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Site investigation SFR

Boremap mapping of core drilled borehole KFR106

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June 2010

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Abstract

This report presents the result from the Boremap mapping of the core drilled borehole KFR106, drilled from an islet ca 220 m southeast of the pier above SFR. The borehole has a length of 300.13 m, and a bearing and inclination of 195.1° and –69.9°, respectively. The purpose of the location and orientation of the borehole is to investigate the possible occurrence of gently dipping, water-bearing structures in the area.

The geological mapping is based on simultaneous study of drill core and borehole image (BIPS). The two lowermost meters of the drill core was mapped in Boremap without access to complementary BIPS-image.

The dominating rock type, which occupies 72% of KFR106, is fine- to medium-grained, metagranite-granodiorite (rock code 101057), which is foliated with a medium to strong intensity. Pegmatite to pegmatitic granite (rock code 101061) is the second most common rock type and it occupies 16% of the mapped interval. It is also frequent as smaller rock occurrences (< 1 m) in other rock types throughout the borehole. Subordinate rock types are fine- to medium-grained granite (rock code 111058), felsic to intermediate metavolcanic rock (rock code 103076), fine- to medium-grained metagranitoid (rock code 101051) and amphibolite (rock code 102017).

Totally 49% of the rock in KFR106 has been mapped as altered, where muscovitization and oxidation is the two most common. Additional shorter intervals of alterations are in decreasing order of abundance quartz dissolution, epidotization, argillization, albitization, chloritization, laumontization and carbonatization.

A total number of 2801 fractures are registered in KFR106. Of these are 1059 open, 1742 sealed and 84 partly open. This result in the following fracture frequencies: 6.0 sealed fractures/m, 3.7 open fractures/m and 0.3 partly open fractures/m. In addition there are 5 narrow brecciated zones, and 20 sealed networks with a total length of 18 m.

The most frequent fracture fillings in KFR106 are calcite, chlorite, quartz, muscovite, laumontite and clay minerals. Oxidized walls occur along 43% of the fractures.

There are one dominating set each of open and sealed fractures in KFR106 oriented 055°/05° and 290°/80°, respectively. In addition there are three vaguely defined sets of sealed fractures; one coincides with the open fracture set and the other two are oriented 035°/70° and 225°/85°.

There are 7 crushed intervals (drill-induced excluded) in KFR106, with a total length of 31 cm.

Sammanfattning

Denna rapport presenterar resultatet från Boremapkarteringen av kärnborrhål KFR106, borrat från en kobbe ca 220 m sydost om piren över SFR. Borrhålets längd är 300,13 m med en bäring och inklination på 195,1° respektive –69,9°. Syftet med läge och orientering på borrhålet är att karaktärisera berget på djupet under en utbyggnad av SFR, och utreda den eventuella förekomsten av flackt stupande, vattenförande strukturer i området.

Den geologiska karteringen baseras på simultan undersökning av borrkärna och borrhålsbild (BIPS). De sista två metrarna av borrkärnan har karterats utan tillgång till BIPS-bild.

Den dominerande bergarten, som utgör 72 % av KFR106, är fin- till medelkornig metagranit-granodiorit (bergartskod 101057), vilken är folierad med medelstark till stark intensitet. Pegmatit till pegmatitisk granit (bergartskod 101061), som upptar 16 % av det karterade intervallet, är den näst vanligaste bergarten. Den förekommer även frekvent i hela borrhålet som kortare förekomster (< 1 m) i andra bergarter. Underordnade bergarter är fin- till medelkornig granit (bergartskod 111058), felsisk till intermediär metavulkanit (bergartskod 103076), fin- till medelkornig metagranitoid (bergartskod 101051) och amfibolit (bergartskod 102017).

Totalt 49 % av berget i KFR106 är karterat som omvandlat, där muskovitisering och oxidation är vanligast. Ytterligare kortare partier med omvandlingar är i minskande ordning kvartsupplösning, epidotisering, leromvandling, albitisering, kloritisering, laumontitisering och karbonatisering.

Antalet registrerade sprickor i KFR106 är 2 801 stycken. Av dessa är 1 059 öppna, 1 742 läkta och 84 delvis öppna. Den resulterande sprickfrekvensen är 6,0 läkta sprickor/m, 3,7 öppna sprickor/m och 0,3 delvis öppna sprickor/m. Dessutom finns det 5 mindre breccierade zoner och 20 läkta spricknätverk med en total längd av 18 m.

De vanligaste sprickmineralen i KFR106 är kalcit, klorit, kvarts, muskovit, laumontite och lermineral. Oxiderat sidoberg förekommer längs 43 % av alla sprickor.

Det finns två förhärskande sprickgrupper i KFR106: en orienterad 055°/05°, som domineras av öppna sprickor, och en orienterad 290°/80° som domineras av läkta sprickor. Dessutom finns ytterligare tre vagt definierade grupper av läkta sprickor. En av dem sammanfaller med den öppna sprickgruppen och de andra två har orienteringar på 035°/70° and 225°/85°.

Det finns 7 sektioner med kross i KFR106 (borrinducerade krossar exkluderade), med en total längd på 31 cm.

Contents

1 Introduction

To be able to host the waste that will arise from closure of the nuclear power plants in the future, SKB intends to extend the existing repository for low- and intermediate-level radioactive waste in Forsmark (SFR). The existing repository, the first of its kind in the world, was ready for operation in 1988. The extension is estimated to be completed in 2020.

A lot of information about the bedrock and groundwater has been gathered during the building of SFR, but some complementary studies are necessary. This document reports the data gained by the Boremap mapping of the core drilled borehole KFR106, which is one of the activities performed within the site investigation at SFR. The borehole KFR106 has a length of 300.13 m and is drilled from an islet located ca 220 m southeast of the pier above SFR (Figure 1-1), and has a bearing and inclination of 195.1° and –69.9°, respectively.

The work was carried out in accordance with activity plan AP SFR-09-027, and controlling documents for this activity are listed in Table 1-1. Both activity plan and method descriptions are SKB's internal controlling documents.

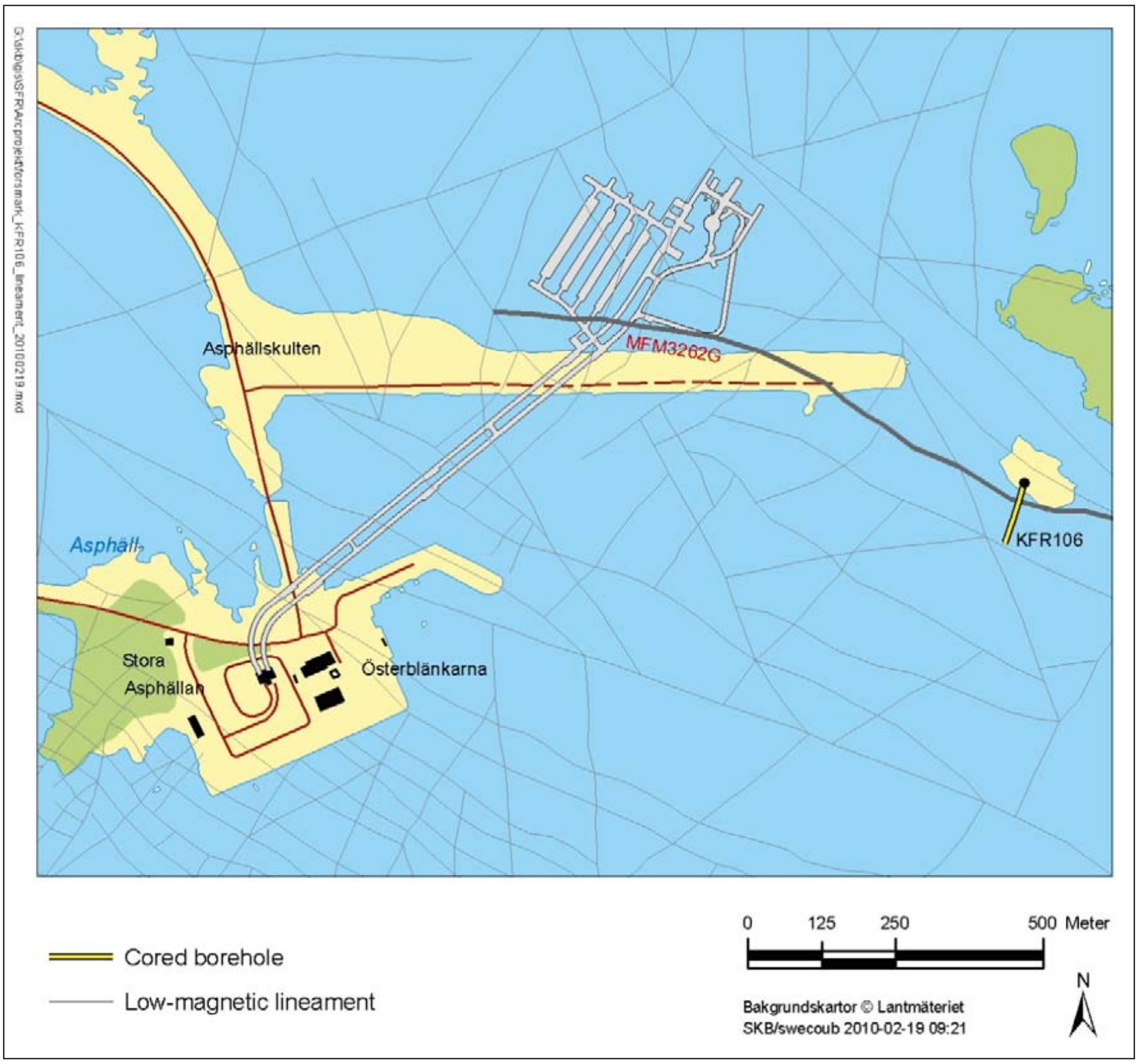

Figure 1-1. *Location of the core drilled borehole KFR106 in relation to SFR. One lineament, expected to intersect the borehole, is highlighted.*

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

Activity plan	Number	Version
Boremapkartering av kärnborrhål KFR106	AP SFR-09-027	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för Boremapkartering	SKB MD 143.006	2.0
Metodbeskrivning för TV-loggning med BIPS	SKB MD 222.006	2.0
Mätsystembeskrivning för Boremap	SKB MD 146.005	1.0
Instruktion: Regler för bergarters benämningar vid platsundersökningen i Forsmark	SKB MD 132.005	1.0

After drilling in August 2009 the borehole was investigated with several logging methods, such as conventional geophysical logging and TV-logging. The latter method implies logging with a colour TV-camera to produce images of the borehole wall, so called BIPS-images (**B**orehole **I**mage **P**rocessing **S**ystem).

The borehole was mapped in the period October–November 2009. Mapping of cored borehole according to the Boremap method is based on simultaneous study of the drill core and the use of BIPS-images of the borehole wall.

The BIPS-image enables the study of fractures and their characteristics along the borehole. Strike and dip of planar structures such as fractures, foliations and rock contacts are calculated and documented with the Boremap method. Schematic presentation of the borehole is presented in a WellCAD-diagram (Appendix 1).

Original data from the reported activity are stored in the primary database Sicada, where they are traceable by the Activity Plan number (AP SFR-09-027). Only data in SKB's databases are accepted for further interpretation and modelling.

2 Objective and scope

The borehole KFR106 is drilled with the aim to investigate the possible occurrence of gently dipping, hydraulically active structures in the rock volume south-east of SFR. The location of the borehole makes it also possible to gather valuable hydrological and hydrochemical information about the bedrock, and to verify the geohydrological model. Lithologies, alterations, ductile structures and the occurrence and character of fractures in the bedrock penetrated by KFR106 were documented. Other data, such as groundwater level and groundwater flow will not be treated in this report.

3 Equipment

3.1 Description of equipment/interpretation tools

Mapping of the borehole based on BIPS-image is performed with the software Boremap v.3.9.6.4. Boremap software is loaded with the rock types and mineral standards used for surface mapping at the Forsmark site investigation, in order to enable correlation with the surface geology. Inclination, bearing and diameter of the borehole are used as in-data for the calculations. The BIPS-image length deviates from the true borehole length and adjustments are made on the basis of reference marks cut into the borehole wall after drilling.

Equipment used to facilitate the core mapping are folding rule, 10% hydrochloric acid, rock hardness tool, hand lens, rag and tap water.

3.1.1 Used BIPS-files and image quality

Information about the BIPS-file is listed in Table 3-1.

The following factors may disturb the mapping:

- Vertical bleached bands on the borehole wall from drill cuttings, either in suspension or after precipitation.
- Brownish coatings probably related to the drilling equipment.

The BIPS-image quality of the borehole KFR106 is generally good. A transparent and continuous vertical bleached band is observed along the entire BIPS-image.

The result from the BIPS-logging is presented in /1/. The interval 297.284–299.395 m (recorded length) is mapped without any complementary BIPS-image.

Table 3-1. Used BIPS-files

Borehole	BIPS-file	Logging date	Logging time	From recorded length (m)	To recorded length (m)
KFR106	KFR106_9-297m_20090921.BIP	2009-09-21	15:20:00	9.109	297.299

4 Execution

4.1 General

Boremap mapping of the core drilled borehole KFR106 is performed and documented according to activity plan AP SFR-09-027 (SKB, internal document). The mapping is supported by the geophysical logs of the borehole (Appendix 2).

The mapping was performed in accordance with the current SKB method descriptions (Table 1-1) and /2/. Information from earlier performed investigations in the area are also helpful in the interpretations /3, 4, 5, 6, 7, 8/.

4.2 Preparations

Background data collected from Sicada (Appendix 3) prior to the Boremap mapping included:

- Borehole direction surveying,
- borehole diameter,
- reference marks in the borehole.

These background data, except for borehole diameter, are imported from Sicada by semiautomatic routines.

General information about the borehole is listed in Table 4-1 and applied length adjustments are listed in Table 4-2.

4.3 Execution of meaurements

4.3.1 Fracture definitions

Definitions of different fracture types and apertures, crush zones and sealed fracture network are found in SKB MD 143.008 and “Kalibrering av Boremapkartering” (v.0.9) which is planned to be implemented in the next version of SKB MD 143.006.

Two types of fractures, broken and unbroken, are registered in Boremap depending on whether the core is split through the core axis or not. All fractures are described with their fracture minerals, width, aperture and roughness. To decide whether a fracture was open, partly open or sealed prior to drilling, the aperture confidence is expressed as “certain”, “probable” or “possible”. The confidence level depends on weathering of fracture surfaces and fit of the core pieces.

Table 4-1. Borehole data for KFR106.

ID-code	Northing	Easting	Bearing (degrees)	Inclination (degrees)	Diameter (mm)	Borehole length (m)	Mapping interval (m)
KFR106	6701540.19	1633591.87	195.1	–69.9	0.076	300.13	9.109–300.13

Table 4-2. Applied length adjustments in KFR106.

Borehole	Recorded length (m)	Adjusted length (m)	Difference (m)
KFR106	49.822	50.000	0.178
	99.747	100.000	0.253
	148.656	149.000	0.344
	199.580	200.000	0.420
	249.413	250.000	0.587
	279.348	280.000	0.652

All fractures with aperture > 0 mm are registered as open or partly open, and all fractures with aperture = 0 mm are registered as sealed in the Sicada database. Normally, unbroken fractures have apertures = 0 and broken apertures > 0 mm. However, unbroken fractures with, for example voids have aperture > 0, and fractures considered to have broken up during the drilling of subsequent handling of the drill core have aperture = 0. The frequency of open and sealed fractures are calculated and shown in the WellCAD-diagram (Appendix 1).

4.3.2 Fracture alteration and joint alteration number

Joint alteration number is mainly related to the thickness and clay content of the mineral fillings /9/. Fractures that are more than 1 mm wide and rich in clay minerals are usually given joint alteration numbers between 2 and 4. The majority of the broken fractures is very thin and seldom contains clay minerals, or very small amounts of clay and chlorite. These fractures have joint alteration numbers between 1 and 2. Since most fractures are within this span, a subdivision with joint alteration number = 1.5 was performed to facilitate both the evaluation process for fracture alterations and the possibility to compare the alterations between different fractures in the boreholes. The use of joint alteration number 1.5 is a remnant from the mapping during the Forsmark site investigation project, and is still in use to enable correlation between boreholes from the two projects.

4.3.3 Mapping of fractures not visible in the BIPS-image

Fractures not visible in the BIPS-image are oriented using the *guideline method* /10/. It is based on the following data:

- Amplitude of the fracture extremes along the drill core.
- The relation between the fracture trace and a well defined structure visible in both drill core and BIPS-image.
- Borehole length relative to a well defined structure visible in both drill core and BIPS-image.

The fractures mapped with the guideline method are registered in Boremap as "non-visible in BIPS".

4.3.4 Mineral codes

In cases where properties or minerals are not represented in the mineral list, the following mineral codes have been used in the mapping of KFR106:

- X1 = Bleached fracture walls.
- X3 = The drill core is broken at a right angle, and the surfaces have a polished appearance. This is caused by rotation of two core pieces along an intermediate fracture, wearing away possible mineral filling. It is impossible to decide whether this fracture is natural or artificial, or if the former is the case, if it was open or sealed *in situ*.
- X8 = Epidotized walls.

4.3.5 Foliation and lineation

The metagranite-granodiorite, which occupies most of the Forsmark area are usually LS tectonites, where lineation dominates over foliation /4/. However, in the SFR area foliation is usually dominating in the metagranite-granodiorite, and hence mapped to a greater extent. Minor folds in the SFR-area deform the planar fabrics, which result in varying intensity of the foliation and lineation. An estimated average of the intensity is mapped for rock types.

The higher strain in the SFR-area relative to the candidate area of the Forsmark site investigation, also appears in the somewhat finer grain-size of the metagranite-granodiorite, which is mapped as "fine- to medium-grained" in the SFR-area.

4.3.6 Alteration

The muscovitization has not been included as alteration standard in the Boremap system. Rocks affected by this type of alteration are mapped as sericitization with a comment "muscovite".

4.3.7 Detection of calcite

In order not to destroy the core for supplementary uranium analysis, hydrochloric acid was not allowed to be applied directly on the drill core to detect the presence of calcite. Fracture fillings were instead scraped off and tested for calcite separately.

4.4 Data handling/post processing

The Boremap mapping of KFR106 is performed on SKB's network, while a backup is saved on a local computer before each break exceeding 15 minutes. When the mapping is finished and quality checked by the operator and by a routine in Boremap, the data is submitted to SKB for exportation to Sicada.

All data are stored in Sicada, and it is only these data that should be used for further interpretation.

The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major revisions entail a revision of the P-report. Minor revisions are normally presented as supplements, available at www.skb.se.

4.5 Nonconformities

There are seven drill induced crushes registered in KFR106, with at total length of 0.28 m, and one core loss at 156.232–156.387 m.

A number of 37 samples were taken at different core lengths from KFR106, with the aim to make uranium series analysis and to determine the oxidation number of the uranium. The samples have a varying length between 9 and 56 cm, and were mapped separately at the end of the mapping. The lack of given core pieces have in certain intervals made it hard to get an overall picture of the core.

4.5.1 Underestimated fracture minerals

Due to the strong colouration of other minerals by hematite, it is detected even though it is macroscopically invisible. Minerals present in the same fracture as hematite run the risk of getting underestimated, as well as less conspicuous minerals in other fractures. To partly reduce this problem, hematite has only been mapped if a red streak is observed; otherwise it is considered to occur only as pigmentation.

5 Result

The data from Boremap mapping of KFR106 is stored in Sicada, and it is only these data that shall be used for further interpretation and modelling. The user of this data should be aware of the assumptions mentioned in Chapter 4. Graphical presentations of the data are given as a WellCAD-diagram in Appendix 1. A summary of rock types and fracture frequency in the borehole is presented in Table 5-1 and 5-2.

5.1 Lithology

The dominating rock type, which occupies 72% of KFR106, is fine- to medium-grained, pinkish or reddish grey metagranite-granodiorite (rock code 101057). It is foliated, except for the interval 76.23–80.52 m where lineation is dominating. Four intervals at 103.23–104.78, 109.26–111.31, 203.15–209.74 and 213.84–218.27 m, are mapped as veined and are distinguished by thin pegmatitic veins concordant along the foliation. The metagranite-granodiorite near the end of the borehole at 270.00–285.73 m, is interpreted as recrystallized. A distinctive feature in KFR106, especially in the second half of the borehole and most prominent in the metagranite-granodiorite is the presence of muscovite, mapped as sericitization.

Pegmatite to pegmatitic granite (rock code 101061) is found in six longer intervals and occupies 16% of the borehole. However, pegmatitic granite is very frequent in the other rock types as smaller rock occurrences (< 1 m) throughout the borehole.

Subordinate rock types are fine- to medium-grained granite (rock code 111058), felsic to intermediate metavolcanic rock (rock code 103076), fine- to medium-grained metagranitoid (rock code 101051) and amphibolite (rock code 102017).

Four occurrences of felsic to intermediate metavolcanic rock that exceeds one meter in length are mapped in KFR106. However, two of them, located at 75.00–76.23 and 80.52–83.62 m, are mixed with amphibolite.

The only occurrence of fine- to medium-grained metagranitoid at 21.93–27.23 m is hard to distinguish from the adjacent fine- to medium-grained granite. The two rock types have a similar appearance and a diffuse and graduational contact.

The only occurrence of amphibolite exceeding one meter in length occurs at 291.36–293.66 m and have dissemination of macroscopically visible magnetite.

The rock type distribution in KFR106 is presented in Table 5-1.

Rock occurrences (rock types < 1 m in length) occupy about 17% of the logged drill core. Generally, they consist of dykes, veins and unspecified occurrences of pegmatite and pegmatitic granite. Additional occurrences, excluded in Table 5-1, are quartz dominated veins (rock code 8021) and undifferentiated granite (rock code 1058).

Table 5-1. Percentage distribution of rock types in KFR106 (rock occurrences excluded).

Borehole	101057	101061	111058	103076	101051	102017
KFR106	72	16	6	3	2	1

5.1.1 Ductile structures

The metagranite-granodiorite in KFR106 is characterized by L-S fabric with a dominance of foliation. A medium to strong intensity is mapped for the foliation.

The felsic to intermediate metavolcanic rock and amphibolite are both mapped as foliated but the foliation often is hard to discern. The same applies for the lineation in fine- to medium-grained granite and fine- to medium-grained metagranitoid.

Three narrow brittle-ductile and 16 ductile shear zones are registered in KFR106. The width are typically around one centimetre but two of the ductile shear zones exceeds 10 cm, and are in addition mapped as a structural feature.

In Figure 5-1 the poles to the foliation planes, the brittle-ductile and ductile shear zones, as well as the lineation in KFR106 is plotted.

5.1.2 Alteration

Totally 49% of the borehole length has been registered as altered in KFR106.

A varying intensity of muscovitization, mapped as sericitization, is the most common alteration and seems to replace biotite in the foliation planes. It is most likely of metamorphic origin. Totally 32% of the borehole is registered as altered with muscovitization, with the most extensive interval at 187.9–248.0 m.

Oxidation is mapped for about 16% of the borehole and is mainly registered at borehole length 13–57 and 263–391 m. In addition, 1,177 fractures are mapped with oxidized walls.

Additional shorter alterations are in decreasing order of abundance quartz dissolution, epidotization, argillization, albitization, chloritization, laumontization and carbonatization.

Quartz dissolution is observed at 285.6–289.7 m, epidotization in two intervals at 257.9–260.4 and 271.1–271.9 m and argillization in three intervals, of which the longest is located at 260.1– 262.6 m. Albitization is, except for the two longer intervals at 253.6–255.1 and 255.9–256.5 m, observed adjacent to amphibolitic rock. Except for the quartz dissolution, which affects pegmatite, these alterations are restricted to the metagranite-granodiorite.

The remaining alterations; chloritization, laumontization and carbonatization, just affect a few centimetres of the borehole.

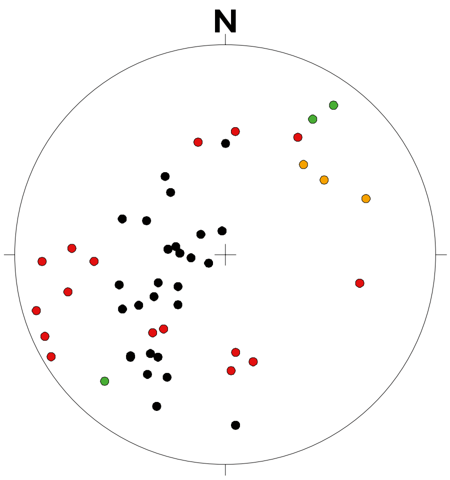

Figure 5-1. *Orientation of poles to foliation planes (•, n=27), ductile shear zones (•, n=16), brittle-ductile shear zones (•, n=3) and the lineation (•, n=3) in KFR106, plotted on the lower hemisphere of a Schmidt equal area stereographic projection.*

5.1.3 Fractures

A total number of 2,801 fractures are registered in KFR106. Of these are 1,059 open (broken with aperture > 0), 1,742 sealed (broken and unbroken fractures with aperture = 0) and 84 are partly open (unbroken fractures with aperture > 0). This result in the following fracture frequencies: 6.0 sealed fractures/m (sealed fractures in sealed fracture networks are excluded), 3.7 open fractures/m (crushes excluded) and 0.3 partly open fractures/m (Table 5-2).

There are one dominating set each of open and sealed fractures in KFR106 with the orientations 055°/05° and 290°/80°, respectively (Figure 5-2a and b). The sealed fractures show a more scattered distribution. Three additional sets, although vaguely defined, are also distinguished. One coincides with the open fracture set and the other two have the orientations 035°/70° and 225°/85°. Fractures mapped in the metagranite-granodiorite coincide to great extent with the orientation of the foliation, and hence are possible foliation fractures. Fractures mapped with no access to BIPS-image are not oriented, and therefore not plotted in the stereograms.

In addition, there are 5 narrow brecciated zones at 16.68–17.41, 18.60–19.38, 19.40–19.53, 51.50–51.54 and 262.81–263.43 m, and 20 sealed networks in KFR106. The first three brecciated zones are most likely one and the same zone, but appear as three in the BIPS-image. The total length of the sealed networks is 18 m, with a piece length that varies between 3 and 40 mm, and a typical borehole length of 0.6–0.9 m. Five of the sealed networks exceeds one meter in length and are located at 32.14–33.93, 165.43–166.52, 257.34–258.58, 260.55–262.80 and 265.14–266.79 m. Partly open fractures in the sealed networks are mapped separately. Taking into account the sealed networks, there are 1,800 additional sealed fractures in KFR106.

There are 8 crushed intervals (drill-induced excluded) in KFR106. The total length of the crushes is 47 cm, with a piece length varying from 3 to 10 mm. The crush at 156.08–156.24 m is located at the same borehole length as the only core loss, and hence is a presumption based on the BIPS-image and not an actual observation.

Table 5-2. Fracture frequencies in KFR106 (crush and sealed fracture networks excluded) expressed as fractures/m.

Borehole	Open fractures	Partly open fractures	Sealed fractures
KFR106	3.7	0.3	6.0

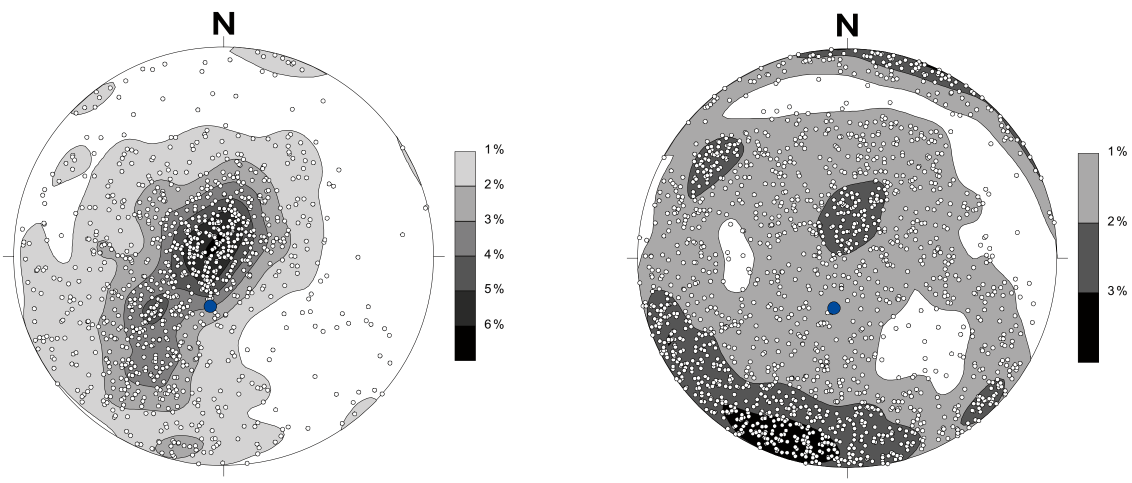

__Figure 5-2.__ Orientation of poles to __a)__ open (n=1,051) and __b)__ sealed fracture (n=1,722) planes, plotted on the lower hemisphere of a Schmidt equal area stereographic projection. Blue dot is borehole projection at start.

The most common minerals in the open fractures, with a representation over 10%, are in decreasing order: chlorite, calcite, muscovite and clay minerals. Of the open fractures have 16% oxidized walls. Minerals represented in over 10% of the sealed fractures are calcite, chlorite, quartz and laumontite. Of the sealed fractures have 58% oxidized walls. There are 29 open, and 2 sealed fractures with "no detectable mineral".

Clay minerals, mainly found in open fractures, with an increased frequency in three intervals at 69–100, 152–157 and 258–263 m.

Pyrite is mapped in 76 fractures and unspecified "sulfides" in 6 fractures in KFR106. These are found throughout the borehole, but with a slight increase in the intervals 17–19, 95–103 and 154–170 m.

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Appendix 1

WellCAD plot KFR106

Title **LEGEND FOR FORSMARK - SFR** **KFR106** **Appendix: 1**

Site FORSMARK - SFR
Borehole KFR106
Plot Date 2010-06-16 23:01:27
Signed data

ROCKTYPE FORSMARK - SFR

- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granitoid, metamorphic
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite, metamorphic, aplitic
- Granite to granodiorite, metamorphic, medium-grained
- Granodiorite, metamorphic
- Tonalite to granodiorite, metamorphic
- Diorite, quarts diorite and gabbro, metamorphic
- Ultramafic rock, metamorphic
- Amphibolite
- Calc-silicate rock (skarn)
- Magnetite mineralization associated with calc-silicate rock (skarn)
- Sulphide mineralization
- Felsic to intermediate volcanic rock, metamorphic
- Mafic volcanic rock, metamorphic
- Sedimentary rock, metamorphic
- Cataclastic rock

ROCK ALTERATION

- Oxidized
- Chloritisized
- Epidotisized
- Weathered
- Tectonized
- Sericitisized
- Quartz dissolution
- Silicification
- Argillization
- Albitization
- Carbonatization
- Saussuritization
- Steatitization
- Uralitization
- Laumontitization
- Fract zone alteration

MINERAL

- Biotite
- Hematite
- Calcite
- Chlorite
- Quartz
- Muscovite
- Pyrite
- Clay Minerals
- Laumontite

STRUCTURE

- Cataclastic
- Schistose
- Gneissic
- Mylonitic
- Ductile Shear Zone
- Brittle-Ductile Zone
- Veined
- Banded
- Massive
- Foliated
- Brecciated
- Lineated

TEXTURE

- Hornfelsed
- Porphyritic
- Ophitic
- Equigranular
- Augen-Bearing
- Unequigranular
- Metamorphic

GRAINSIZE

- Aphanitic
- Fine-grained
- Fine to medium grained
- Medium to coarse grained
- Coarse-grained
- Medium-grained

STRUCTURE ORIENTATION

- Cataclastic
- Brecciated
- Bedded
- Schistose
- Mylonitic
- Foliated
- Lineated
- Ductile Shear Zone
- Veined
- Gneissic
- Brittle-Ductile Shear Zone
- Banded

ROCK ALTERATION INTENSITY

- No intensity
- Faint
- Weak
- Medium
- Strong

ROUGHNESS

- Planar
- Undulating
- Stepped
- Irregular

SURFACE

- Rough
- Smooth
- Slickensided

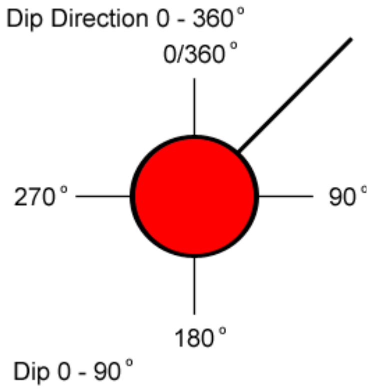
CRUSH ALTERATION

- Slightly Altered
- Moderately Altered
- Highly Altered
- Completley Altered
- Gouge
- Fresh

FRACTURE ALTERATION

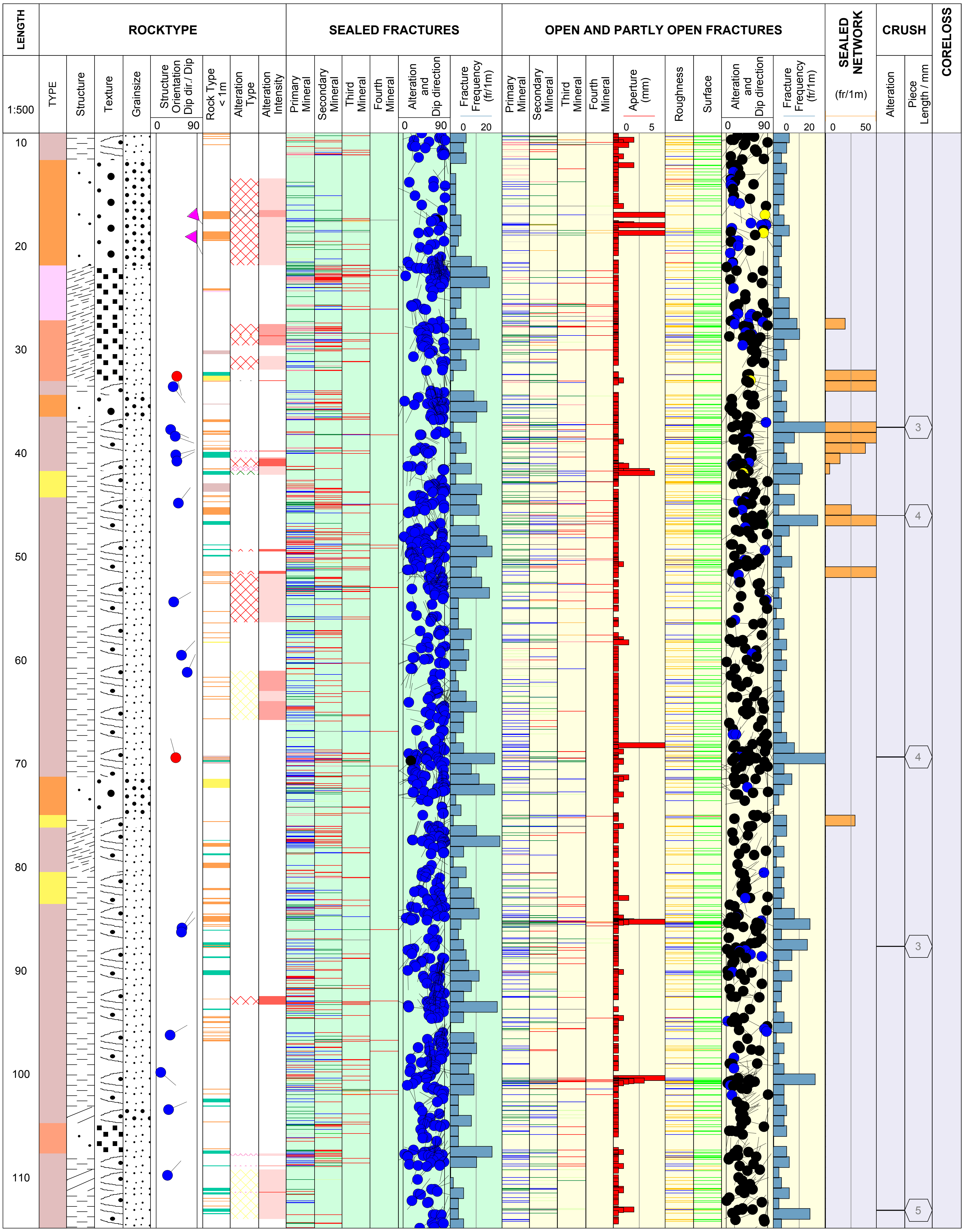
- Highly Altered
- Completely Altered
- Gouge
- Fresh
- Slightly Altered
- Moderately Altered

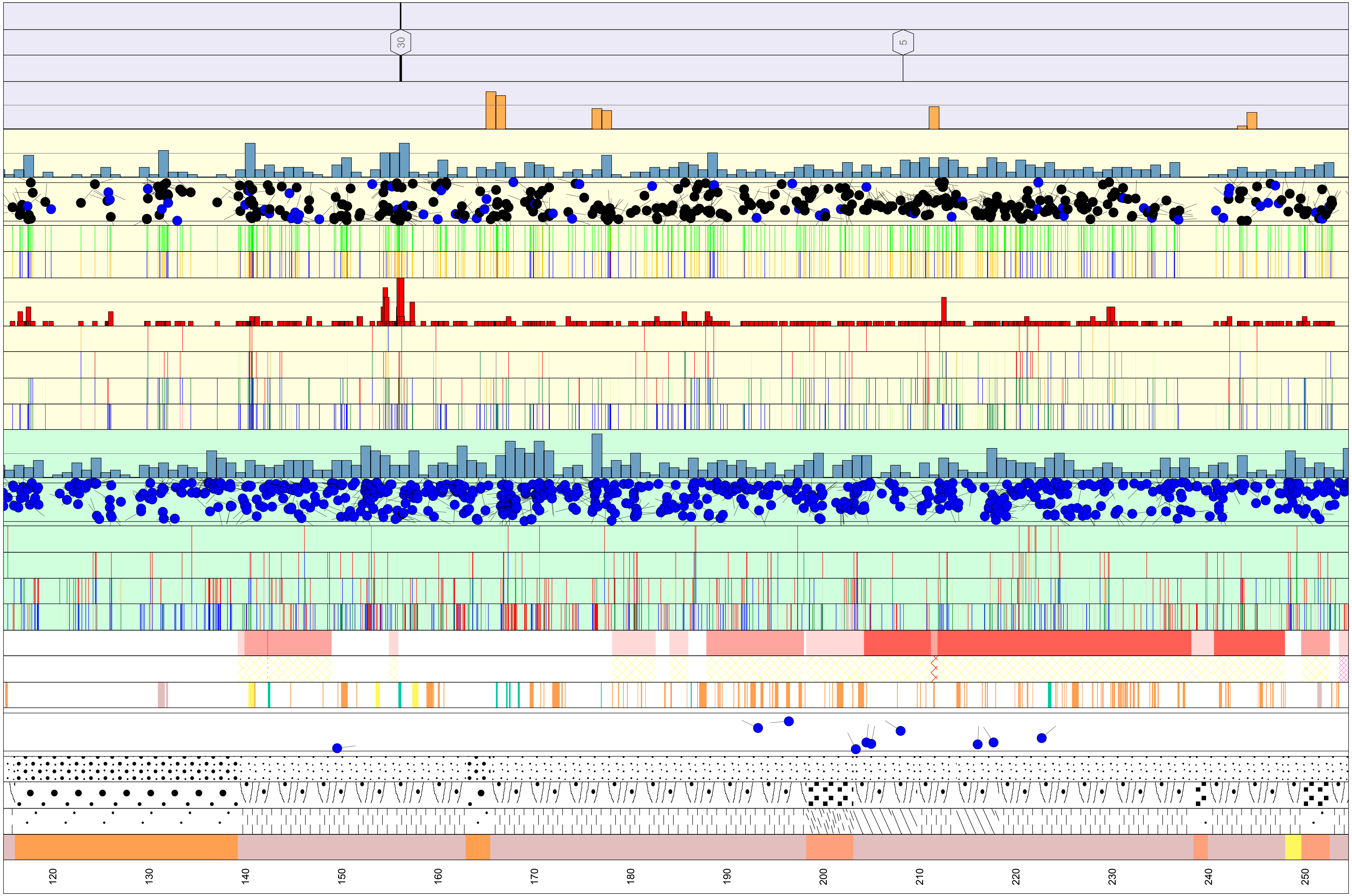
FRACTURE DIRECTION
STRUKTURE ORIENTATION

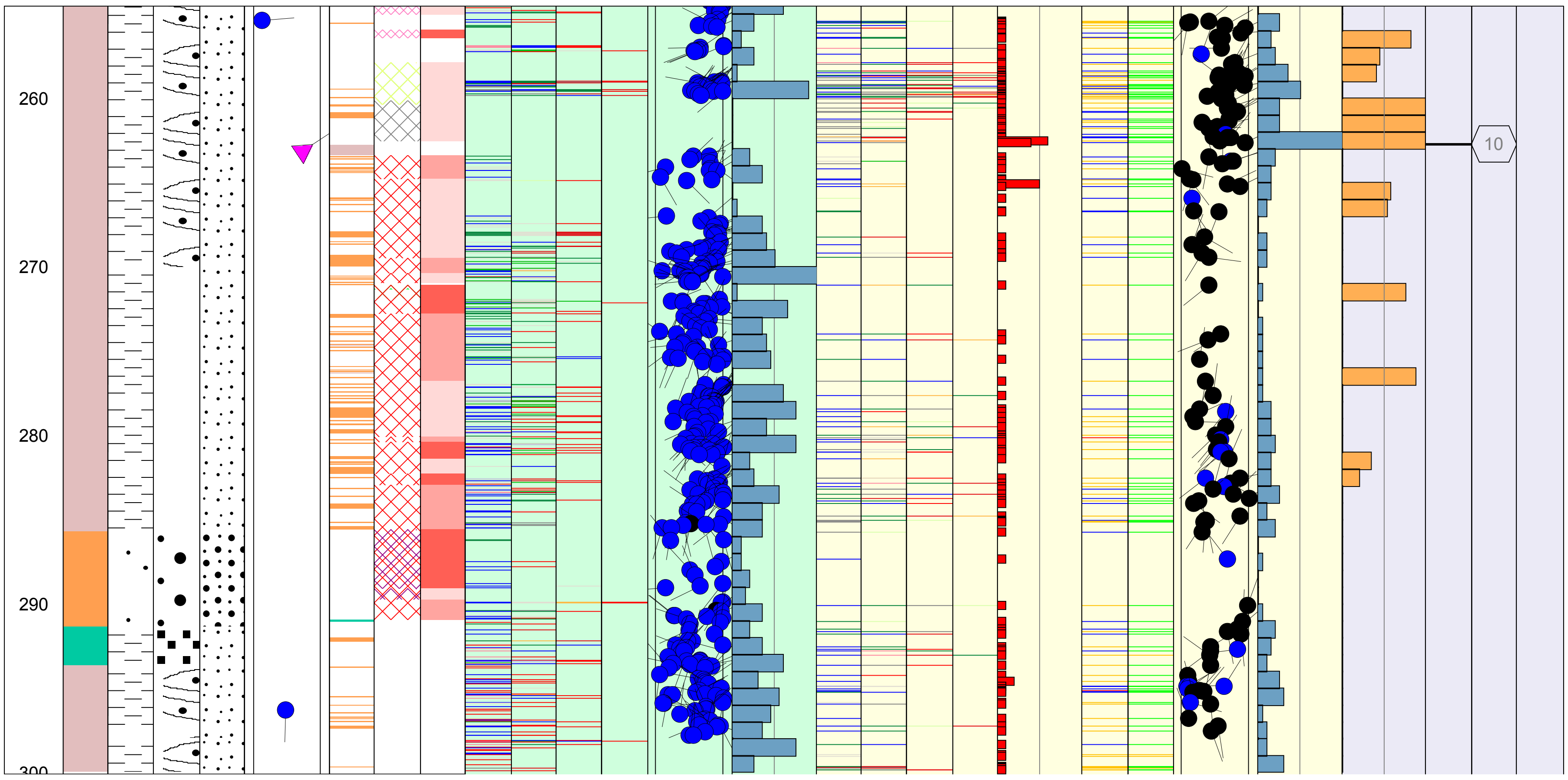


Title **GEOLOGY IN KFR106** **Appendix: 1**

Site	FORSMARK - SFR	**Coordinate System**	RT90-RHB70
Borehole	KFR106	**Northing [m]**	6701541.19
Diameter [mm]	76	**Easting [m]**	1633592.14
Length [m]	300.130	**Elevation [m.a.s.l.]**	1.06
Bearing [°]	195.11	**Drilling Start Date**	2009-08-19 14:32:00
Inclination [°]	-70.26	**Drilling Stop Date**	2009-09-03 01:16:00
Date of coremapping	2009-09-28 10:49:00	**Plot Date**	2010-06-16 23:01:27
Rocktype data from	p_rock	**Signed data**	

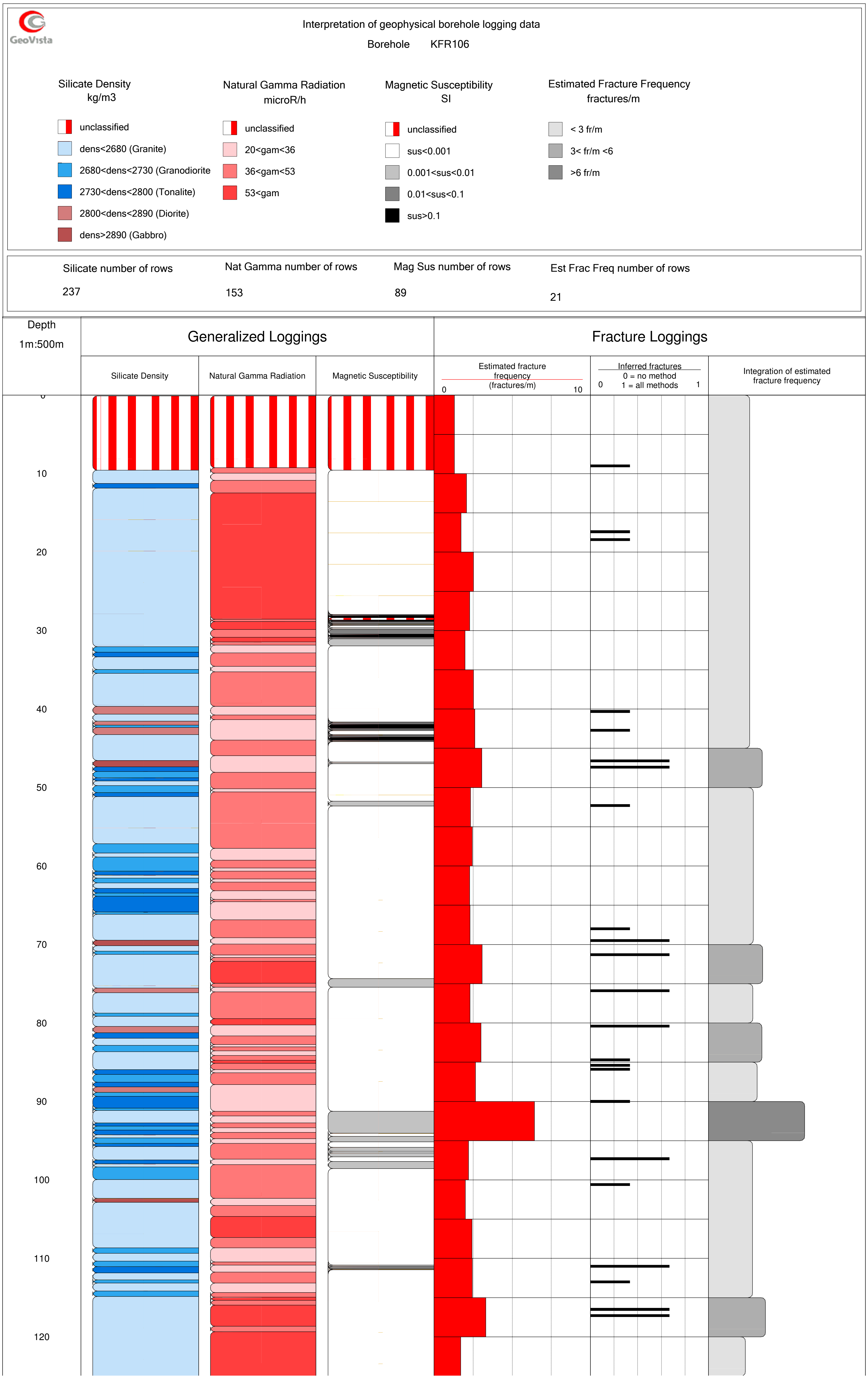


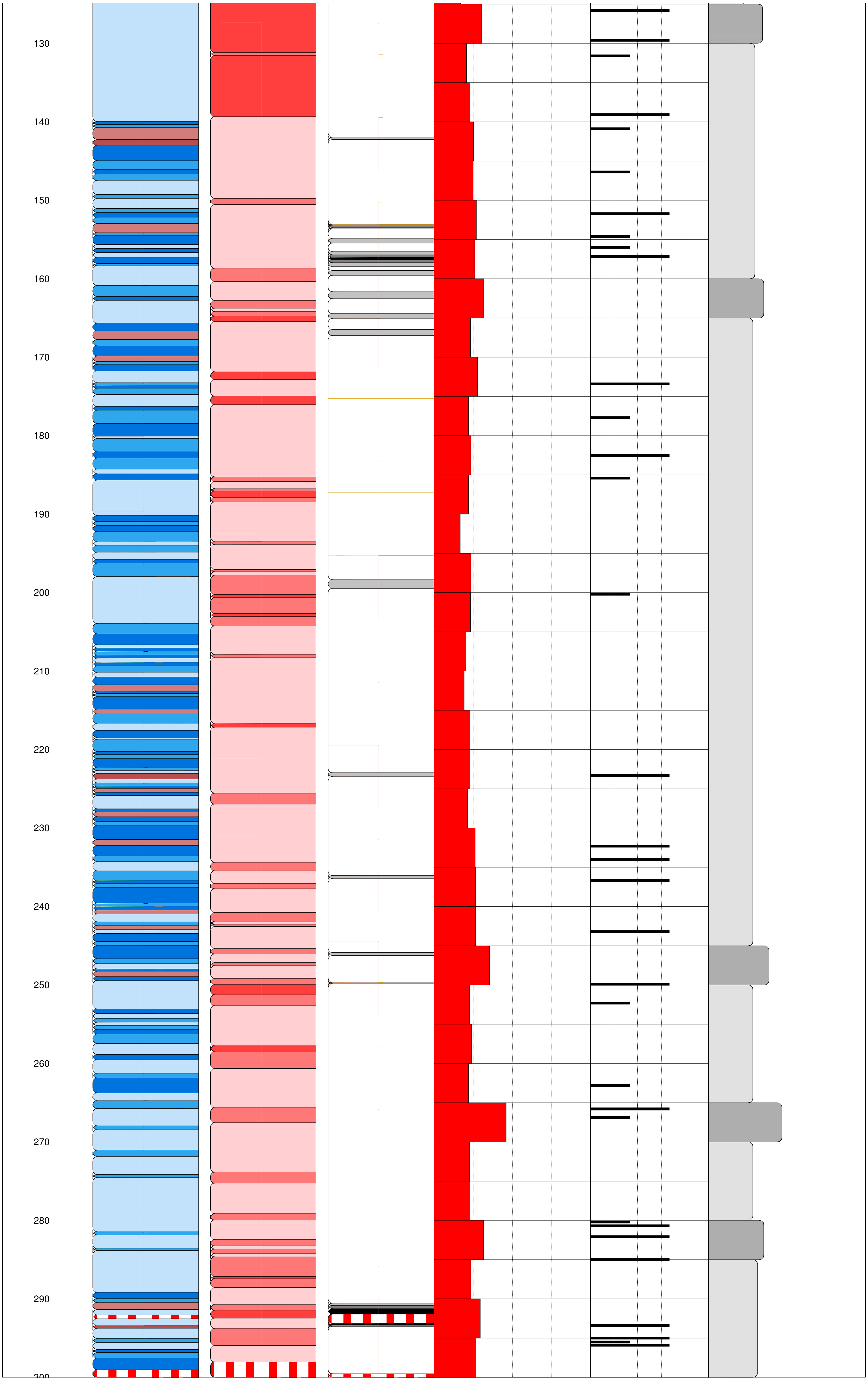

30
5
120
130
140
150
160
170
180
190
200
210
220
230
240
250

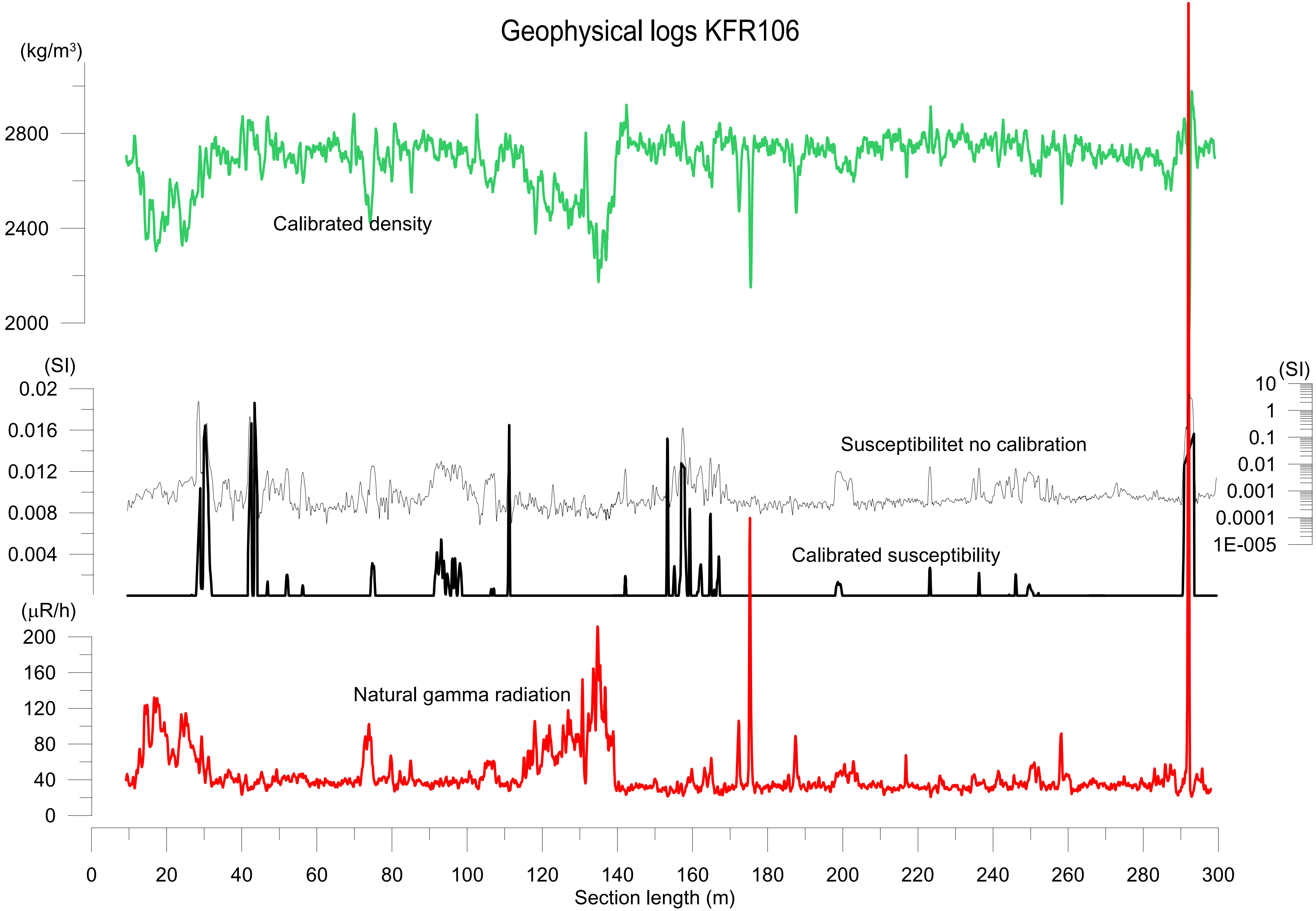

260
270
280
290
300
10

Appendix 2

Generalized geophysical logs and plots of resampled and calibrated geophysical data from KFR106




130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300


Geophysical logs KFR106
(kg/m³)
2800
2400
2000
Calibrated density
(SI)
0.02
0.016
0.012
0.008
0.004
Susceptibilitet no calibration
Calibrated susceptibility
(SI)
10
1
0.1
0.01
0.001
0.0001
1E-005
(µR/h)
200
160
120
80
40
0
Natural gamma radiation
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
Section length (m)

In data

Borehole Direction T – Surveying: Borehole direction

KFR106, 2009-09-23 14:15:00

Length (m)	Bearing (degrees)	Inclination (degrees)	Bearing Err (degrees)	Inclination Err (degrees)	Magnetic Bearing (degrees)	In Use Flag	Coord System	QC
0.00	195.1133	–69.8917	0.2000	0.2000		*	RT90-RHB70	*

Printout from SICADA 2010-09-13 15:28:43.

Hole Diam T – Drilling: Borehole diameter

KFR106, 2009-08-19 14:32:00–2009-09-03 01:16:00 (9.130–300.130 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment	QC
0.310	9.130	0.1520		*
9.130	300.130	0.0757	Corac N3/50	*

Printout from SICADA 2009-11-26 10:52:09.

Reference Mark T – Reference mark in drillhole

KFR106, 2009-09-03 06:00:00–2009-09-03 12:00:00 (50.000–280.000 m)

Bhlen (m)	Rotation Speed (rpm)	Start Flow (l/h)	Stop Flow (l/h)	Stop Pressure (bar)	Cutter Time (s)	Trace Detectable	Cutter Diameter (mm)	Comment	QC
50.00	400.00	200.000	400.000	38.0	35.00	Yes		Cutting ok	*
100.00	400.00	250.000	500.000	38.0	45.00	Yes		Cutting ok	*
149.00	400.00	250.000	600.000	38.0	45.00	Yes		Cutting ok	*
200.00	400.00	300.000	600.000	38.0	45.00	Yes		Cutting ok	*
250.00	400.00	300.000	800.000	40.0	65.00	Yes		Cutting ok, weaker stop indication.	*
280.00	400.00	400.000	1,100.000	45.0	300.00	Yes		No cutting stop indication but the reference mark is presumably done.	*

Printout from SICADA 2009-11-26 11:14:20.