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Revised October 2006

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December 2004

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Keywords: Forsmark, Geophysics, Geology, Borehole, Bedrock, Fractures, Field note: Forsmark 314, AP-PF 400-04-40.

Reading instruction

For revision no. 1 of this report a recalculation of the oriented radar data has been carried out.

The strike and dip of the oriented radar data are now recalculated using the right-hand-rule method, e.g. 040/80 corresponds to a strike of N40°E and a dip of 80° to the SE. The new values for strike and dip are updated in Chapter 5.1 as well as in Appendix 1.

The revised report also presents updated identification codes from rock units, in accordance with the revised method description for single-hole interpretation. The term "confidence level" also replaces the term "uncertainty" in accordance with the revised method description.

Appendices 1–4 are updated.

Abstract

This report contains geological single-hole interpretations of the cored borehole KFM05A and the percussion boreholes HFM14–15 and HFM19 in Forsmark. The geological single-hole interpretation combines the geological core mapping, interpreted geophysical logs and borehole radar measurements to interpret where lithological rock units and possible deformation zones occur in the boreholes.

The geological single-hole interpretation shows that four rock units (RU1–RU4) occur in KFM05A. The borehole can be divided into seven separate units along the borehole length due to the degree of fracture frequency as well as the repetition of rock units RU1–RU4. Medium-grained metagranite-granodiorite and fine- to medium-grained occur in the borehole. One section contains a mixture of amphibolite and fine-grained material with diorite to quartz-dioritic composition. Fine- to medium-grained metagranitoid, pegmatitic granite and amphibolite occur in small sections. Five possible deformation zones have been identified in KFM05A (DZ1–DZ5).

One rock unit is interpreted in the percussion borehole HFM14 (RU1). The unit is dominated by medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite, aplitic metagranite and one section of fine- to medium-grained metagranitoid. Two possible deformation zones have been identified in HFM14 (DZ1–DZ2).

The percussion borehole HFM15 is dominated by medium-grained metagranite-granodiorite with subordinate occurrences of amphibolite (RU1). In the lower part of the borehole occur subordinate occurrences of pegmatitic granite and aplitic metagranite. One possible deformation zone has been identified in HFM15 (DZ1).

One rock unit is interpreted in the percussion borehole HFM19 (RU1). The unit is dominated by medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, aplitic metagranite, amphibolite and fine- to medium-grained metagranitoid. Two possible deformation zones have been identified in HFM19 (DZ1–DZ2).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhål KFM05A samt hammarborrhålen HFM14, HFM15 och HFM19 i Forsmark. Den geologiska enhålstolkningen syftar till att utifrån data från den geologiska karteringen, tolkade geofysiska loggar och borrhålsradarmätningar indikera olika litologiska enheters fördelning i borrhålen samt möjliga deformationszoners läge och utbredning.

Denna undersökning visar att det i KFM05A finns 4 litologiska enheter. Baserat på graden av sprickfrekvens samt repetition av vissa enheter kan borrhålet delas in i 7 sektioner. Medelkorning metagranit-granodiorit samt en fin- till medelkornig variant av denna bergart förekommer i större delen av borrhålet. Ett parti i borrhålet innehåller en blandning av amfibolit och finkornigt material med diorit till kvartsdioritisk sammansättning. I mindre omfattning förekommer dessutom fin- till medelkornig metagranitoid, pegmatitisk granit och amfibolit. Fem möjliga deformationszoner har identifierats i KFM05A.

Hammarborrhål HFM14 domineras av medelkornig metagranit-granodiorit med mindre inslag av pegmatitisk granit, amfibolit, aplitisk metagranit och en förekomst av fin- till medelkornig metagranitoid. Två möjliga deformationszoner har identifierats i HFM14.

Hammarborrhål HFM15 domineras av medelkornig metagranit-granodiorit med mindre inslag av amfibolit. I den nedre delen av borrhålet förekommer dessutom mindre mängder av pegmatitisk granit och aplitisk metagranit. En möjlig deformationszon har identifierats i HFM15.

Hammarborrhål HFM19 domineras av medelkornig metagranit-granodiorit med mindre inslag av pegmatitisk granit, aplitisk metagranit, amfibolit och fin- till medelkornig metagranitoid. Två möjliga deformationszoner har identifierats i HFM19.

Contents

1 Introduction

Much of the primary geological and geophysical borehole data stored in the SKB database SICADA need to be integrated and synthesized before they can be used for modelling in the 3D-CAD system Rock Visualisation System (RVS). The end result of this procedure is a geological single-hole interpretation, which consists of an integrated series of different logs and accompanying descriptive documents.

This document reports the geological single-hole interpretation of four boreholes at drill-site 5 (DS5) in the Forsmark area. These include the cored borehole KFM05A and the percussion-drilled boreholes HFM14, HFM15 and HFM19 (Figure 1-1).

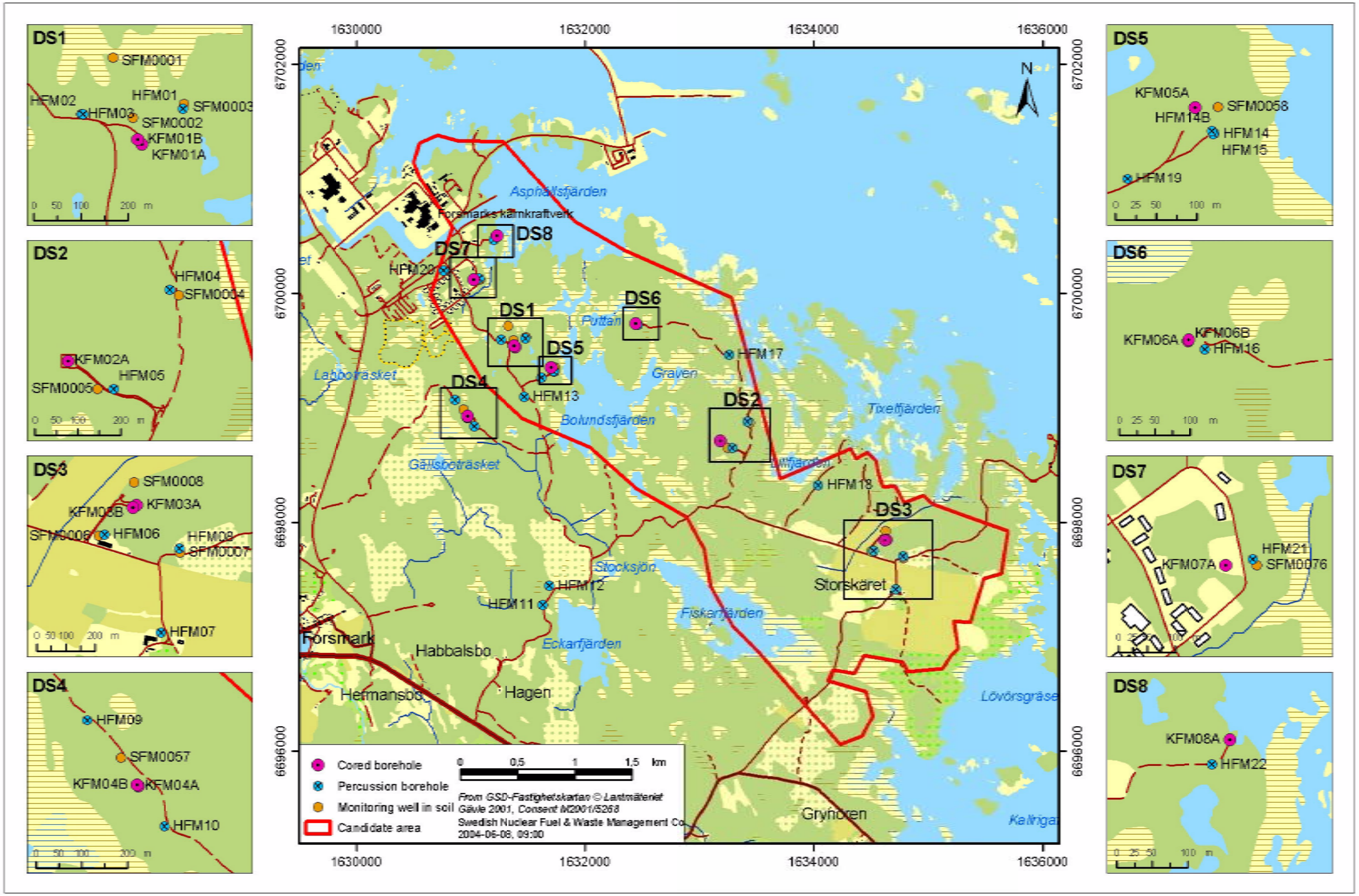


Figure 1-1. *Map showing the position of the boreholes KFM05A and HFM14, HFM15 and HFM19.*

2 Objective and scope

A geological single-hole interpretation is carried out in order to identify and briefly describe the major rock units and possible deformation zones within a borehole. The work involves an integrated interpretation of data from the geological mapping of the borehole (Boremap), different borehole geophysical logs and borehole radar data and, when available, reflection seismic anomalies. The results from the geological single-hole interpretation are presented in a WellCad plot. A detailed description of the technique is provided in the method description for geological single-hole interpretation (SKB MD 810.003, internal document).

3 Data used for the geological single-hole interpretation

The following data are used for the single-hole interpretation of the boreholes at drill site 5:

- Boremap data (including BIPS and geological mapping data) /1 and 2/.
- Generalized geophysical logs and their interpretation /3, 4 and 5/.
- Radar data and their interpretation /6, 7 and 8/.

The material used as a basis for the geological single-hole interpretation was a WellCad plot consisting of parameters from Boremap-mapping, geophysical logs and borehole radar. An example of a WellCad plot used during the geological single-hole interpretation is shown in Figure 3-1. The plot consists of ten main columns and several subordinate columns. These include:

1: Depth along borehole

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

3: Unbroken fractures
  3.1: Primary mineral
  3.2: Secondary mineral
  3.3: Third mineral
  3.4: Fourth mineral
  3.5: Alteration, dip direction

4: Broken fractures
  4.1: Primary mineral
  4.2: Secondary mineral
  4.3: Third mineral
  4.4: Fourth mineral
  4.5: Aperture (mm)
  4.6: Roughness
  4.7: Surface
  4.8: Alteration, dip direction

5: Crush zones
  5.1: Primary mineral
  5.2: Secondary mineral
  5.3: Third mineral
  5.4: Fourth mineral
  5.5: Roughness

    5.6: Surface
    5.7: Crush alteration, dip direction
    5.8: Piece (mm)
    5.9: Sealed network
    5.10: Core loss

6: Fracture frequency
    6.1: Open fractures
    6.2: Sealed fractures

7: Geophysics
    7.1: Magnetic susceptibility
    7.2: Natural gamma radiation
    7.3: Possible alteration
    7.4: Silicate density
    7.5: Estimated fracture frequency

8: Radar
    8.1: Length
    8.2: Angle

9: Reference mark (not used for percussion-drilled boreholes)

10: BIPS

The geophysical logs are described below:

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

Natural gamma radiation: The rock has been classified into sections of low, medium, and high natural gamma radiation. Low radiation may indicate mafic rock types and high radiation may indicate younger fine-grained granite or pegmatite. The rock with high natural gammaradiation has been included in the younger, Group D intrusive suite /9/.

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

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

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

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

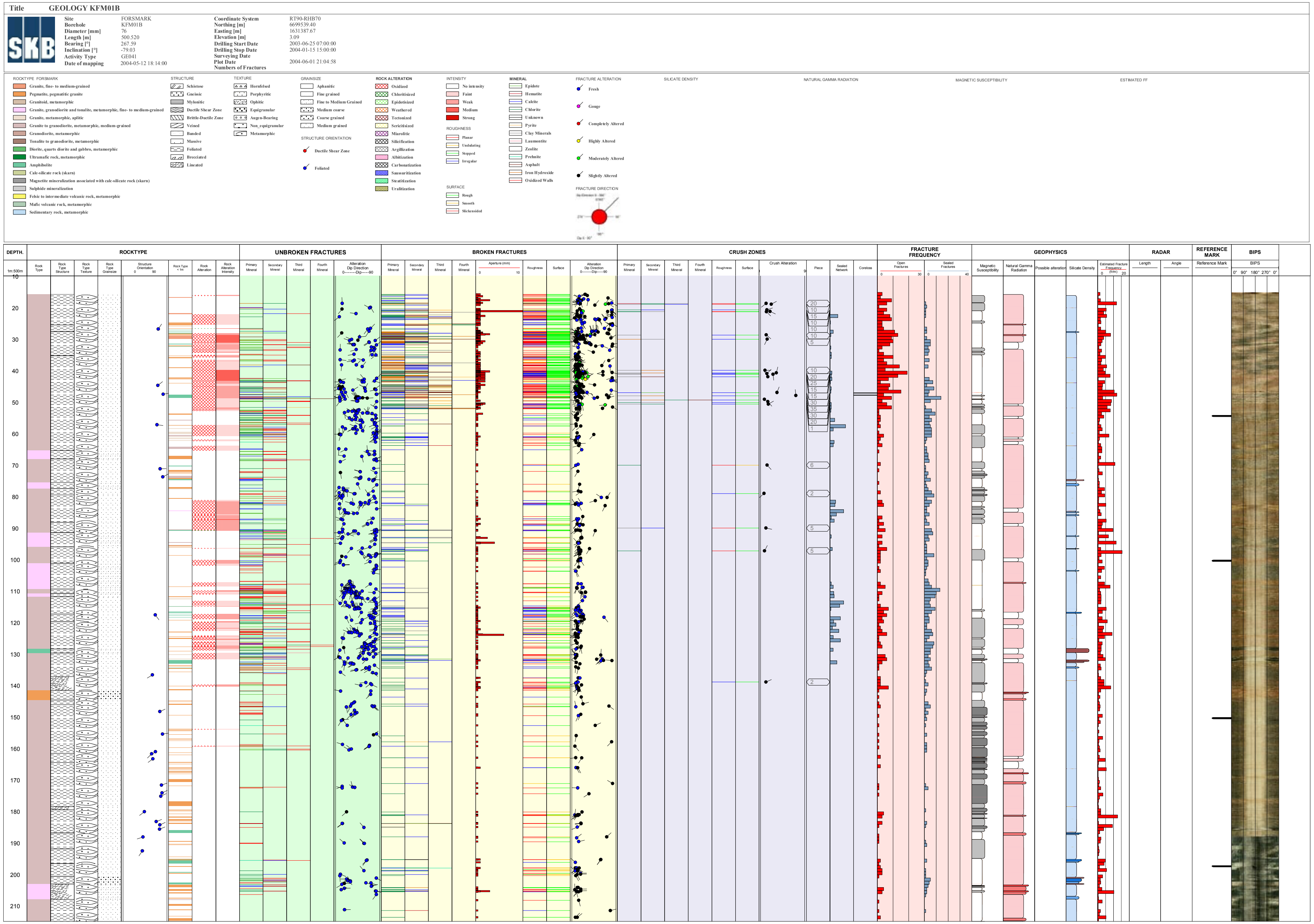


Figure 3-1. Example of WellCad plot used as a basis for the single-hole interpretation.

4 Execution of the geological single-hole interpretation

The geological single-hole interpretation has been carried out by a group of experts consisting of both geologists and geophysicists. Several of these participants previously participated in the development of the source material for the single-hole interpretation. All data to be used (see above) are visualized side by side in a borehole document extracted from the software WellCad.

Stage 1 in the working procedure is to study the rock type related logging data and to merge sections of similar rock types, or sections where one rock type is very dominant, into rock units (minimum length of c 5 m). Each rock unit is indicated and provided with a description for the WellCad picture.

Stage 2 is to identify possible deformation zones by visual inspection of geological mapping (fracture frequency, alteration, etc), geophysical data, and radar data. The section of each identified possible deformation zone is indicated and described in the WellCad picture.

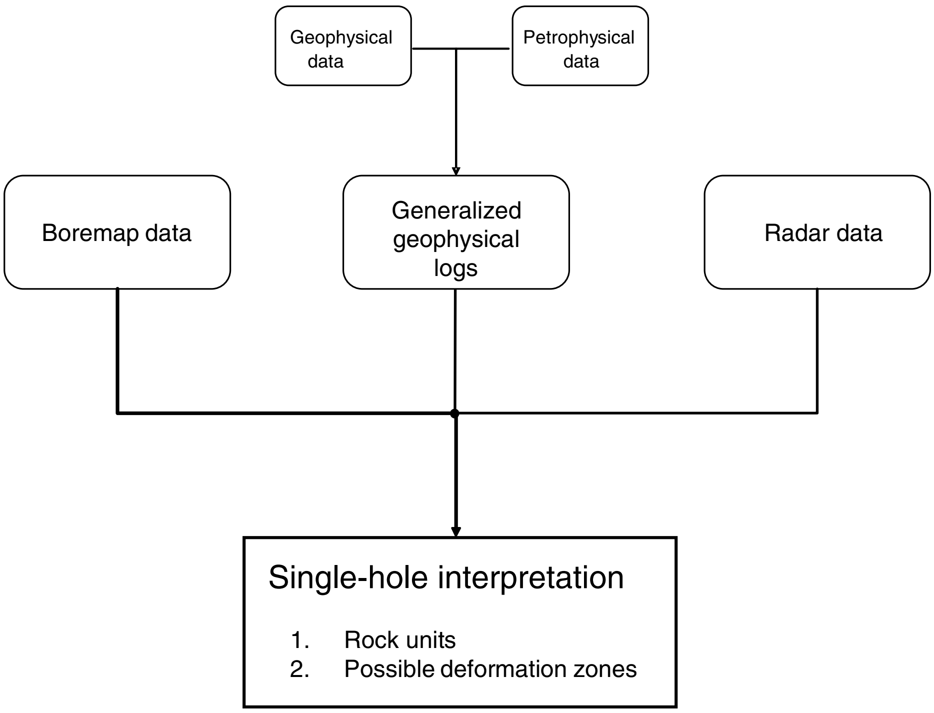


Figure 4-1. *Schematic block diagram of geological single-hole interpretation.*

4.1 Nonconformities

In some cases alternative orientations for oriented radar reflectors are presented. One of the alternatives is considered to be correct, but due to uncertainty in the interpretation of radar data, a decision concerning which of the alternatives that represent the true orientation cannot be made.

5 Results

The detailed results of the geological single-hole interpretations are presented as print-outs from the software WellCad (Appendix 1 for KFM05A, Appendix 2 for HFM14, Appendix 3 for HFM15, and Appendix 4 for HFM19). The confidence in the interpretation of rock units and possible deformation zones is made on the following basis: 3 = high, 2 = medium and 1 = low.

5.1 KFM05A

The borehole can be divided into four different rock units, some of which are recurrent in the borehole. For this reason, the borehole is divided into seven rock sections:

102–237 m RU1: Fine- to medium-grained variety of the otherwise medium-grained metagranite-granodiorite, with minor occurrences of pegmatitic granite and amphibolite, and one occurrence of fine- to medium-grained metagranitoid. Generally increased fracture frequency relative to the remaining part of the borehole, outside possible deformation zones. Confidence level = 3.

237–286 m RU2: Fine- to medium-grained variety of the otherwise medium-grained metagranite-granodiorite, with minor occurrences of pegmatitic granite and amphibolite. Confidence level = 3.

286–349 m RU3a: Medium-grained metagranite-granodiorite, with minor occurrences of pegmatitic granite and amphibolite. Confidence level = 3.

349–362 m RU4: Heterogeneous mixture between amphibolite and fine-grained material with dioritic to quartz-dioritic composition. Subordinate occurrences of medium-grained metagranite-granodiorite and pegmatitic granite. Sub-parallel radar reflector 30–40 m from the borehole axis. Low magnetic susceptibility. Confidence level = 3.

362–676 m RU3b: Medium-grained metagranite-granodiorite, with minor occurrences of pegmatitic granite, amphibolite and in the interval 570–620 m fine- to medium-grained metagranitoid. Also two 1–2 m wide occurrences of felsic to intermediate metavolcanic rock at c 507 and 538 m. Sub-parallel radar reflector 30–40 m from the borehole axis, visible down to 430 m. Confidence level = 3.

676–720 m RU5: Fine- to medium-grained metagranitoid of granodioritic to tonalitic composition with subordinate medium-grained metagranite-granodiorite and pegmatitic granite. Amphibolite is absent in the fine- to medium-grained metagranitoid. Contacts between the fine- to medium-grained metagranitoid and the medium-grained metagranite-granodiorite are gradual and the two rocks are often difficult to separate in the contact zone. Anomalous high silica density and low susceptibility. Confidence level = 3.

720–1,000 m RU3c: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite and fine- to medium-grained metagranitoid. Lower frequency of amphibolite compared to the remaining part of the borehole. Sub-parallel radar reflector 30–50 m from the borehole axis, from 840 m to the end of the borehole. Confidence level = 3.

Five possible deformation zones are indicated in KFM05A:

102–114 m DZ1: Marked increase of flat-lying, open fractures, with apertures ranging up to more than 1 cm. Two crush zones. Mostly clay minerals, calcite and some fractures filled with fine-grained, clay-dominated material, inferred to be a clastic sedimentary rock. Faint oxidation throughout the interval. Low resistivity, which is apparent down to 125 m. No indication in the sonic and susceptibility data. One oriented radar reflector at 111.3 m with the orientation 192/53 or 100/20 and one non-oriented at 103.4 m with the angle 37 degrees to the borehole axis. Confidence level = 3.

416–436 m DZ2: Increased frequency of mostly sealed, steeply dipping fractures. Apertures generally less than 0.5 mm. Predominant fracture minerals are calcite, prehnite, chlorite, epidote and laumontite. Faint to medium oxidation. Low resistivity. No indication in the sonic and susceptibility data. Four oriented radar reflectors at 417.3 m (011/80), 424.2 m (151/88), 424.7 m (166/72 or 299/9) and at 427.6 m (092/24 or 200/65). Two non-oriented radar reflectors occur at 427.5 m and 431.1 m with the angle to borehole axis 35 and 53 degrees, respectively. Confidence level = 3.

590–796 m DZ3: Increased frequency of mostly sealed, steeply dipping fractures, with a sharp contact on both sides to a very little fractured bedrock. Two distinctive intervals, 609–616 m and 712–720 m, with dense fracture network and faint to weak oxidation. Faint to medium oxidation is locally observed along the whole interval. Predominant fracture minerals are laumontite, calcite, chlorite and hematite staining. Laumontite is prominent in the dense fracture network intervals. Apertures are generally less than 1 mm, with one ranging up to 4 mm. Low resistivity in the densely fractured intervals. Moderate resistivity anomalies in the remaining part. Susceptibility and sonic velocity seem to be unaffected. Totally 49 radar reflectors in the interval. Six radar reflectors in the upper of the densely fractured interval, and one at 610.9 m yield a more confident orientation of 232/25. Four radar reflectors in the lower of the densely fractured interval; three are oriented 123/71, 063/80 and 338/37. Confidence level = 1 for the whole interval and 3 for the densely fractured intervals.

892–916 m DZ4: Increased frequency of mostly sealed, steeply dipping fractures. Open fractures with apertures less than 1 mm and faint to weak oxidation are concentrated in the lower part of the interval. Predominant fracture minerals are laumontite, calcite and chlorite. Moderate resistivity anomalies. Susceptibility and sonic velocity seem to be unaffected. Two oriented radar reflectors at 903.2 m (086/48) and 909.3 m (041/26). Six non-oriented radar reflectors with angle in the interval 8-41 degrees to borehole axis. Confidence level = 2.

936–950 m DZ5: Increased frequency of both open and sealed, steeply dipping fractures. Part of the interval shows faint to weak oxidation. Predominant fracture minerals are laumontite, calcite and chlorite. Apertures less than 1 mm. Three radar reflectors; two oriented 282/65 and 299/81. Moderate resistivity anomalies. Susceptibility and sonic velocity seem to be unaffected. Two oriented radar reflectors at 932.9 m (001/33 or 005/75) and 946.1 m (258/65). Confidence level = 2.

5.2 HFM14

The borehole consists of one rock unit:

3–149 m RU1: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite, aplitic metagranite and one occurrence of fine- to medium-grained metagranitoid. Weak oxidation has affected the bedrock, more or less along the whole borehole length. In the upper 50 m, there are two crush zones and two fractures with apertures wider than 1 cm. These are also indicated in the radar measurements and as narrow geophysical anomalies. Confidence level = 2.

Two possible deformation zones are indicated:

68–76 m DZ1: Increased frequency of open, flat-lying fractures, some with apertures wider than 1 cm. Mostly chlorite and unknown fracture filling minerals. Four radar reflectors with an intersection angle of 16–80° to the borehole axis. Low magnetic susceptibility and resistivity. Several caliper anomalies. Confidence level = 3.

92–104 m DZ2: Slight increase of open, flat-lying fractures, with apertures less than 2 mm. Five crush zones (5–32 cm wide) in the lower half of the interval. Fracture filling minerals include quartz and chlorite. Four radar reflectors with an intersection angle of 50–63° to the borehole axis. Generally low magnetic susceptibility and resistivity. Several caliper anomalies. Confidence level = 3.

5.3 HFM15

The borehole consists of one rock unit:

4–99 m RU1: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite and aplitic metagranite, predominantly in the lower half of the borehole, and four minor (< 2 dm wide) occurrences of amphibolite. Weak oxidation has affected the bedrock, more or less along the whole borehole length. Generally increased fracture frequency relative to the remaining part of the borehole, outside the possible deformation zone, in the length intervals 4–27.5 m and 63.5–75 m. These are also indicated in the radar measurements and as narrow geophysical anomalies. Two crush zones (14 and 60 cm wide) in the upper 11 m of the borehole. Confidence level = 2.

There is one possible deformation zone in the borehole:

86–96 m DZ1: Increased frequency of open, flat-lying fractures, with apertures less than 2 mm. Mostly chlorite and unknown fracture filling minerals. Two radar reflectors with an intersection angle around 50° to the borehole axis. Low magnetic susceptibility and resistivity. Several caliper anomalies. Confidence level = 3.

5.4 HFM19

The borehole consists of one rock unit:

11–185 m RU1: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, aplitic metagranite, amphibolite and fine- to medium-grained metagranitoid. Locally weak oxidation. Two c 3 m wide occurrences of amphibolite in the lowermost part of the borehole. High magnetic susceptibility in the uppermost 50 m of the borehole. Generally increased fracture frequency relative to the remaining part of the borehole, outside the possible deformation zone, down to 26 m. One 10 cm wide crush zone at 12.5 m. Confidence level = 2.

Two possible deformation zones are indicated:

121–148 m DZ1: Increased frequency of predominantly open fractures. Fractures in the lower 10 m of the interval are steeply dipping. Mostly chlorite, calcite and unknown fracture filling minerals. Except for one fracture with an aperture wider than 1 cm in the uppermost part, all apertures are less than 3 mm. Locally weak oxidation. Four radar reflectors with an intersection angle of 10–76° to the borehole axis. A few sonic and moderate resistivity anomalies. Confidence level = 2.

168–185 m DZ2: Marked increase of both open and sealed fractures. Identified fracture minerals include chlorite, calcite, quartz, hematite and prehnite. Apertures generally less than 2 mm, except for one fracture with an aperture wider than 10 mm in the uppermost part. Generally weak oxidation. Low magnetic susceptibility and resistivity. Confidence level = 3.

6 Comments

The results from the geological single-hole interpretations of KFM05A, HFM14, HFM15 and HFM19 are presented in WellCad plots (Appendices 1–4). Each WellCad plot consists of the following columns:

1: Depth along borehole

2: Rock type

3: Rock alteration

4: Sealed fractures

5: Open fractures

6: Silicate density

7: Magnetic susceptibility

8: Natural gamma radiation

9: Estimated fracture frequency

10: Description: Rock unit

11: Stereogram for sealed fractures in rock unit (blue symbols)

12: Stereogram for open fractures in rock unit (red symbols)

13: Description: Possible deformation zone

14: Stereogram for sealed fractures in possible deformation zone (blue symbols)

15: Stereogram for open fractures in possible deformation zone (red symbols)

7 References

/1/ SKB P-rapport P-04-295. Boremap mapping of telescopic drilled borehole KFM05A. Petersson J, Berglund J, Wängnerud A, Danielsson P, Stråhle A.

/2/ SKB P-rapport P-04-112. Boremap mapping of percussion boreholes HFM13–15 and HFM19. Nordman C.

/3/ SKB P-rapport P-04-145. Geophysical borehole logging in borehole KFM01B, HFM14, HFM15, HFM16, HFM17 and HFM18. Nielsen U T, Ringgaard J.

/4/ SKB P-rapport P-04-153. Geophysical borehole logging in borehole KFM05A and HFM19. Nielsen U T, Ringgaard J.

/5/ SKB P-rapport P-04-154. Interpretation of borehole geophysical measurements in KFM05A, HFM14, HFM15 and HFM19. Mattsson H, Keisu M, Thunehed H.

/6/ SKB P-rapport P-04-68. RAMAC and BIPS logging in borehole HFM13, HFM14 and HFM15. Gustafsson J, Gustafsson C.

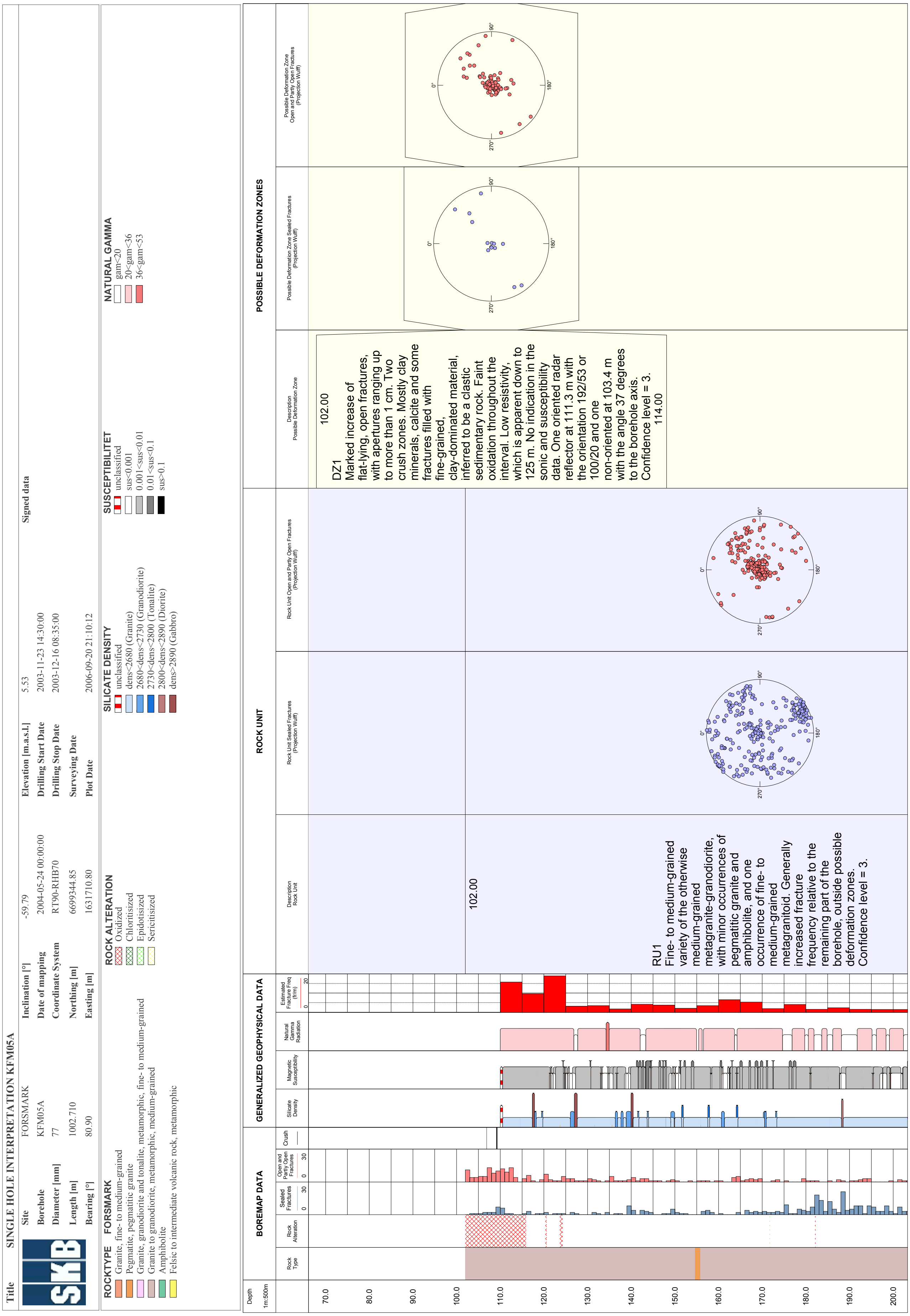
/7/ SKB P-rapport P-04-69. RAMAC and BIPS logging in borehole KFM06A, HFM16, HFM17, HFM18 and HFM19. Gustafsson J, Gustafsson C.

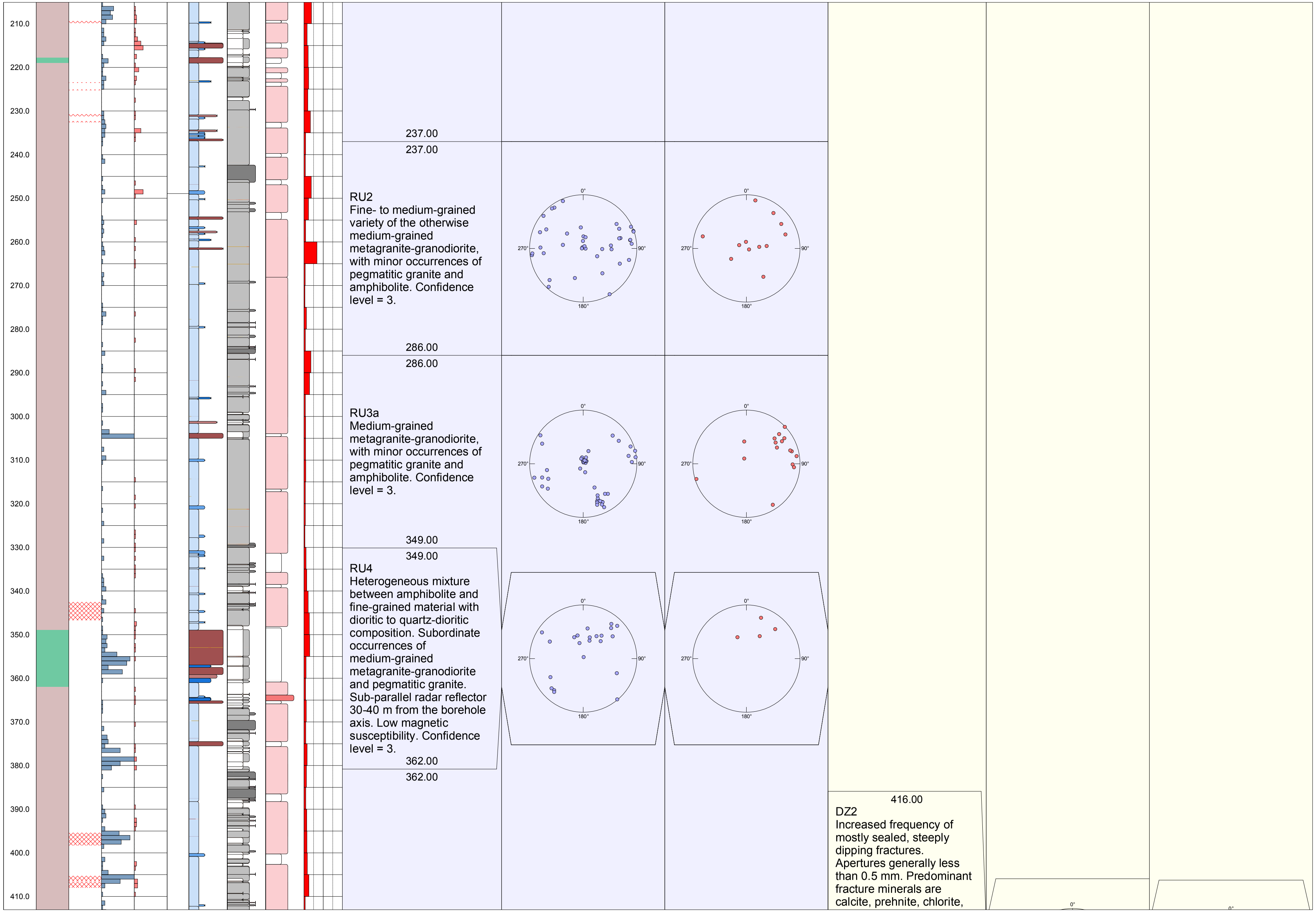
/8/ SKB P-rapport P-04-152. RAMAC and BIPS logging in borehole KFM05A. Gustafsson J, Gustafsson C (in preparation).

/9/ SKB P-03-75. Bedrock mapping. Rock types, their petrographic and geochemical characteristics, and a structural analysis of the bedrock based on Stage 1 (2002) surface data. Stephens M B, Lundqvist S, Bergman T, Andersson J, 2003.

Appendix 1

Geological single-hole interpretation for KFM05A

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220.0
230.0
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270.0
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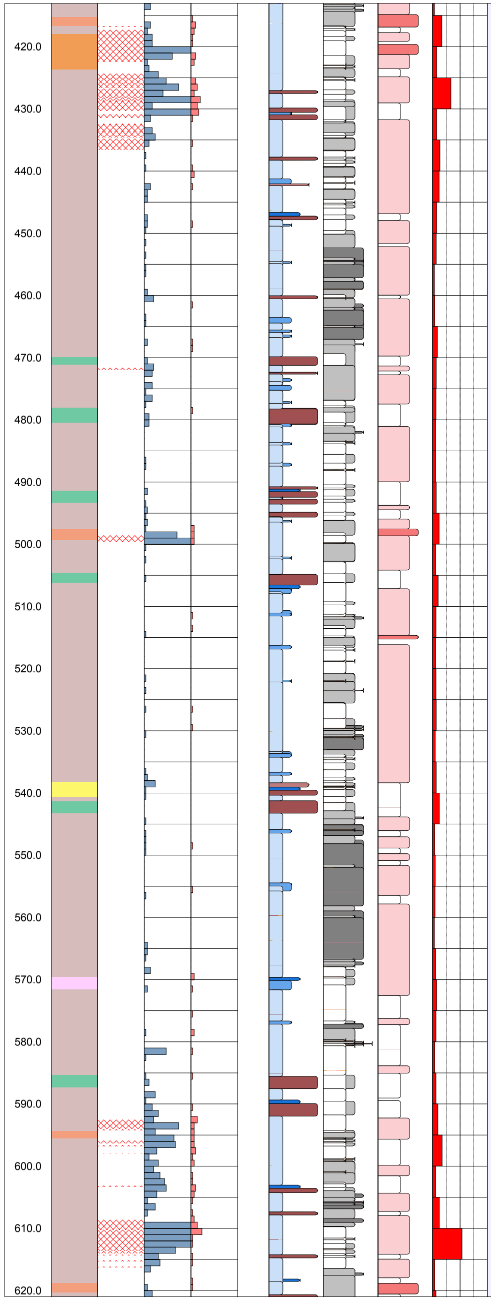
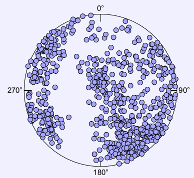
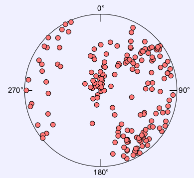
300.0
310.0
320.0
330.0
340.0
350.0
360.0
370.0
380.0
390.0
400.0
410.0
237.00
237.00
RU2
Fine- to medium-grained variety of the otherwise medium-grained metagranite-granodiorite, with minor occurrences of pegmatitic granite and amphibolite. Confidence level = 3.
286.00
286.00
RU3a
Medium-grained metagranite-granodiorite, with minor occurrences of pegmatitic granite and amphibolite. Confidence level = 3.
349.00
349.00
RU4
Heterogeneous mixture between amphibolite and fine-grained material with dioritic to quartz-dioritic composition. Subordinate occurrences of medium-grained metagranite-granodiorite and pegmatitic granite. Sub-parallel radar reflector 30-40 m from the borehole axis. Low magnetic susceptibility. Confidence level = 3.
362.00
362.00
416.00
DZ2
Increased frequency of mostly sealed, steeply dipping fractures. Apertures generally less than 0.5 mm. Predominant fracture minerals are calcite, prehnite, chlorite,



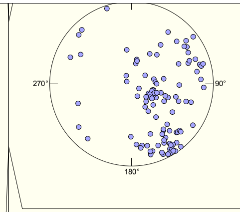
RU3b
Medium-grained metagranite-granodiorite, with minor occurrences of pegmatitic granite, amphibolite and in the interval 570-620 m fine- to medium-grained metagranitoid. Also two 1-2 m wide occurrences of felsic to intermediate metavolcanic rock at c. 507 and 538 m.
Sub-parallel radar reflector 30-40 m from the borehole axis, visible down to 430 m. Confidence level = 3.

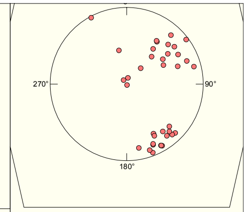




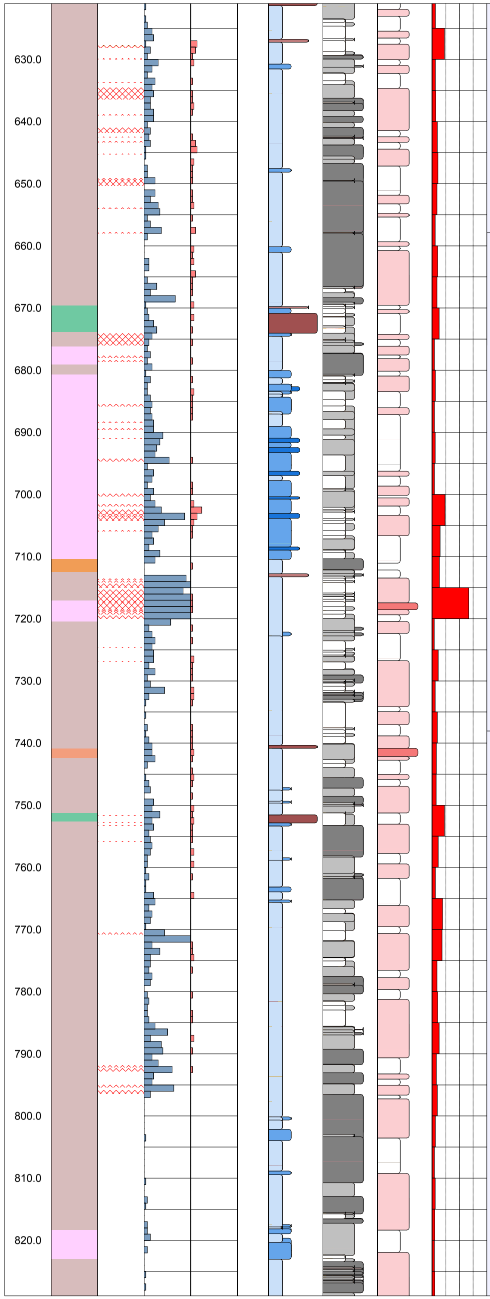
epidote and laumontite. Faint to medium oxidation. Low resistivity. No indication in the sonic and susceptibility data. Four oriented radar reflectors at 417.3 m (011/80), 424.2 m (151/88), 424.7 m (166/72 or 299/9) and at 427.6 m (092/24 or 200/65). Two non-oriented radar reflectors occur at 427.5 m and 431.1 m with the angle to borehole axis 35 and 53 degrees, respectively. Confidence level = 3.

436.00





590.00



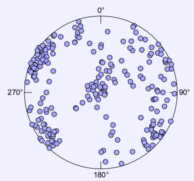
676.00

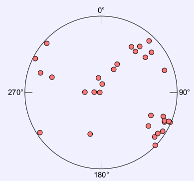
676.00

RU5
Fine- to medium-grained metagranitoid of granodioritic to tonalitic composition with subordinate medium-grained metagranite-granodiorite and pegmatitic granite. Amphibolite is absent in the fine- to medium-grained metagranitoid. Contacts between the fine- to medium-grained metagranitoid and the medium-grained metagranite-granodiorite are gradual and the two rocks are often difficult to separate in the contact zone. Anomalous high silica density and low susceptibility. Confidence level = 3.

720.00

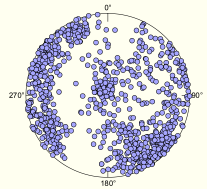
720.00

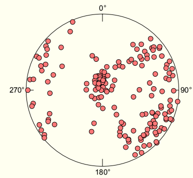


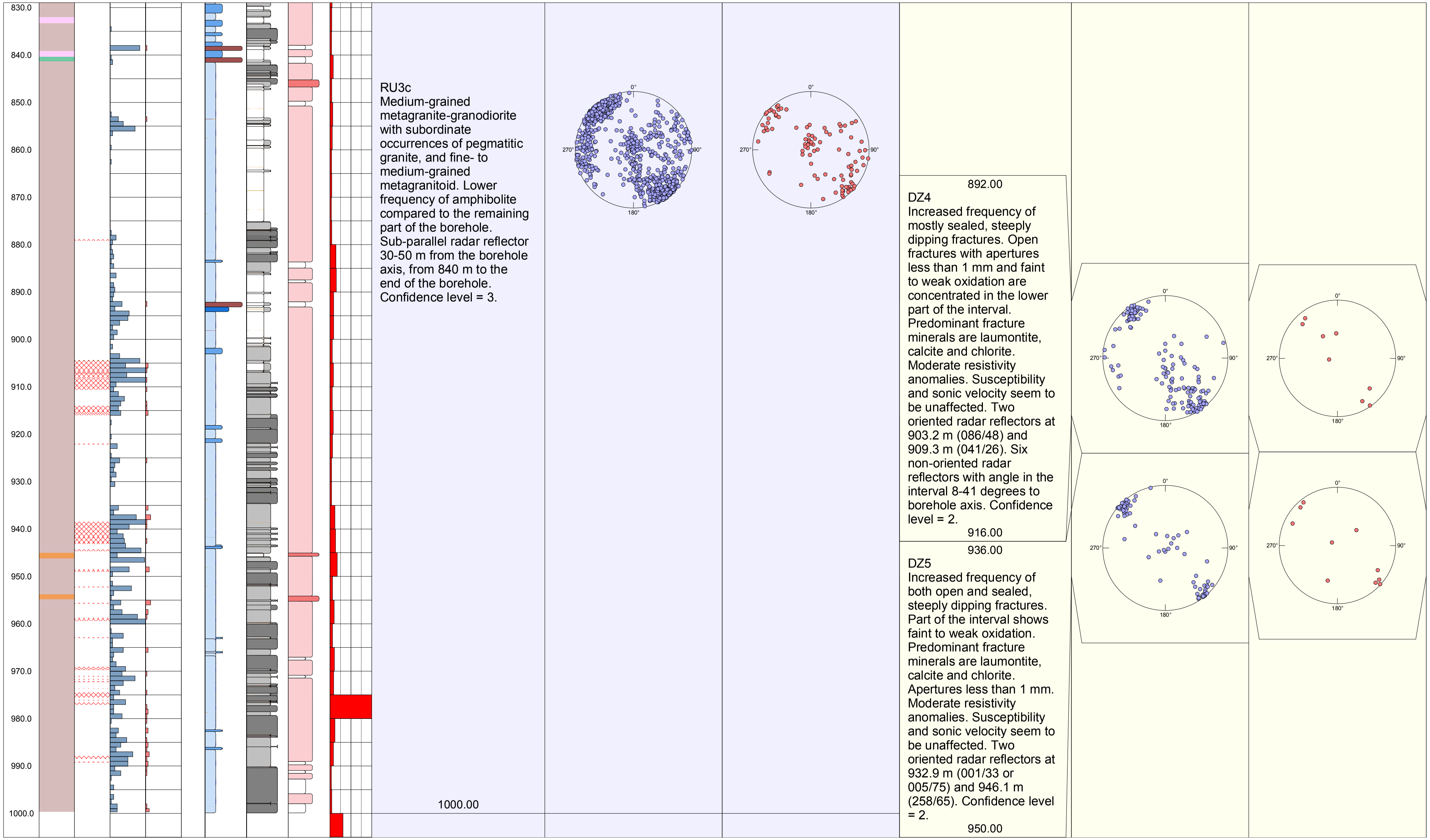


DZ3
Increased frequency of mostly sealed, steeply dipping fractures, with a sharp contact on both sides to a very little fractured bedrock. Two distinctive intervals, 609–616 m and 712–720 m, with dense fracture network and faint to weak oxidation. Faint to medium oxidation is locally observed along the whole interval. Predominant fracture minerals are laumontite, calcite, chlorite and hematite staining. Laumontite is prominent in the dense fracture network intervals. Apertures are generally less than 1 mm, with one ranging up to 4 mm. Low resistivity in the densely fractured intervals. Moderate resistivity anomalies in the remaining part. Susceptibility and sonic velocity seem to be unaffected. Totally 49 radar reflectors in the interval. Six radar reflectors in the upper of the densely fractured interval, and one at 610.9 m yield a more confident orientation of 232/25. Four radar reflectors in the lower of the densely fractured interval; three are oriented 123/71, 063/80 and 338/37. Confidence level = 1 for the whole interval and confidence level = 3 for the densely fractured intervals.

796.00

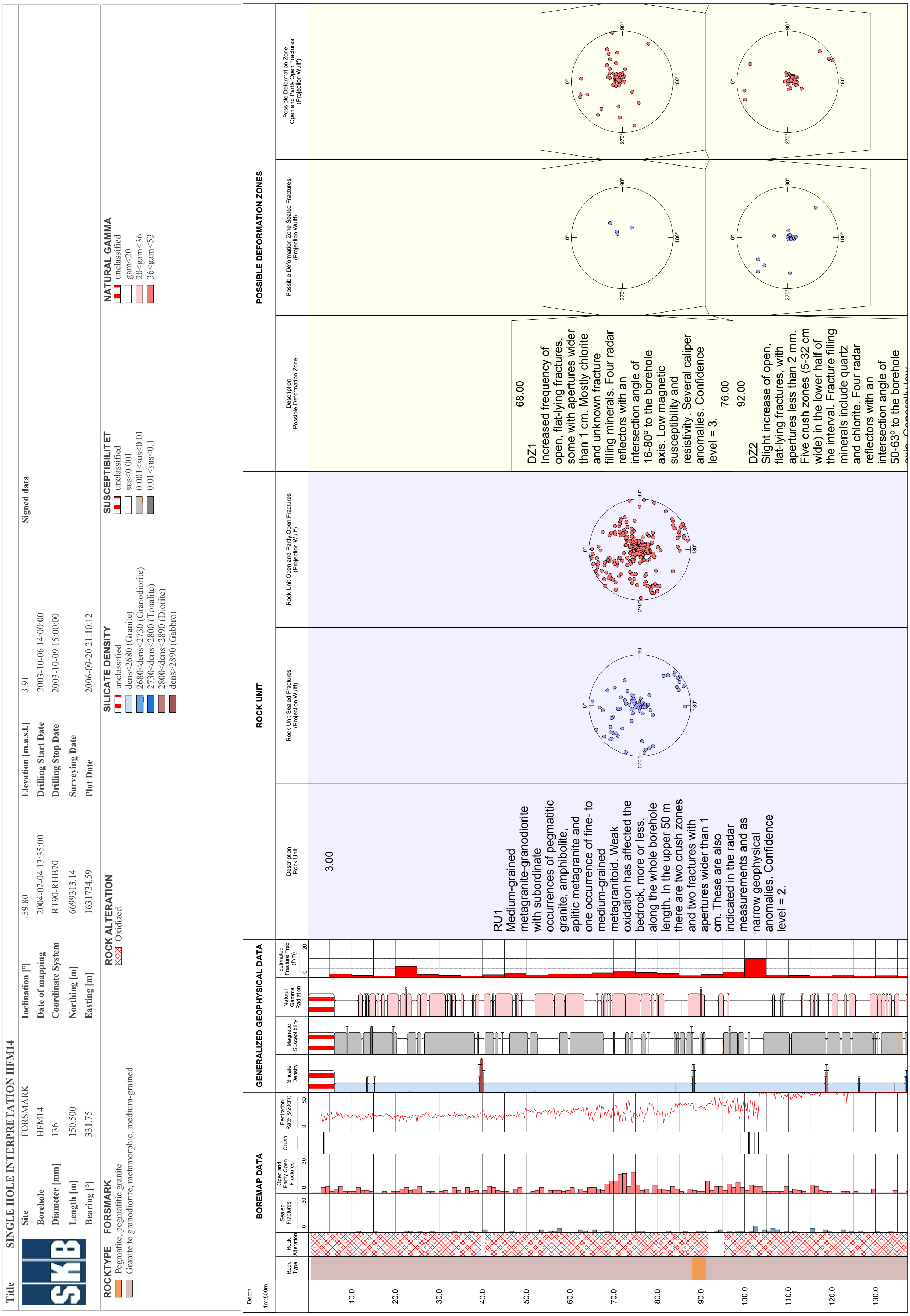


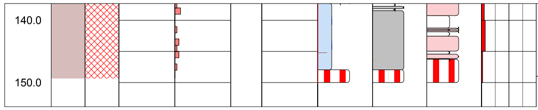



830.0
840.0
850.0
860.0
870.0
880.0
890.0
900.0
910.0
920.0
930.0
940.0
950.0
960.0
970.0
980.0
990.0
1000.0
RU3c
Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, and fine- to medium-grained metagranitoid. Lower frequency of amphibolite compared to the remaining part of the borehole. Sub-parallel radar reflector 30-50 m from the borehole axis, from 840 m to the end of the borehole. Confidence level = 3.
1000.00
892.00
DZ4
Increased frequency of mostly sealed, steeply dipping fractures. Open fractures with apertures less than 1 mm and faint to weak oxidation are concentrated in the lower part of the interval. Predominant fracture minerals are laumontite, calcite and chlorite. Moderate resistivity anomalies. Susceptibility and sonic velocity seem to be unaffected. Two oriented radar reflectors at 903.2 m (086/48) and 909.3 m (041/26). Six non-oriented radar reflectors with angle in the interval 8-41 degrees to borehole axis. Confidence level = 2.
916.00
936.00
DZ5
Increased frequency of both open and sealed, steeply dipping fractures. Part of the interval shows faint to weak oxidation. Predominant fracture minerals are laumontite, calcite and chlorite. Apertures less than 1 mm. Moderate resistivity anomalies. Susceptibility and sonic velocity seem to be unaffected. Two oriented radar reflectors at 932.9 m (001/33 or 005/75) and 946.1 m (258/65). Confidence level = 2.
950.00
0°
90°
180°
270°

Appendix 2

Geological single-hole interpretation for HFM14

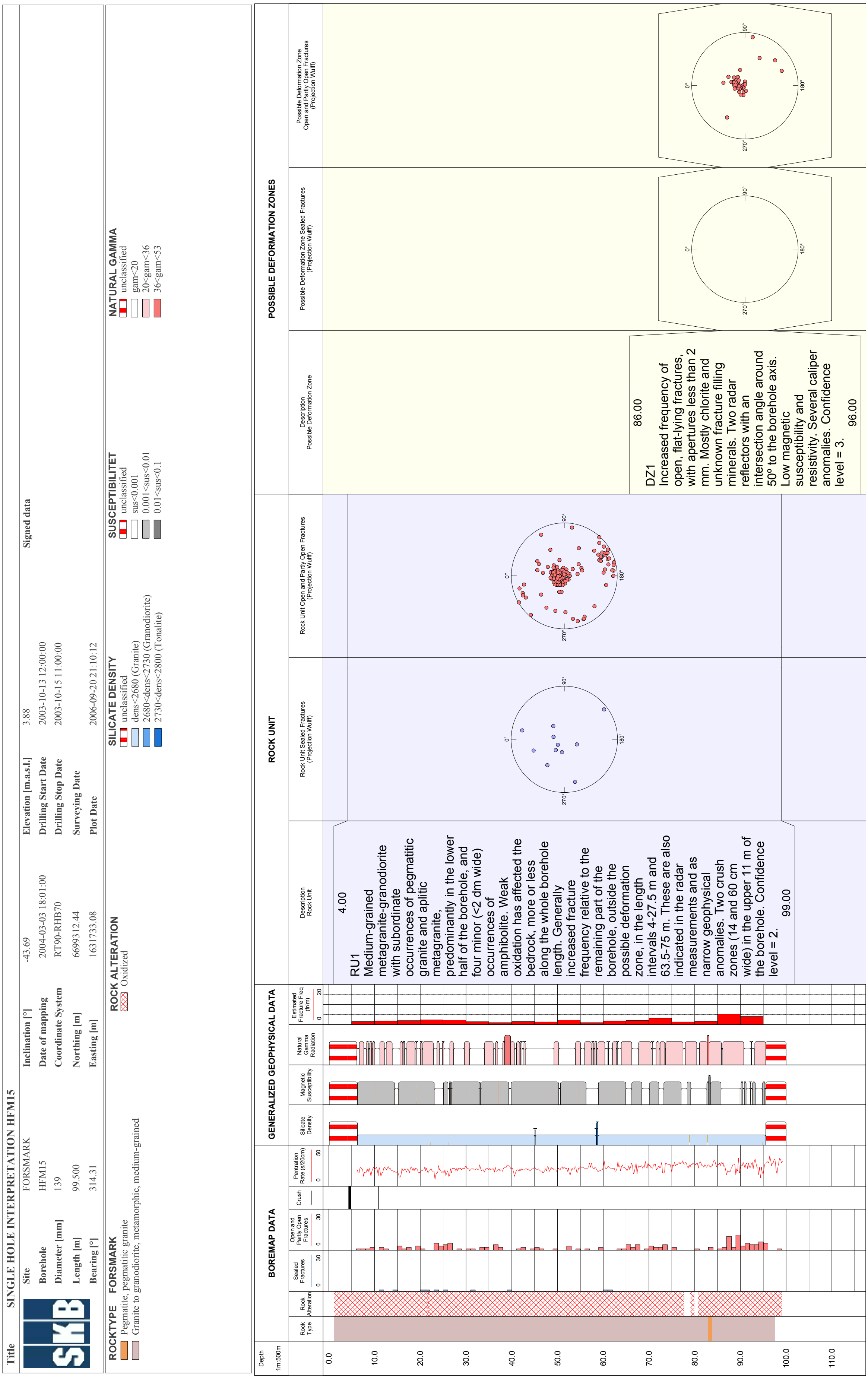




149.00

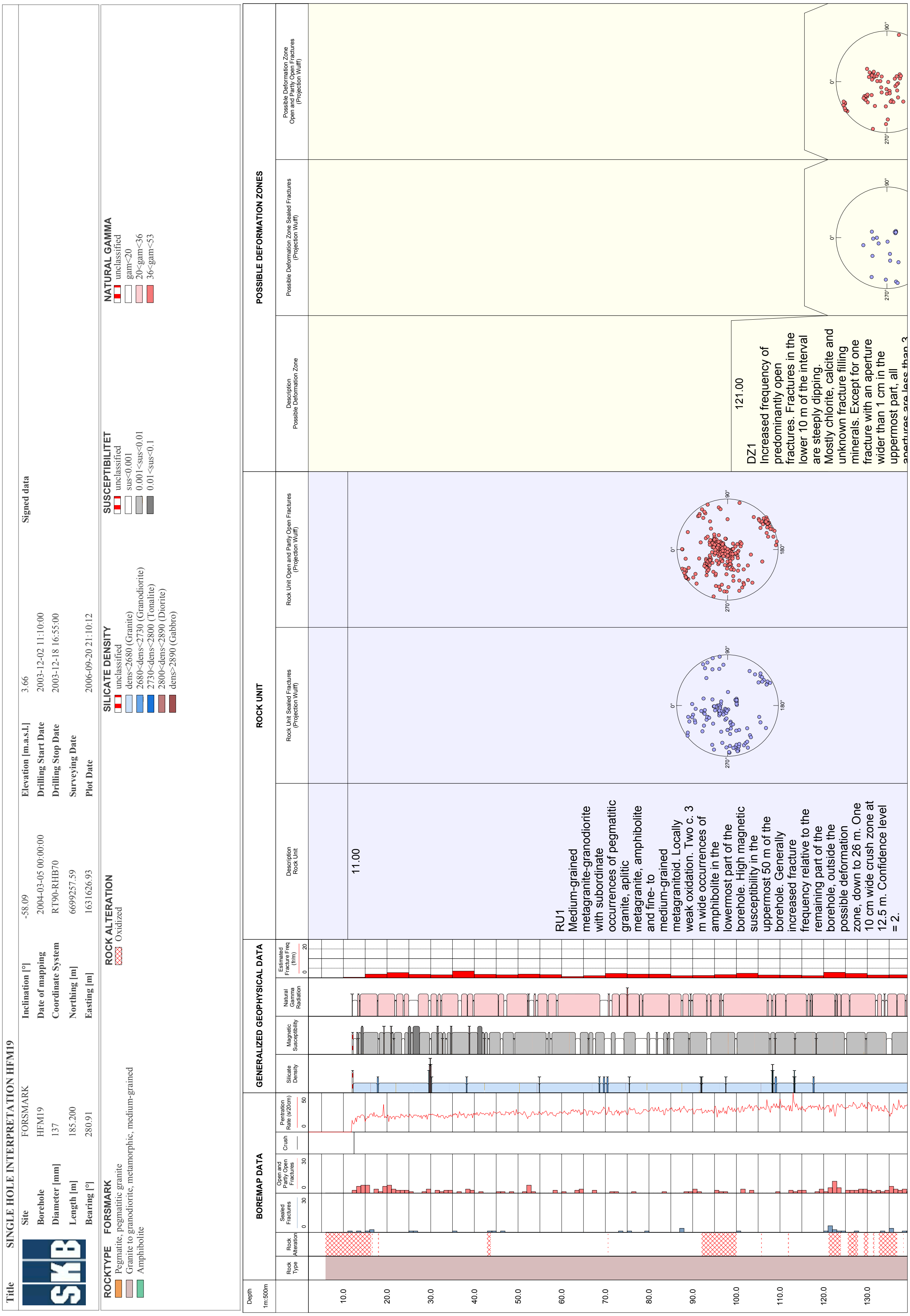
axis. Generally low magnetic susceptibility and resistivity. Several caliper anomalies. Confidence level = 3.
104.00

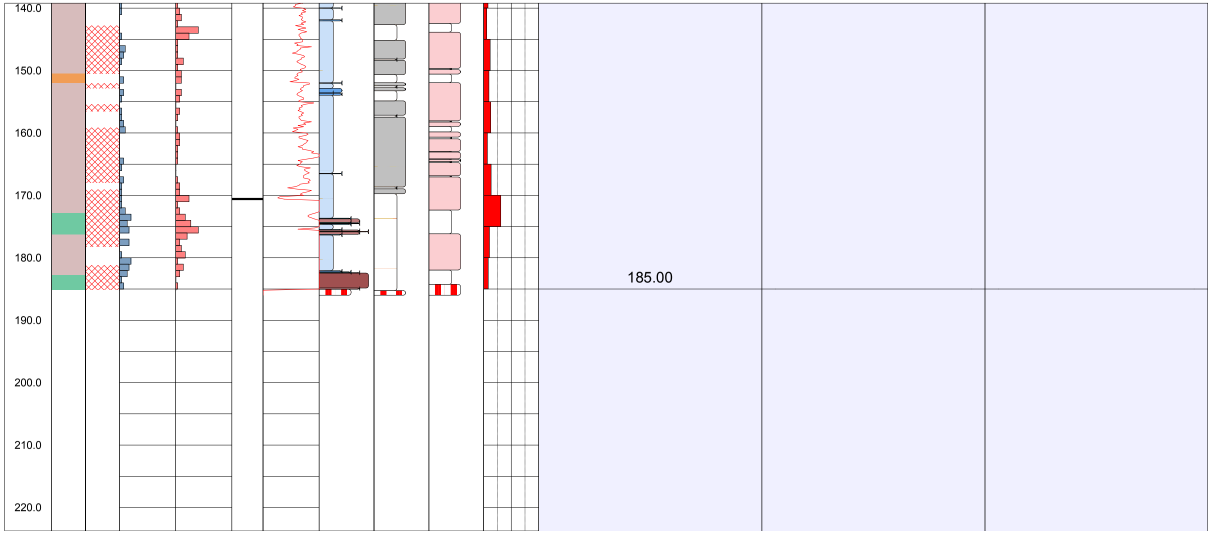
Geological single-hole interpretation for HFM15



Appendix 4

Geological single-hole interpretation for HFM19





apertures are less than
mm. Locally weak oxidation. Four radar reflectors with an intersection angle of 10-76 ° to the borehole axis. A few sonic and moderate resistivity anomalies. Confidence level = 2.
148.00

168.00
DZ2
Marked increase of both open and sealed fractures. Identified fracture minerals include chlorite, calcite, quartz, hematite and prehnite. Apertures generally less than 2 mm, except for one fracture with an aperture wider than 10 mm in the uppermost part. Generally weak oxidation. Low magnetic susceptibility and resistivity. Confidence level = 3.
185.00