Report

P-21-25

October 2022

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Sofia Winell

Eva Samuelsson

SVENSK KÄRNBRÄNSLEHANTERING AB

SWEDISH NUCLEAR FUEL
AND WASTE MANAGEMENT CO

Box 3091, SE-169 03 Solna
Phone +46 8 459 84 00
skb.se

SVENSK KÄRNBRÄNSLEHANTERING

ISSN 1651-4416
SKB P-21-25
ID 1914790
October 2022

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Keywords: Geology, Rock units, Possible deformations zone, Borehole.

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Summary

This report presents the geological single-hole interpretation (SHI) of the core drilled boreholes KFR117–KFR121, drilled from the pier above SFR.

To identify rock units (RU) and possible deformation zones (PDZ) in the boreholes the interpretation combines the geological mapping, geophysical- and hydrogeological logs. The hydrogeological data are included for description and comparative purposes, and are not used for the identification and interpretation of possible deformation zones. A brief description including arguments for identification/division and associated estimates of interpretation confidence is reported of each rock unit and possible deformation zone.

The number of RUs in individual boreholes varies from two to five and some of the RUs are divided into subunits. PDZs are interpreted in KFR118–KFR121. Two possible deformation zones with low to medium confidence are interpreted in each of the boreholes KFR118–KFR120. In KFR121 four PDZs are interpreted with medium to high confidence.

Sammanfattning

Denna rapport presenterar den geologiska enhålstolkningen (SHI) av kärnborrhålen KFR117–KFR121, borrade från piren över SFR.

För att identifiera bergenheter (RU) och möjliga deformationszoner (PDZ) i borrhålen kombineras tolkningen av den geologiska karteringen, generaliserade geofysiska och hydrogeologiska loggar. Hydrogeologisk data ingår bara för beskrivning och i jämförande syfte och används inte för identifiering och tolkning av eventuella deformationszoner. En kort beskrivning inklusive argument för identifiering/uppdelning och tillhörande bedömning av konfidens redovisas för varje bergenhet och eventuell deformationszon i rapporten.

Antalet RUs i de enskilda borrhålen varierar från två till fem och en del av bergenheterna är uppdelade i underenheter. PDZs är identifierade i KFR118–KFR121. Två PDZs är identifierade med konfidensgrad låg och medel i vart och ett av borrhålen KFR118–KFR120. I KFR121 har fyra PDZs identifierats med medel till hög konfidens.

Contents

1 Introduction

Primary geological and geophysical borehole data stored in the SKB database SICADA need to be integrated and synthesized before they can be used for deterministic, 3D geological modelling. The integrated synthesis is provided by the SKB method of geological SHI (SKB MD 810.003), which aims to identify and describe all the RUs that exceed a minimum length of 5–10 m along the borehole, as well as PDZs that are intersected by the borehole. The identification of these geological features is carried out independently for each borehole, in connection with an analysis of base data and an inspection of the drill core. The end result of this procedure is an integrated series of different logs and accompanying descriptions.

This document reports the geological SHI of the cored boreholes KFR117–KFR121, drilled from the pier above SFR, Figure 1-1.

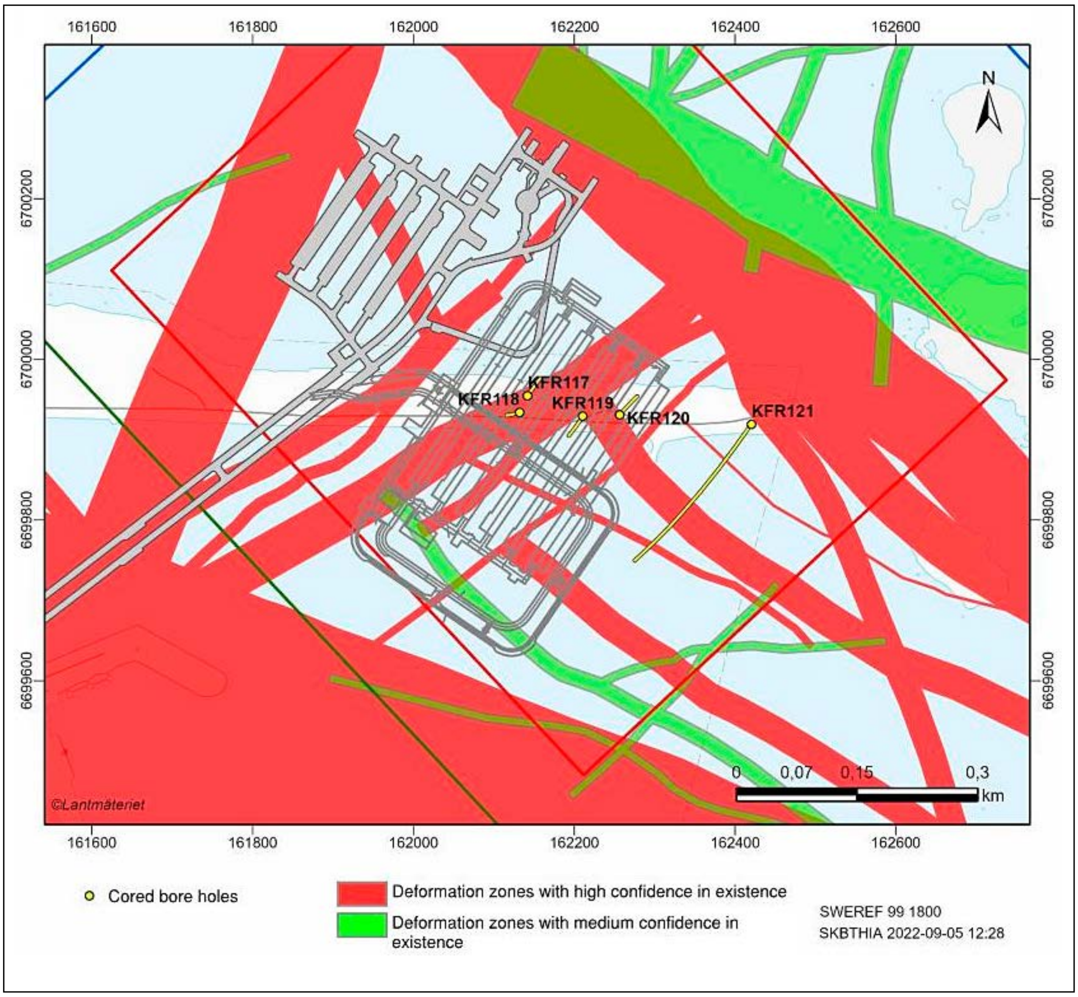


Figure 1-1. *Surface projection of boreholes KFR117–KFR121. SFR1 and SFR3 are highlighted in light- and dark grey, respectively.*

The work was carried out in accordance with activity plan AP SFK-20-046. The controlling documents for performing this activity are listed in Table 1-1. Both the activity plan and method description are SKB's internal controlling documents.

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

Activity plan	Number	Version
Enhålstolkning KFR117–KFR121	AP SFK-20-046	1.0

Method description	Number	Version
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	3.0

2 Objective and scope

A geological SHI is performed in order to merge sections of similar geological character into RUs and identify all PDZs within a borehole. The work involves an integrated interpretation of data from the geological borehole mapping, geophysical borehole logs and hydrological borehole data. The result is presented in a WellCAD-plot for each borehole and a brief description of the gelogical characteristics of each RU and PDZ.

The geological mapping of the cored boreholes involves documentation of the bedrock with the Boremap system, which combines drill core mapping with a simultaneous inspection of an oriented image obtained by optical televiewer (OPTV) of the borehole wall.

Borehole logs used as basis for the geological SHI are presented in a WellCAD plot. A more detailed description of the SHI work is provided in the method description SKB MD 810.003. The work reported here concerns stage 1 in the SHI, as defined in the method description.

3 Data used for the geological single-hole interpretation

The following data and interpretations have been used for the SHI of the boreholes KFR117–KFR121:

- Boremap data, including OPTV-images, drill cores.
- Natural gamma logging, gamma–gamma logging, caliper, magnetic susceptibility, sonic full wave form logging, acoustic televiewer and resistivity logging.
- Single hole hydraulic injection tests in KFR117–KFR120, single point resistance (SPR) and difference flow logging in KFR119 and KFR121.

A WellCAD-plot visualising parameters from the geological mapping, geophysical logging and hydrological measurements are used as a basis for the geological SHI work. Hydraulic data were included strictly for comparative purposes and were not used in the actual interpretation procedure. The plot consists of ten main columns with several subordinate columns. These include:

1. Length along the borehole
2. Elevation (meter below sea level; RH2000)
3. Rock type
   - Rock occurrence (< 1 m)
   - Rock type structure
   - Rock type texture
   - Rock type grain size
   - Structure orientation
   - Rock alteration
   - Rock alteration intensity
4. Fault rock
   - Fault rock
   - Fault rock orientation
5. Fracture frequency
   - Open total
   - Sealed total
   - Fracture, open, orientation
   - Fracture, broken, orientation
   - Total fractures
   - Open aperture
   - Open width
   - Sealed width
6. Fracture alteration orientation
   - Open alteration
   - Sealed alteration
   - Surface
7. Sealed network
8. Crush zones and core loss
   - Crush zone
   - Piece length
   - Core loss

9. Geophysics
   - Natural gamma radiation
   - Caliper
   - Density
   - Focused resistivity
   - Magnetic susceptibility
   - Sonic P- and S-wave velocities and attenuation
10. Hydrology
   - SPR
   - Transmissivity

4 Execution of the geological single-hole interpretation

The geological SHI was performed by a group of geoscientists consisting of geologists, geophysicists and hydrogeologists, of which several have participated in the development of the source material for the SHI. All data to be used (see Chapter 3) are visualized side by side in a borehole document in the software WellCAD. The working procedure is summarized in the text below.

4.1 General

The SHI is initiated by a study of all types of primary data (rock type, composition, grain-size, alteration, fracturing, ductile deformation, geohysical data, etc) related to the character of the rock types in order to merge intervals of similar geological character into RUs. A minimum length of c 5 m is generally used. Each RU is defined in terms of the borehole length interval and a brief description. The confidence in the interpretation of a RU is based on three classes: 3 = high, 2 = medium and 1 = low. The use of low or medium degree of confidence is generally restricted to percussion drilled boreholes, where no drill core is available.

The next step is identification of PDZs by visual inspection of the results of the geological mapping (fracture frequency, aperture, alteration, etc) in combination with the geophysical data. The section of each identified PDZ is defined in terms of the borehole length interval and a brief description of its characteristics including arguments for identification/division and the rock types affected by the PDZ. The confidence in the interpretation of a PDZ is made on the following basis: 3 = high, 2 = medium and 1 = low.

If its needed the OPTV-image can be inspected during the working procedure. Following the definitions of RUs and PDZs, with their respective confidence estimates, the drill cores are inspected in order to verify the interpretation, or if necessary adjust the selection of their boundaries. The estimated confidence level may also be revised based on the ocular core inspection.

Brittle PDZs have been identified primarily on the basis of the frequency of fractures, according to the concept presented in Figure 4-1. Tensional fractures (joints) or shear fractures (faults) are not distinguished. Both the damage zone, 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. It should be emphasized that the identification of a PDZ is not limited to the absolute fracture frequency; the basis is the *relative* fracture frequency along with other indications. 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.

Single point resisitence (SPR) is used for identification of water bearing fractures, characterize deformation zones and in some cases the occurence of bedrock alteration. Single hole hydraulic injection tests with corresponding interpretations of hydraulic transmissivity according to Moye (1967) were available for KFR117, KFR118, KFR119 and KFR120. Difference flow logging and corresponding interpretions of hydraulic transmissivity were available for KFR119 and KFR121.

Natural gamma can be used for identification of rock type and alteration. It is also used for length matching of different loggings. High radiation indicates younger rock types as pegmatitic granite (101061) and fine-grained granite (111058). Density can be used for rock type identification and along with seismic velocities are input for rock mechanical properties. The density provides general information on the mineral composition of the rock type.

Caliper, resistivity and full wave sonic are mainly used for identification of larger fractures and fracture zones. Caliper provides a continuous measurement of the diameter of the borehole.

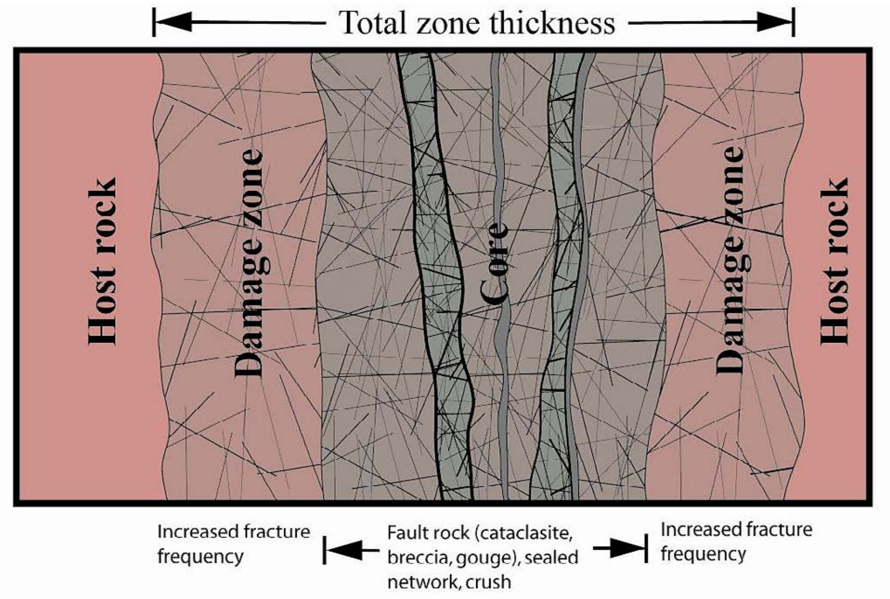


Figure 4-1. *Terminology for brittle deformation zones (modified after Munier et al. 2003).*

Resistivity is a measure of the ability to conduct an electric current that relates directly to porosity and fracture intensity and can be used to support identification of open fractures or fractures filled with clay minerals.

Velocity for the full wave sonic is dependent on the density of the rock type and can be used to support identification of larger fractures and brittle zones.

The resistivity and sonic velocities decrease with increased fracture frequency.

Magnetic susceptibility is connected to the magnetite content of the rock and can be used for characterization of rock types and alteration (oxidation and magnetite content connected to fractures).

5 Results

The results of the SHI of KFR117–KFR121 are presented in WellCAD-plots in Appendix 1.

5.1 KFR117

Rock units

The borehole consists of four rock units, RU1–RU4. RU2 occurs in two separate length intervals as RU2a and RU2b.

9.00–50.59 m

RU1: Medium-grained metagranite-granodiorite (101057) with four subordinate occurrences of pegmatitic granite (101061) and one amphibolite (102017). Confidence level = 3.

50.59–67.36 m

RU2a: Pegmatitic granite (101061) and one subordinate occurrence of medium-grained metagranite-granodiorite (101057). Confidence level = 3.

67.36–93.78 m

RU3: Fine- to medium-grained granite (111058) with one subordinated occurrence of medium-grained metagranite-granodiorite (101057). An increased magnetic susceptibility up to 750×10^{-5} IS is seen for the fine- to medium-grained granite (111058). Confidence level = 3.

93.78–119.70 m

RU4: Medium-grained metagranite-granodiorite (101057) with subordinate occurrences of felsic to intermediate metavolcanic rock (103076), pegmatitic granite (101061) and amphibolite (102017). The metagranite (101057) and metavolcanic rock (103076) are partly altered by muscovitization and all occurrences of amphibolite are altered by chloritization. Confidence level = 3.

119.70–175.91

RU2b: Pegmatitic granite (101061) with three subordinate occurrences of medium-grained metagranite-granodiorite (101057) and two felsic to intermediate metavolcanic rock (103076). Confidence level = 3.

Possible deformation zones

No PDZs have been identified in KFR117.

5.2 KFR118

The borehole consists of two rock units, RU1 and RU2. RU1 occurs in two separate length intervals as RU1a and RU1b.

12.33–37.41 m

RU1a: Medium-grained metagranite-granodiorite (101057) with one subordinate occurrences of pegmatitic granite (101061). Confidence level = 3.

37.41–164.23 m

RU2: Fine- to medium-grained granite (111058) with two subordinate occurrences of pegmatitic granite (101061) and one occurrence of medium-grained metagranite-granodiorite (101057). The magnetic susceptibility for the fine- to medium-grained granite (111058) varies from very low values up to 500×10^{-5} IS. Confidence level = 3.

164.23–175.48 m

RU1b: Pegmatitic granite (101061) and medium-grained metagranite-granodiorite (101057). Confidence level = 3.

Possible deformation zones

Two PDZs have been interpreted in KFR118. The first with confidence level = 1 and the second with confidence level = 2.

22.6–36.4 m

PDZ1: An increased number of sealed fractures and twelve sealed networks with a total length of 5.06 m. Predominating minerals in open fractures are calcite, chlorite and laumontite and in sealed fractures calcite, laumontite, chlorite and hematite. Apertures are generally ≤ 0.5 mm with a few apertures ranging up to 1 mm. Two brecciated fault rocks at 29.54 and 32.22 m, with widths of 30 and 7 cm and approximate orientations of 015°/60° and 030°/55°, respectively. Host rock is pegmatitic granite (101061).

The intervals at 23.0–24.5 and 29.2–33.4 m show decreased resistivity down to 1 700 Ωm, and decreased P- and S-wave velocities.

Moyes transmissivity from single hole hydraulic tests was found to be 1.3×10^{-6} m^2/s from three 6 m sections in the interval 20–38 m. The most transmissive section is between 20–26 m, having a value of 1.1×10^{-6} m^2/s. Confidence level = 1.

147.1–175.5 m

PDZ2: Increased number of sealed fractures and fourteen sealed networks with a total length of 6.48 m. Predominating minerals in open fractures are calcite, clay minerals, chlorite and laumontite and in sealed calcite, laumontite hematite and chlorite. Several fractures with apertures ranging up to 4 mm. The majority of the open fractures are moderately or highly altered. Several very thin, 1–2 mm, cataclastic fault rocks and one 15 cm wide brecciated fault rock. Shorter intervals of oxidation, argillization and chloritization. Host rocks is fine- to medium-grained granite (111058) with subordinate occurrences of medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061).

There are several anomalies with very low resistivities (under 1 000 Ωm) located at 148.8, 150.6, 153.2, 158.4, 161.4, 164.0, 168.0 and 170.2 m, which often coincides with prominent caliper anomalies and decreased P-and S-wave velocities.

Moyes transmissivity from single hole hydraulic tests is 5×10^{-9} m^2/s from five 6 m sections in the interval 144.7–172.5 m. Confidence level = 2.

5.3 KFR119

The borehole consists of three rock units, RU1–RU3. RU1 occurs in three separate length intervals as RU1a to RU1c, and RU3 in two length intervals as RU3a and RU3b.

9.03–32.81 m

RU1a: Pegmatitic granite (101061) and one subordinate occurrence of medium-grained metagranite-granodiorite (101057) with abundant pegmatitic veins. Confidence level = 3.

32.81–56.11 m

RU2: Fine- to medium-grained metagranitoid (101051) and one subordinate occurrence of pegmatitic granite (101061). Confidence level = 3.

56.11–91.40 m

RU3a: Medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061) in alternating intervals. The metagranite-granodiorite (101057) have abundant pegmatitic veins. Confidence level = 3.

91.40–123.31 m

RU1b: Pegmatitic granite (101061) with two subordinated occurrences of fine- to medium-grained granite (111058). Confidence level = 3.

123.31–149.20 m

RU3b: Medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061). All three intervals of metagranite-granodiorite (101057) have abundant thin pegmatitic veins. Confidence level = 3.

149.20–176.47 m

RU1c: Pegmatitic granite (101061) and one subordinate occurrence of fine- to medium-grained granite (111058) and one occurrence of medium-grained metagranite-granodiorite (101057). Confidence level = 3.

Possible deformation zones

Two PDZs have been interpreted in KFR119. The first with confidence level = 1 and the second with confidence level = 2.

94.0–107.0 m

PDZ1: Increased number of sealed fractures and four sealed networks with a total length of 3.13 m. Predominating minerals in open fractures are calcite, chlorite and laumontite and in sealed fractures calcite, laumontite and oxidized walls. All apertures are ≤ 0.5 mm. Four minor brecciated fault rocks with widths ranging from 2 to 16 cm and the approximate orientations 035°/45°, 260°/85°, 030°/60° and 035°/65°. Three of the fault rocks are altered by laumontitization. Host rocks for PDZ1 are pegmatitic granite (101061) and fine- to medium-grained granite (111058).

Three intervals at 96.6–100.1, 101.4–103.6 and 105.6–107.0 m show decreased resistivity down to 2 800 Ωm and decreased P- and S-wave velocities.

Moyes transmissivity from single hole hydraulic tests is 5×10^{-8} m^2/s from three 6 m sections in the interval 92.2–110.2 m. Difference flow logging showed two flow anomalies at 97.3 and 98.6 m, both with transmissivities of 4×10^{-8} m^2/s. Confidence level = 1.

164.0–176.47 m

PDZ2: Increased frequency of sealed fractures and three sealed networks with a total length of 4.63 m. Dominating minerals in open fractures are calcite, chlorite and oxidized walls, and in sealed fractures calcite and chlorite. All apertures are ≤ 0.5 mm. One cataclastic and two brecciated fault rocks in the interval 164.7–169.7 m with widths of 2, 36 and 4 cm, respectively. The first two fault rocks have the approximate orientations 090°/45° and 015°/65°. The third fault rock does not fully intersect the borehole and has an uncertain orientation. Two narrow intervals are altered by laumontitization, of which one is a fault rock. One minor occurrence of amphibolite (102017) is altered by chloritization. Host rocks is pegmatitic granite (101061), medium-grained metagranite-granodiorite (101057) and fine- to medium-grained granite (111058).

The resistivity and P-and S-velocities are decreased in a predominant part of this interval having maxima at sections 166.7–168.7 and 172.7–174.6 m.

Moyes transmissivity from single hole hydraulic tests is 1×10^{-9} m^2/s from two 6 m sections in the interval 161.6–173.6 m. Difference flow logging showed no anomalies. Confidence level = 2.

5.4 KFR120

The borehole consists of five rock units, RU1–RU5. RU1–RU3 occurs in two separate length intervals, marked as a and b.

12.00–51.56 m

RU1a: Medium-grained metagranite-granodiorite (101057) with alternating occurrences of pegmatitic granite (101061). The metagranite-granodiorite (101057) have abundant pegmatitic veins. An increased magnetic susceptibility is seen for the medium-grained metagranite-granodiorite (101057) in the interval 47.90–50.80 m. Confidence level = 3.

51.56–75.17 m

RU2a: Fine- to medium-grained granite (111058) with subordinate occurrences of medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061). The fine- to medium-grained granite (111058) have an increased magnetic susceptibility up to $1\,400 \times 10^{-5}$ SI. Confidence level = 3.

75.17–84.13 m

RU3a: Amphibolite (102017) with one subordinate occurrence of pegmatitic granite (101061). Local alteration by faint to weak albitization and muscovitization. Confidence level = 3.

84.13–101.53 m

RU2b: Fine- to medium-grained granite (111058) with subordinate occurrences of medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061). An increased magnetic susceptibility is seen for the fine- to medium-grained granite (111058). Confidence level = 3.

101.53–129.72 m

RU4: Pegmatitic granite (10106). Confidence level = 3.

129.72–143.41 m

RU5: Medium-grained metagranite-granodiorite (101057), pegmatitic granite (101061) and fine- to medium-grained granite (111058). Confidence level = 3.

143.41–163.22 m

RU3b: Amphibolite (102017) with one subordinate occurrence of pegmatitic granite (101061). Confidence level = 3.

163.22–176.91 m

RU1b: Medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061). The metagranite-granodiorite (101057) have abundant pegmatitic veins. Confidence level = 3.

Possible deformation zones

Two PDZs have been interpreted in KFR120. The first with confidence level = 1 and the second with confidence level = 2.

61.0–74.0 m

PDZ1: Increased frequency of sealed fractures and nine sealed networks with a total length of 2.72 m. Predominant minerals in open fractures are calcite, chlorite and laumontite and in sealed fractures calcite, laumontite, oxidized walls and chlorite. Fracture apertures are generally ≤ 0.5 mm. Four thin (c 1–8 cm) brecciated fault rocks with an approximate orientation of 045°/50° and one cataclastic fault rock (c 1 cm) with orientation 350°/65°. Shorter intervals of argillization, oxidation, chloritization and laumontitization. Host rocks is fine- to medium-grained granite (111058), medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061).

The resistivity is decreased to 1 500 Ωm in two intervals at 61.0–64.1 and 68.0–70.6 m, which coincides with decreased P- and S-wave velocities. The average resistivity for the entire PDZ is 10 500 Ωm. The upper part of the PDZ1 has increased magnetic susceptibility with values up to 440 SI 10^{-5}.

Moyes transmissivity from single hole hydraulic tests is 4×10^{-7} m^2/s from three 6 m sections in the interval 60.5–78.5 m. The most transmissive interval is between 60.5–66.5 m, having a value of 3.6×10^{-7} m^2/s. Confidence level = 1.

129.70–173.0 m

PDZ2: A slight increased frequency of sealed fractures and 28 sealed networks with a total length of 8.59 m. Predominant minerals in both open and sealed fractures, but in different proportions, are chlorite, calcite, laumontite, hematite and oxidized walls. Fracture apertures are generally ≤ 0.5 mm with a few ranging up to 2.5 mm. Eight thin (0.6–2.3 cm) brecciated fault rocks with an approximate orientation of 085°/45°. Oxidation is affecting ca 4.5 m of the interval and additional minor alterations are muscovitization, argillization, chloritization and laumontitization. Host rocks are pegmatitic granite (101061), medium-grained metagranite-granodiorite (101057), amphibolite (102017) and fine- to medium-grained granite (111058).

The resistivity shows two major minima at lengths 137.9–142.1 and 160.9–165.1 m with values down to 1 800 Ωm. These minima coincide with decreased P- and S-wave velocities. The average resistivity for the whole PDZ is 17 000 Ωm. There are two intervals with increased magnetic susceptibility at 144.3–148.4 and 154.3–163.5 m with values up to $3\,500 \times 10^{-5}$ SI.

Moyes transmissivity from single hole hydraulic tests is 8×10^{-8} m^2/s from nine 6 m sections in the interval 125.5–175 m. Confidence level = 2.

5.5 KFR121

The borehole consists of five rock units, RU1–RU5. RU1, RU3 and RU4 occurs in three separate length intervals marked with a to c, RU2 in two length intervals as RU2a and RU2b.

41.13–68.78 m

RU1a: Medium-grained metagranite-granodiorite (101057) with three minor (< 1 m) amphibolitic (102017) occurrences and abundant pegmatitic (101061) veins. The metagranite-granodiorite (101057) is altered by faint to medium albitization in the most upper part, and by muscovitization in two intervals in the lower half. Confidence level = 3.

68.78–95.79 m

RU2a: Amphibolite (102017) and medium-grained metagranite-granodiorite (101057) with two subordinate occurrences of pegmatitic granite (101061) and one occurrence of fine- to medium-grained metagranitoid (101051). Both the metagranite-granodiorite (101057) and pegmatitic granite (101061) are altered by muscovitization in the lower half of RU2a. The amphibolite shows increased magnetic susceptibility with values up to $14\,000 \times 10^{-5}$ SI. Confidence level = 3.

95.79–112.72 m

RU1b: Medium-grained metagranite-granodiorite (101057) with abundant pegmatitic (101061) veins. The metagranite-granodiorite (101057) is extensively altered by muscovitization and faint albitization. Confidence level = 3.

112.72–131.17 m

RU3a: Pegmatitic granite (101061). Confidence level = 3.

131.17–152.43 m

RU1c: Medium-grained metagranite-granodiorite (101057) with several minor occurrences (< 1 m) of amphibolite (102017) and abundant pegmatitic veins (101061). Extensive faint albitization of the metagranite-granodiorite (101057). Confidence level = 3.

152.43–175.74 m

RU4a: Medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061). The metagranite-granodiorite (101057) have minor occurrences of amphibolite (< 1 m) and abundant veins of pegmatitic granite (101061). The metagranite-granodiorite (101057) is locally altered by faint albitization. Confidence level = 3.

175.74–198.08 m

RU2b: Medium-grained metagranite-granodiorite (101057) and amphibolite (102017). The metagranite-granodiorite (101057) have minor occurrences (< 1 m) of pegmatitic granite (101061) and amphibolite (102017) and is extensively altered by muscovitization and faint to weak albitization. The amphibolite in the upper part shows increased magnetic susceptibility with values up to $8\,800 \times 10^{-5}$ SI. Confidence level = 3.

198.08–225.95 m

RU3b: Pegmatitic granite (101061) with two subordinate occurrences of medium-grained metagranite-granodiorite (101057). Confidence level = 3.

225.95–251.55 m

RU4b: Medium-grained metagranite-granodiorite (101057) and one subordinate occurrence of pegmatitic granite (101061). Several minor (< 1 m) occurrences of amphibolite (102017) and abundant veins of pegmatitic granite (101061). Extensive faint to medium albitization of the metagranite-granodiorite. Confidence level = 3.

251.55–273.67 m

RU5: Felsic- to intermediate metavolcanic rock (103076) and one subordinate occurrence of amphibolite (102017) and medium-grained metagranite-granodiorite (101057). Local albitization of the metagranite-granodiorite (101057). Confidence level = 3.

273.67–323.12 m

RU4c: Medium-grained metagranite-granodiorite (101057), pegmatitic granite (101061) and one subordinate occurrence of fine- to medium-grained granite (111058). Some minor (< 1 m) occurrences of amphibolite (102017) and abundant veins of pegmatitic granite (101061). Confidence level = 3.

323.12–362.53 m

RU3c: Pegmatitic granite (101061). Confidence level = 3.

Possible deformation zones

Four PDZs have been interpreted in KFR121. The first and third PDZ have confidence level = 2 and the second and fourth confidence level = 3.

89.0–100.0 m

PDZ1: An increased frequency of mainly sealed fractures and sealed fracture networks, but also a slight increase of open fractures. The four sealed networks have a total length of 4.8 m. Predominant minerals in open fractures are calcite, hematite and oxidized walls and in sealed fractures oxidized walls, calcite, laumontite and hematite. Apertures are generally ≤ 0.5 mm, with a few apertures in the range 1–2.5 mm. One brecciated fault rock at 94.20–94.30 m, altered by laumontitization. Locally weak to medium oxidation in the interval 93.83–94.42 and 95.80–96.75 m. Host rocks are metagranite-granodiorite (101057) and amphibolite (102017).

The resistivity is decreased with average values of 4 500 Ωm. The P- and S-wave velocities are generally low with three shorter intervals with very low P-velocity values down to 3 700 m/s. There is one caliper anomaly connected to the lowest P-velocity. The magnetic susceptibility is low.

Difference flow logging showed ten flow anomalies with a summed transmissivity of 2×10^{-7} m^2/s.

Confidence level = 2.

131.0–149.0 m

PDZ2: Increased frequency of sealed fractures and four sealed networks with a total length of 7.5 m. Predominant minerals in open fractures are calcite, oxidized walls, chlorite and laumontite and in sealed fractures oxidized walls, calcite and laumontite. All apertures but one are ≤ 0.5 mm. Extensive alteration with oxidation, albitization, muscovitization, laumontitization, steatitization and chloritization. Three minor brecciated fault rocks in the interval 135.7–136.8 m, approximately oriented 240°/80°, 200°/85° and 040°/60°. Host rock is metagranite-granodiorite (101057).

The resistivity shows two major minima at lengths 134.8–139.4 and 142.5–147.1 m, with values down to 790 Ωm. These minima coincide with decreased P- and S-wave velocities. The average resistivity for the whole PDZ is 17 000 Ωm. There are three caliper anomalies connected to the lowest P-velocity. The magnetic susceptibility is low.

Difference flow logging showed one flow anomaly at 148.8 with a transmissivity of 3×10^{-8} m^2/s. Confidence level = 3.

225.0–233.0 m

PDZ3: Increased frequency of sealed fractures, primarily by one extensive sealed network at 226.95–232.06 m. A slight increased frequency also for open fractures. Predominant minerals in open fractures are chlorite, calcite, laumontite and oxidized walls and in sealed fractures laumontite, oxidized walls and calcite. All open fractures have apertures ≤ 0.5 mm. The only alteration is extensive albitization of the metagranite-granodiorite (101057). Host rocks are metagranite-granodiorite (101057) and pegmatitic granite (101061).

The resistivity shows three minima down to 1800 Ωm, with an average of 10000 Ωm. The P-velocity is slightly decreased to 4800 m/s in the upper half, and a S-velocity minimum at 232.3 m that coincides with a small caliper anomaly. The magnetic susceptibility is low.

Difference flow logging showed five flow anomalies with a summed transmissivity of 5×10^{-8} m^2/s. Confidence level = 2.

276.8–337.0 m

PDZ4: Increased frequency of open, sealed and sealed fracture networks. The sealed fracture networks have a total length of 23.9 m. The core of the possible deformation zone is defined at 289.8–303.1 m and is characterized by one crushed interval at 289.83–290.00 m and three brecciated fault rocks at 291.79–291.88, 292.22–292.60 and 302.95–303.04 m, approximately oriented 040°/60°, 250°/80° and 025°/55°. The zone core is intensively and extensively altered by oxidation, laumontitization and argillization and with a higher proportion of moderately- and highly altered fractures. The deformation zone outside the core is primarily characterized by an increase of sealed fractures and shorter intervals of oxidation, laumontitization and chloritization. One crushed interval at 326.32–327.54 m. The most fractured and altered interval of the crush is missing in a core loss. Predominant minerals in open fractures are calcite, laumontite, oxidized walls and chlorite and in sealed fractures oxidized walls, laumontite and calcite. Apertures are generally ≤ 0.5 mm, with a few apertures in the range 1–2.5 mm. Host rocks are metagranite-granodiorite (101057) and pegmatitic granite (101061).

The resistivity shows major minima at length 289.7–300.5 m, and several additional shorter intervals with the minimum 147 Ωm. These coincides with decreased P- and S-wave velocities and are coupled with large caliper anomalies. The average resistivity is 7000 Ωm. The magnetic susceptibility is low.

Difference flow logging showed fifteen flow anomalies with a summed transmissivity of 8×10^{-6} m^2/s. The flow anomalies with the highest transmissivities are 1×10^{-6} m^2/s at 321.9 m and 6×10^{-6} m^2/s at 327.5 m. Confidence level = 3.

References

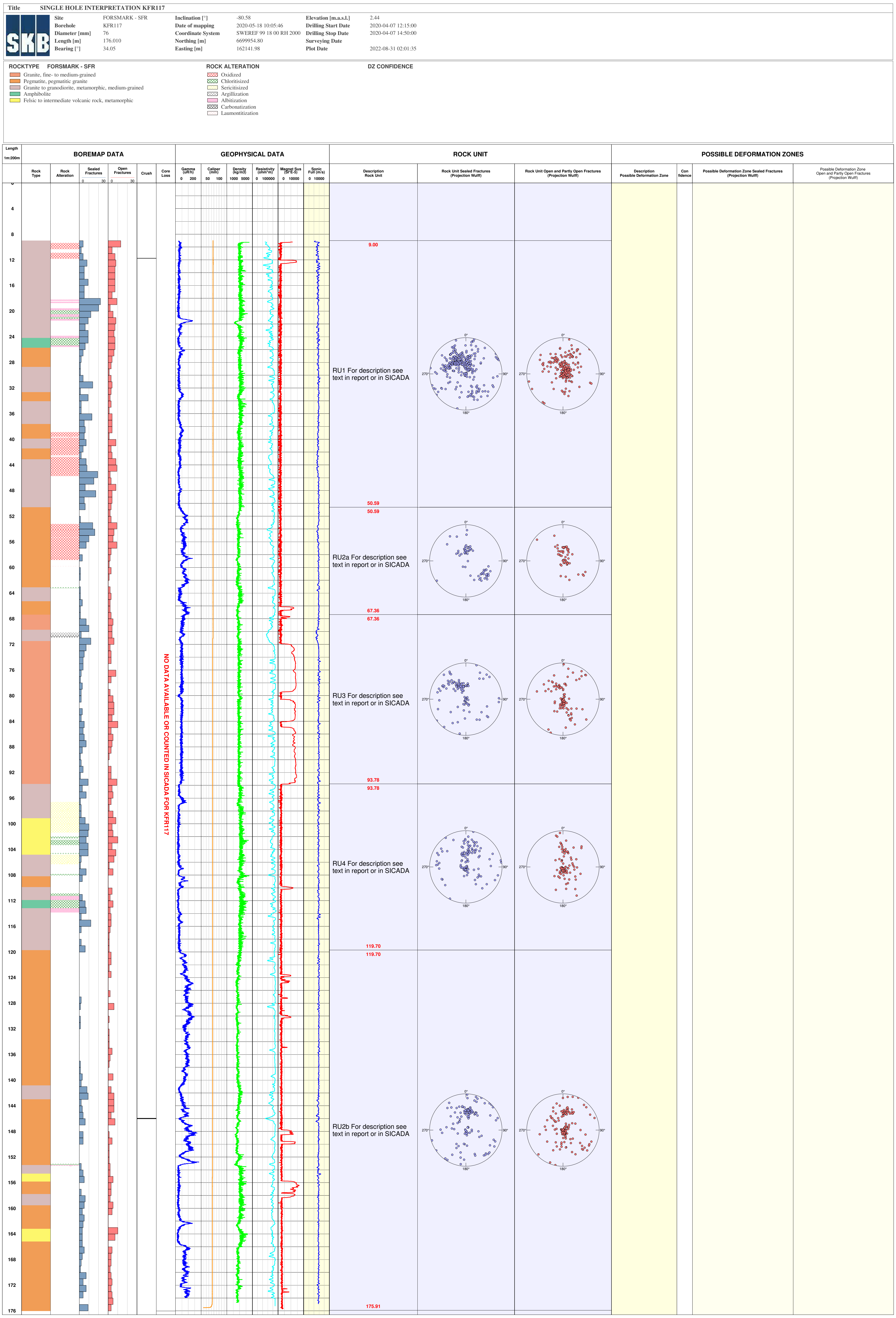
SKB's (Svensk Kärnbränslehantering AB) publications can be found at www.skb.com/publications.

Moye D G, 1967. Diamond drilling for foundation exploration. Civil Engineering Transactions, Institution of Engineers, Australia, 95–100.

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.

Appendix

WellCAD-plots of the SHI for KFR117–KFR121



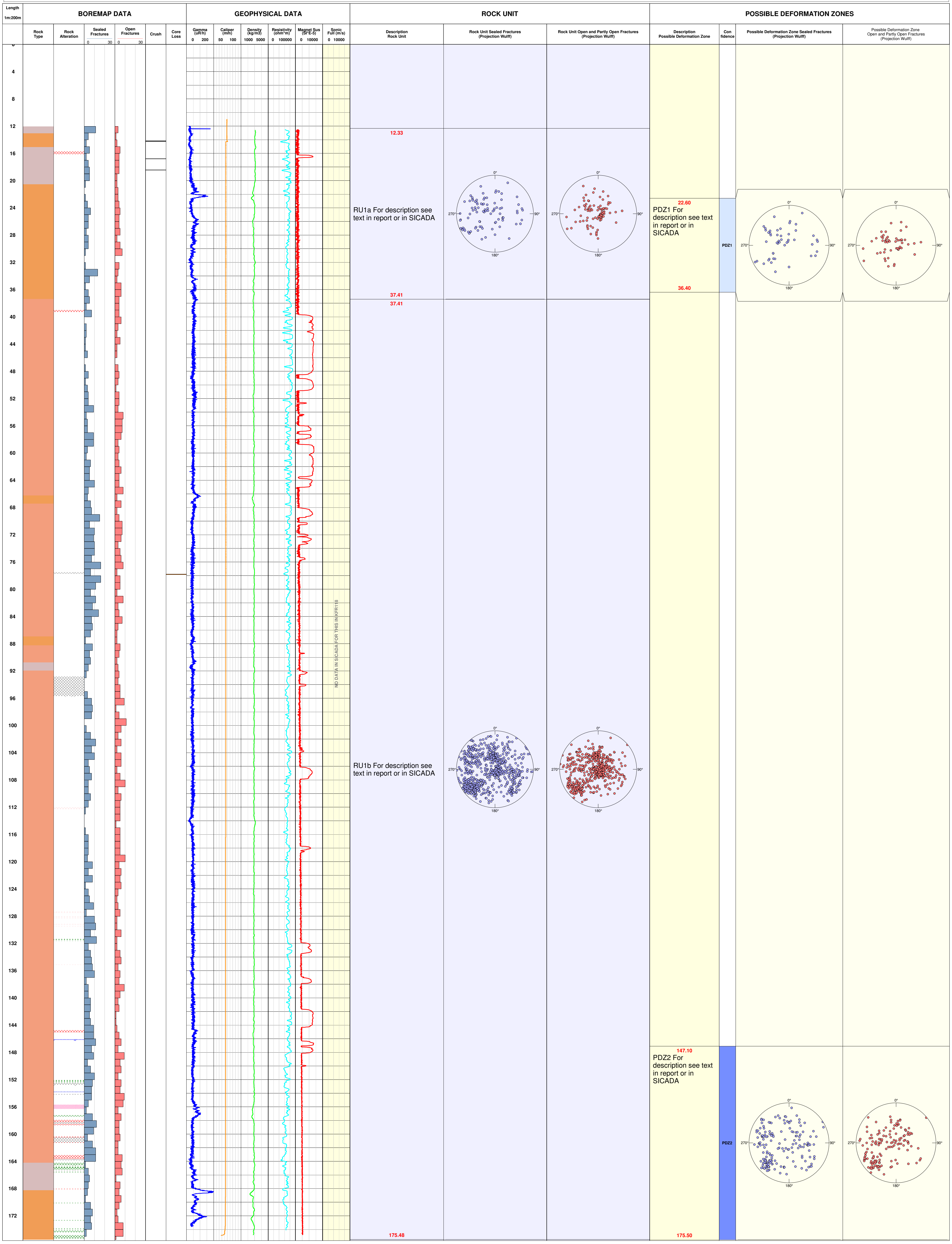
Title SINGLE HOLE INTERPRETATION KFR118

Site	FORSMARK - SFR	**Inclination [°]**	-85.58	**Elevation [m.a.s.l.]**	3.16
Borehole	KFR118	**Date of mapping**	2020-06-22 14:08:09	**Drilling Start Date**	2020-04-07 15:00:00
Diameter [mm]	76	**Coordinate System**	SWEREF 99 18 00 RH 2000	**Drilling Stop Date**	2020-04-07 18:00:00
Length [m]	175.480	**Northing [m]**	6699934.01	**Surveying Date**	
Bearing [°]	236.00	**Easting [m]**	162132.41	**Plot Date**	2022-08-31 02:01:35

ROCKTYPE FORSMARK - SFR
- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granite to granodiorite, metamorphic, medium-grained

ROCK ALTERATION
- Oxidized
- Chloritisized
- Argillization
- Albitization
- Saussuritization
- Laumontitization

DZ CONFIDENCE
- Confidence 1
- Confidence 2

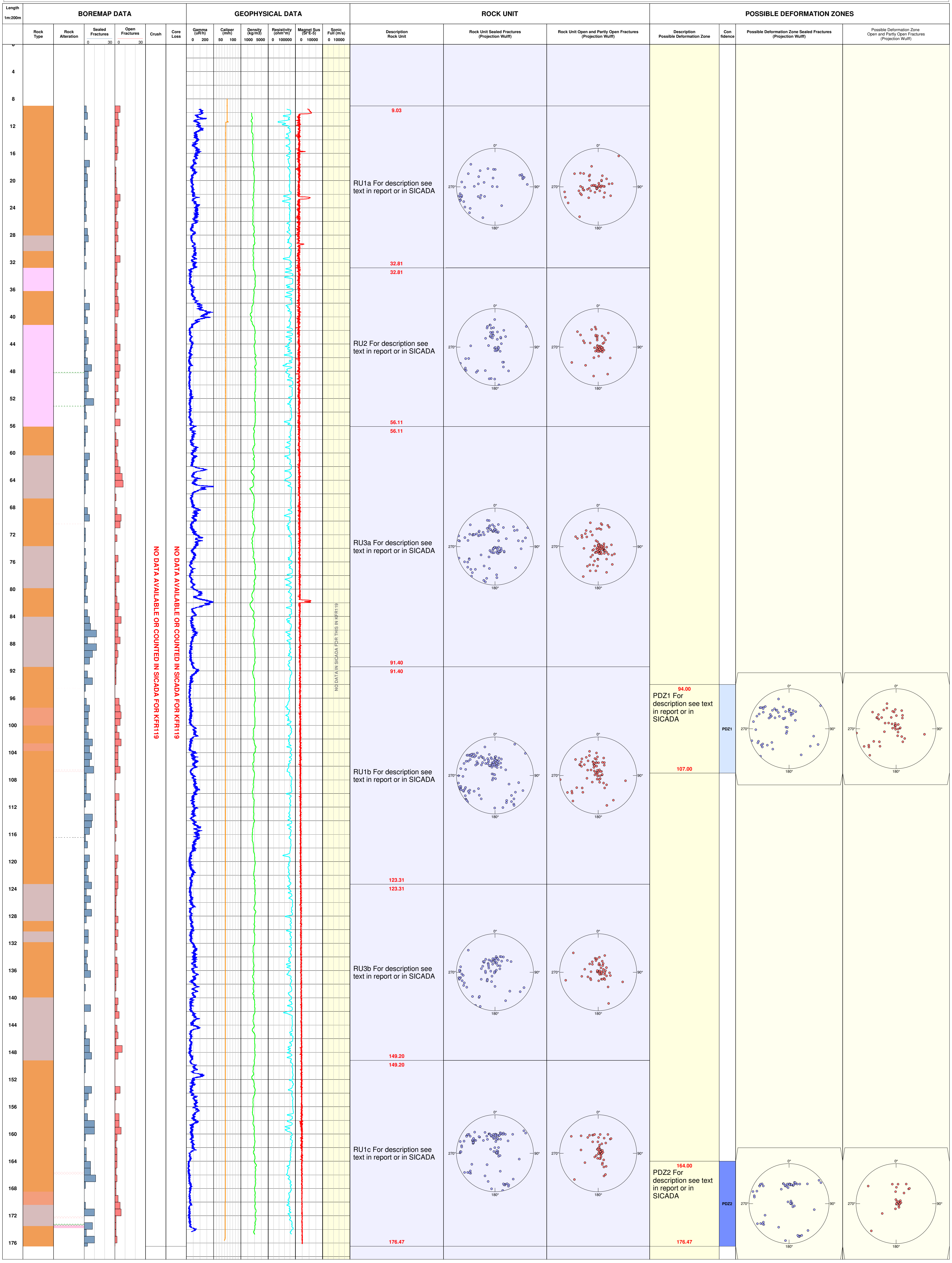


Title	SINGLE HOLE INTERPRETATION KFR119				
Site	FORSMARK - SFR	Inclination [°]	-80.78	Elevation [m.a.s.l.]	3.10
Borehole	KFR119	Date of mapping	2020-06-25 07:56:46	Drilling Start Date	2020-04-07 08:15:00
Diameter [mm]	76	Coordinate System	SWEREF 99 18 00 RH 2000	Drilling Stop Date	2020-04-07 11:15:00
Length [m]	176.470	Northing [m]	6699929.31	Surveying Date	
Bearing [°]	210.48	Easting [m]	162210.71	Plot Date	2022-08-31 02:01:35

ROCKTYPE FORSMARK - SFR
- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite to granodiorite, metamorphic, medium-grained

ROCK ALTERATION
- Oxidized
- Chloritisized
- Albitization
- Carbonatization
- Laumontitization

DZ CONFIDENCE
- Confidence 1
- Confidence 2



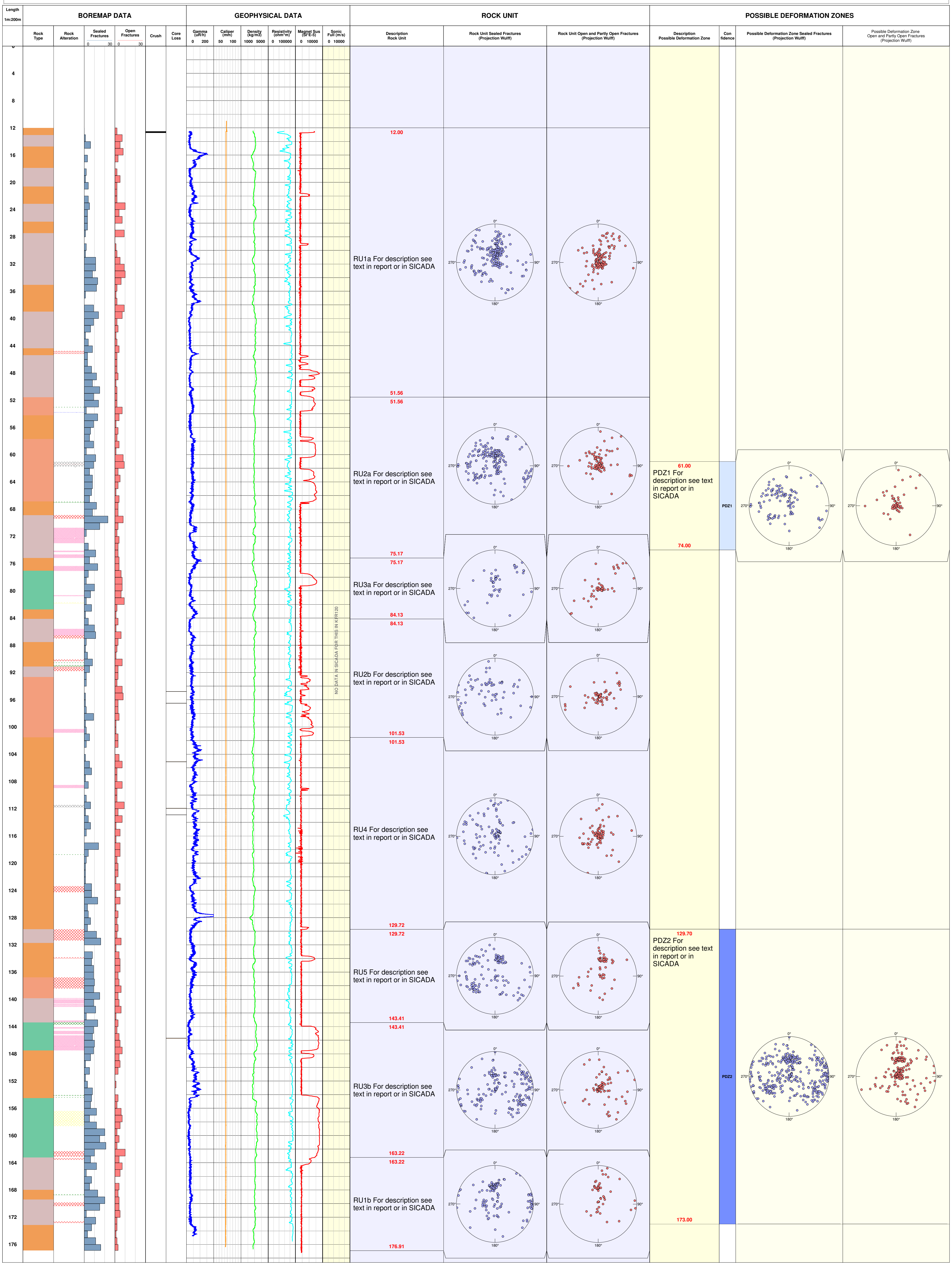
Title SINGLE HOLE INTERPRETATION KFR120

Site	FORSMARK - SFR	**Inclination [°]**	-79.87	**Elevation [m.a.s.l.]**	3.19
Borehole	KFR120	**Date of mapping**	2020-09-28 11:52:48	**Drilling Start Date**	2020-04-06 08:15:00
Diameter [mm]	76	**Coordinate System**	SWEREF 99 18 00 RH 2000	**Drilling Stop Date**	2020-04-06 18:45:00
Length [m]	176.910	**Northing [m]**	6699930.77	**Surveying Date**	
Bearing [°]	37.41	**Easting [m]**	162256.47	**Plot Date**	2022-08-31 02:01:35

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

ROCK ALTERATION
- Oxidized
- Chloritisized
- Sericitisized
- Argillization
- Albitization
- Saussuritization
- Laumontitization

DZ CONFIDENCE
- Confidence 1
- Confidence 2



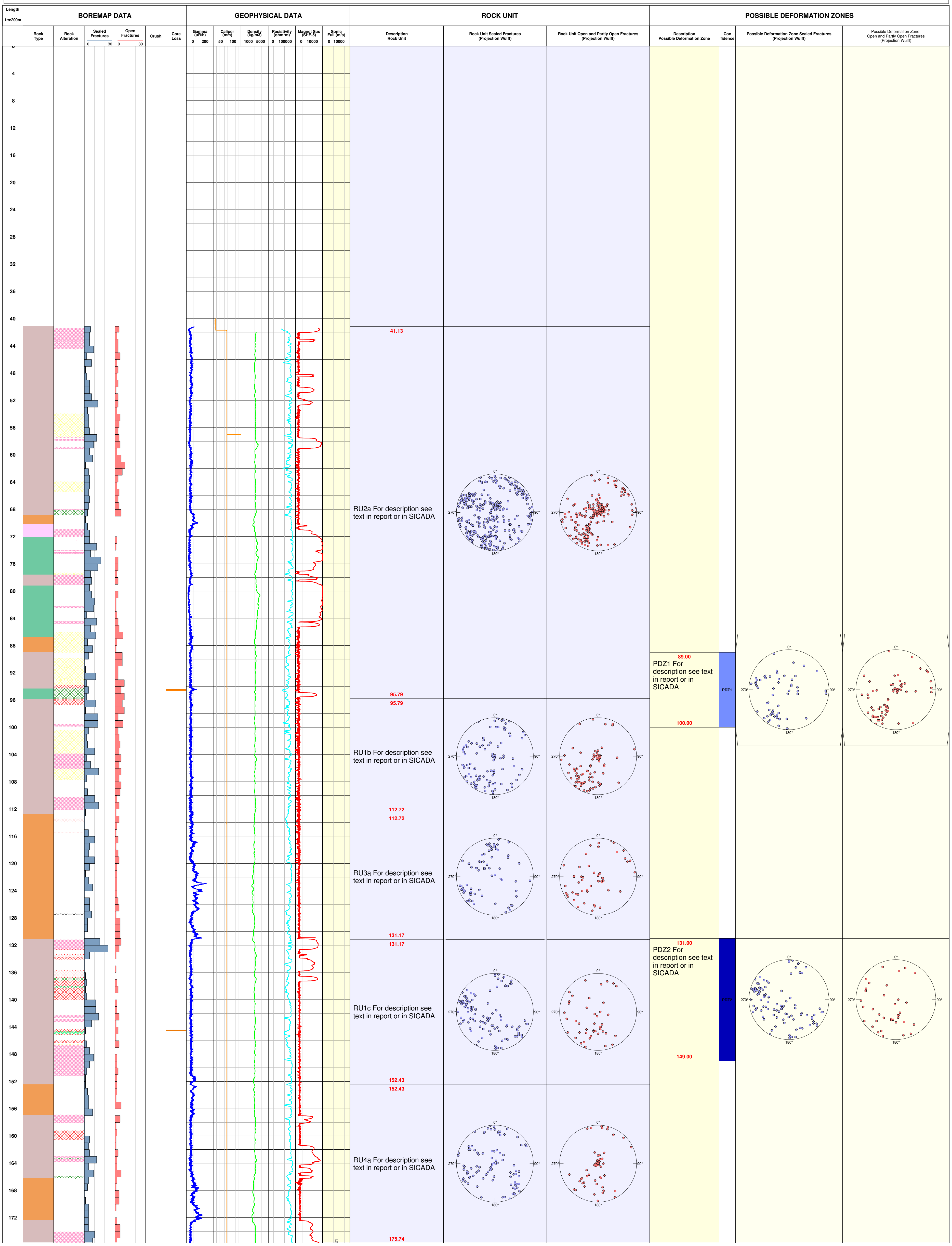
Title SINGLE HOLE INTERPRETATION KFR121

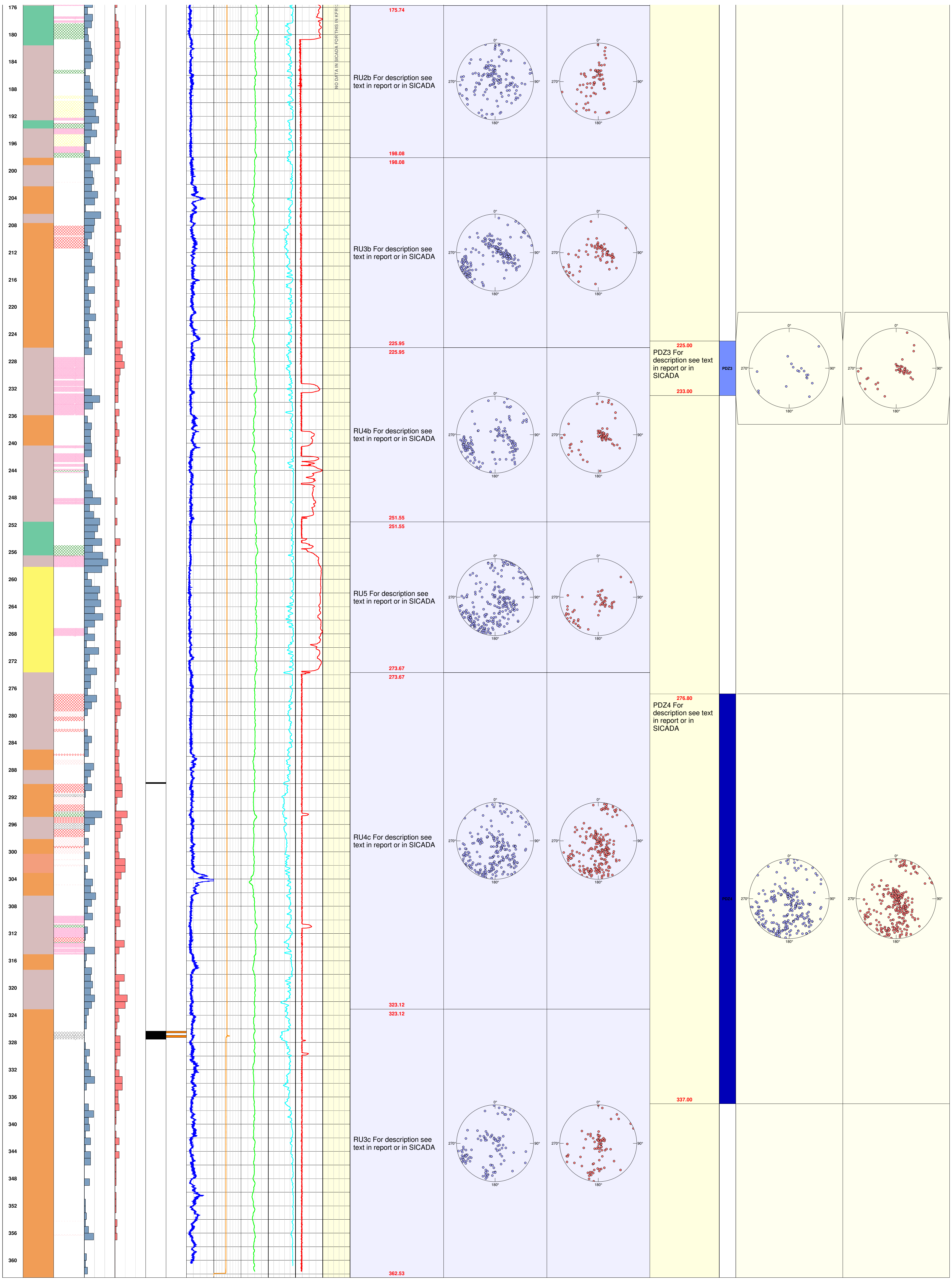
Site	FORSMARK - SFR	**Inclination [°]**	-52.44	**Elevation [m.a.s.l.]**	2.87
Borehole	KFR121	**Date of mapping**	2020-09-08 16:11:27	**Drilling Start Date**	2020-03-31 09:00:00
Diameter [mm]	76	**Coordinate System**	SWEREF 99 18 00 RH 2000	**Drilling Stop Date**	2020-04-30 09:45:00
Length [m]	362.530	**Northing [m]**	6699919.24	**Surveying Date**	
Bearing [°]	215.97	**Easting [m]**	162420.29	**Plot Date**	2022-08-31 02:01:35

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

ROCK ALTERATION
- Oxidized
- Chloritisized
- Sericitisized
- Argillization
- Albitization
- Carbonatization
- Steatitization
- Laumontitization

DZ CONFIDENCE
- Confidence 2
- Confidence 3





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180°
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Arkitektkopia AB, Bromma, 2022

SKB is responsible for managing spent nuclear fuel and radioactive waste produced by the Swedish nuclear power plants such that man and the environment are protected in the near and distant future.

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