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Revised October 2006

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Geological single-hole interpretation of KFM02A and HFM04-05 (DS2)

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June 2004

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Keywords: Forsmark, Geophysics, Geology, Borehole, Bedrock, Fractures, Field note: Forsmark 314, AP PF 400-03-07.

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, 2 and 3 are updated.

Abstract

This report constitutes geological single-hole interpretations of the cored boreholes KFM02A and the percussion boreholes HFM04-05 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 four lithological rock units occur in KFM02A. The rock units are further subdivided into 16 sections. Generally, medium-grained metagranite-granodiorite dominates, while pegmatite, amphibolite and fine-medium grained metagranitoid occur as subordinate rock types. Ten possible deformation zones have been identified in KFM02A.

The percussion borehole HFM04 is dominated by medium-grained metagranite-granodiorite. Pegmatite and amphibolite occur as subordinate rock types. Two possible deformation zones have been identified in HFM04.

The percussion borehole HFM05 is dominated by medium-grained metagranite-granodiorite. Pegmatite and amphibolite occur as subordinate rock types. One possible deformation zone has been identified in HFM05.

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhål KFM02A och hammarborrhål HFM04-05 i Forsmark. Den geologiska enhålstolkningen syftar till att utifrån data från den geologiska karteringen, tolkade geofysiska loggar, borrhålsradarmätningar och seismiska reflektorer indikera olika litologiska enheters fördelning i borrhålen samt möjliga deformationszoners läge och utbredning.

Denna undersökning visar att det i KFM02A finns 4 litologiska enheter och 16 olika sektioner i borrhålet. Generellt sett dominerar medelkornig metagranit-granodiorit, medan pegmatit, amfibolit och finkornig metagranitoid förekommer i mindre omfattning. I KFM02A har tio möjliga deformationszoner identifierats.

Hammarborrhål HFM04 domineras av medelkornig metagranit-granodiorit med mindre inslag av amfibolit och pegmatit. Två möjliga deformationszoner har identifierats i HFM04.

Hammarborrhål HFM05 domineras av medelkornig metagranit-granodiorit med mindre inslag av amfibolit och pegmatit. En möjlig deformationszon har identifierats i HFM05.

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 three boreholes at drilling site 2 (DS2) in the Forsmark area. These include the cored borehole KFM02A and the percussion-drilled boreholes HFM04 and HFM05 (Figure 1-1).

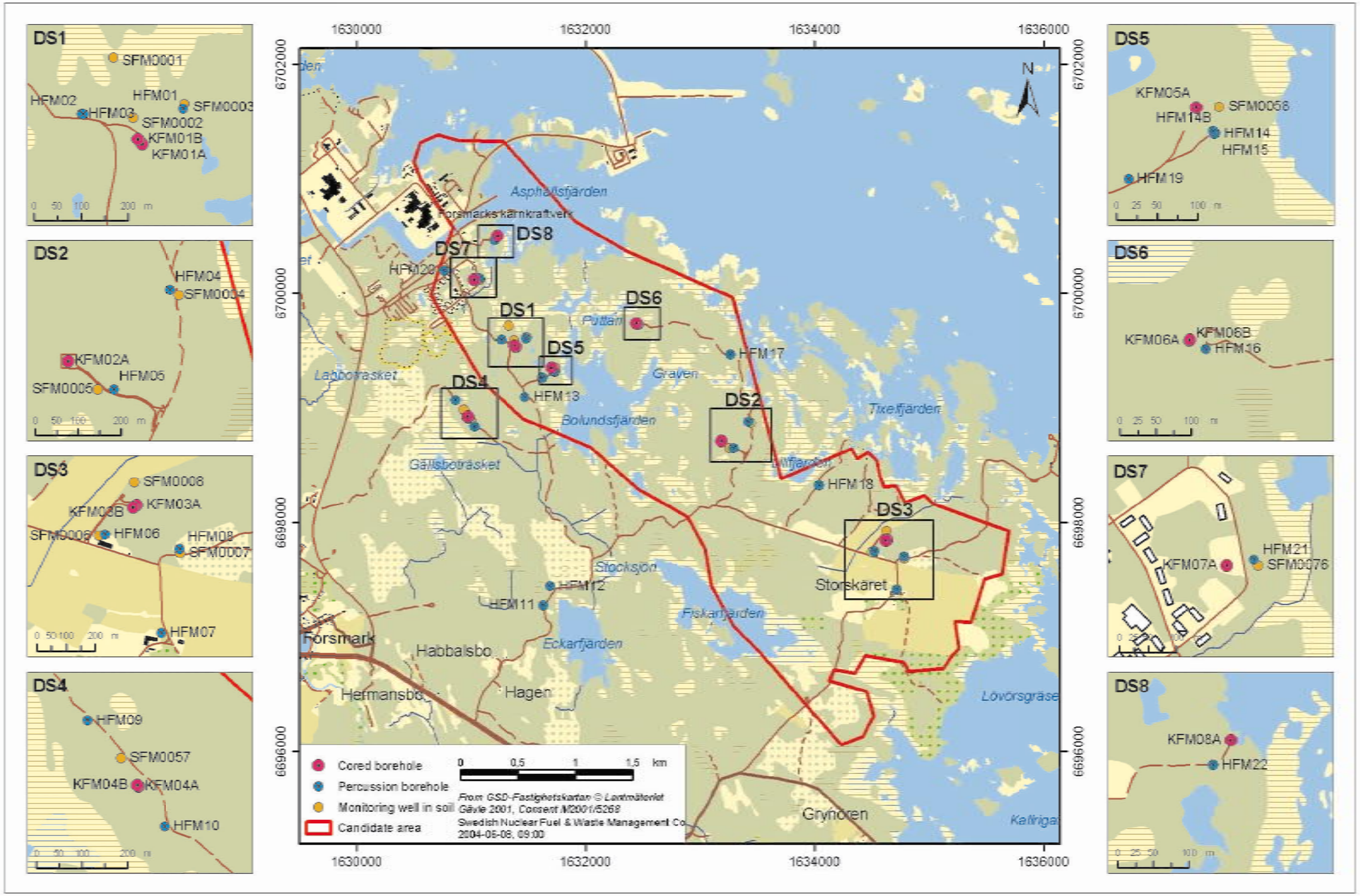


Figure 1-1. *Map showing the location of drilling site 2 (DS2) and the position of the boreholes KFM02A and HFM04-05.*

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:

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

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 /7/.

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 /8/.

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 sonic and focused resistivity 300 in the cored hole and calculated from lateral, short and long normal resistivity and SPR in the percussion drilled holes. 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.

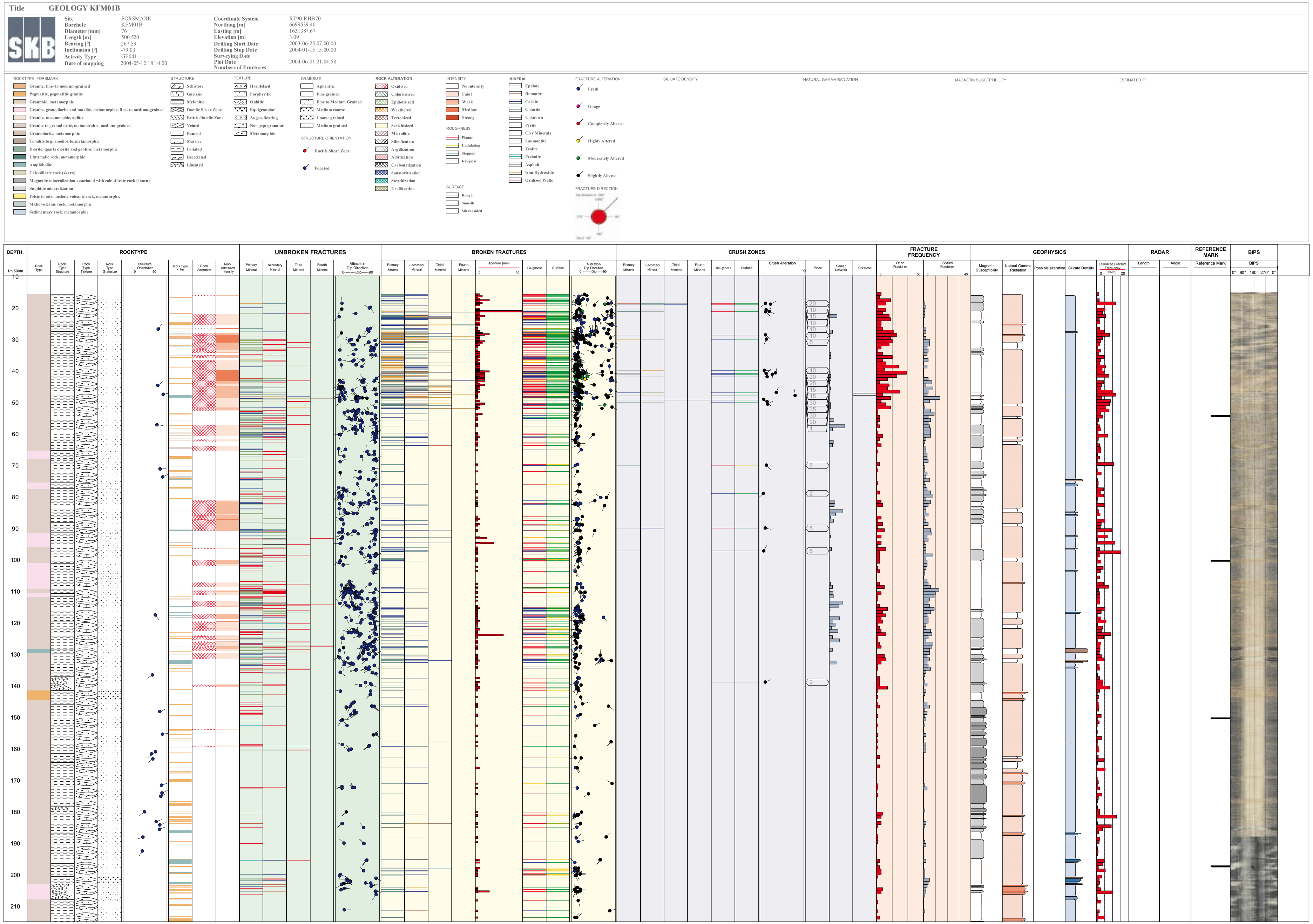


Figure 3-1. Example of WellCad plot used as basis for the single-hole interpretation.

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.

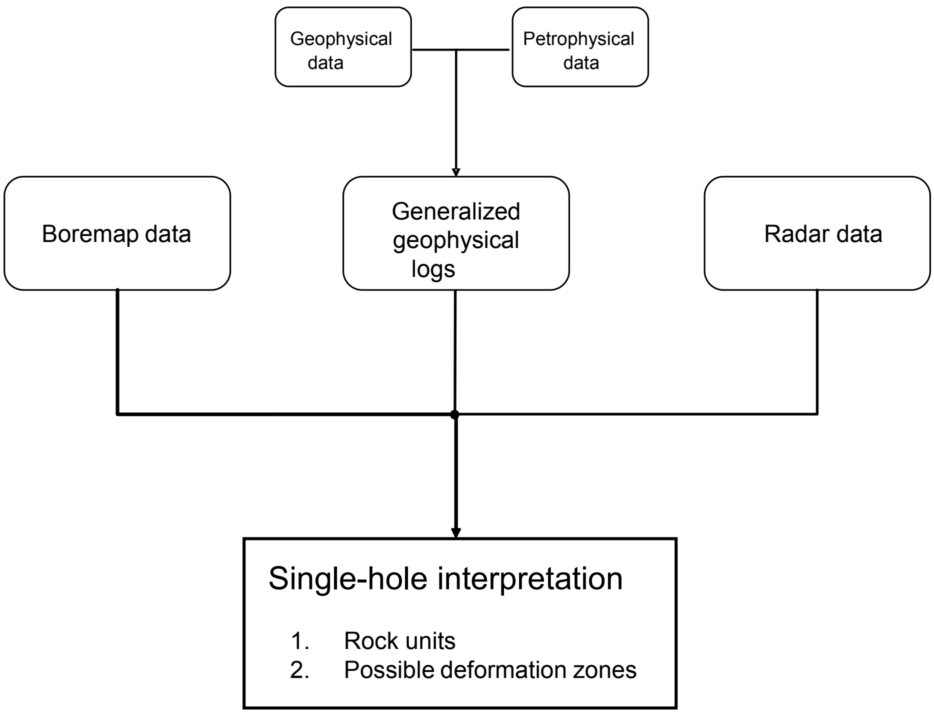


Figure 4-1. Schematic block diagram of geological single-hole interpretation

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 KFM02A, Appendix 2 for HFM04, and Appendix 3 for HFM05). 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 KFM02A

The borehole can be divided into 4 rock units. Depending on small variations in the occurrence of subordinate rock types, the borehole is divided into the following 16 rock sections:

12-96 m	RU1a: Medium-grained metagranite to granodiorite with subordinate occurrences of amphibolite (mainly limited to the lower 50 m of the interval) and pegmatitic granite (primarily in the upper 40 m of the interval). Percussion-drilled part of the borehole. Boremap mapping based on BIPS-image and examination of drill cuttings. Confidence level = 3.
100-155 m	RU1a: Medium-grained metagranite to granodiorite with subordinate occurrences of amphibolite and pegmatitic granite. Confidence level = 3.
155-205 m	RU2a: Heterogenous interval, predominantly with a fine-grained metagranitoid. The second most important bedrock component is the medium-grained metagranite-granodiorite, and then the amphibolite. The central part of the interval is strongly oxidised with three minor intervals of vuggy metagranitoid. Confidence level = 3.
205-240 m	RU1b: Same dominant rock as between 100-155 m depth, with one about 5 m wide occurrence of fine-grained metagranitoid and several minor occurrences of pegmatitic granite. Confidence level = 3.
240-310 m	RU3: Vuggy metagranite (low density, resistivity, susceptibility and P-wave velocity) subjected to a strong albite-hematite-chlorite alteration /9/. Also some minor occurrences of fine-grained metagranitoid, amphibolite and pegmatitic granite. All these are altered. Radar measurements indicate a limited extension in at least one direction. Confidence level = 3.
310-485 m	RU1c: Same dominant rock as between 100-155 m depth, with one about 8 m wide occurrence of fine-grained metagranitoid, one about 3 m wide amphibolite and some minor occurrences of pegmatitic granite, fine-grained metagranite and amphibolite. Indications of sub-parallel radar reflectors outside the borehole are observed. Confidence level = 3.
485-520 m	RU2b: Heterogeneous interval, predominantly with the fine-grained metagranitoid. The second most important bedrock component is the metagranite-granodiorite, and then pegmatitic granite. Also some subordinate amphibolite. Most of the interval has been subjected to a variable degree of oxidation. Confidence level = 3.

520-540 m	RU1d: Same dominant rock as between 100-155 m depth, with several minor occurrences of pegmatitic granite and amphibolite. To a variable extent oxidised. Confidence level = 3.
540-575 m	RU2c: The upper two thirds of the interval consists of fine-grained metagranite, whereas the lower third is more heterogeneous and composed of amphibolite, pegmatitic granite and the medium-grained metagranite-granodiorite. Confidence level = 3.
575-600 m	RU1e: Same dominant rock as between 100-155 m depth. Confidence level = 3.
600-635 m	RU2d: Fine-grained metagranite and the medium-gained metagranite-granodiorite in approximately equal proportions. Also, several minor occurrences of pegmatitic granite. Confidence level = 3.
635-835 m	RU1f: Same dominant rock as between 100-155 m depth, with some up to 8 m wide occurrences of fine-grained metagranitoid, amphibolite and pegmatitic granite. The uppermost part of the interval has been subjected to a variable extent of oxidation. Confidence level = 3.
835-867 m	RU2e: Heterogeneous interval, predominantly with the fine-grained metagranitoid, and then the medium-grained metagranite-granodiorite and amphibolite. Also some subordinate occurrences of pegmatitic granite. Confidence level = 3.
867-903 m	RU1g: Same dominant rock as between 100-155 m depth, with several minor occurrences of pegmatitic granite, up to about 1.5 m in width. Confidence level = 3.
903-938 m	RU4: A homogeneous interval of a tonalitic (high density, low gamma) variety of the fine-grained metagranitoid. Also with some minor occurrences of amphibolite and pegmatitic granite. Confidence level = 3.
938-1001 m	RU1h: Same dominant rock as between 100-155 m depth, with several minor occurrences of pegmatitic granite and amphibolite. Confidence level = 3.

Ten possible deformation zones are indicated:

79-91 m	DZ1: Possible zone which actually consists of three more well-defined sites with increased fracture aperture. Slightly higher fracture frequency close to the lowest site. Correspond to three low resistivity anomalies. Several distinct radar reflectors 68-79 degrees to the borehole axis. Confidence level = 2.
110-122 m	DZ2: Increased frequency of open fractures, often measurable apertures and calcite coating. Includes several crush zones. Some of the interval has been subjected to strong clay alteration (high gamma). Characterised by very low resistivity and P-wave velocity, as well as low susceptibility. Distinct radar reflectors at 112.5 m with the orientation 090/41, at 113.7 m with the orientation 090/5 and at 121.6 m with the orientation 090/52 or 090/46. Confidence level = 3.

160-184 m DZ3: Increased frequency of both sealed and open fractures, some with measurable apertures. Typically chlorite and/or calcite coated fractures. Most of the interval is more or less strongly oxidised with three minor occurrences of vuggy metagranite. Characterised by very low resistivity and P-wave velocity, as well as low susceptibility. Seismic reflector (A3) with an inferred intersection depth at 180 m, and an orientation of 065/25. One non-oriented radar reflector at 169.3 m with the angle 90 degrees to borehole axis. Three oriented radar reflectors occur at 164.4 m with the orientation 105/17 or 314/20, 173.9 m with the orientation 043/18 or 251/11 and at 176.3 m with the orientation 038/44. Confidence level = 3.

266-267 m DZ4: Crush zone. Caliper indicated a large cavity, >150 mm. Confidence level = 2.

303-310 m DZ5: Increased frequency of sealed, but to some extent also open fractures. Typically chlorite and/or calcite coated fractures. Most of the interval is more or less strongly oxidised. Not visible in the geophysical logs, though it is visible as a radar reflector (54 degrees to the borehole axis at 308.9 m). Confidence level = 2.

415-520 m DZ6: A wide zone with increased frequency of both open and sealed fractures. Typically chlorite and/or calcite coated fractures. The uppermost part and the lower 30 m of the interval are variably oxidised. Displays a variable susceptibility down to 462 m depth, and below that a more consistently low susceptibility. The whole interval shows a low resistivity and P-wave velocity. Seismic reflector (A2) with an inferred intersection depth at 470 m, and an orientation of 080/22 and a reflector (F1) with an inferred intersection depth at 500 m, and an orientation of 020/20. Two non-oriented radar reflectors occur at 468.4 m and 503.1 m with the angle to borehole axis of 42 and 49 degrees, respectively. Several oriented radar reflectors with variable orientation (275/12 or 061/17, 099/73 or 283/71, 232/71, 217/22, 021/5, 013/18, 033/46, 261/34, 028/5 or 005/4, 337/6 and 044/32). Confidence level = 3.

520-600 m DZ7: A zone characterised by an increased frequency of sealed fractures, but relatively few open fractures. Mostly epidote sealing and oxidised wall rock. Little indications in the geophysical logs. Seismic reflector (B2) with an inferred intersection depth at 600 m, and an orientation of 030/25. Six non-oriented radar reflectors occur with the angle to borehole axis of 15, 90, 70, 63, 13 and 38 degrees. Five oriented radar reflectors occur at 532.9 m (075/36), 549.8 m (193/22), 560.8 m (355/29 or 158/20), 566.2 m (013/68 or 191/56) and 596.9 m (045/60 or 228/48). Confidence level = 2.

893-905 m DZ8: Increased frequency of open fractures, often with measurable apertures and calcite and/or chlorite coating. The interval 893-899 m displays low resistivity, susceptibility and P-wave velocity. The contact between RU1 and RU4, in the lower end of the marked interval, shows a high frequency of open fractures. Also low resistivity and P-wave velocity. The contact is also visible as a radar reflector (55 degrees to the borehole axis at 903.7 m). Another non-oriented radar reflector occurs at 895.7 m with the angle 61 degrees to borehole axis. Confidence level = 3.

922-925 m DZ9: Similar to the 893-905 m interval, but also with an increased frequency of sealed fractures. Probably associated with contacts between various minor rock occurrences of pegmatitic granite and amphibolite found in the interval. Low resistivity and high gamma. A non-oriented radar reflector occurs at 924.4 m with the angle 70 degrees to the borehole axis. Confidence level = 3.

976-982 m DZ10: Slightly increased frequency of both open and sealed fractures. Mostly calcite and chlorite coatings. Rather low susceptibility. Seismic reflector (B4) with an inferred intersection depth at 980 m, and an orientation of 050/28. A non-oriented radar reflector occurs at 980.2 m with the angle 57 degrees to the borehole axis. Confidence level = 2.

5.2 HFM04

The borehole consists of one rock unit:

12-222 m RU1: Predominantly medium-grained metagranite-granodiorite with lower density and higher gamma in the upper 80-90 m. Subordinate occurrences of amphibolite, especially in the interval 110-150 m, whereas occurrences of pegmatitic granite mainly occur in the intervals 70-110 m and below 150 m depth. Confidence level = 3.

Two possible deformation zones are indicated:

61-64 m DZ1: Increased frequency of both sealed and open fractures associated with an about 1 m wide occurrence of amphibolite. Probably mostly chlorite and calcite coating, and most have apertures of 1-2 mm. Also, some alteration, including both oxidation and chloritization. Caliper indicates a large cavity. Low resistivity and susceptibility. Distinct radar reflector 47 degrees to the borehole axis. Confidence level = 3.

183-187 m DZ2: Slightly increased fracture frequency within a major occurrence of pegmatitic granite. Open fractures seems to have chlorite coating, whereas the sealed fractures mainly contain laumontite. Apertures are generally 1 mm or less. Low resistivity and susceptibility. Radar reflector 49 degrees to the borehole axis. Confidence level = 2.

5.3 HFM05

The borehole consists of one rock unit:

12-199 m RU1: Predominantly medium-grained metagranite-granodiorite with low to medium susceptibility. Subordinate occurrences of amphibolite and pegmatitic granite throughout the whole borehole. Confidence level = 3.

There is one possible deformation zone in the borehole:

153-154 m DZ1: Crush zone associated with strong oxidation. Very low susceptibility and resistivity. Distinct radar reflector 56 degrees to the borehole axis. Orientation estimated from the BIPS-image 065/40 degrees. Confidence level = 3.

6 Comments

The results from the geological single-hole interpretations of the KFM02A, HFM04 and HFM05 are presented in WellCad plots (Appendices 1-3). 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-03-98. Boremap mapping of telescopic drilled borehole KFM02A. Petersson J, Wängnerud A, Stråhle A.

/2/ SKB P-report P-03-21. Boremap mapping of percussion boreholes HFM04 and HFM05. Nordman C.

/3/ SKB P-report P-04-98. Interpretation of borehole geophysical measurements in KFM02A, KFM03A, KFM03B and HFM04 to HFM08. Hans Thunehed.

/4/ SKB P-report P-04-97. Geophysical borehole logging. Borehole KFM02A, KFM03A and KFM03B. Nielsen U T, Ringgaard J.

/5/ SKB P-report P-03-53 Geophysical, radar and BIPS logging in boreholes HFM04, HFM05, and the percussion drilled part of KFM02A. Nilsson P, Gustafsson C.

/6/ SKB P-report P-04-40. RAMAC and BIPS logging in borehole KFM02A. Gustafsson J, Gustafsson C.

/7/ SKB R-report R-02-43. Reflection seismic studies in the Forsmark area – stage 1. Juhlin C, Bergman B, Palm H.

/8/ 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.

/9/ SKB P-report P-03-77. Dissolution of quartz, vug formation and new grain growth associated with post-metamorphic hydrothermal alteration in KFM02A. Forsmark site investigation. Möller C, Snäll S, Stephens M B.

Appendix 1

Geological single-hole interpretation for KFM02A

Title SINGLE HOLE INTERPRETATION KFM02A

Site	FORSMARK	**Inclination [°]**	-85.37	**Elevation [m.a.s.l.]**	7.35	**Signed data**
Borehole	KFM02A	**Date of mapping**	2003-04-22 00:00:00	**Drilling Start Date**	2002-11-20 14:03:00	
Diameter [mm]	77	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2002-11-26 11:35:00	
Length [m]	1002.440	**Northing [m]**	6698712.50	**Surveying Date**		
Bearing [°]	275.76	**Easting [m]**	1633182.86	**Plot Date**	2006-10-12 21:59:42	

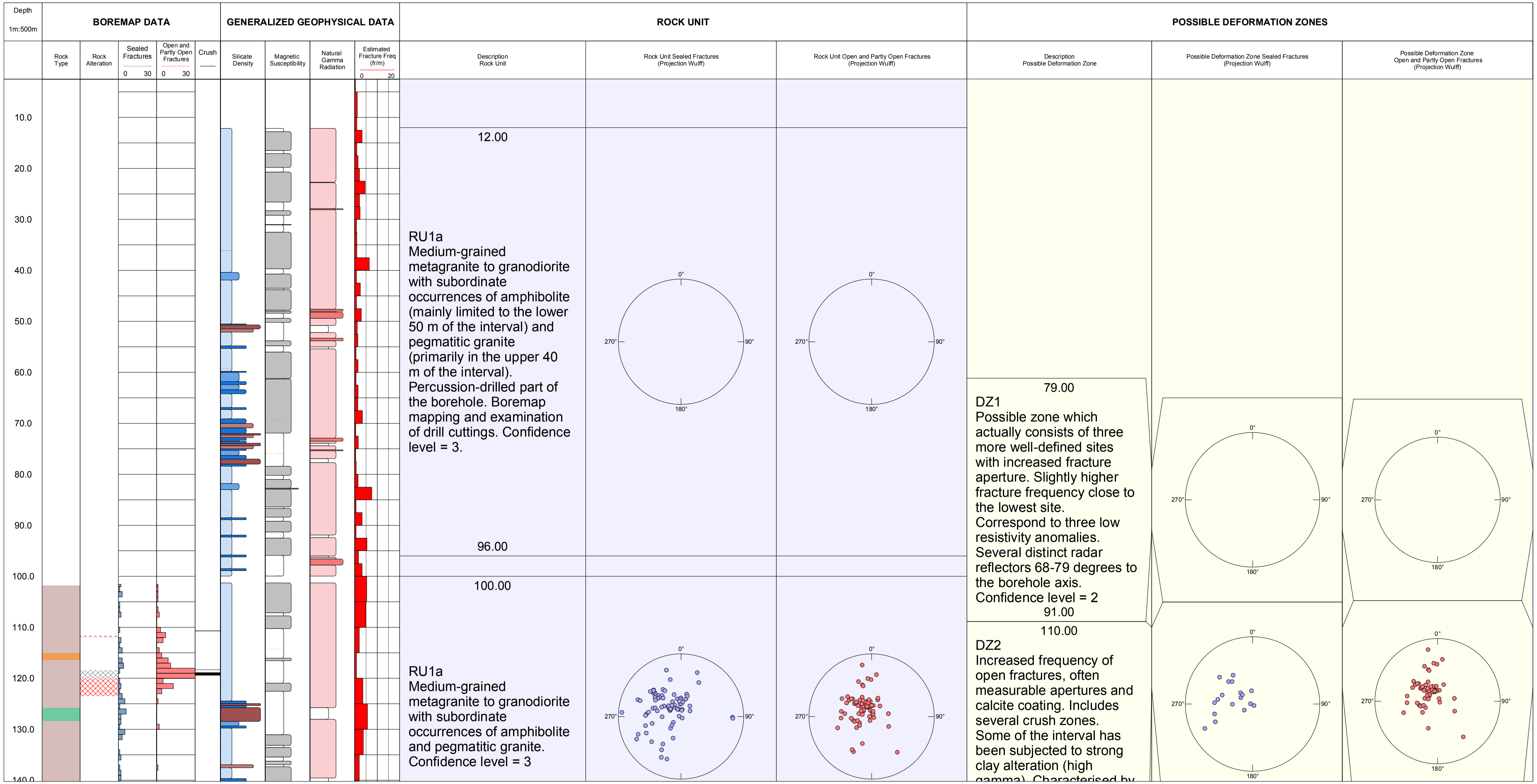
ROCKTYPE FORSMARK
- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite

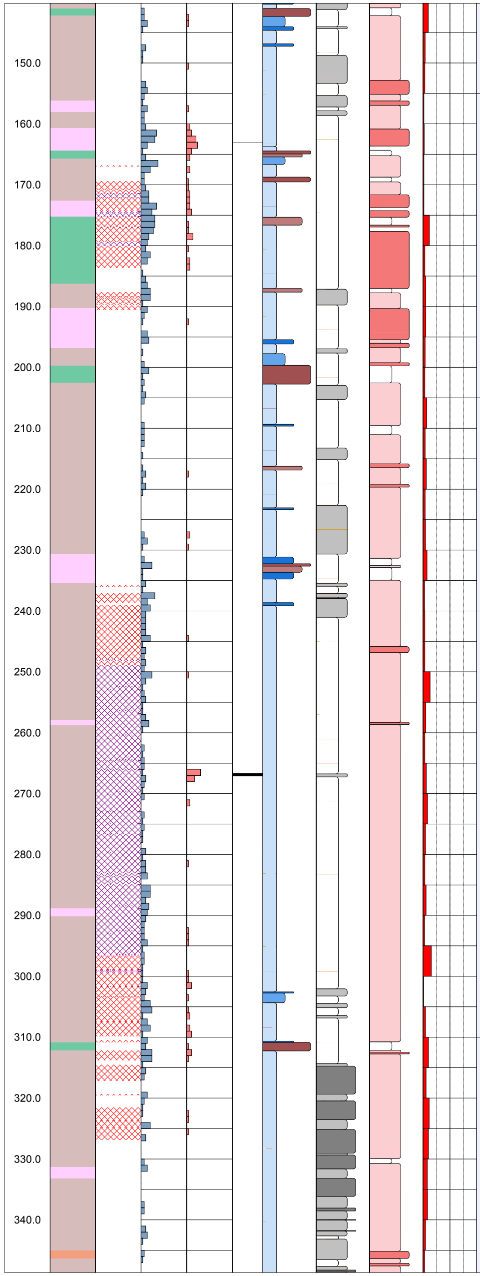
ROCK ALTERATION
- Oxidized
- Epidotisized
- Quartz dissolution
- Argillization
- Albitization
- Saussuritization

SILICATE DENSITY
- 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
- gam<20
- 36<gam<53
- unclassified
- 20<gam<36
- gam<20
- 20<gam<36
- 36<gam<53





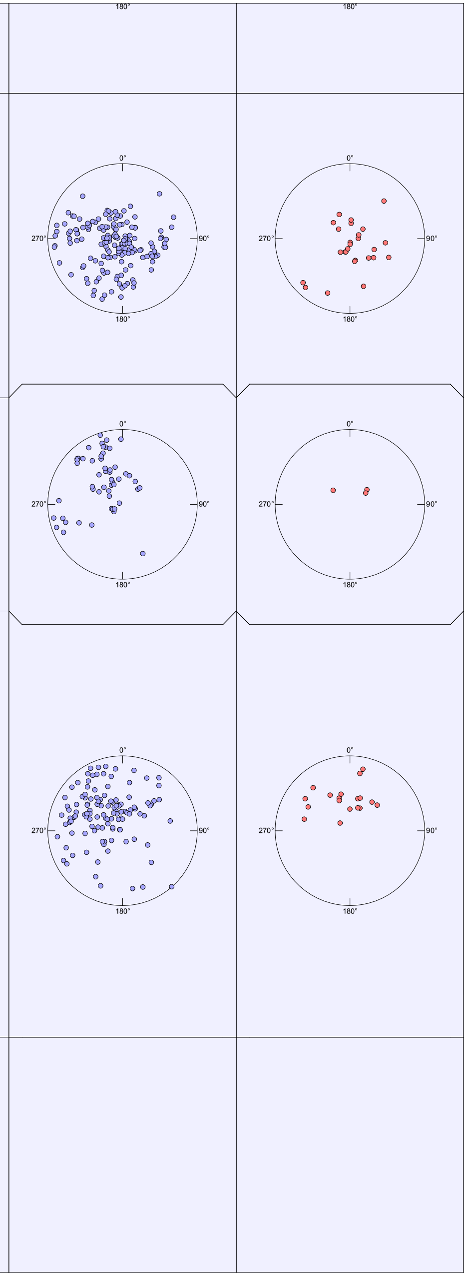
155.00

155.00
RU2a
Heterogenous interval, predominantly with a fine-grained metagranitoid. The second most important bedrock component is the metagranite-granodiorite, and then the amphibolite. The central part of the interval is strongly oxidised with three minor intervals of vuggy metagranitoid. Confidence level = 3.
205.00

205.00
RU1b
Same dominant rock as between 100-155 m depth, with one about 5 m wide occurrence of fine-grained metagranitoid and several minor occurrences of pegmatitic granite. Confidence level = 3
240.00

240.00
RU3
Vuggy metagranite (low density, resistivity, susceptibility and P-wave velocity) subjected to a strong albite-hematite-chlorite alteration. Also some minor occurrences of fine-grained metagranitoid, amphibolite and pegmatitic granite. All also altered. The radar measurements indicate a limited extension in at least one direction. Confidence level = 3
310.00

310.00

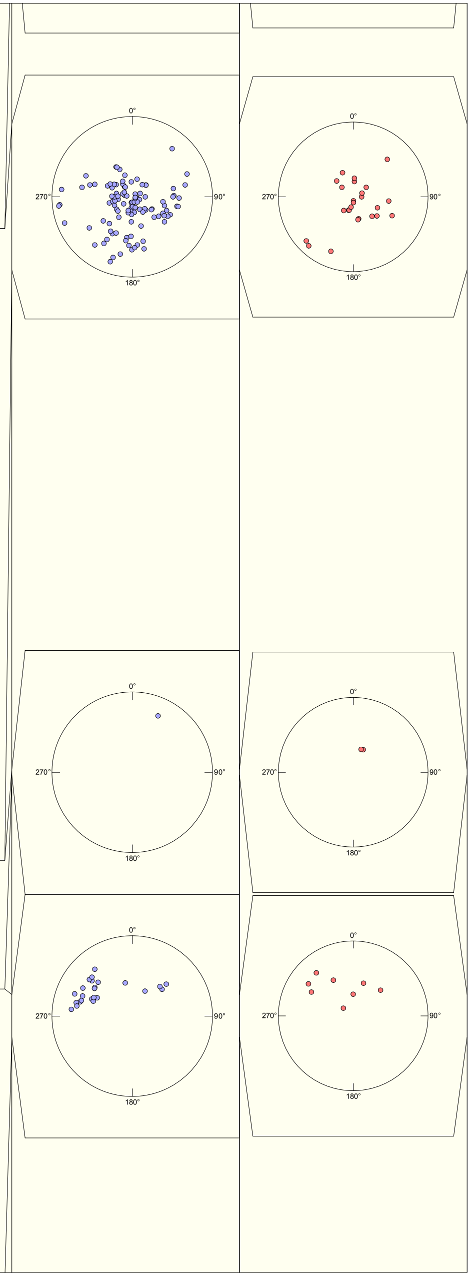


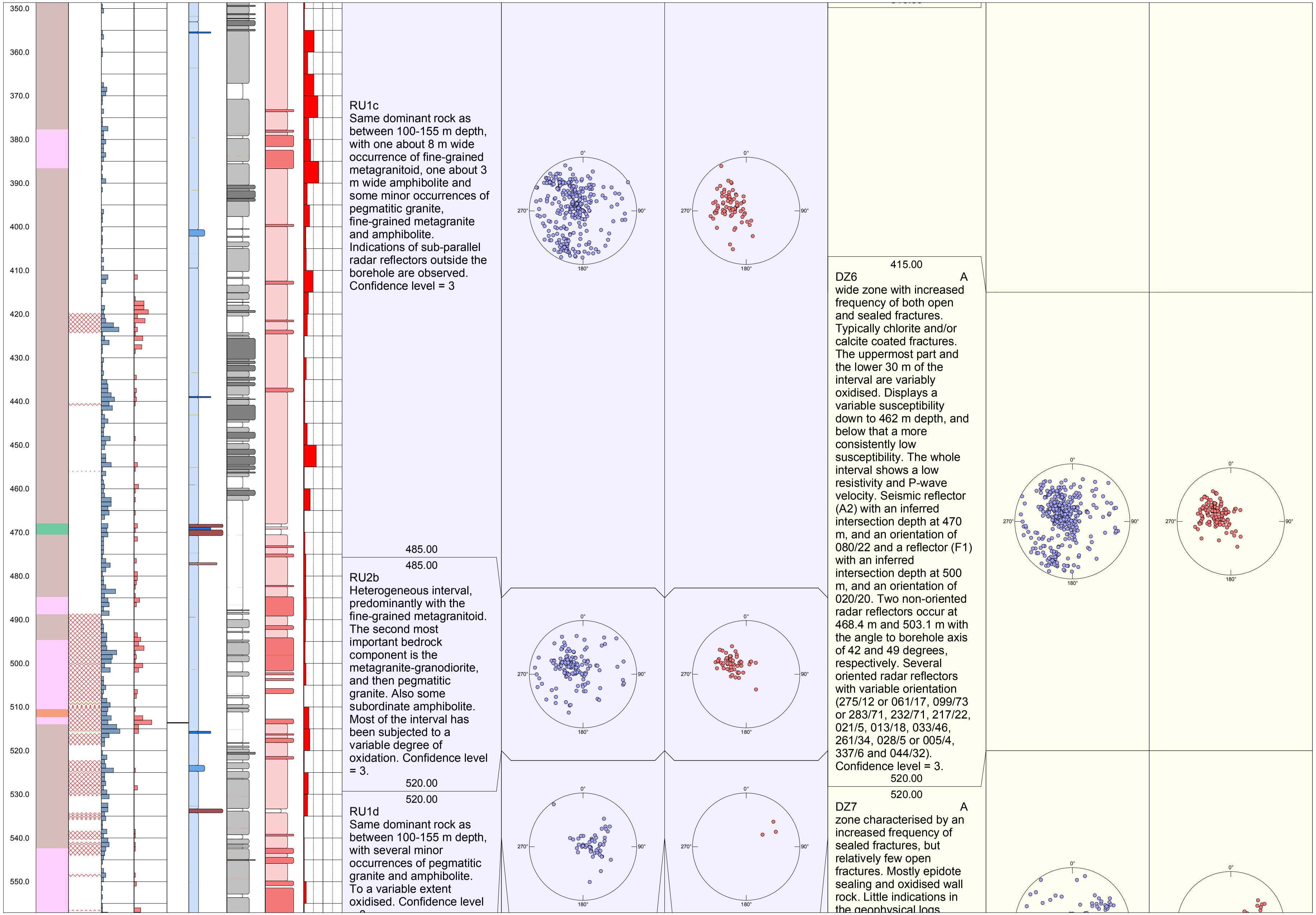
gamma). Characterised by very low resistivity and P-wave velocity, as well as low susceptibility. Distinct radar reflectors at 112.5 m with the orientation 090/41, at 113.7 m with the orientation 090/5 and at 121.6 m with the orientation 090/52 or 090/46. Confidence level = 3.
122.00

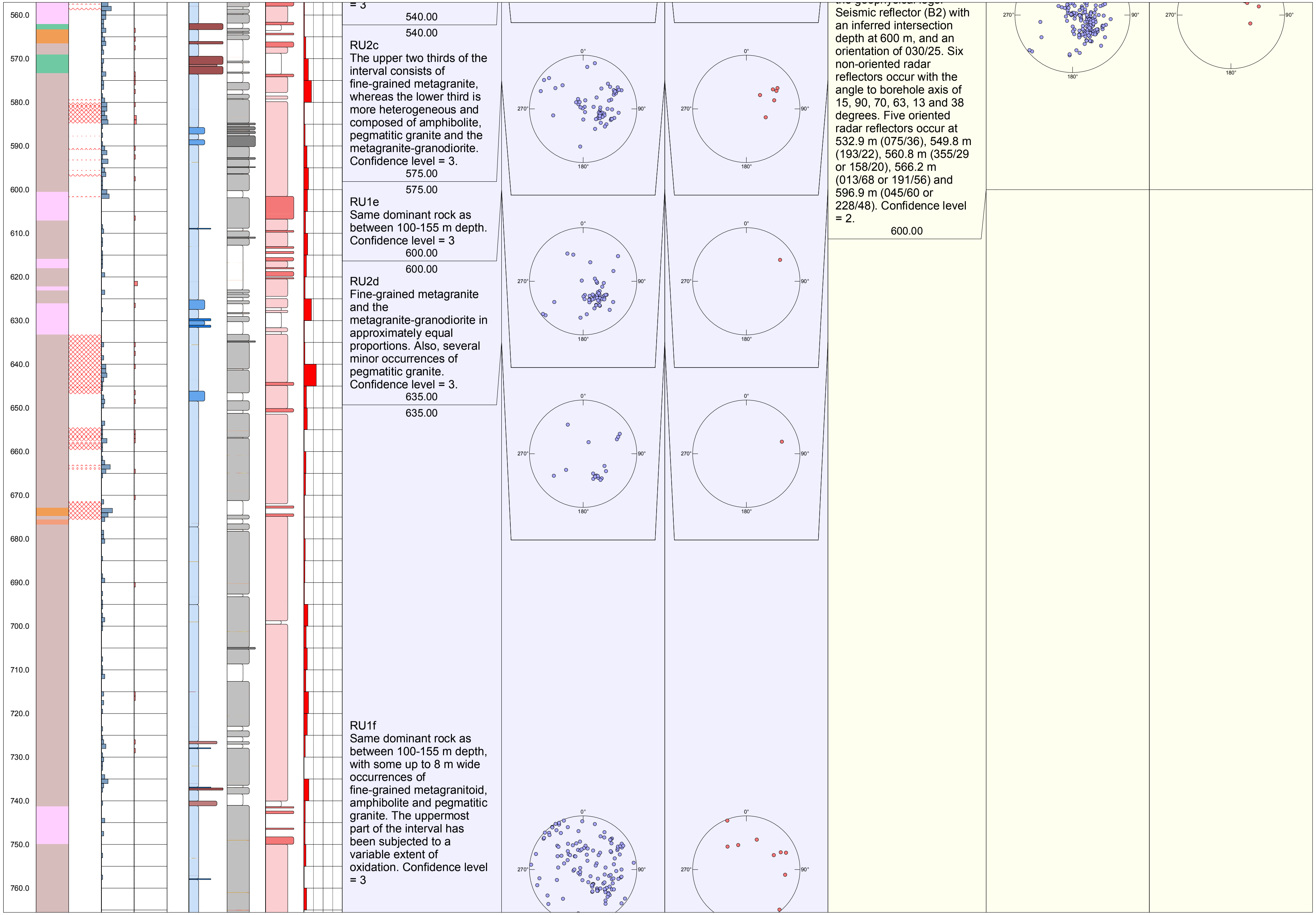
160.00
DZ3
Increased frequency of both sealed and open fractures, some with measurable apertures. Typically chlorite and/or calcite coated fractures. Most of the interval is more or less strongly oxidised with three minor occurrences of vuggy metagranite.
Characterised by very low resistivity and P-wave velocity, as well as low susceptibility. Seismic reflector (A3) with an inferred intersection depth at 180 m, and an orientation of 065/25. One non-oriented radar reflector at 169.3 m with the angle 90 degrees to borehole axis. Three oriented radar reflectors occur at 164.4 m with the orientation 105/17 or 314/20, 173.9 m with the orientation 043/18 or 251/11 and at 176.3 m with the orientation 038/44. Confidence level = 3.
184.00

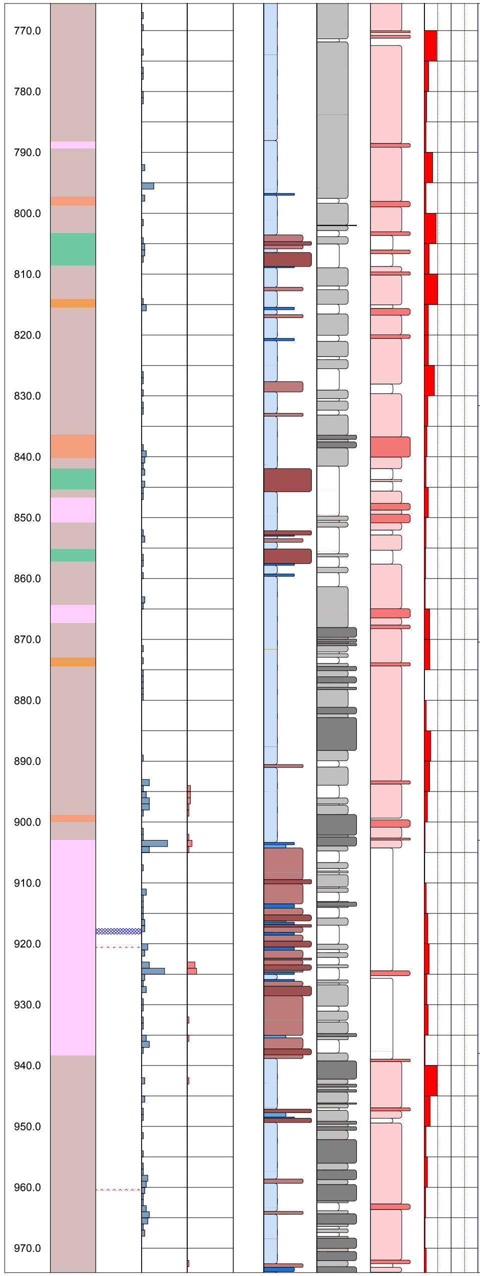
266.00
DZ4
Crush zone. Caliper indicated a large cavity, >150 mm. Confidence level = 2
267.00

303.00
DZ5
Increased frequency of sealed, but to some extent also open fractures. Typically chlorite and/or calcite coated fractures. Most of the interval is more or less strongly oxidised. Not visible in the geophysical logs, though it is visible as a radar reflector (54 degrees to the borehole axis at 308.9 m). Confidence level = 2.
310.00




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
RU1c
Same dominant rock as between 100-155 m depth, with one about 8 m wide occurrence of fine-grained metagranitoid, one about 3 m wide amphibolite and some minor occurrences of pegmatitic granite, fine-grained metagranite and amphibolite. Indications of sub-parallel radar reflectors outside the borehole are observed. Confidence level = 3
485.00
485.00
RU2b
Heterogeneous interval, predominantly with the fine-grained metagranitoid. The second most important bedrock component is the metagranite-granodiorite, and then pegmatitic granite. Also some subordinate amphibolite. Most of the interval has been subjected to a variable degree of oxidation. Confidence level = 3.
520.00
520.00
RU1d
Same dominant rock as between 100-155 m depth, with several minor occurrences of pegmatitic granite and amphibolite. To a variable extent oxidised. Confidence level
415.00
DZ6
A
wide zone with increased frequency of both open and sealed fractures. Typically chlorite and/or calcite coated fractures. The uppermost part and the lower 30 m of the interval are variably oxidised. Displays a variable susceptibility down to 462 m depth, and below that a more consistently low susceptibility. The whole interval shows a low resistivity and P-wave velocity. Seismic reflector (A2) with an inferred intersection depth at 470 m, and an orientation of 080/22 and a reflector (F1) with an inferred intersection depth at 500 m, and an orientation of 020/20. Two non-oriented radar reflectors occur at 468.4 m and 503.1 m with the angle to borehole axis of 42 and 49 degrees, respectively. Several oriented radar reflectors with variable orientation (275/12 or 061/17, 099/73 or 283/71, 232/71, 217/22, 021/5, 013/18, 033/46, 261/34, 028/5 or 005/4, 337/6 and 044/32). Confidence level = 3.
520.00
520.00
DZ7
A
zone characterised by an increased frequency of sealed fractures, but relatively few open fractures. Mostly epidote sealing and oxidised wall rock. Little indications in the geophysical logs
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
760.0
= 3
540.00
540.00
RU2c
The upper two thirds of the interval consists of fine-grained metagranite, whereas the lower third is more heterogeneous and composed of amphibolite, pegmatitic granite and the metagranite-granodiorite. Confidence level = 3.
575.00
575.00
RU1e
Same dominant rock as between 100-155 m depth. Confidence level = 3
600.00
600.00
RU2d
Fine-grained metagranite and the metagranite-granodiorite in approximately equal proportions. Also, several minor occurrences of pegmatitic granite. Confidence level = 3.
635.00
635.00
RU1f
Same dominant rock as between 100-155 m depth, with some up to 8 m wide occurrences of fine-grained metagranitoid, amphibolite and pegmatitic granite. The uppermost part of the interval has been subjected to a variable extent of oxidation. Confidence level = 3
Seismic reflector (B2) with an inferred intersection depth at 600 m, and an orientation of 030/25. Six non-oriented radar reflectors occur with the angle to borehole axis of 15, 90, 70, 63, 13 and 38 degrees. Five oriented radar reflectors occur at 532.9 m (075/36), 549.8 m (193/22), 560.8 m (355/29 or 158/20), 566.2 m (013/68 or 191/56) and 596.9 m (045/60 or 228/48). Confidence level = 2.
600.00
0°
90°
180°
270°

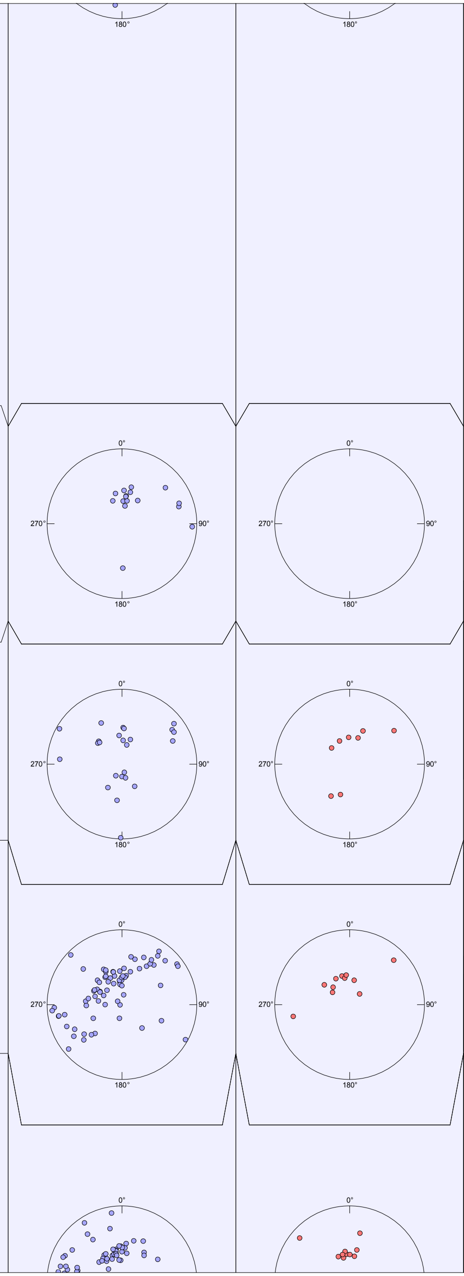


835.00
835.00
RU2e
Heterogenous interval, predominantly with the fine-grained metagranitoid, and then the metagranite-granodiorite and amphibolite. Also some subordinate occurrences of pegmatitic granite. Confidence level = 3
867.00

867.00
RU1g
Same dominant rock as between 100-155 m depth, with several minor occurrences of pegmatitic granite, up to about 1.5 m in width. Confidence level = 3
903.00

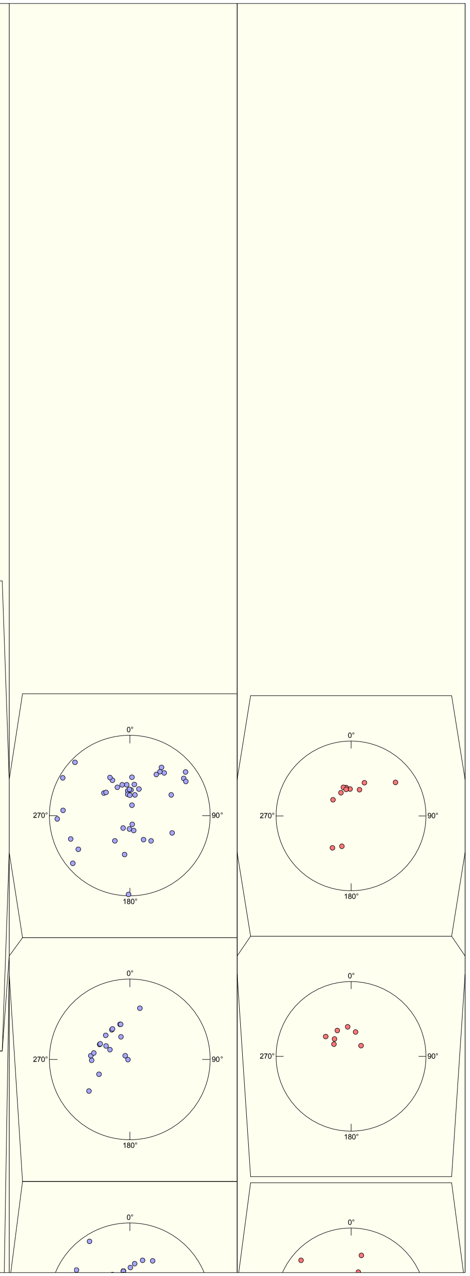
903.00
RU4
A homogeneous interval of a tonalitic (high density, low gamma) variety of the fine-grained metagranitoid. Also with some minor occurrences of amphibolite and pegmatitic granite. Confidence level = 3.
938.00

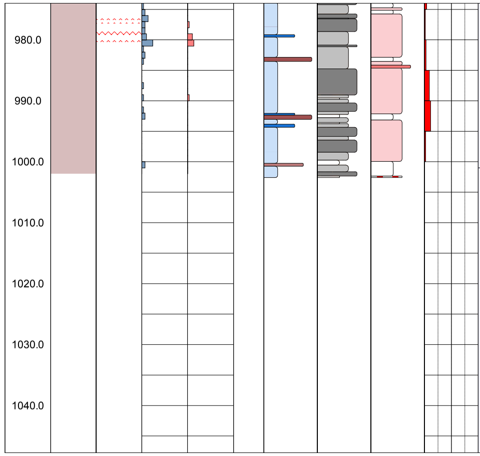
938.00
RU1h
Same dominant rock as between 100-155 m depth, with several minor occurrences of pegmatitic



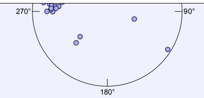
893.00
DZ8
Increased frequency of open fractures, often with measurable apertures and calcite and/or chlorite coating. The interval 893-899 m displays low resistivity, susceptibility and P-wave velocity. The contact between RU1 and RU4, in the lower end of the marked interval, shows a high frequency of open fractures. Also low resistivity and P-wave velocity. The contact is also visible as a radar reflector (55 degrees to the borehole axis at 903.7 m). Another non-oriented radar reflector occurs at 895.7 m with the angle 61 degrees to borehole axis. Confidence level = 3.
905.00

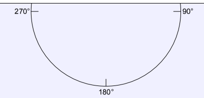
922.00
DZ9
Similar to the 893-905 m interval, but also with an increased frequency of sealed fractures. Probably associated with contacts between various minor rock occurrences of pegmatitic granite and amphibolite found in the interval. Low resistivity and





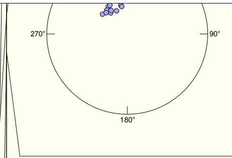
granite and amphibolite.
Confidence level = 3
1001.00

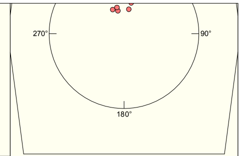




high gamma. A non-oriented radar reflector occurs at 924.4 m with the angle 70 degrees to the borehole axis. Confidence level = 3.
925.00

976.00
DZ10
Slightly increased frequency of both open and sealed fractures. Mostly calcite and chlorite coatings. Rather low susceptibility. Seismic reflector (B4) with an inferred intersection depth at 980 m, and an orientation of 050/28. A non-oriented radar reflector occurs at 980.2 m with the angle 57 degrees to the borehole axis. Confidence level = 2.
982.00





Appendix 2

Geological single-hole interpretation for HFM04

Title SINGLE HOLE INTERPRETATION HFM04

Site	FORSMARK	**Inclination [°]**	-84.25	**Elevation [m.a.s.l.]**	3.87	**Signed data**
Borehole	HFM04	**Date of mapping**	2003-01-31 00:00:00	**Drilling Start Date**	2002-11-19 13:00:00	
Diameter [mm]	138	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2002-12-03 12:00:00	
Length [m]	221.700	**Northing [m]**	6698878.97	**Surveying Date**		
Bearing [°]	336.87	**Easting [m]**	1633420.73	**Plot Date**	2006-09-20 21:10:12	

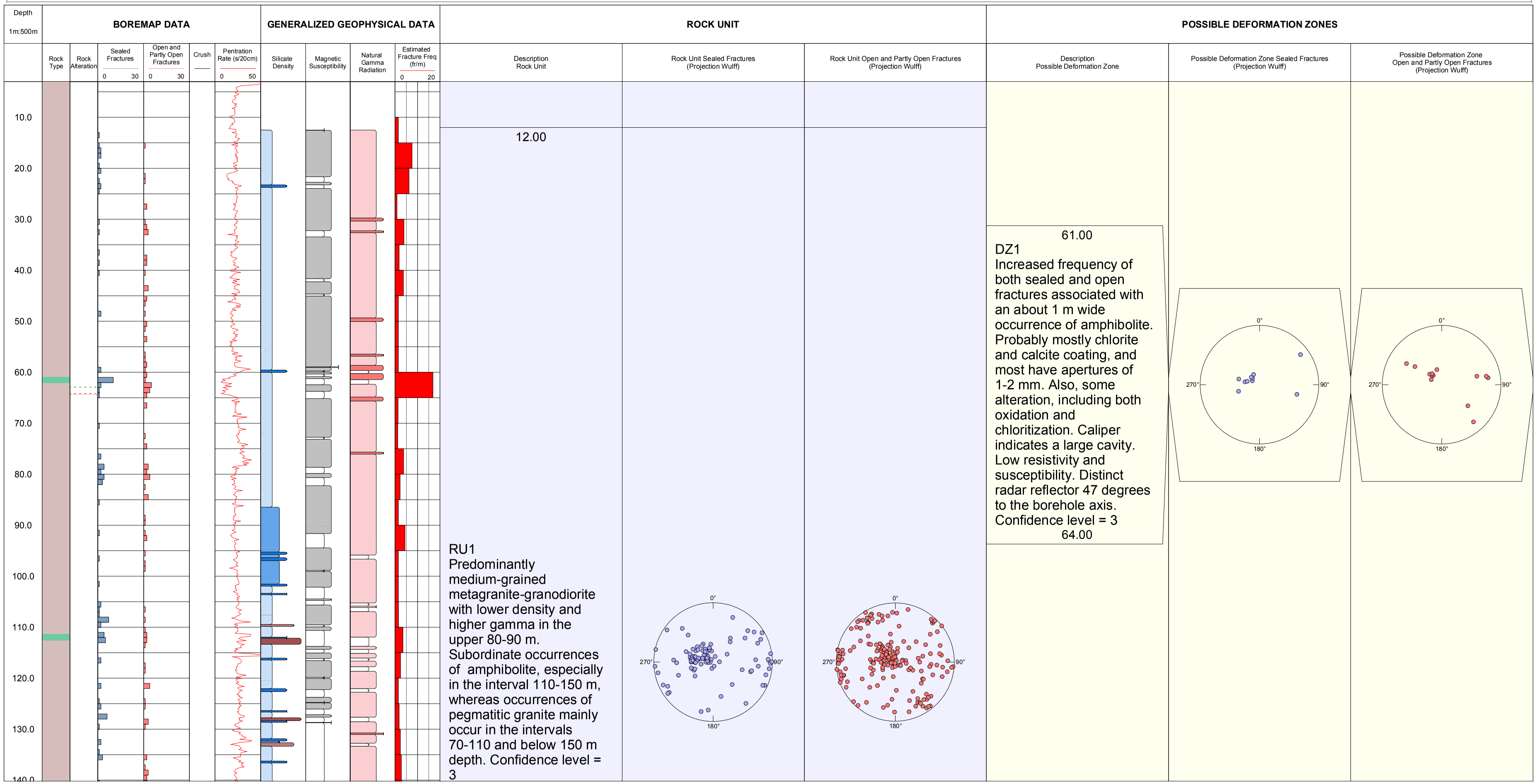
ROCKTYPE FORSMARK
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite, metamorphic, aplitic
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite

ROCK ALTERATION
- Oxidized
- Chloritisized

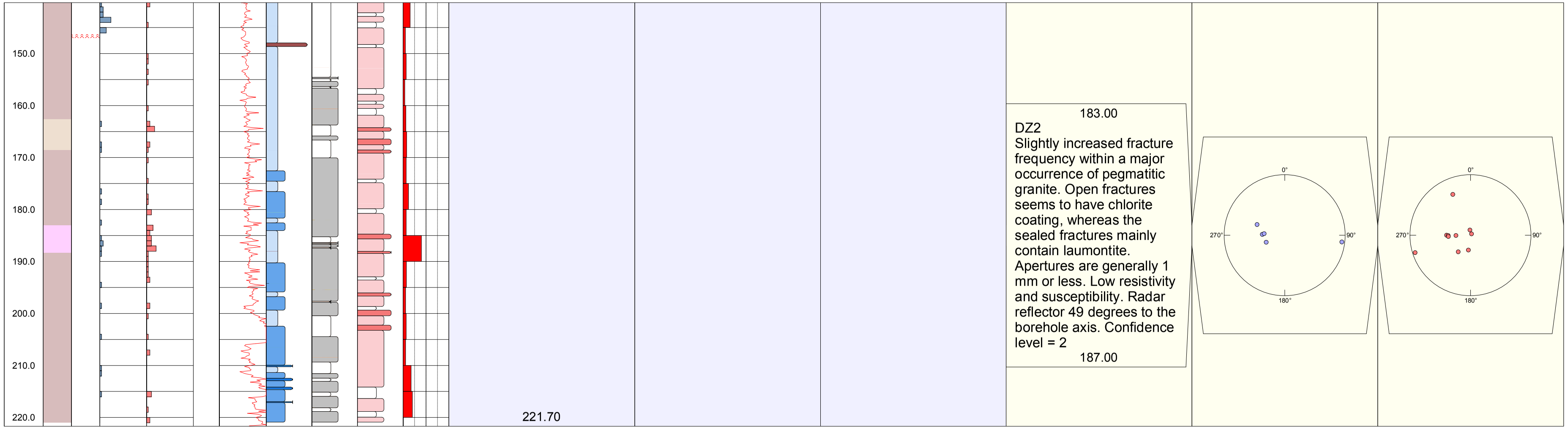
SILICATE DENSITY
- dens<2680 (Granite)
- 2680<dens<2730 (Granodiorite)
- 2730<dens<2800 (Tonalite)
- 2800<dens<2890 (Diorite)
- dens>2890 (Gabbro)

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

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



Page 1


150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
221.70
183.00
DZ2
Slightly increased fracture frequency within a major occurrence of pegmatitic granite. Open fractures seems to have chlorite coating, whereas the sealed fractures mainly contain laumontite. Apertures are generally 1 mm or less. Low resistivity and susceptibility. Radar reflector 49 degrees to the borehole axis. Confidence level = 2
187.00
0°
90°
180°
270°
0°
90°
180°
270°

Appendix 3

Geological single-hole interpretation for HFM05

Title	SINGLE HOLE INTERPRETATION HFM05				
Site	FORSMARK	Inclination [°]	-84.95	Elevation [m.a.s.l.]	7.67
Borehole	HFM05	Date of mapping	2003-02-19 00:00:00	Drilling Start Date	2002-12-04 13:18:00
Diameter [mm]	134	Coordinate System	RT90-RHB70	Drilling Stop Date	2002-12-16 17:36:00
Length [m]	200.100	Northing [m]	6698647.28	Surveying Date	
Bearing [°]	335.59	Easting [m]	1633289.72	Plot Date	2006-09-20 21:10:12

Signed data

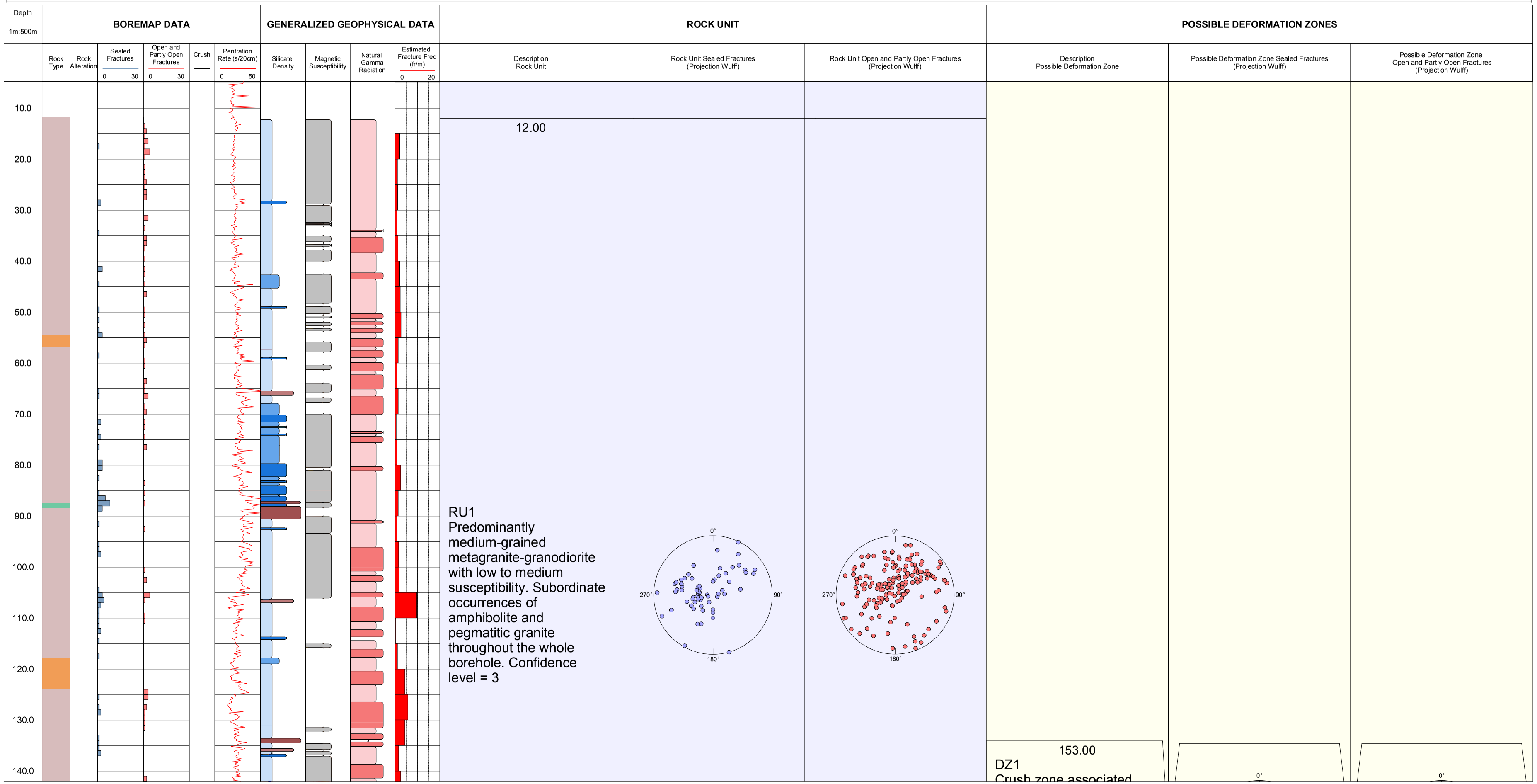
ROCKTYPE FORSMARK
- Pegmatite, pegmatitic granite
- Granite to granodiorite, metamorphic, medium-grained
- Amphibolite

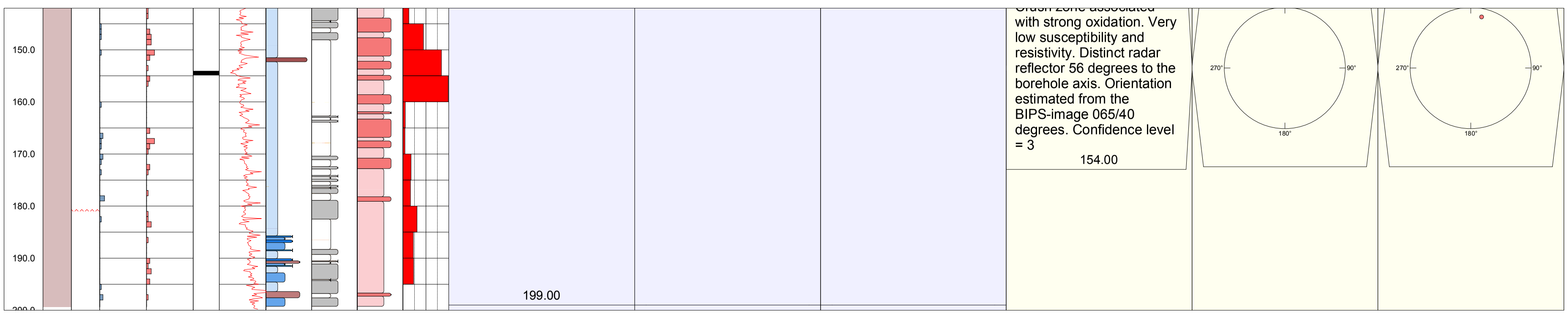
ROCK ALTERATION
- Oxidized

SILICATE DENSITY
- 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

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




150.0
160.0
170.0
180.0
190.0
199.00
Crush zone associated with strong oxidation. Very low susceptibility and resistivity. Distinct radar reflector 56 degrees to the borehole axis. Orientation estimated from the BIPS-image 065/40 degrees. Confidence level = 3
154.00
270°
90°
180°