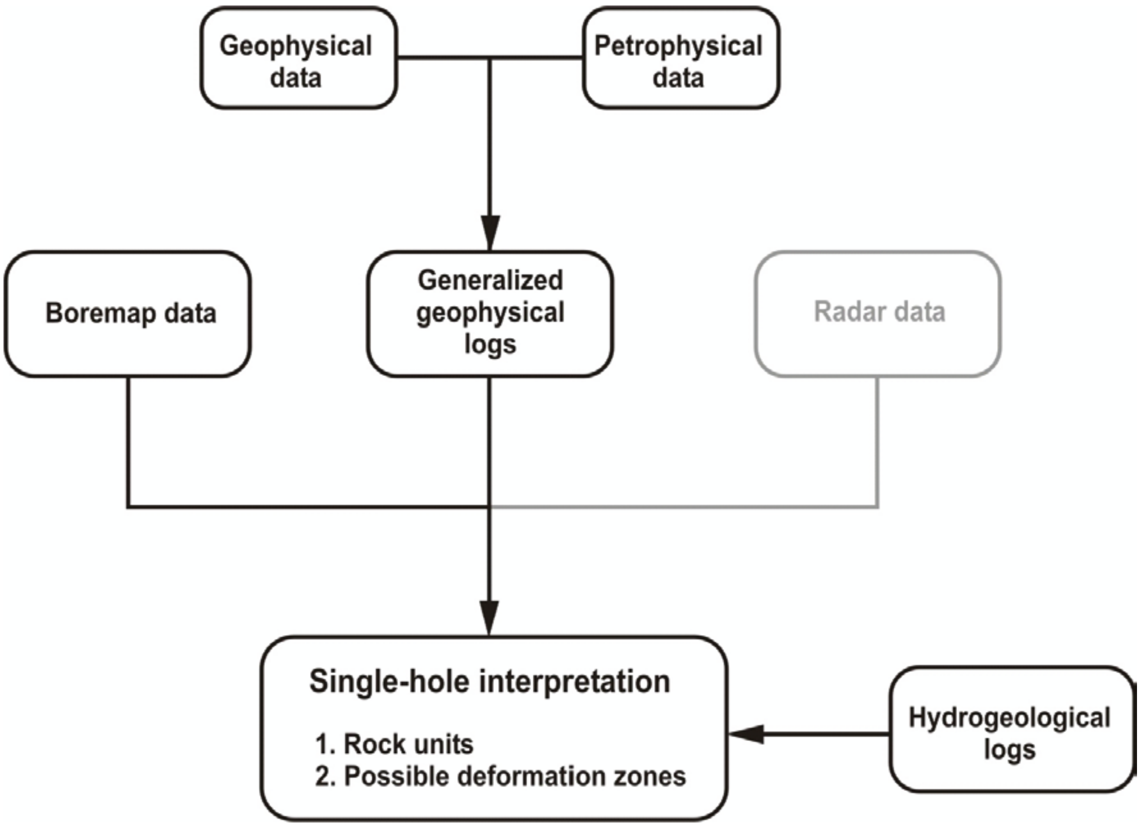

Figure 4-1. *Schematic chart showing the procedure for the development of a geological single-hole interpretation. The radar data box is shaded to illustrate that no radar logs were available in the present case.*

Inspection of BIPS images is carried out wherever it is judged necessary during the working procedure. Furthermore, following the definition of rock units and possible 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 boundaries are adjusted.

Possible deformation zones that are brittle in character have been identified primarily on the basis of the frequency of fractures, according to the concept presented in /Munier et al. 2003/. Brittle deformation zones defined by an increased frequency of extensional fractures (joints) or shear fractures (faults) are not distinguished. Both the transitional part, with a fracture frequency in the range 4–9 fractures/m, and the core part, with a fracture frequency > 9 fractures/m, have been included in each zone (Figure 4-2). The frequencies of open and sealed fractures have been assessed in the identification procedure, and the character of the zone has been described accordingly. Partly open fractures are included together with open fractures in the brief description of each zone. The presence of bedrock alteration, the occurrence and, locally, orientation of radar reflectors, the resistivity, SPR, P-wave velocity, caliper and magnetic susceptibility logs have all assisted in the identification of the zones. The anomalies in these parameters that assist with the interpretation are presented in the short description.

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 boreholes KFR102B and KFR103 (Figure 4-3 to Figure 4-4). A 5 m window and 1 m steps have been used in the calculation procedure. The moving average for open fractures alone, the total number of open (including open, partly open and crush), the sealed fractures alone, and the total number of sealed fractures (including sealed and sealed fracture networks) are shown in each diagram.

Generally, the occurrence and orientation of radar anomalies within the possible deformation zones are used during the identification of these zones. However, no radar measurements were available for KFR102B and KFR103.

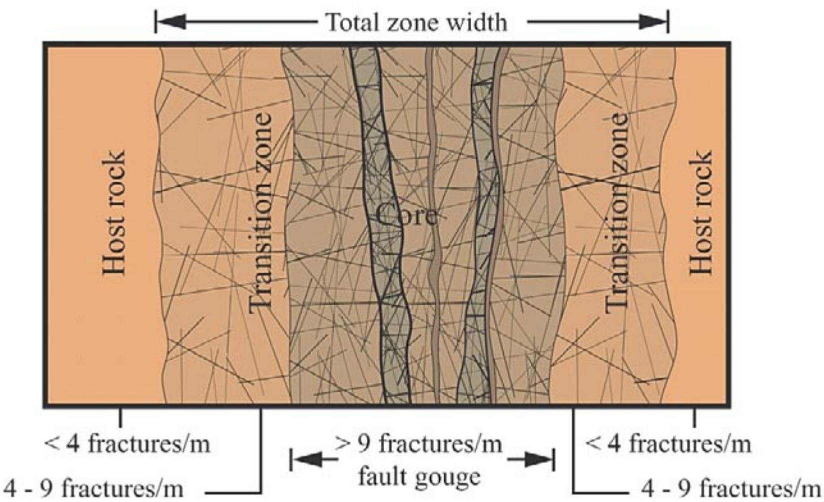

Figure 4-2. *Schematic illustration of the structure of a brittle deformation zone. After /Munier et al. 2003/.*

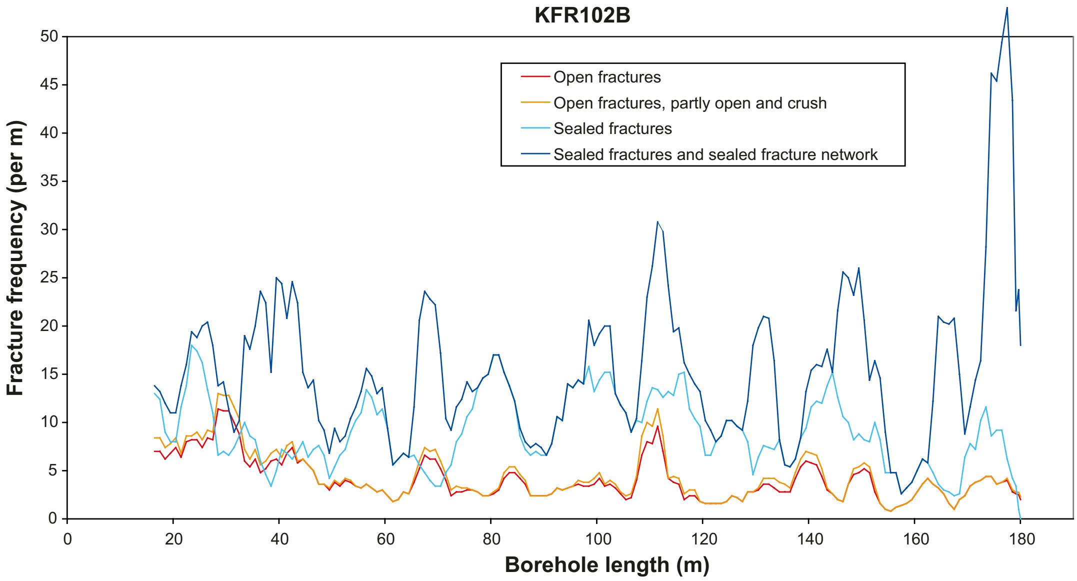

Figure 4-3. *Fracture frequency plot for KFR102B. Moving average with a 5 m window and 1 m steps.*

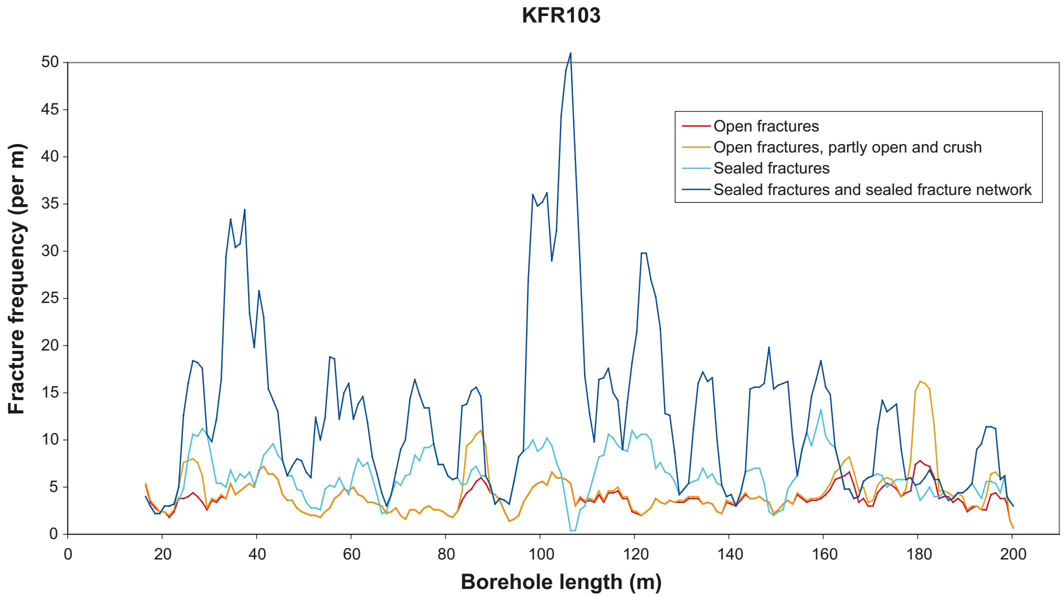

Figure 4-4. *Fracture frequency plot for KFR103. Moving average with a 5 m window and 1 m steps.*

4.2 Hydrogeological single-hole interpretation

The hydrogeological single-hole interpretation has been carried out by a hydrogeologist as a second step after, but in immediate connection to, the geological single-hole interpretation. All data to be used are presented side by side in the same borehole document as the geological and geophysical data. The hydrogeological columns were however not accessible at the geological interpretation stage.

In this particular case the single-hole interpretation concerned two cored boreholes with differential flow logging data.

The methodology of the hydrogeolocial single-hole interpretation was to study the hydrogeological data for the identified possible deformation zones. The flow anomalies and hydraulic properties of each zone were then evaluated and described in comparison to the properties of the whole borehole.

4.3 Nonconformities

A difference in the currently applied methodology compared to earlier single-hole interpretations (SKB MD 810.003) is that hydrogeological single-hole interpretation was performed after that the rock units and the possible deformation zones were defined for each borehole.

The last 0.75 m (179.33–180.08 m length) of KFR102B and the last 1.67 m (198.83–200.50 m) of KFR103 were mapped without access to BIPS-image.

Borehole radar measurements were not available for any of the two boreholes.

The data used for calibration of the magnetic susceptibility logs are from the preceding Forsmark site investigation for a deep repository.

5 Results

The results of the geological single-hole interpretations of KFR102B and KFR103 are presented as print-outs from the software WellCAD in Appendix 1.

5.1 KFR102B

The orientation of the borehole at TOC (Top Of Casing) is 344.9°/–55.1°.

Rock Units

The borehole can be divided into four different rock units, RU1–RU4. All rock units have been interpreted with a high degree of confidence.

13.94–48.26 m

RU1: Metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), felsic- to intermediate metavolcanic rock (103076) and amphibolite (102017). Slightly increased frequency of open fractures relative to other rock units, possible deformation zones excluded. The bulk resistivity is significantly decreased throughout the interval relative to remaining part of the borehole. Confidence level = 3.

48.26–82.16 m

RU2: Generally weakly foliated metagranite-granodiorite (101057) with minor occurrences of pegmatitic granite (101061), amphibolite (102017) and one occurrence of intermediate metavolcanic rock (103076). Confidence level = 3.

82.16–157.87 m

RU3: Generally moderately to strongly foliated metagranite-granodiorite (101057) and amphibolite (102017). The latter spatially associated with subordinate occurrences of felsic to intermediate metavolcanic rock (103076). Minor occurrences of pegmatitic granite (101061) throughout the interval. Confidence level = 3.

157.87–180.08 m

RU4: Pegmatitic granite (101061), fine- to medium-grained granite (111058) and metagranite-granodiorite (101057) with two minor occurrences of amphibolite (102017). Confidence level = 3.

Possible deformation zones

Four possible deformation zones of brittle character have been interpreted in KFR102B, one with a medium degree of confidence and the other three with a high degree of confidence.

67–70 m

DZ1: Increased frequency of open fractures and sealed fracture networks. One fracture with slickensides and one with gouge. Minor brecciated intervals with up to 1–2 mm wide vugs at 67.26–67.44 and 68.82–68.96 m. Generally moderately oxidized. Fracture apertures up to 1.5 mm. Predominant minerals in sealed fracture networks are laumontite, calcite and adularia, and in open fractures chlorite, calcite, laumontite and pyrite. Decreased resistivity and magnetic susceptibility throughout the interval. Metagranite-granodiorite (101057) and pegmatitic granite (101061). Confidence level = 3.

The transmissivity of the interval is about $9 \cdot 10^{-7}$ m^2/s. The transmissivity is dominated by a flow anomaly at 67.7 m, which probably corresponds to an open fracture at 67.6 m.

109–114 m

DZ2: Increased frequency of open and sealed fractures and sealed fracture networks. Fracture apertures up to 1.5 mm. Locally weak to medium oxidation. Predominant minerals in sealed fractures are calcite, chlorite, laumontite, adularia and quartz and in open fractures chlorite, calcite, laumontite and clay minerals. Significantly decreased resistivity and magnetic susceptibility in the interval 109–111 m. In the remaining part of the section the resistivity and magnetic susceptibility are partly decreased along minor intervals. Metagranite-granodiorite (101057), pegmatitic granite (101061) and amphibolite (102017). Confidence level = 3.

The transmissivity of the interval is about $1 \cdot 10^{-7}$ m^2/s and is dominated by two flow anomalies at 109.1 and 109.7 m, the latter corresponding to several open fractures.

149.5–150.5 m

DZ3: Increased frequency of open fractures and one crushed interval at 150.01–150.06 m. Fracture apertures up to 1 mm. No alteration. Predominant minerals in open fractures are chlorite, pyrite and laumontite. Significantly decreased resistivity and magnetic susceptibility. There is also one major calliper anomaly in the section. Metagranite-granodiorite (101057) and pegmatitic granite (101061). Confidence level = 2.

One single flow anomaly at 149.8 m corresponding to several open fractures with a transmissivity of $5 \cdot 10^{-6}$ m^2/s. This is the most transmissive anomaly in the borehole.

173–180 m

DZ4: Increased frequency of sealed fractures and sealed fracture networks. Brecciated interval at 176.01–176.04, 178.92–179.10 and 179.66–179.74 m. Predominant minerals in sealed fractures and sealed fracture networks are calcite, chlorite, laumontite and adularia. Minor interval of medium oxidation. Significantly decreased resistivity and magnetic susceptibility in the interval 172.0–173.5 m. In the remaining part of the section the resistivity and magnetic susceptibility are partly decreased along minor intervals. Pegmatitic granite (101061), metagranite-granodiorite (101057), felsic to intermediate metavolcanic rock (103076), fine- to medium-grained granite (111058) and amphibolite (102017). Confidence level = 3.

An isolated cluster of relatively high-transmissive flow anomalies at 172.0–173.6 m. Total transmissivity of $2 \cdot 10^{-6}$ m^2/s. No flow logging data below approximately 173.8 m.

5.2 KFR103

The orientation of the borehole at TOC is 179.9°/–55.1°.

Rock Units

The borehole can be divided into five different rock units, RU1–RU5. Rock units 3 and 4 occur in two and three separate length intervals, respectively. All rock units have been interpreted with a high degree of confidence.

13.03–45.99 m

RU1: Generally moderately foliated and muscovite-rich metagranite-granodiorite (101057). The wet density of the metagranite-granodiorite is increased and varies in the range 2,710–2,740 kg/m^3. Subordinate occurrences of amphibolites (102017), pegmatitic granite (101061) and one occurrence of felsic to intermediate metavolcanic rock (103076). Confidence level = 3.

45.99–59.34 m

RU2: Pegmatitic granite (101061). Confidence level = 3.

59.34–103.60 m

RU3a: Generally moderately foliated metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), amphibolites (102017), felsic to intermediate metavolcanic rock (103076) and one of fine- to medium-grained granite (111058). Confidence level = 3.

103.60–118.01 m

RU4a: Felsic to intermediate metavolcanic rock (103076) with subordinate occurrences of metagranite-granodiorite (101057) and minor occurrences of pegmatitic granite (101061) and amphibolite (102017). Confidence level = 3.

118.01 – 133.03 m

RU3b: Moderately foliated metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), amphibolites (102017) and one minor occurrence of felsic to intermediate metavolcanic rock (103076). Confidence level = 3.

133.03–153.76 m

RU5: Pegmatitic granite (101061) with subordinate occurrences of metagranite-granodiorite (101057) and amphibolites (102017). Confidence level = 3.

153.76–161.99 m

RU4b: Felsic to intermediate metavolcanic rock (103076) with subordinate occurrences of pegmatitic granite (101061), amphibolite (102017) and one minor occurrence of metagranite-granodiorite (101057). Confidence level = 3.

161.99–200.50 m

RU3c: Generally moderately foliated metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), amphibolites (102017) and felsic to intermediate metavolcanic rock (103076). Confidence level = 3.

Possible deformation zones

Three possible deformation zones of brittle character have been interpreted in KFR103, all three with a high degree of confidence.

24.5–26.5 m

DZ1: Increased frequency of open and sealed fractures and sealed fracture networks. One crushed interval at 25.95–26.12 m. Fracture apertures up to 1mm. Locally moderate oxidation. Predominant minerals in sealed fractures and sealed fracture networks are calcite, chlorite, laumontite and adularia and in open fractures and the crushed interval chlorite, muscovite, calcite and hematite. Significantly decreased bulk resistivity and magnetic susceptibility in the section 15–26.5 m. Metagranite-granodiorite (101057), amphibolite (102017) and pegmatitic granite (101061). Confidence level = 3.

One single flow anomaly at 26.4 m ($T = 3 \cdot 10^{-7}$ m^2/s). There is an increased frequency of flow anomalies and a high transmissivity ($T = 1 \cdot 10^{-5}$ m^2/s) of the whole upper part of the borehole down to approximately 70 m borehole length.

84–91 m

DZ2: Increased frequency of open fractures and two crushed intervals at 85.67–85.71 and 86.61–86.74 m. Fracture apertures up to 1mm. Locally faint oxidation. Predominant minerals in open fractures and crushed intervals are calcite, chlorite and hematite. Locally significantly decreased resistivity and magnetic susceptibility. There are also two caliper anomalies at c. 85.9 m and 86.8 m. Metagranite-granodiorite (101057), pegmatitic granite (101061), amphibolite (102017) and felsic to intermediate metavolcanic rock (103076). Confidence level = 3.

A cluster of high-transmissive flow anomalies at 84.6–86.8 m ($T = 2 \cdot 10^{-5}$ m^2/s) corresponding to a large open fracture and the two crushed intervals.

180–182.5 m

DZ3: Increased frequency of open fractures and two crushed intervals at 180.69–180.73 and 181.89–182.01 m. Three intervals of core loss at 181.16–181.22, 181.28–181.40 and 181.96–182.00 m. Fracture apertures 0.5 mm or less. Faint to moderate oxidation. Predominant minerals in open fractures and crushed intervals are chlorite, calcite, clay minerals, iron hydroxide and muscovite. Significantly decreased bulk resistivity and magnetic susceptibility along the entire section. Metagranite-granodiorite (101057), pegmatitic granite (101061) and amphibolite (102017). Confidence level = 3.

An isolated cluster of flow anomalies at 180.7–187.9 m. The flow anomalies correspond to crushes and core losses. Total transmissivity of $1 \cdot 10^{-5}$ m^2/s.

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WellCAD images

Title	SINGLE HOLE INTERPRETATION KFR102B					
Site	FORSMARK - SFR	Inclination [°]	-55.09	Elevation [m.a.s.l.]	2.51	Signed data
Borehole	KFR102B	Date of mapping	2008-09-29 14:13:00	Drilling Start Date	2008-05-07 10:30:00	
Diameter [mm]	76	Coordinate System	RT90-RHB70	Drilling Stop Date	2008-05-07 17:00:00	
Length [m]	180.080	Northing [m]	6701740.53	Surveying Date		
Bearing [°]	344.89	Easting [m]	1633343.91	Plot Date	2009-06-09 23:09:46	

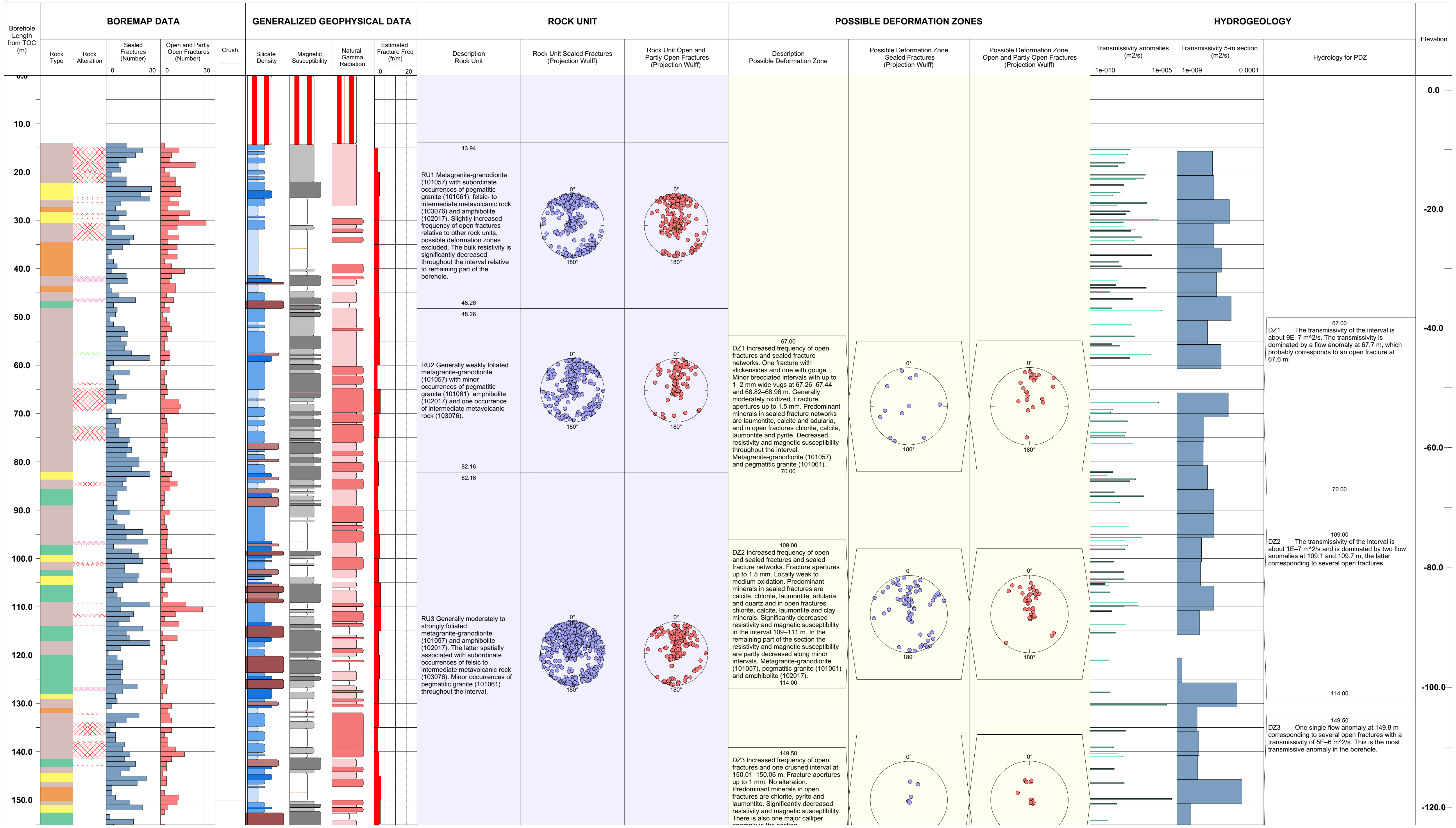
ROCKTYPE FORSMARK - SFR
- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite
- Felsic to intermediate volcanic rock, metamorphic

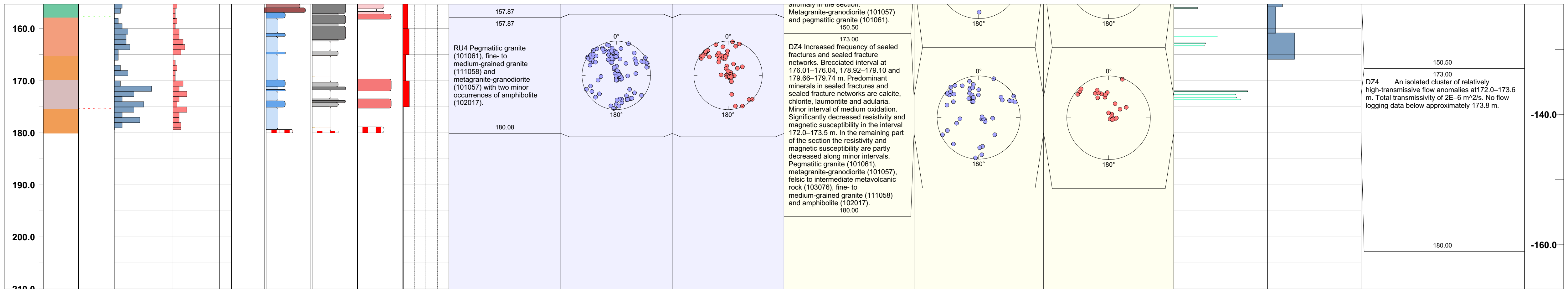
ROCK ALTERATION
- Oxidized
- Epidotisized
- Albitization
- Saussuritization
- Laumontitization

SILICATE DENSITY (kg/m³)
- unclassified
- dens<2680 (Granite)
- 2680<dens<2730 (Granodiorite)
- 2730<dens<2800 (Tonalite)
- 2800<dens<2890 (Diorite)
- dens>2890 (Gabbro)

SUSCEPTIBILITET (SI)
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA (µR/h)
- unclassified
- gam<20
- 20<gam<36
- 36<gam<53




160.0
170.0
180.0
190.0
200.0
157.87
157.87
RU4 Pegmatitic granite (101061), fine- to medium-grained granite (111058) and metagranite-granodiorite (101057) with two minor occurrences of amphibolite (102017).
180.08
0°
180°
0°
180°
Metagranite-granodiorite (101057) and pegmatitic granite (101061).
150.50
173.00
DZ4 Increased frequency of sealed fractures and sealed fracture networks. Brecciated interval at 176.01–176.04, 178.92–179.10 and 179.66–179.74 m. Predominant minerals in sealed fractures and sealed fracture networks are calcite, chlorite, laumontite and adularia. Minor interval of medium oxidation. Significantly decreased resistivity and magnetic susceptibility in the interval 172.0–173.5 m. In the remaining part of the section the resistivity and magnetic susceptibility are partly decreased along minor intervals. Pegmatitic granite (101061), metagranite-granodiorite (101057), felsic to intermediate metavolcanic rock (103076), fine- to medium-grained granite (111058) and amphibolite (102017).
180.00
180°
0°
180°
180°
0°
180°
150.50
173.00
DZ4 An isolated cluster of relatively high-transmissive flow anomalies at172.0–173.6 m. Total transmissivity of 2E–6 m^2/s. No flow logging data below approximately 173.8 m.
180.00
-140.0
-160.0

Title	SINGLE HOLE INTERPRETATION KFR103					
Site	FORSMARK - SFR	**Inclination [°]**	-55.09	**Elevation [m.a.s.l.]**	2.43	**Signed data**
Borehole	KFR103	**Date of mapping**	2008-10-23 13:17:00	**Drilling Start Date**	2008-05-08 10:15:00	
Diameter [mm]	76	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2008-05-08 16:00:00	
Length [m]	200.500	**Northing [m]**	6701737.13	**Surveying Date**		
Bearing [°]	179.90	**Easting [m]**	1633347.20	**Plot Date**	2009-06-09 23:09:46	

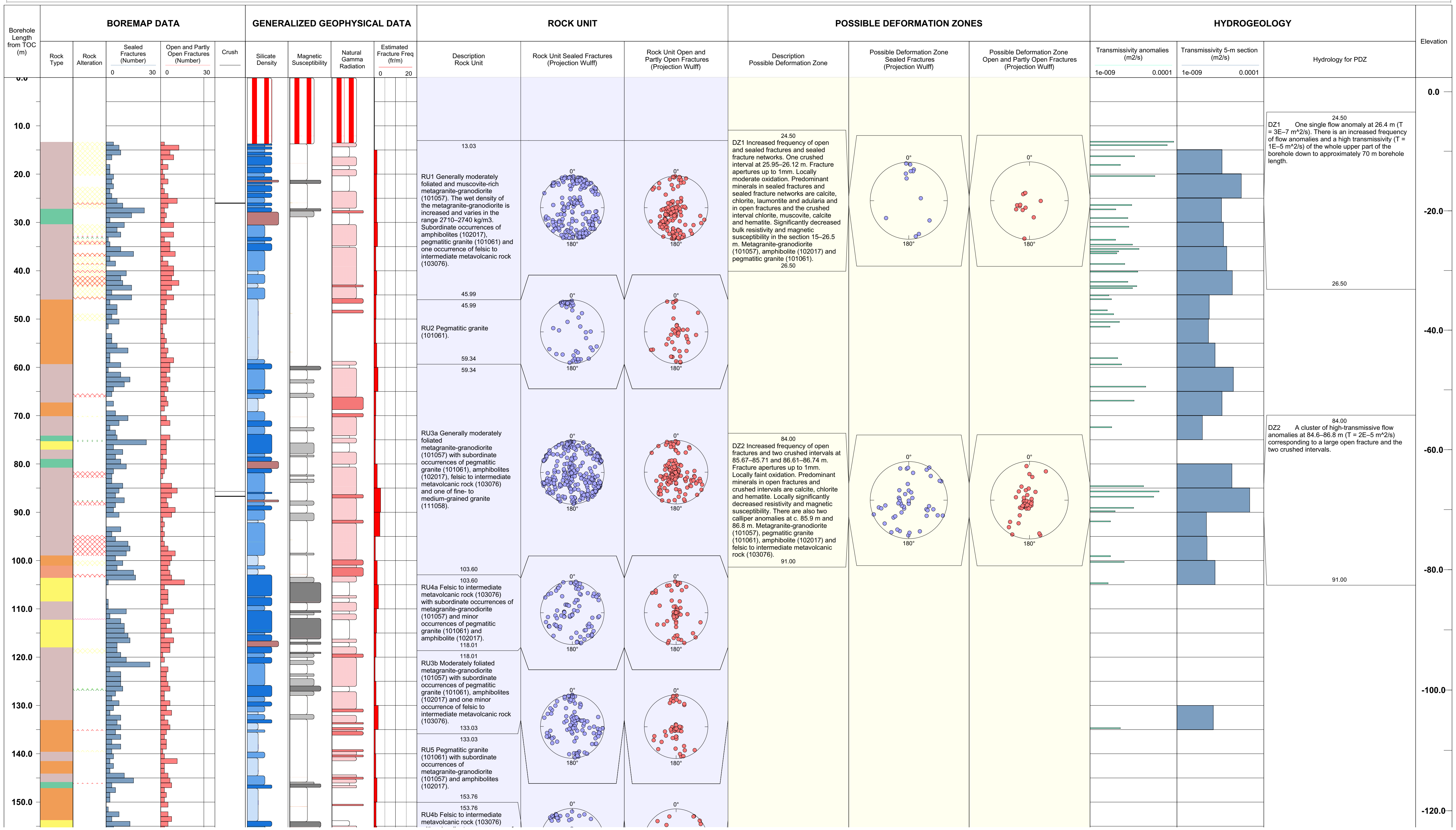
ROCKTYPE FORSMARK - SFR
- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite
- Felsic to intermediate volcanic rock, metamorphic

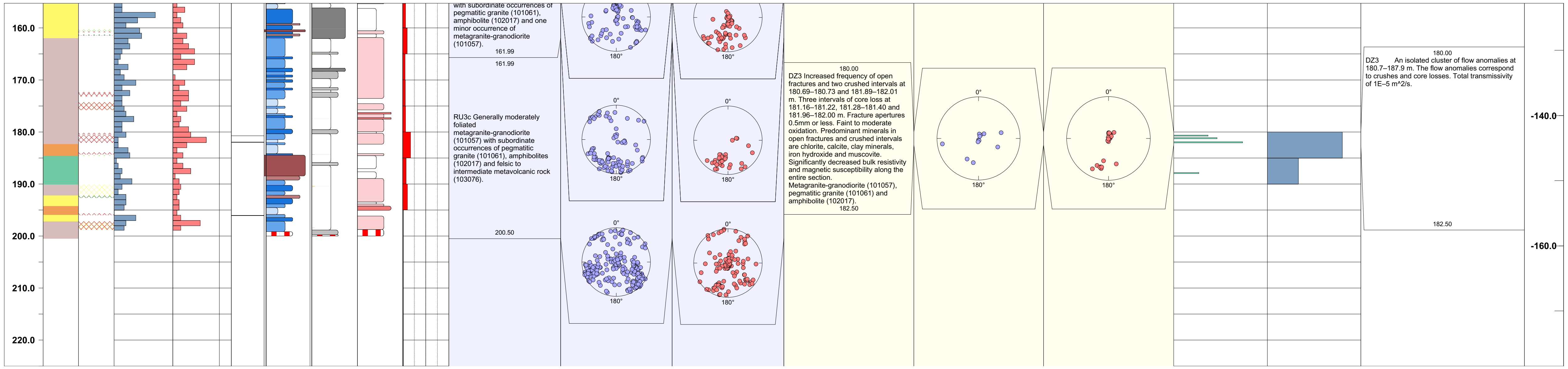
ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Sericitisized
- Albitization

SILICATE DENSITY (kg/m³)
- unclassified
- dens<2680 (Granite)
- 2680<dens<2730 (Granodiorite)
- 2730<dens<2800 (Tonalite)
- 2800<dens<2890 (Diorite)
- dens>2890 (Gabbro)

SUSCEPTIBILITET (SI)
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA (μR/h)
- unclassified
- gam<20
- 20<gam<36
- 36<gam<53





160.0
170.0
180.0
190.0
200.0
210.0
220.0
with subordinate occurrences of pegmatitic granite (101061), amphibolite (102017) and one minor occurrence of metagranite-granodiorite (101057).
161.99
161.99
RU3c Generally moderately foliated metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), amphibolites (102017) and felsic to intermediate metavolcanic rock (103076).
200.50
0°
180°
180.00
DZ3 Increased frequency of open fractures and two crushed intervals at 180.69–180.73 and 181.89–182.01 m. Three intervals of core loss at 181.16–181.22, 181.28–181.40 and 181.96–182.00 m. Fracture apertures 0.5mm or less. Faint to moderate oxidation. Predominant minerals in open fractures and crushed intervals are chlorite, calcite, clay minerals, iron hydroxide and muscovite. Significantly decreased bulk resistivity and magnetic susceptibility along the entire section. Metagranite-granodiorite (101057), pegmatitic granite (101061) and amphibolite (102017).
182.50
180.00
DZ3 An isolated cluster of flow anomalies at 180.7–187.9 m. The flow anomalies correspond to crushes and core losses. Total transmissivity of 1E–5 m^2/s.
182.50
-140.0
-160.0