P-04-116

Revised October 2006

Forsmark site investigation

Geological single-hole interpretation of KFM01A, KFM01B and HFM01-03 (DS1)

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June 2004

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Keywords: Forsmark, Geophysics, Geology, Borehole, Bedrock, Fractures, Field note: Forsmark 314, AP PF 400-04-38.

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 and 5.2 as well as in Appendix 1 and Appendix 2.

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 1-5 are updated.

Abstract

This report constitutes geological single-hole interpretations of the cored boreholes KFM01A and KFM01B, as well as the percussion boreholes HFM01-03 in Forsmark. The geological single-hole interpretation combines the geological core mapping, interpreted geophysical logs, borehole radar measurements and seismic reflectors to interpret where lithological rock units and possible deformation zones occurs in the boreholes.

The geological single-hole interpretation shows that three lithological rock units occur in borehole KFM01A, while one rock unit occurs in KFM01B. A subdivision of rock units into sections, have been made using fracture frequency. Generally, medium-grained metagranite-granodiorite dominates in KFM01A and KFM01B. Amphibolite, pegmatitic granite and a fine-medium grained metagranitoid occurs as subordinate rock types. Three possible deformation zones have been identified in KFM01A. Three possible deformation zones have also been identified in KFM01B.

The percussion borehole HFM01 is dominated by medium-grained metagranite-granodiorite. Pegmatitic granite and amphibolite occurs as subordinate rock types. One possible deformation zone has been identified in HFM01.

The percussion borehole HFM02 is dominated by medium-grained metagranite-granodiorite. Pegmatitic granite, amphibolite and fine-medium grained metagranitoid, occurs as subordinate rock types. One possible deformation zone has been identified in HFM02.

The percussion borehole HFM03 is dominated by medium-grained metagranite-granodiorite with amphibolite as a subordinate rock type. No deformation zone has been identified in HFM03.

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålen KFM01A, KFM01B samt hammarborrhålen HFM01-03 i Forsmark. Den geologiska enhålstolkningen syftar till att utifrån data från den geologiska karteringen, tolkade geofysiska loggar, borrhåls-radarmätningar och seismiska reflektorer indikera olika litologiska enheters fördelning i borrhålen samt möjliga deformationszoners läge och utbredning.

Denna undersökning visar att det i KFM01A finns tre litologiska enheter medan KFM01B har en litologisk enhet. En vidare uppdelning i sektioner har gjorts med sprickfrekvensen som bas. Generellt sett dominerar medelkornig metagranit-granodiorit i KFM01A och KFM01B. Amfibolit, pegmatitisk granit och fin- till medelkornig metagranitoid före-kommer i mindre omfattning. Tre möjliga deformationszoner har identifierats i KFM01A. Även i KFM01B har tre möjliga deformationszoner identifierats.

Hammarborrhål HFM01 domineras av medelkornig metagranit-granodiorit med smärre inslag av pegmatitisk granit och amfibolit. En möjlig deformationszon har identifierats i HFM01.

Hammarborrhål HFM02 domineras av medelkornig metagranit-granodiorit med mindre inslag av pegmatitisk granit och amfibolit samt ett mindre parti med fin- till medelkornig granitoid. En möjlig deformationszon har identifierats i HFM02.

Hammarborrhål HFM03 domineras av medelkornig metagranit-granodiorit med inslag av amfibolit. Ingen möjlig deformationszon har identifierats i HFM03.

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 modeling 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 five boreholes at drilling site 1 (DS1) in the Forsmark area. These include the cored boreholes KFM01A and KFM01B and the percussion-drilled boreholes HFM01, HFM02 and HFM03 (Figure 1-1).

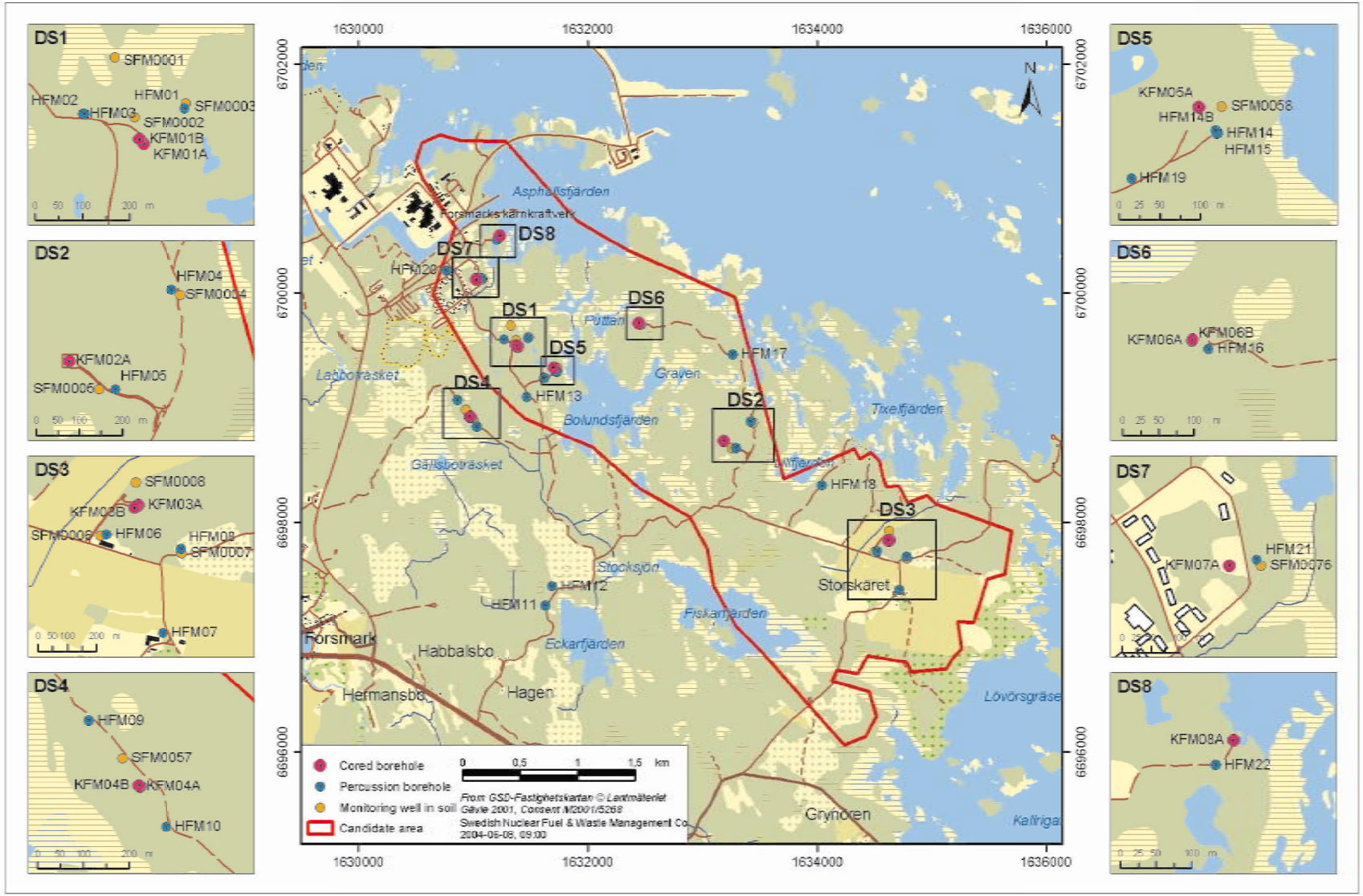


Figure 1-1. *Map showing the location of drilling site 1 (DS1) and position of the boreholes KFM01A, KFM01B and HFM01-03.*

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 geological single-hole interpretation:

- Boremap data (including BIPS and geological mapping data) /1, 2 and 3/.
- Generalized geophysical logs and their interpretation /4, 5 and 6/.
- Radar data and their interpretation /7, 8 and 9/.
- Reflection seismic reflector data and their interpretation /10/.

The reflection seismic measurements were not carried out in the borehole but on the ground surface. The measurements and the data evaluation were completed before the borehole was drilled and the reflectors used in this report correspond to those that were predicted to intersect the borehole /10/.

The material used as 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

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 marks. (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. All these rocks have been included in the younger, Group D intrusive suite /11/.

Silicate density: This parameter indicates the density of the rock after subtraction of the magnetite 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.

Possible alteration: This parameter has only been used slightly in the geological single-hole interpretation in the Forsmark area.

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.

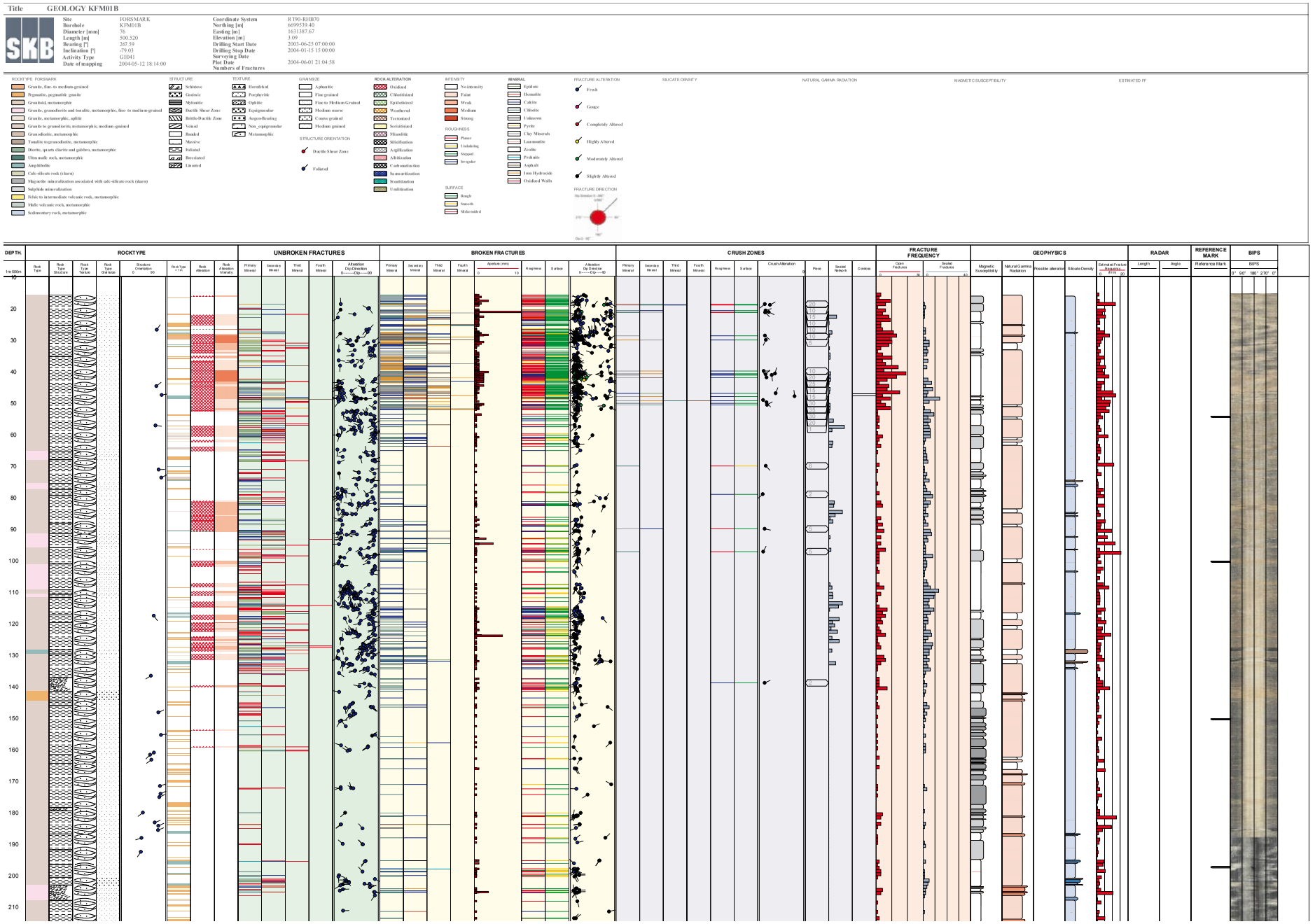


Figure 3-1. *Example of WellCad plot used as basis for the single-hole interpretation.*

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 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 from the WellCad plot.

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 plot.

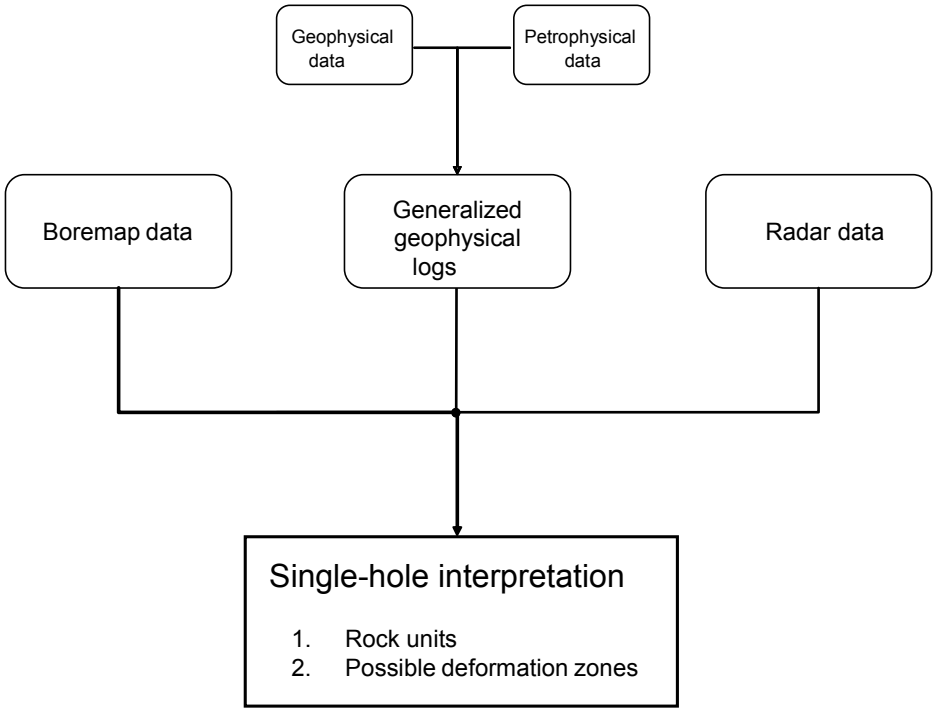


Figure 4-1. *Schematic block diagram of geological single-hole interpretation.*

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 KFM01A, Appendix 2 for KFM01B, Appendix 3 for HFM01, Appendix 4 for HFM02, and Appendix 5 for HFM03). 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 KFM01A

The borehole consists of three rock unit types, RU1-RU3. Further division on the basis of degree of fracture frequency has also been carried out for one of these rock units. In all, the borehole has been divided into eight sections of distinct rock character.

29-51 m RU1: Medium-grained metagranite-granodiorite. Percussion-drilled part of the borehole. Contains a possible deformation zone and a generally increased fracture frequency relative to the remaining borehole outside the possible deformation zones. Boremap mapping based on BIPS-image and examination of drill cuttings. Confidence level = 3.

51-100 m RU1: Medium-grained metagranite-granodiorite. Percussion-drilled part of the borehole. Only examination of drill cuttings. Confidence level = 1.

102-290 m RU1: Medium-grained metagranite-granodiorite with subordinate occurrences of amphibolite, pegmatitic granite and fine- to medium-grained metagranitoid. Generally an increased fracture frequency relative to the remaining part of the borehole outside the possible deformation zones. Several zones of oxidation are also present. A sub-parallel distinct radar reflector can be followed from approximately 110 to 170 m along the borehole and at a distance of 50 m outside the borehole. Confidence level = 3.

290-503 m RU2a: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and fine- to medium-grained metagranitoid. A sub-parallel distinct radar reflector can be followed from approximately 240 to 380 m along the borehole and at a distance of 10-50 m outside the borehole. Confidence level = 3.

503-560 m RU3: Heterogeneous mixture of medium-grained metagranite-granodiorite, fine- to medium-grained metagranitoid with granitic to granodioritic composition (indicated from silicate density measurements), pegmatitic granite and subordinate amphibolite. Strong variation in magnetic susceptibility and natural gamma radiation. A sub-parallel distinct radar reflector can be followed from approximately 460 to 560 m along the borehole and at a distance of 0-20 m outside the borehole. Confidence level = 3.

560-808 m RU2b: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and fine- to medium-grained metagranitoid. A sub-parallel distinct radar reflector can be followed from approximately 710 to 890 m along the borehole and at a distance of 15-30 m outside the borehole. Confidence level = 3.

808-865 m RU4: Fine- to medium-grained metagranitoid (granitic to granodioritic composition as indicated from silicate density measurements), with subordinate amphibolite, pegmatitic granite, medium-grained metagranite-granodiorite and calc-silicate rock. Lowermost ten metres of the section have lower magnetic susceptibility and natural gamma radiation. Indications of sub-parallel radar reflectors can be observed. Confidence level = 3.

865-1001 m RU2c: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and fine- to medium-grained metagranitoid. Confidence level = 3.

Three possible deformation zones have been recognised:

36-48 m DZ1: One three decimetre-wide and one two decimetre wide crush zone and an increased frequency of open fractures in the upper part and of sealed fractures in the lower part of the zone. Both crush zones are supported by caliper and density anomalies. Other geophysical data indicating fractures are lacking. Seismic reflector (possible A2) with an inferred intersection depth at 0 m, orientation 080/22 and seismic reflector (possible B4) with an inferred intersection depth at 10 m, orientation 050/28. Two distinct radar reflectors with an intersection angle of 75 degrees to the borehole axis. Confidence level = 3.

386-412 m DZ2: Increased frequency of sealed fractures associated with a weak oxidation. Predominant infilling minerals are chlorite and laumontite. A few sharp anomalies in the focused resistivity and caliper data. Radar reflectors occur at 387.0 m with the orientation 044/45 or 232/25 and at 398.6 m with the orientation 236/66 or 054/82. A non-oriented radar reflector occurs at 403.6 m with an intersection angle of 10 degrees to the borehole axis. Confidence level = 2.

639-684 m DZ3: Strongly increased frequency of sealed fractures, mostly filled by laumontite. Distinct concentration of fractures striking NE and dipping steeply towards SE. Also a weak oxidation of the whole zone. Major anomalies in the focused resistivity and caliper data. No clear indication in the P-wave velocity. Radar reflectors occur at 641.3 m with the orientation 191/32, at 651.9 m with the orientation 055/51 or 248/29, at 659.3 m with the orientation 223/86 and at 663.5 m with the orientation 348/53. One non-oriented radar reflector occurs at 648.3 m with an angle of 4 degrees to borehole axis. Confidence level = 3.

5.2 KFM01B

The borehole can be divided into one rock unit, which on the basis of the degree of fracture frequency can be divided into two sections.

16-141 m RU1: Medium-grained metagranite-granodiorite with subordinate occurrences of fine- to medium-grained metagranitoid (granitic to granodioritic composition as indicated from silicate density measurements), pegmatitic granite and a few amphibolite bodies. The interval 92-112 m is dominated by the fine- to medium-grained metagranitoid and coincides between 102-109 m with a positive natural gamma radiation anomaly. This rock unit contains two possible deformation zones (16-53 and 107-135 m), and two sections (53-107 and 135-141 m) with five crush zones and a generally increased fracture frequency relative to the remaining borehole outside the possible deformation zones. Generally weak to faint oxidation and low susceptibility. Confidence level = 3.

141-502 m RU2: Medium-grained metagranite-granodiorite with subordinate pegmatitic granite, amphibolite and fine- to medium-grained metagranitoid. Positive natural gamma radiation anomalies at 202-206 and 222-225 m that correspond to fine- to medium-grained granitoids. Low susceptibility along the section 195-215 m that does not coincide with alteration and a possible deformation zone. Confidence level = 3.

Three possible deformation zones are indicated:

16-53 m DZ1: Several crush zones and strongly increased frequency of open fractures. The most common fracture filling minerals are calcite, chlorite and asphalt. Also with a variable degree of oxidation (faint to medium). The possible deformation zone is also supported by several distinct anomalies in the focused resistivity and P-wave velocity data. Four non-oriented radar reflectors with an intersection angle of 64-90 degrees to the borehole axis and one distinct at 49.9 m with an angle of 9 degrees to borehole axis. At 40.8 m occurs a reflector with the orientation 033/9 or 341/15 and at 49.2 m with the orientation 025/33 or 240/15. Confidence level = 3.

107-135 m DZ2: Increased frequency of sealed fractures with epidote and laumontite as dominant fracture filling minerals. Also with a variable degree of oxidation (faint to weak). Fractures are indicated in the focused resistivity data, but not in any of the other geophysical logs. Three non-oriented radar reflectors occur with an angle of 71-81 degrees to borehole axis and one with an angle of 10 degrees to borehole axis. Radar reflectors occur at 111.1 m with the orientation 153/71, at 122.4 m with the orientation 339/33 and at 131.4 m with the orientation 018/43 or 216/22. Confidence level = 3.

415-454 m DZ3: Two crush zones and increased frequency of sealed fractures. Calcite, laumontite, chlorite and prehnite as the dominant fracture filling minerals. Also with a variable degree of oxidation, ranging from faint to strong in intensity. The possible deformation zone is also supported by several distinct anomalies in the focused resistivity, caliper and P-wave velocity data. Three non-oriented radar reflectors occur with an angle of 42-65 degrees to borehole axis and one with an angle of 6 degrees to borehole axis. Radar reflectors occur at 417.5 m with the orientation 018/66 or 205/33 and at 445.7 m with the orientation 028/49 or 238/19. Confidence level = 3.

5.3 HFM01

The borehole consists of one rock unit:

31-197 m RU1: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite and amphibolite. Confidence level = 3.

One possible deformation zone is indicated:

35-44 m DZ1: One crush zone at 43 m and a single fracture with an aperture wider than 1 cm at 35 m. Distinct low P-wave velocity, caliper and low focused resistivity anomaly at 35-37 and 42-43 m. One weak radar reflector at 42 m; intersection angle 88 degrees to the borehole axis. Confidence level = 2.

5.4 HFM02

The borehole consists of one rock unit:

25-99 m RU1: Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and one occurrence of fine- to medium-grained metagranitoid. Confidence level = 3.

There is one possible deformation zone in the borehole:

42-47 m DZ1: Increased fracture frequency, several with apertures wider than 1 cm. Low P-wave velocity and caliper anomalies. One clear radar reflector at 42 m; intersection angle 73 degrees to the borehole axis. Confidence level = 3.

5.5 HFM03

The borehole consists of one rock unit:

13-26 m RU1: Medium-grained metagranite-granodiorite with two metres of amphibolite in the lowermost part. Also two crush zones at 15 and 21 m; coincide with low resistivity and caliper anomalies, as well as radar reflectors (intersection angles 60 and 90 degrees to the borehole axis). Confidence level = 3.

No possible deformation zone was identified in this borehole.

6 Comments

The results from the geological single-hole interpretations of the KFM01A, KFM01B, HFM01, HFM02 and HFM03 are presented in WellCad plots (Appendices 1-5). Each WellCad plot consists of the following columns:

1: Depth

2: Rock type

3: Rock alteration

4: Sealed fractures (blue symbols)

5: Open fractures (red symbols)

6: Silicate density

7: Susceptibility

8: Natural gamma radiation

9: Estimated fracture frequency

10: Comment: Rock unit

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

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

13: Comment: 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)

Fractures not visible in BIPS are included in the data.

7 References

/1/ SKB P-report P-03-23. Boremap mapping of telescopic drilled borehole KFM01A. Petersson J, Wängnerud A.

/2/ SKB P-report P-04-114. Boremap mapping of borehole KFM01B. Berglund J, Petersson J, Wängnerud A, Danielsson P, Stråhle A.

/3/ SKB P-report P-03-20. Boremap mapping of percussion boreholes HFM01-03. Nordman C.

/4/ SKB P-report P-04-80. Interpretation of borehole geophysical measurements in KFM01A, KFM01B, HFM01, HFM02 and HFM03. Mattsson H. (prel title)

/5/ SKB P-report P-04-145. Borehole logging in borehole KFM01B, HFM14, HFM15, HFM16, HFM17 and HFM18. Nielsen U T, Ringgaard J.

/6/ SKB P-report P-03-103. Geophysical borehole logging. Borehole KFM01A, HFM01 and HFM02. Nielsen U T, Ringgaard J.

/7/ SKB P-report P-03-39. Geophysical, radar and BIPS logging in boreholes HFM01, HFM02, HFM03 and the percussion drilled part of KFM01A. Gustafsson C, Nilsson P.

/8/ SKB P-report P-03-45. RAMAC and BIPS logging in borehole KFM01A. Aaltonen J, Gustafsson C.

/9/ SKB P-report P-04-79. RAMAC and BIPS logging in borehole KFM01B and RAMAC re-logging in KFM01A with the directional antenna. Aaltonen J, Gustafsson C. (prel. title)

/10/ SKB R-report R-02-43. Reflection seismic studies in the Forsmark area – stage 1. Juhlin C, Bergman B, Palm H.

/11/ SKB P-report P-03-75. Forsmark site investigation. 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.

Appendix 1

Geological single-hole interpretation for KFM01A

Title SINGLE HOLE INTERPRETATION KFM01A

Site	FORSMARK	**Inclination [°]**	-84.72	**Elevation [m.a.s.l.]**	3.13	**Signed data**
Borehole	KFM01A	**Date of mapping**	2003-01-23 00:00:00	**Drilling Start Date**	2002-05-07 09:30:00	
Diameter [mm]	76	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2002-06-10 12:50:00	
Length [m]	1001.490	**Northing [m]**	6699529.81	**Surveying Date**		
Bearing [°]	318.35	**Easting [m]**	1631397.16	**Plot Date**	2006-09-20 21:10:12	

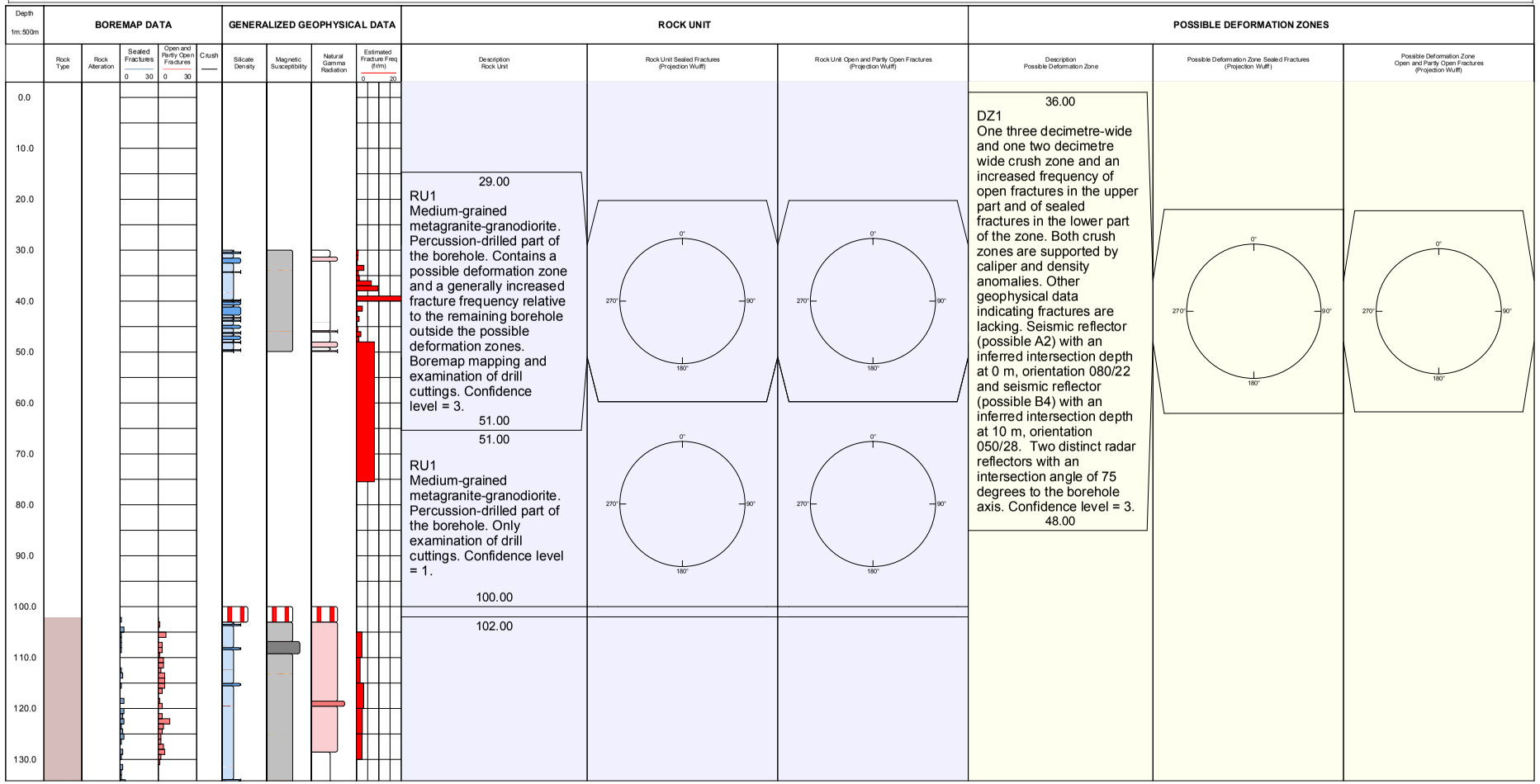
ROCKTYPE FORSMARK
- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite
- Calc-silicate rock (skarn)

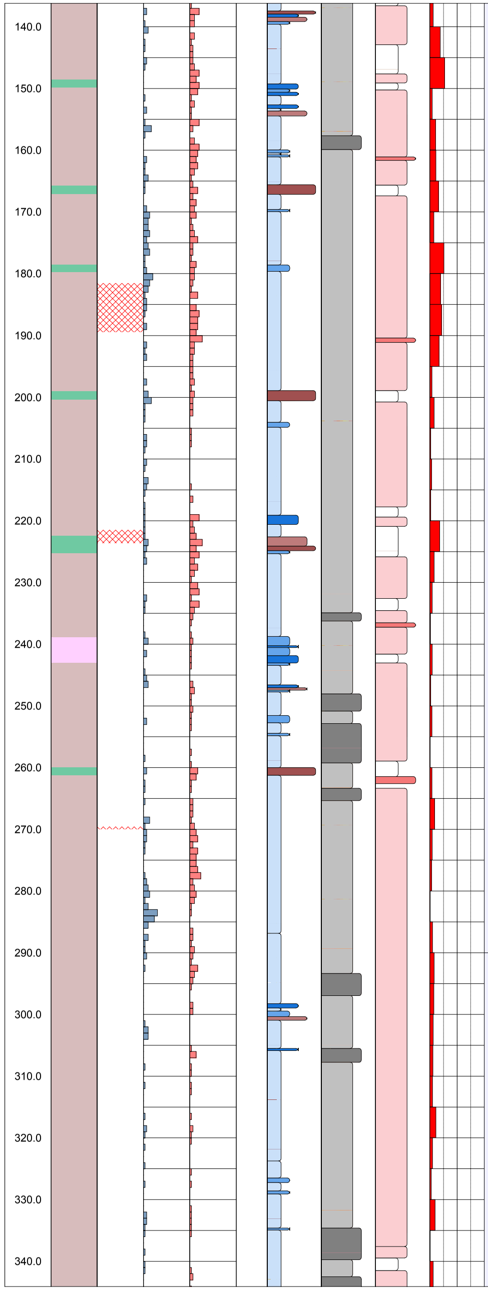
ROCK ALTERATION
- Oxidized

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

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- gam<20
- 20<gam<36
- 36<gam<53

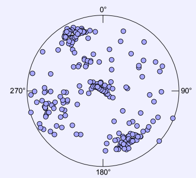


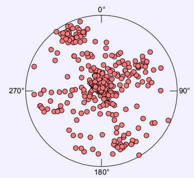


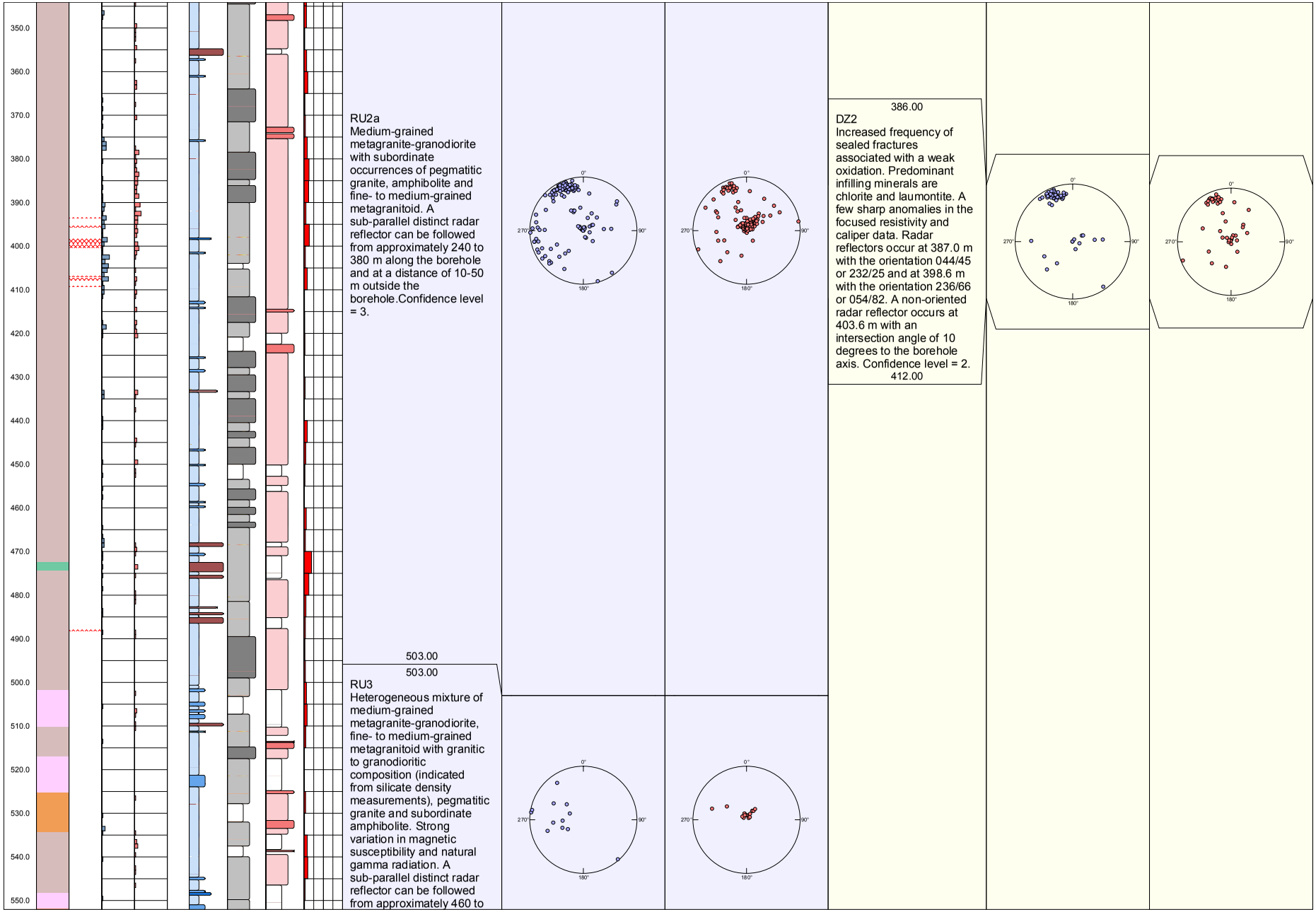
RU1
Medium-grained metagranite-granodiorite with subordinate occurrences of amphibolite, pegmatitic granite and fine- to medium-grained metagranitoid. Generally an increased fracture frequency relative to the remaining part of the borehole outside the possible deformation zones. A sub-parallel distinct radar reflector can be followed from approximately 110 to 170 m along the borehole and at a distance of 50 m outside the borehole. Confidence level = 3.

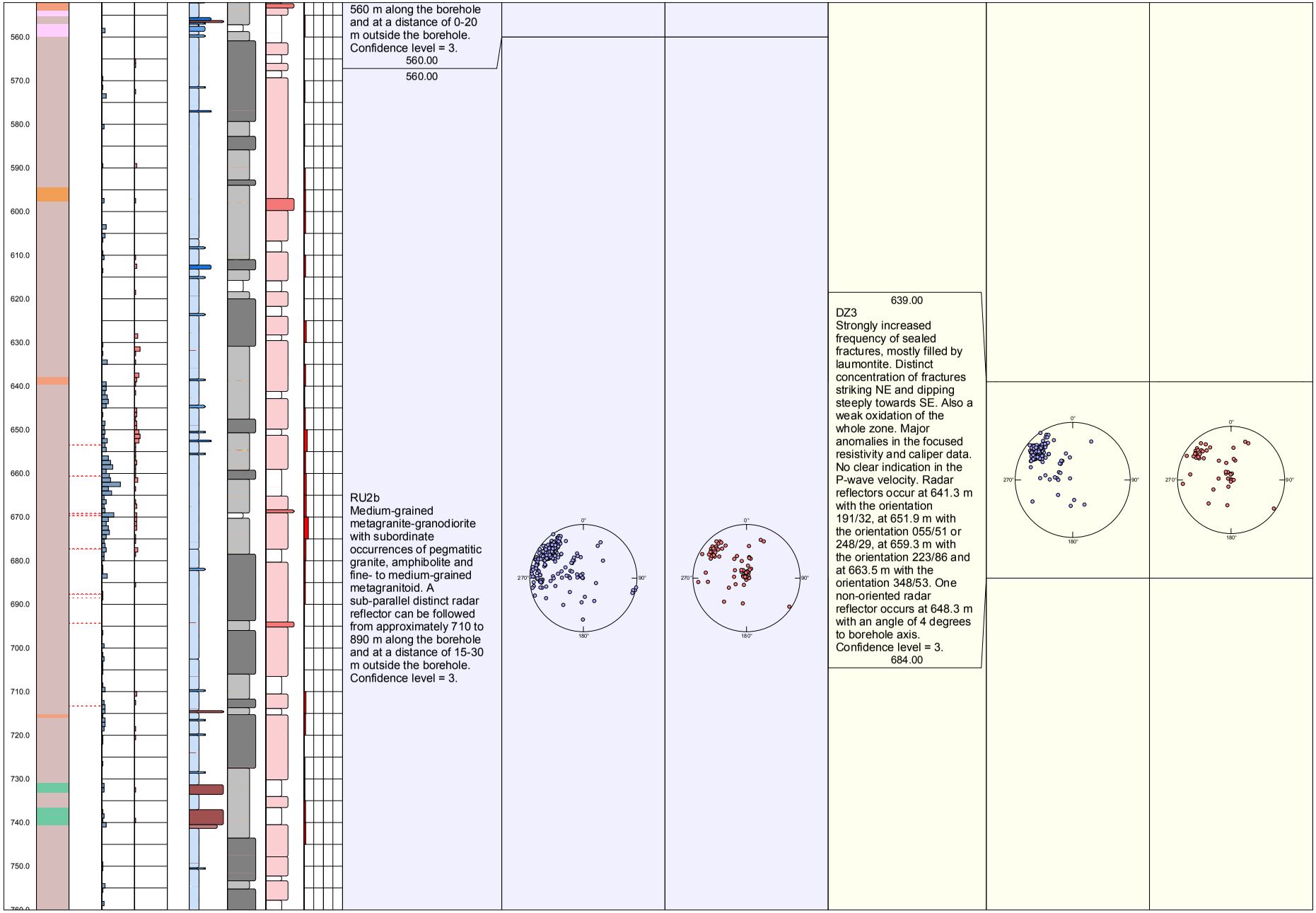
290.00

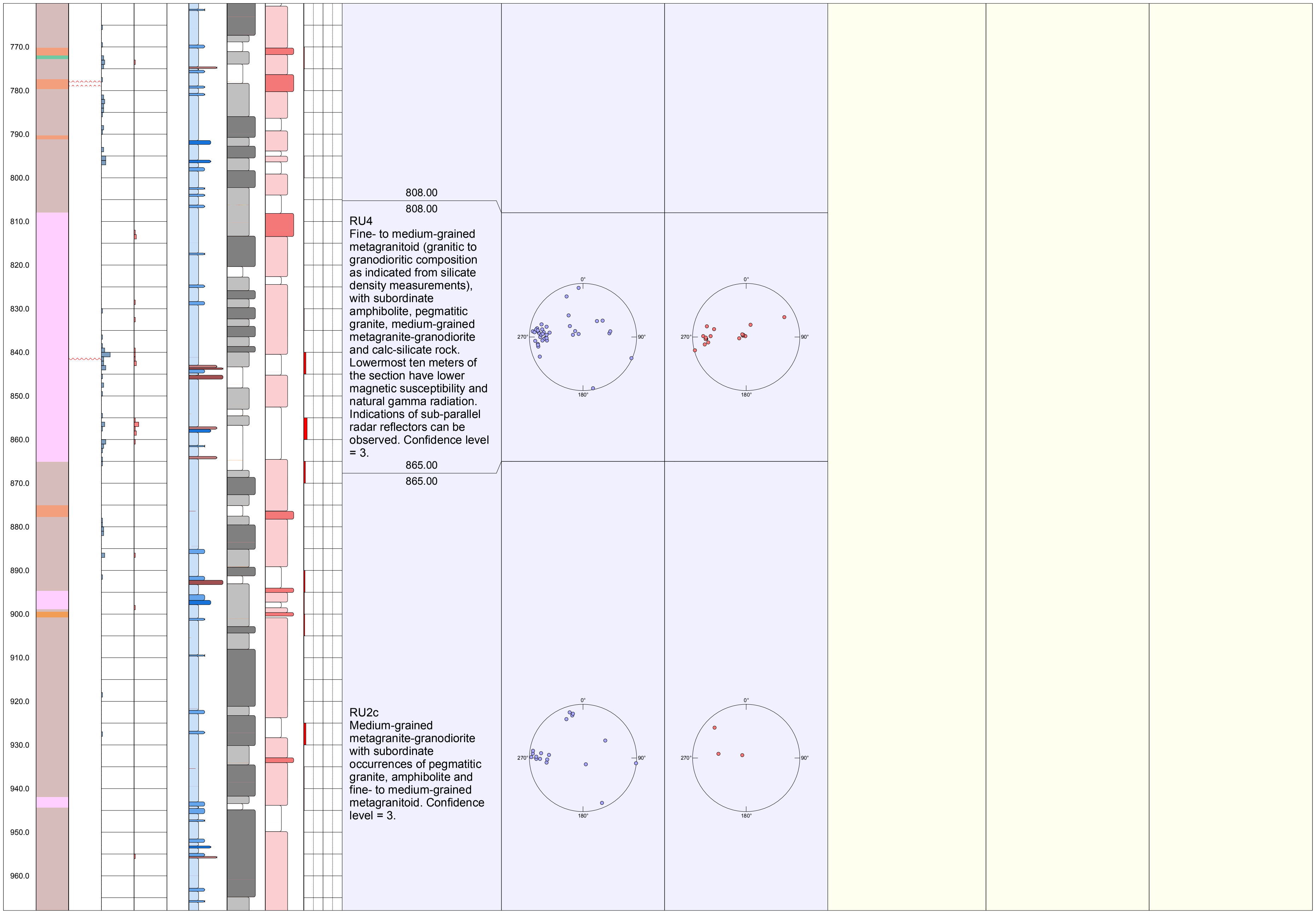
290.00

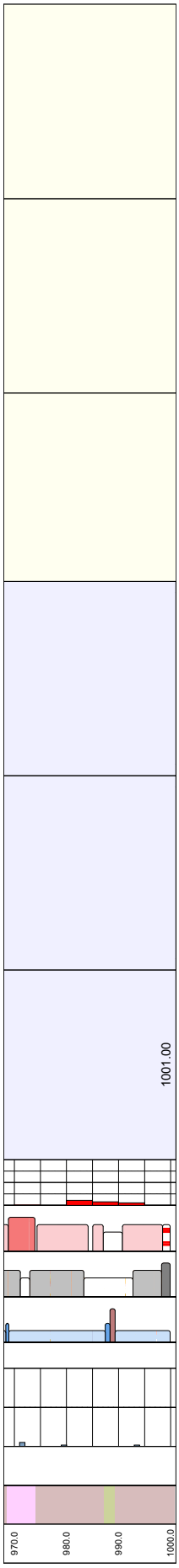





350.0
360.0
370.0
380.0
390.0
400.0
410.0
420.0
430.0
440.0
450.0
460.0
470.0
480.0
490.0
500.0
510.0
520.0
530.0
540.0
550.0
RU2a
Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and fine- to medium-grained metagranitoid. A sub-parallel distinct radar reflector can be followed from approximately 240 to 380 m along the borehole and at a distance of 10-50 m outside the borehole.Confidence level = 3.
503.00
503.00
RU3
Heterogeneous mixture of medium-grained metagranite-granodiorite, fine- to medium-grained metagranitoid with granitic to granodioritic composition (indicated from silicate density measurements), pegmatitic granite and subordinate amphibolite. Strong variation in magnetic susceptibility and natural gamma radiation. A sub-parallel distinct radar reflector can be followed from approximately 460 to
386.00
DZ2
Increased frequency of sealed fractures associated with a weak oxidation. Predominant infilling minerals are chlorite and laumontite. A few sharp anomalies in the focused resistivity and caliper data. Radar reflectors occur at 387.0 m with the orientation 044/45 or 232/25 and at 398.6 m with the orientation 236/66 or 054/82. A non-oriented radar reflector occurs at 403.6 m with an intersection angle of 10 degrees to the borehole axis. Confidence level = 2.
412.00
0°
90°
180°
270°


560.0
570.0
580.0
590.0
600.0
610.0
620.0
630.0
640.0
650.0
660.0
670.0
680.0
690.0
700.0
710.0
720.0
730.0
740.0
750.0
560 m along the borehole and at a distance of 0-20 m outside the borehole. Confidence level = 3.
560.00
560.00
RU2b
Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and fine- to medium-grained metagranitoid. A sub-parallel distinct radar reflector can be followed from approximately 710 to 890 m along the borehole and at a distance of 15-30 m outside the borehole. Confidence level = 3.
639.00
DZ3
Strongly increased frequency of sealed fractures, mostly filled by laumontite. Distinct concentration of fractures striking NE and dipping steeply towards SE. Also a weak oxidation of the whole zone. Major anomalies in the focused resistivity and caliper data. No clear indication in the P-wave velocity. Radar reflectors occur at 641.3 m with the orientation 191/32, at 651.9 m with the orientation 055/51 or 248/29, at 659.3 m with the orientation 223/86 and at 663.5 m with the orientation 348/53. One non-oriented radar reflector occurs at 648.3 m with an angle of 4 degrees to borehole axis. Confidence level = 3.
684.00
0°
90°
180°
270°


770.0
780.0
790.0
800.0
810.0
820.0
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
808.00
808.00
RU4
Fine- to medium-grained metagranitoid (granitic to granodioritic composition as indicated from silicate density measurements), with subordinate amphibolite, pegmatitic granite, medium-grained metagranite-granodiorite and calc-silicate rock. Lowermost ten meters of the section have lower magnetic susceptibility and natural gamma radiation. Indications of sub-parallel radar reflectors can be observed. Confidence level = 3.
865.00
865.00
RU2c
Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and fine- to medium-grained metagranitoid. Confidence level = 3.
0°
90°
180°
270°


1001.00
970.0
980.0
990.0
1000.0

Appendix 2

Geological single-hole interpretation for KFM01B

Title	SINGLE HOLE INTERPRETATION KFM01B					
	Site	FORSMARK	**Inclination [°]**	-79.03	**Elevation [m.a.s.l.]**	3.09
	Borehole	KFM01B	**Date of mapping**	2004-03-05 08:29:00	**Drilling Start Date**	2003-06-25 07:00:00
	Diameter [mm]	76	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2003-07-01 10:44:00
	Length [m]	500.520	**Northing [m]**	6699539.40	**Surveying Date**	
	Bearing [°]	267.59	**Easting [m]**	1631387.67	**Plot Date**	2006-09-20 21:10:12

Signed data

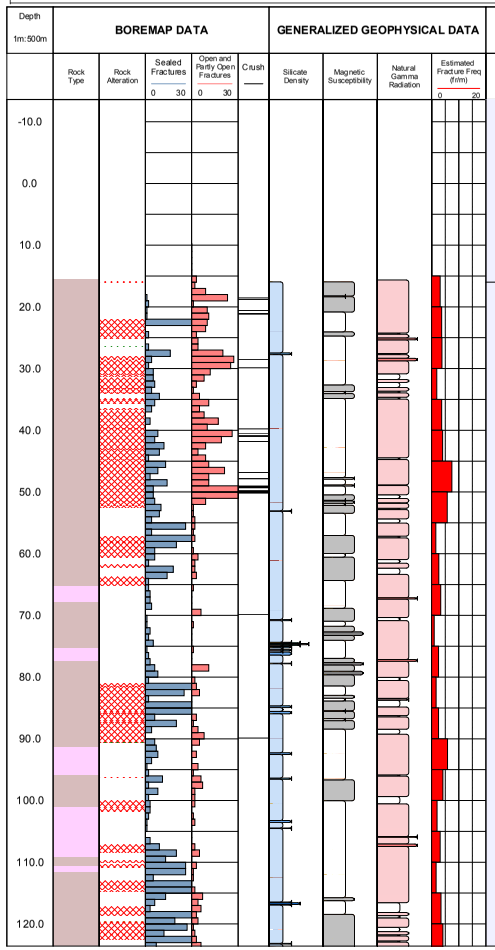
ROCKTYPE FORSMARK
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite

ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized

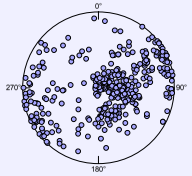
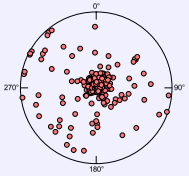
SILICATE DENSITY
- unclassified
- dens<2680 (Granite)
- 2680<dens<2730 (Granodiorite)
- 2730<dens<2800 (Tonalite)
- 2800<dens<2890 (Diorite)
- dens>2890 (Gabbro)

SUSCEPTIBILITET
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

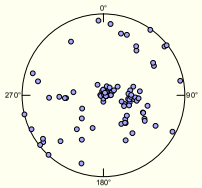
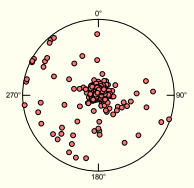
NATURAL GAMMA
- unclassified
- gam<20
- 20<gam<36
- 36<gam<53

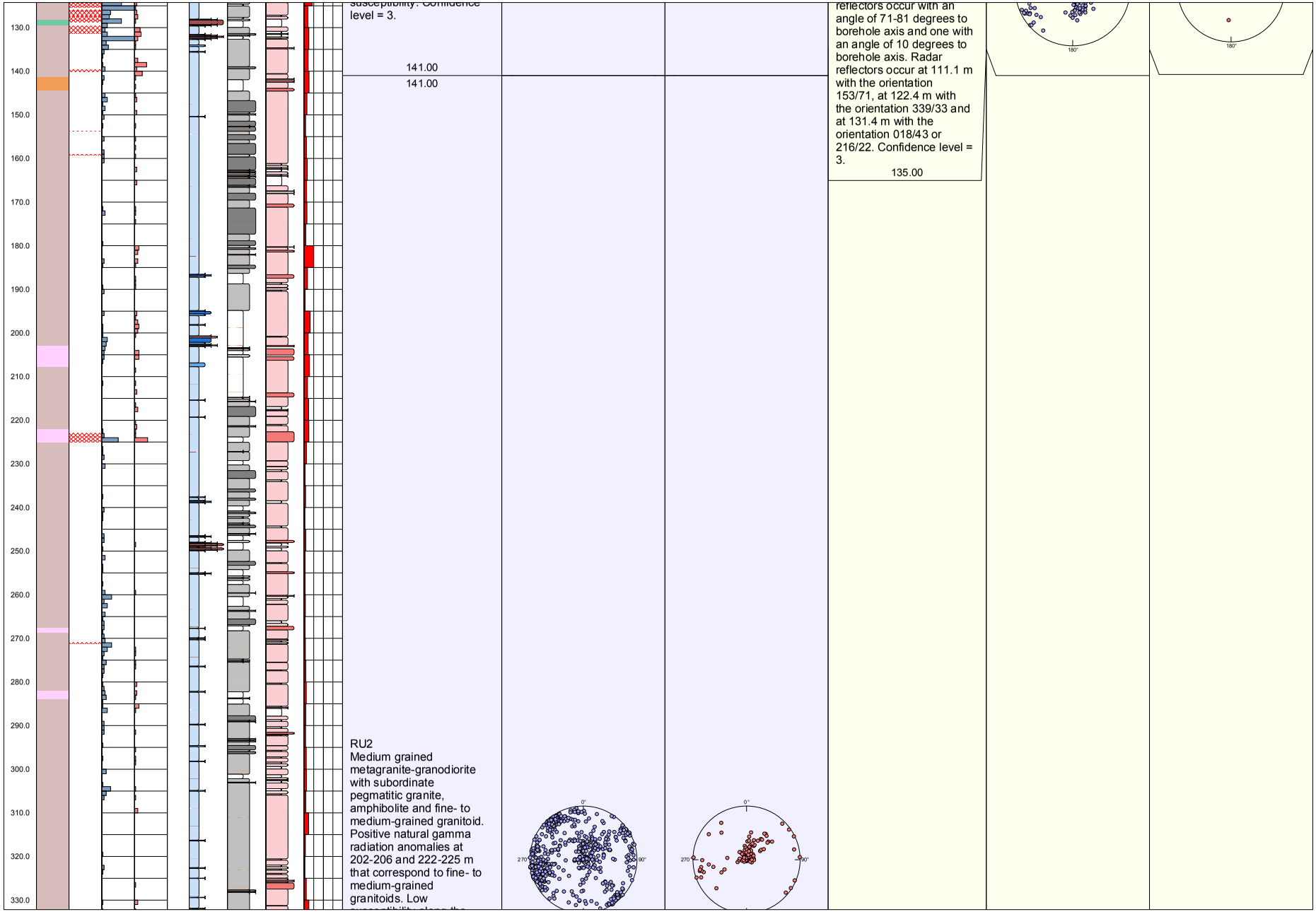


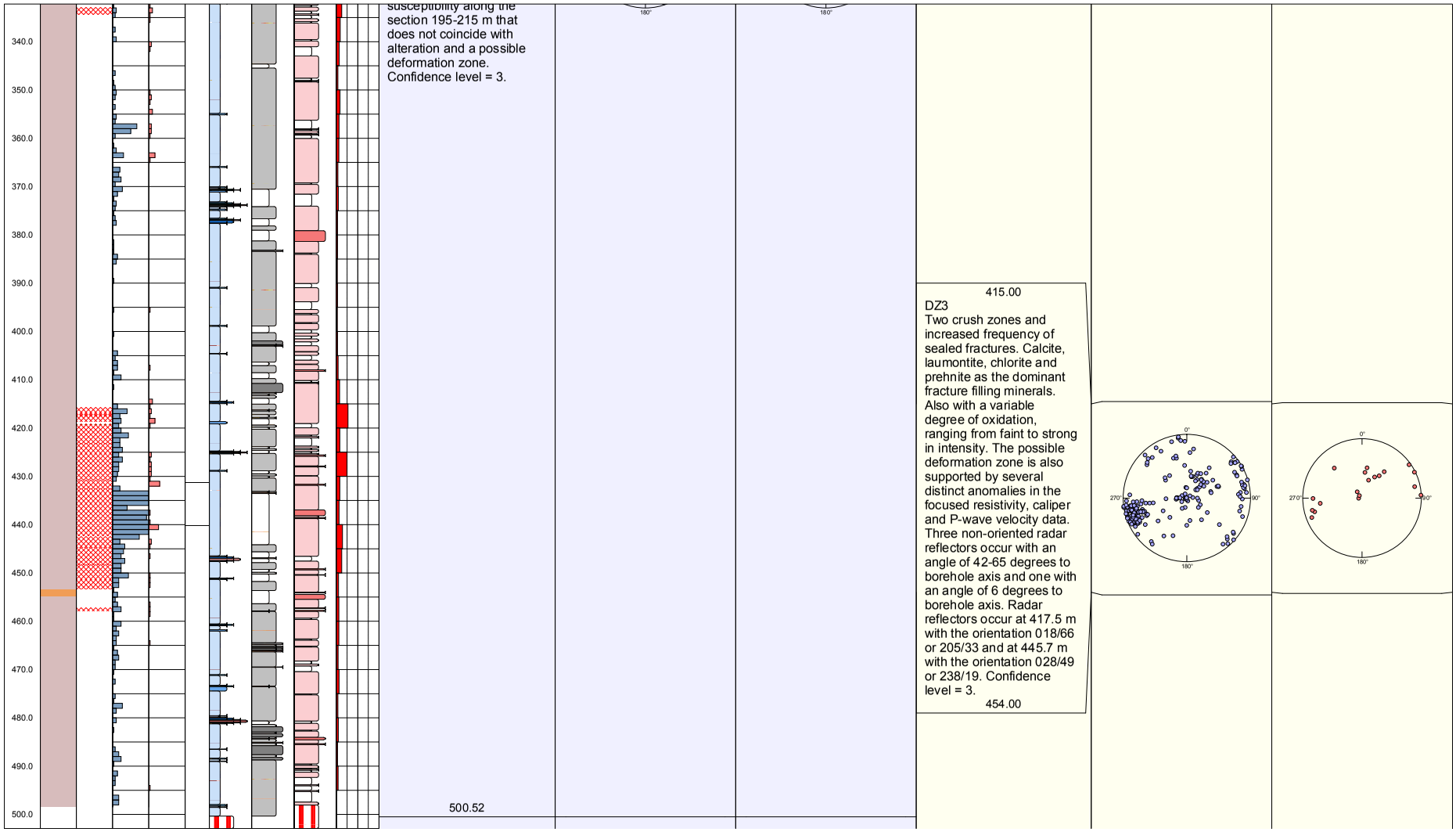
ROCK UNIT

Description Rock Unit	Rock Unit Sealed Fractures (Projection Wulff)	Rock Unit Open and Partly Open Fractures (Projection Wulff)
16.00 RU1 A. Medium-grained metagranite-granodiorite with subordinate occurrences of fine- to medium-grained granitoid (granitic to granodioritic composition as indicated from silicate density measurements), pegmatitic granite and a few amphibolite bodies. The interval 92-112 m is dominated by the fine- to medium-grained granitoid and coincides between 102-109 m with a positive natural gamma radiation anomaly. This rock unit contains two possible deformation zones (16-53 and 107-135 m), and two sections (53-107 and 135-141 m) with five crush zones and a generally increased fracture frequency relative to the remaining borehole outside the possible deformation zones. Generally weak to faint oxidation and low		

POSSIBLE DEFORMATION ZONES

Description Possible Deformation Zone	Possible Deformation Zone Sealed Fractures (Projection Wulff)	Possible Deformation Zone Open and Partly Open Fractures (Projection Wulff)
16.00 DZ1 Several crush zones and strongly increased frequency of open fractures. The most common fracture filling minerals are calcite, chlorite and asphalt. Also with a variable degree of oxidation (faint to medium). The possible deformation zone is also supported by several distinct anomalies in the focused resistivity and P-wave velocity data. Four non-oriented radar reflectors with an intersection angle of 64-90 degrees to the borehole axis and one distinct at 49.9 m with an angle of 9 degrees to borehole axis. At 40.8 m occurs a reflector with the orientation 033/9 or 341/15 and at 49.2 m with the orientation 025/33 or 240/15. Confidence level = 3. 53.00 107.00 DZ2 Increased frequency of sealed fractures with epidote and laumontite as dominant fracture filling minerals. Also with a variable degree of oxidation (faint to weak). Fractures are indicated in the focused resistivity data, but not in any of the other geophysical logs. Three non-oriented radar		


susceptibility. Confidence level = 3.
141.00
141.00
reflectors occur with an angle of 71-81 degrees to borehole axis and one with an angle of 10 degrees to borehole axis. Radar reflectors occur at 111.1 m with the orientation 153/71, at 122.4 m with the orientation 339/33 and at 131.4 m with the orientation 018/43 or 216/22. Confidence level = 3.
135.00
RU2
Medium grained metagranite-granodiorite with subordinate pegmatitic granite, amphibolite and fine- to medium-grained granitoid. Positive natural gamma radiation anomalies at 202-206 and 222-225 m that correspond to fine- to medium-grained granitoids. Low
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
230.0
240.0
250.0
260.0
270.0
280.0
290.0
300.0
310.0
320.0
330.0
0°
90°
180°
270°


340.0
350.0
360.0
370.0
380.0
390.0
400.0
410.0
420.0
430.0
440.0
450.0
460.0
470.0
480.0
490.0
500.0
susceptibility along the section 195-215 m that does not coincide with alteration and a possible deformation zone. Confidence level = 3.
500.52
415.00
DZ3
Two crush zones and increased frequency of sealed fractures. Calcite, laumontite, chlorite and prehnite as the dominant fracture filling minerals. Also with a variable degree of oxidation, ranging from faint to strong in intensity. The possible deformation zone is also supported by several distinct anomalies in the focused resistivity, caliper and P-wave velocity data. Three non-oriented radar reflectors occur with an angle of 42-65 degrees to borehole axis and one with an angle of 6 degrees to borehole axis. Radar reflectors occur at 417.5 m with the orientation 018/66 or 205/33 and at 445.7 m with the orientation 028/49 or 238/19. Confidence level = 3.
454.00
0°
90°
180°
270°

Appendix 3

Geological single-hole interpretation for HFM01

Title	SINGLE HOLE INTERPRETATION HFM01					
	Site	FORSMARK	**Inclination [°]**	-77.50	**Elevation [m.a.s.l.]**	1.73
	Borehole	HFM01	**Date of mapping**	2003-01-23 00:00:00	**Drilling Start Date**	2002-04-18 14:30:00
	Diameter [mm]	140	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2002-05-03 17:22:00
	Length [m]	200.200	**Northing [m]**	6699605.18	**Surveying Date**	
	Bearing [°]	34.06	**Easting [m]**	1631484.55	**Plot Date**	2006-09-20 21:10:12

Signed data

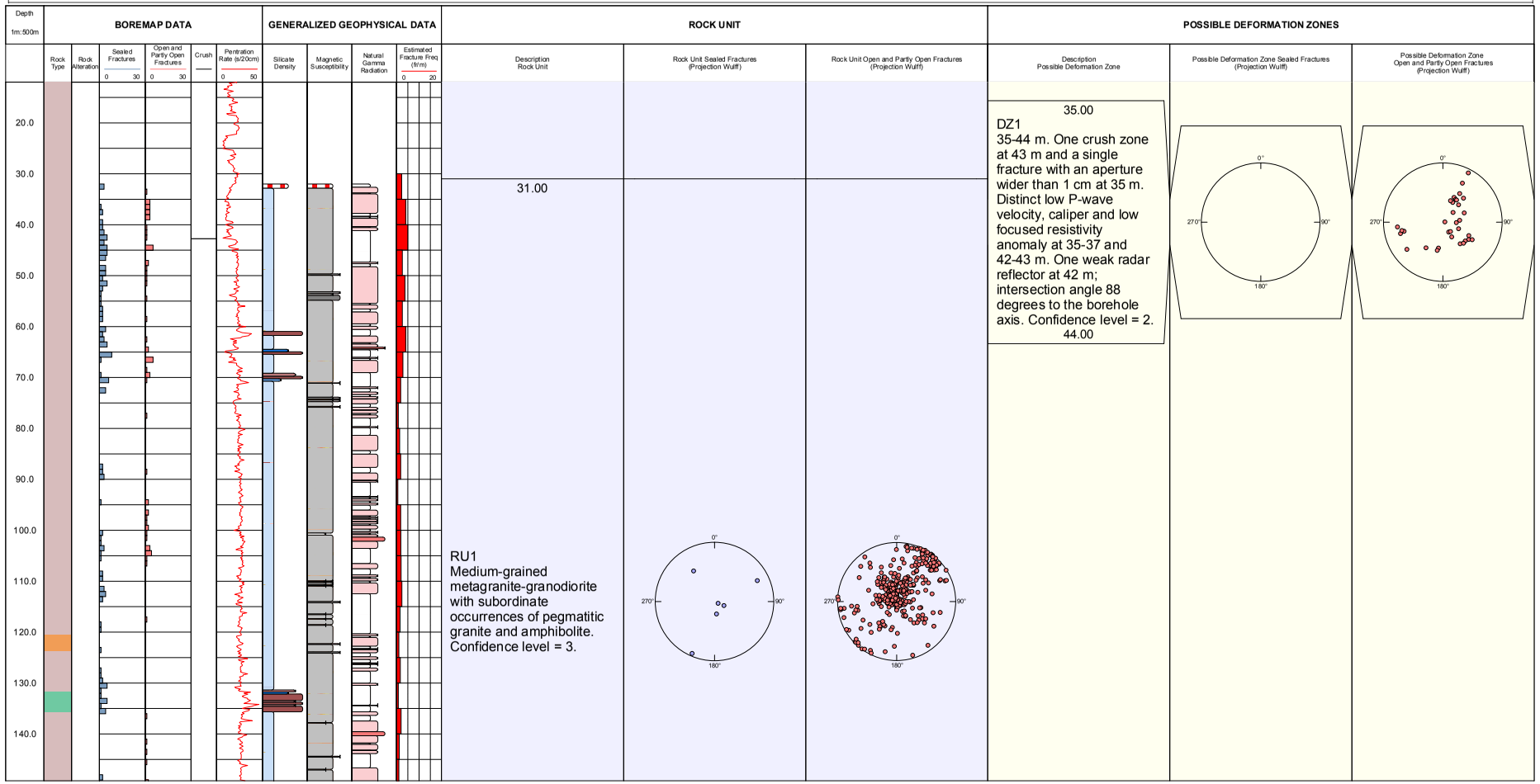
ROCKTYPE FORSMARK
- Pegmatite, pegmatitic granite
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite

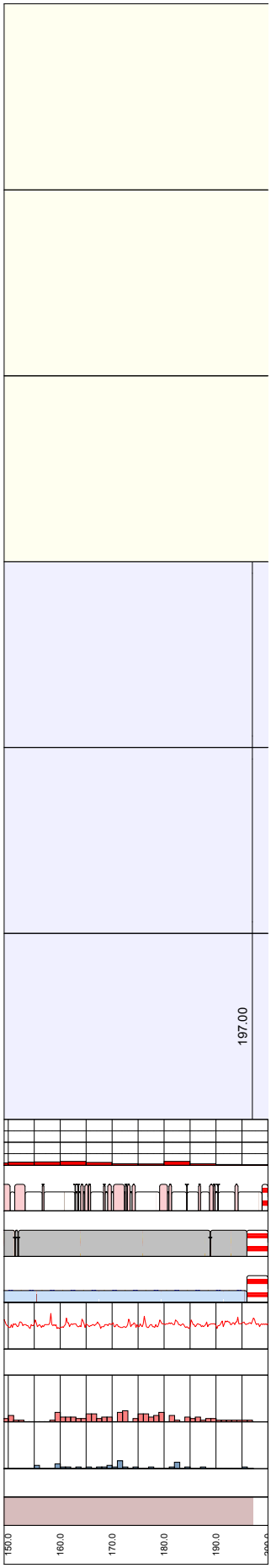
ROCK ALTERATION

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

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- gam<20
- 20<gam<36
- 36<gam<53




197.00
150.0
160.0
170.0
180.0
190.0

Appendix 4

Geological single-hole interpretation for HFM02

Title SINGLE HOLE INTERPRETATION HFM02

Site	FORSMARK	**Inclination [°]**	-87.78	**Elevation [m.a.s.l.]**	3.05	**Signed data**
Borehole	HFM02	**Date of mapping**	2003-01-29 00:00:00	**Drilling Start Date**	2002-05-07 10:00:00	
Diameter [mm]	137	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2002-05-21 12:00:00	
Length [m]	100.000	**Northing [m]**	6699593.21	**Surveying Date**		
Bearing [°]	6.52	**Easting [m]**	1631268.67	**Plot Date**	2006-09-20 21:10:12	

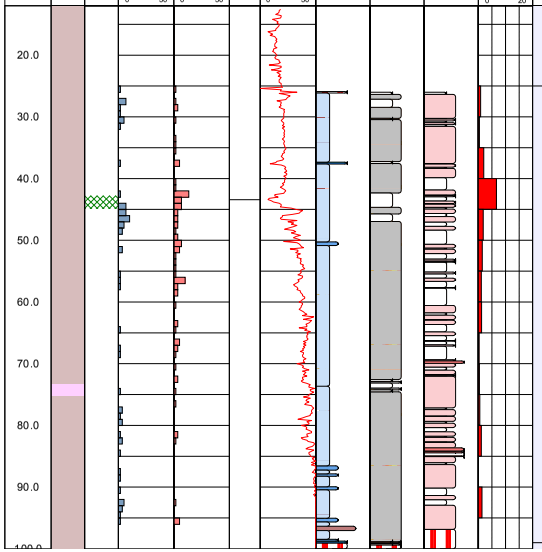
ROCKTYPE FORSMARK
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite to granodiorite, metamorphic, medium-grained

ROCK ALTERATION
- Chloritisized

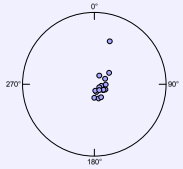
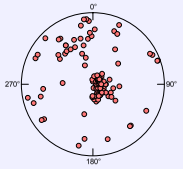
SILICATE DENSITY
- unclassified
- dens<2680 (Granite)
- 2680<dens<2730 (Granodiorite)
- 2730<dens<2800 (Tonalite)
- 2800<dens<2890 (Diorite)

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01

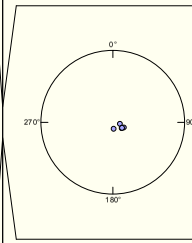
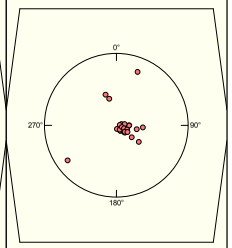
NATURAL GAMMA
- unclassified
- gam<20
- 20<gam<36
- 36<gam<53



ROCK UNIT

Description Rock Unit	Rock Unit Sealed Fractures (Projection Wulff)	Rock Unit Open and Partly Open Fractures (Projection Wulff)
25.00 RU1 Medium-grained metagranite-granodiorite with subordinate occurrences of pegmatitic granite, amphibolite and one occurrence of fine- to medium-grained granitoid. Confidence level = 3. 99.00		

POSSIBLE DEFORMATION ZONES

Description Possible Deformation Zone	Possible Deformation Zone Sealed Fractures (Projection Wulff)	Possible Deformation Zone Open and Partly Open Fractures (Projection Wulff)
42.00 DZ1 Increased fracture frequency, several with apertures above 1 cm. Low P-wave velocity and caliper anomalies. One clear radar reflector at 42 m; intersection angle 73 degrees to the borehole axis. Confidence level = 3. 47.00		

Appendix 5

Geological single-hole interpretation for HFM03

Title SINGLE HOLE INTERPRETATION HFM03

Site	FORSMARK	**Inclination [°]**	-87.27	**Elevation [m.a.s.l.]**	3.15	**Signed data**
Borehole	HFM03	**Date of mapping**	2003-01-30 00:00:00	**Drilling Start Date**	2002-05-27 12:30:00	
Diameter [mm]	136	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2002-05-28 12:30:00	
Length [m]	26.000	**Northing [m]**	6699592.81	**Surveying Date**		
Bearing [°]	264.53	**Easting [m]**	1631272.63	**Plot Date**	2006-09-20 21:10:12	

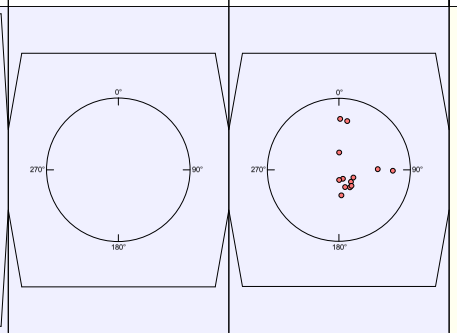
ROCKTYPE FORSMARK
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite

ROCK ALTERATION

SILICATE DENSITY
- unclassified
- dens<2680 (Granite)
- 2730<dens<2800 (Tonalite)

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01

NATURAL GAMMA
- 20<gam<36
- unclassified
- gam<20

Depth 1m:500m	BOREMAP DATA						GENERALIZED GEOPHYSICAL DATA				ROCK UNIT			POSSIBLE DEFORMATION ZONES		
	Rock Type	Rock Alteration	Sealed Fractures (0 30)	Open and Partly Open Fractures (0 30)	Crush	Penetration Rate (s/20cm) (0 50)	Silicate Density	Magnetic Susceptibility	Natural Gamma Radiation	Estimated Fracture Freq (ff/m) (0 20)	Description Rock Unit	Rock Unit Sealed Fractures (Projection Wulff)	Rock Unit Open and Partly Open Fractures (Projection Wulff)	Description Possible Deformation Zone	Possible Deformation Zone Sealed Fractures (Projection Wulff)	Possible Deformation Zone Open and Partly Open Fractures (Projection Wulff)
0.0											13.00 RU1 Medium-grained metagranite-granodiorite with two meters of amphibolite in the lowermost part. Also two crush zones at 15 and 21 m; coincide with low resistivity and caliper anomalies, as well as radar reflectors (intersection angles 60 and 90 degrees to the borehole axis). Confidence level = 3. 26.00					
10.0																
20.0																
30.0																
40.0																