P-06-83

Forsmark site investigation

Geological single-hole interpretation of KFM06C

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May 2006

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Keywords: Forsmark, Geophysics, Geology, Borehole, Bedrock, Fractures, AP-PF 400-05-107.

Abstract

This report presents geological single-hole interpretation of the cored borehole KFM06C at Forsmark. The interpretation combines the geological core mapping, interpreted geophysical logs and borehole radar measurements to identify where rock units and possible deformation zones occur in the boreholes. A brief description of the character of each rock unit and deformation zone is provided.

The geological single-hole interpretation shows that six rock units (RU1–RU6) occur in KFM06C. However, the borehole can be divided into seven separate sections due to the repetition of RU2 (RU2a and RU2b). Medium-grained metagranite-granodiorite (101057) dominates the upper half of the borehole and altered aplitic metagranite (101058) the lower half. Other rock types of volumetric importance include one section with amphibolite (102017) and another with felsic to intermediate metavolcanic rock (103076) occur in the borehole. Subordinate rock types are pegmatitic granite (101061), fine- to medium-grained metagabbro/metadiorite (101033), fine- to medium-grained metagranitoid (101051) and calc-silicate rock (108019).

Five possible deformation zones of brittle character have been identified in KFM06C (DZ1–DZ5).

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhål KFM06C i Forsmark. Den geologiska enhålstolkningen syftar till att utifrån den geologiska karteringen, tolkade geofysiska loggar och borrhålsradarmätningar indikera olika litologiska enheters fördelning i borrhålet samt möjliga deformationszoners läge och utbredning. En kort beskrivning av varje bergenhet och deformationszon presenteras.

Denna undersökning visar att det i KFM06C finns sex litologiska enheter (RU1–RU6). Baserat på repetition av enheten RU2 (RU2a och RU2b) kan borrhålet delas in i sju sektioner. Medelkornig metagranit-granodiorit (101057) dominerar den övre delen av borrhålet, medan omvandlad aplitisk metagranit (101058) förekommer i den nedre delen av borrhålet. Andra volymmässigt viktiga bergartstyper inkluderar en sektion med amfibolit (102017) och en annan sektion med en felsisk till intermediär vulkanisk bergart (103076) finns i borrhålet. I mindre omfattning förekommer även pegmatitisk granit (101061), fin- till medelkornig metagabbro/metadiorit (101033), fin- till medelkornig metagranitoid (101051) och kalksilikatbergart (108019).

Fem möjliga deformationszoner som är spröda har identifierats i KFM06C (DZ1–DZ5).

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 Rock Visualization 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 borehole KFM06C at drill site 6 (DS6) in the Forsmark area. The horizontal projections of the boreholes in the candidate area are shown in Figure 1-1. The work was carried out in accordance with activity plan SKB PF 400-05-107. The controlling documents for performing this activity are listed in Table 1-1. Both the activity plan and method description are SKB's internal controlling documents.

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

Activity plan	Number	Version
	AP PF 400-05-107	1.0
Method description	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	3.0 (in prep.)

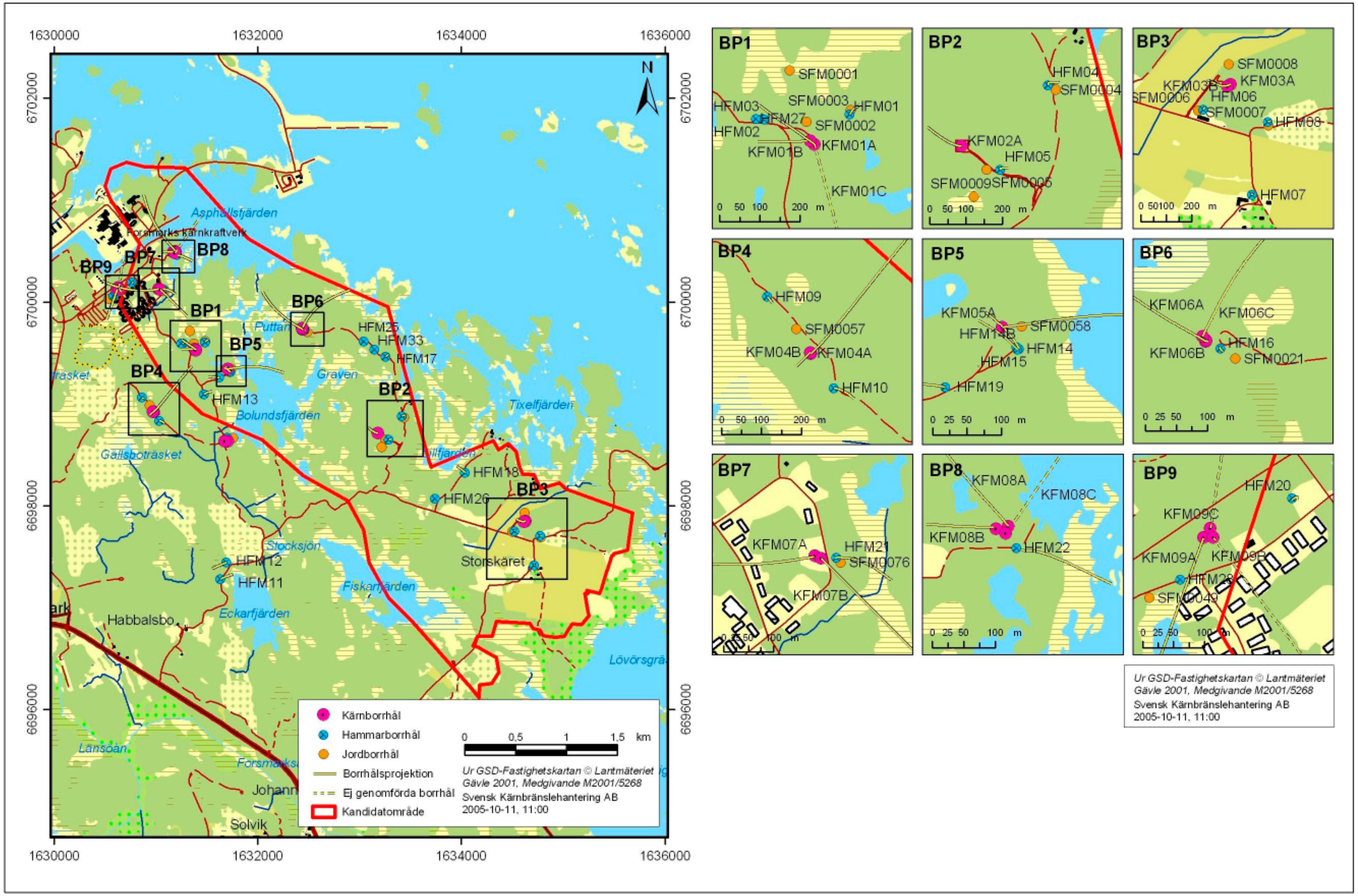

Figure 1-1. *Map showing horizontal projection of the boreholes in the candidate area and the position of the cored borehole KFM06C.*

2 Objective and scope

A geological single-hole interpretation is carried out in order to identify and to describe briefly the characteristics of 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. The geological mapping of the cored boreholes involves a documentation of the character of the bedrock in the drill core. This work component is carried out in combination with an inspection of the oriented image of the borehole walls that is obtained with the help of the *B*orehole *I*mage *P*rocessing *S*ystem (BIPS). The geological mapping of the percussion boreholes focuses more attention on an integrated interpretation of the information from the geophysical logs and the BIPS images. For this reason, the results from the percussion borehole mapping are more uncertain. The interpretations of the borehole geophysical and radar logs are available when the single-hole interpretation is completed. The result from the geological single-hole interpretation is presented in a WellCad plot. A more 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 and interpretations have been used for the single-hole interpretation of the borehole KFM06C:

- Boremap data (including BIPS and geological mapping data) /1/.
- Generalized geophysical logs and their interpretation /2/.
- Radar data and their interpretation /3/.

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

1: Length along the 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 rocks with high natural gamma radiation have been included in the younger, Group D intrusive suite /4/.

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, P-wave velocity 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.

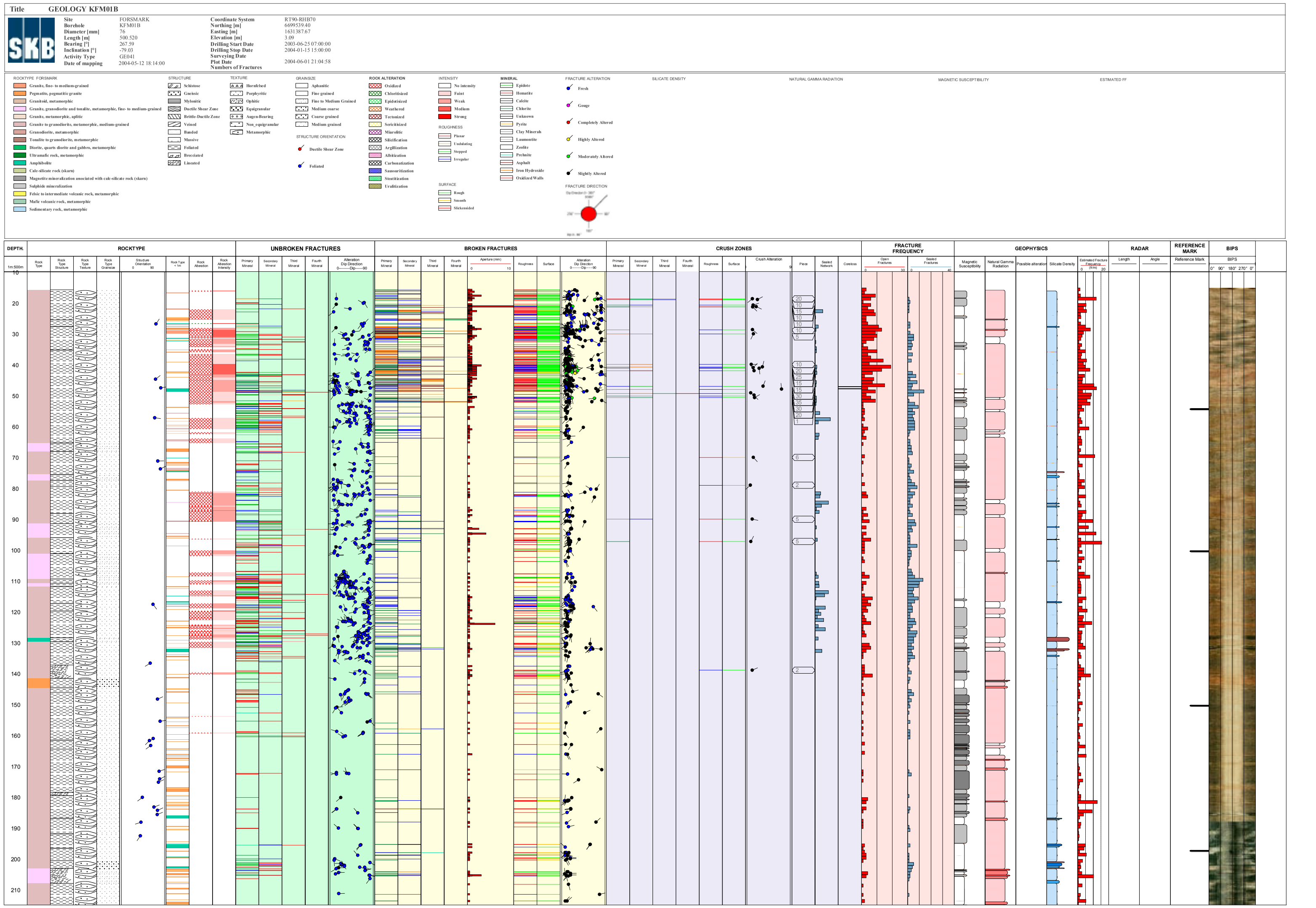

Figure 3-1. Example of WellCad plot (from borehole KFM01B) used as a basis for the single-hole interpretation.

4 Execution of the geological single-hole interpretation

4.1 General

The geological single-hole interpretation has been carried out by a group of geoscientists consisting of both geologists and geophysicists. Several of these geoscientists 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. The working procedure is summarized in Figure 4-1 and in the text below.

Stage 1 in the working procedure is to study all types of data (rock type, rock alteration, silicate density, natural gamma radiation, etc) related to the character of the rock type 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 defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. The confidence in the interpretation of a rock unit is made on the following basis: 3 = high, 2 = medium, 1 = low.

Stage 2 in the working procedure is to identify deformation zones by visual inspection of the results of the geological mapping (fracture frequency, fracture mineral, aperture, alteration, etc) in combination with the geophysical logging and radar data. The section of each identified deformation zone is defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. The confidence in the interpretation of a deformation zone is made on the following basis: 3 = high, 2 = medium and 1 = low.

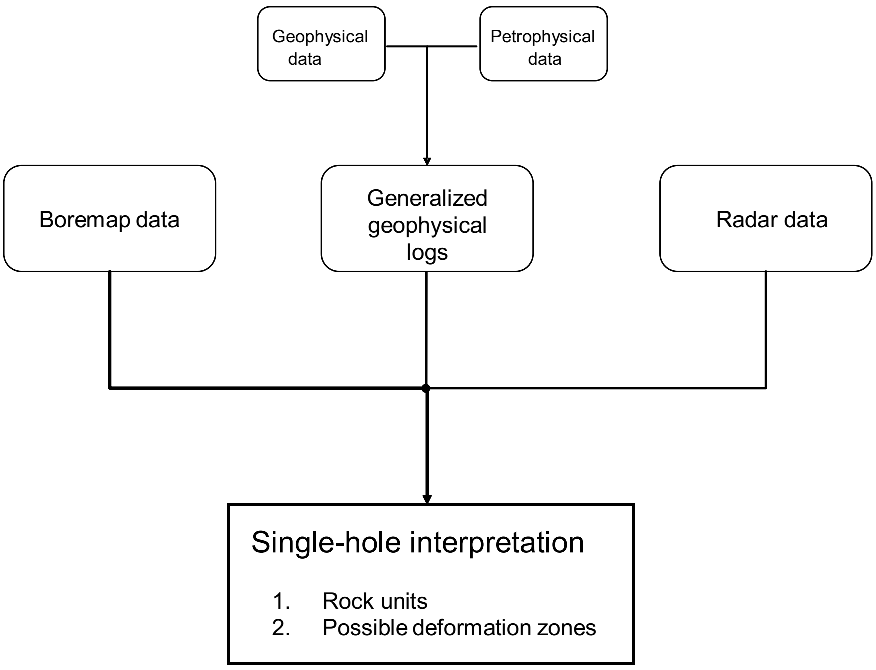

Figure 4-1. *Schematic chart that shows the procedure for the development of a geological single-hole interpretation.*

Inspection of BIPS images is carried out wherever it is judged necessary during the working procedure. Furthermore, following definition of rock units and deformation zones, with their respective confidence estimates, the drill cores are inspected in order to check the selection of the boundaries between these geological entities. If judged necessary, the location of these boundaries is adjusted.

Deformation zones that are brittle in character have been identified primarily on the basis of the frequency of fractures, according to the concept presented in /5/. Brittle deformation zones defined by an increased fracture frequency of extensional fractures (joints) or shear fractures (faults) are not distinguished. Both the transitional part, with a fracture frequency in the range 4–9 fractures/m, and the core part, with a fracture frequency > 9 fractures/m, have been included in each zone (Figure 4-2). The frequencies of open and sealed fractures have been assessed in the identification procedure, and the character of the zone has been described accordingly. Partly open fractures are included together with open fractures in the brief description of each zone. The presence of bedrock alteration, the occurrence and, locally, inferred orientation of radar reflectors, the resistivity, SPR, P-wave velocity, caliper and magnetic susceptibility logs have all assisted in the identification of the zones. The anomalies in these parameters that assist with the identification are presented in the short description.

Since the frequency of fractures is of key importance for the definition of the possible deformation zones, a moving average plot for this parameter is shown for the cored borehole KFM06C (Figure 4-3). A 5 m window and 1 m steps have been used in the calculation procedure. The moving averages for open fractures alone, the total number of open fractures (open, partly open and crush), the sealed fractures alone, and the total number of sealed fractures (sealed and sealed fracture network) are shown in this diagram.

The occurrence and orientation of radar anomalies within the possible deformation zones are used during the identification of possible deformation zones. An overview of the borehole radar measurement in KFM06C is shown in Figure 4-4.

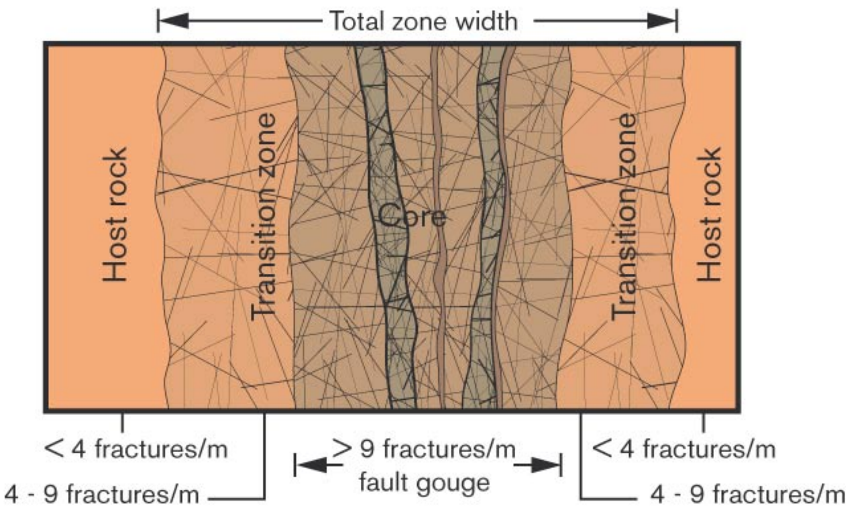

Figure 4-2. *Terminology for brittle deformation zones (after /5/).*

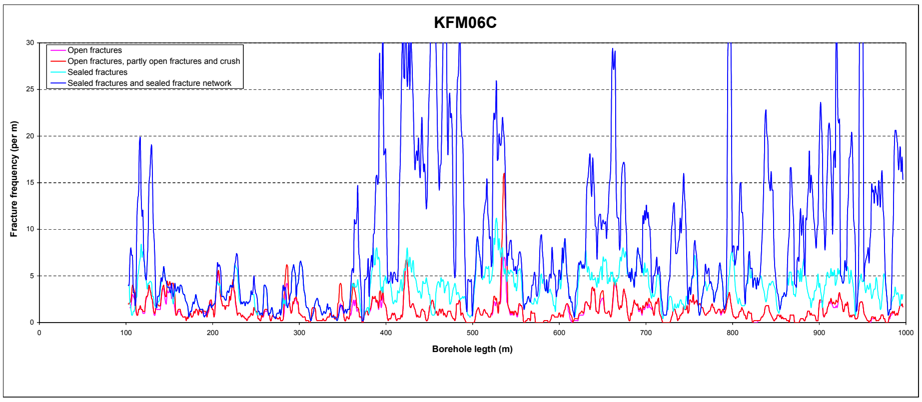

Figure 4-3. *Fracture frequency plot for KFM06C. Moving average with a 5 m window and 1 m steps.*

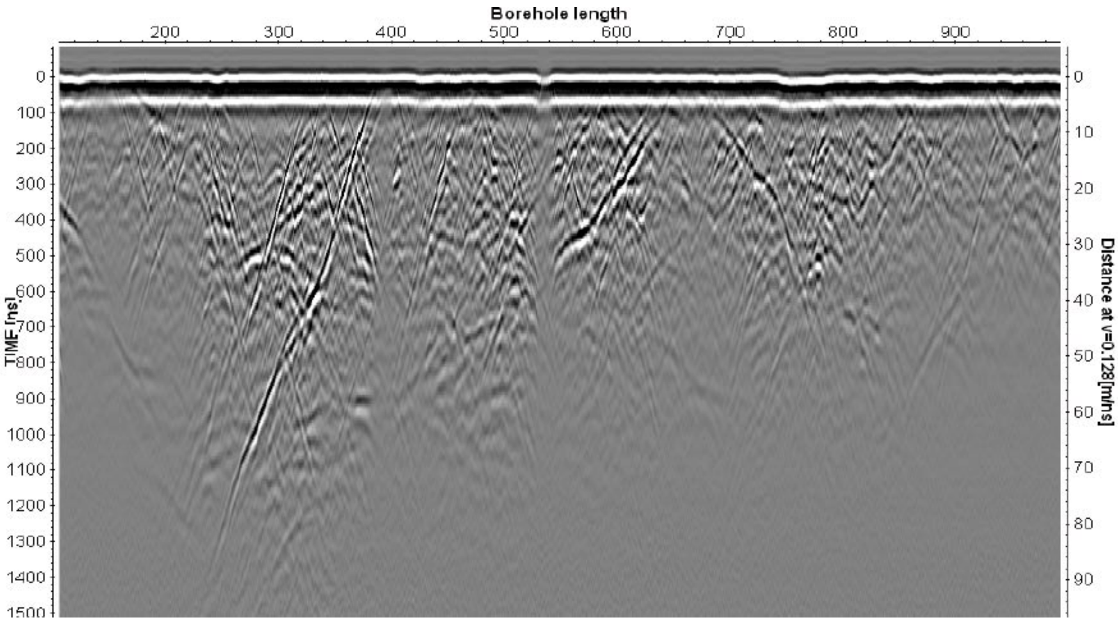

Figure 4-4. *Overview (20 MHz data) of the borehole radar measurement in KFM06C.*

4.2 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.

Orientations from directional radar are presented as strike/dip using the right-hand rule.

5 Results

The result of the geological single-hole interpretation is presented as print-outs from the software WellCad (Appendix 1 for KFM06C).

5.1 KFM06C

The borehole direction at the start is 026.1/–60.1.

Rock units

The borehole can be divided into six different rock units, RU1–RU6 that have been recognized with a high degree of confidence. Rock unit RU2 occurs at two separate borehole intervals. These are distinguished using the identification codes RU2a and RU2b.

102.131–411.146 m

RU1: Medium-grained metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), fine- to medium-grained metagabbro/metadiorite (101033) and amphibolite (102017). In addition, a few occurrences of felsic to intermediate metavolcanic rock (103076), fine- to medium-grained metagranitoid (101051) and aplitic metagranite (101058). Anomalously high frequency of open and sealed fractures in two intervals (205–230 and 284–305 m) relative to the bedrock outside possible deformation zones. The lower interval also includes a 10 cm wide crush zone. Anomalously low magnetic susceptibility ($5–20\times10^{-5}$ SI) in the interval 200–270 m, which corresponds to a greyish variety of the medium-grained metagranite-granodiorite (101057). Confidence level = 3.

411.146–745.050 m

RU2a: Aplitic metagranite (101058) generally affected by faint to medium albitization, which in part corresponds to decreased natural gamma radiation. Subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amphibolite (102017). In addition, one occurrence of fine- to medium-grained quartz-bearing metadiorite (101033) and one of felsic to intermediate metavolcanic rock (103076). Anomalously high frequency of sealed fractures and locally faint to weak oxidation below 560 m relative to the upper part of the borehole outside possible deformation zones. Confidence level = 3.

745.050–785.470 m

RU3: Amphibolite (102017) with subordinate occurrences of pegmatitic granite (101061). Confidence level = 3.

785.470–796.298 m

RU4: Felsic to intermediate metavolcanic rock (103076). Confidence level = 3.

796.298–898.132 m

RU2b: Aplitic metagranite (101058) generally affected by faint to medium albitization, which in part corresponds to decreased natural gamma radiation and slightly increased density. Subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061), medium-grained metagranite-granodiorite (101057) and amphibolite (102017). In addition, a few metre wide interval dominated by calc-silicate rock (108019). Anomalously high frequency of sealed fractures, sealed fracture networks and locally faint to weak oxidation relative to the upper part of the borehole outside possible deformation zones. Confidence level = 3.

898.132–951.233 m

RU5: Foliated, fine- to medium-grained metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061) and amphibolite (102017). Anomalously high frequency of sealed fractures, sealed fracture networks and faint to weak oxidation relative to the upper part of the borehole outside possible deformation zones. Partly decreased magnetic susceptibility (< 0.001 SI) in the interval c 919–940 m. Confidence level = 3.

951.233–1,000.430 m

RU6: Aplitic metagranite (101058), generally affected by faint to medium albitization, foliated, fine- to medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061). Subordinate occurrences of amphibolite (102017). Anomalously high frequency of sealed fractures, sealed fracture networks and faint to weak oxidation relative to the upper part of the borehole outside possible deformation zones. Partly decreased magnetic susceptibility (< 0.001 SI) and natural gamma radiation (< 20 μR/h) in the interval c 974–984 m. Confidence level = 3.

Possible deformation zones

Five deformation zones of brittle character and with a variable degree of confidence have been recognized in KFM06C:

102–169 m

DZ1: Increased frequency of sealed and open fractures. Sealed fracture networks are concentrated in the upper half, while open fractures with apertures over 10 mm and a 5 cm wide crush zone are concentrated in the lower half. Fracture apertures are typically less than 1 mm. Faint to medium oxidation throughout the entire interval. The open/partly open fractures are predominantly gently dipping. The sealed fractures are both gently and steeply dipping with a variable strike in the steeply dipping fractures. The most frequent fracture filling minerals in the order of decreasing abundance include calcite, chlorite, clay minerals, pyrite, hematite and a few fractures with asphalt. Large number of distinct low resistivity anomalies along the entire deformation zone. There is also a general decrease in the bulk resistivity in combination with low P-wave velocity anomalies in the interval c 140–155 m. Twenty non-oriented and five oriented radar reflectors are identified. The oriented radar reflectors occur at 138.5 m (180/89), 139.8 m (209/17 or 090/68), 145.9 m (104/67), 151.9 m (112/64 or 020/3) and at 152.6 m (183/82). Decreased radar amplitude at 105 m, 115–120 m, 125–130 m, 140–150 m and 155 m. DZ1 consists of medium-grained metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), fine- to medium-grained metagabbro/metadiorite (101033) and amphibolite (102017). Confidence level = 3.

359–400 m

DZ2: Increased frequency of sealed fractures and sealed fracture networks, especially in the lower part. Two crush zones (4 and 5 cm wide), one at the top and one near the bottom of the possible zone. Fracture apertures are typically less than 1 mm, with a few that ranges up to 2 mm. Faint to medium oxidation throughout the entire interval. The open/partly open fractures are predominantly gently dipping. The sealed fractures are both gently and steeply dipping. One set strikes NE or NNE. Other sealed steeply dipping fractures strike SE and dip variably to the SW. The most frequent fracture filling minerals in the order of decreasing abundance include calcite and chlorite. There is a general decrease in the bulk resistivity in combination with a large number of distinct low resistivity anomalies along the interval 385–400 m. There is also a thin but distinct low P-wave velocity anomaly and caliper anomaly at section coordinate 394.5 m. Nine non-oriented and five oriented radar reflectors are identified. The oriented radar reflectors occur at 361.7 m (190/9 or 109/68), 376.6 m (135/79 or 002/19), 380.9 m (140/90), 388.4 m (115/66 or 161/5) and 392.9 m (262/11 or 111/79). One persistent non-oriented radar reflector intersects the borehole at 394 m with the angle 38 degrees and can be traced at least 80 m away from the borehole. Decreased radar amplitude at 360 m and 395 m. DZ2 consists of medium-grained metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), fine- to medium-grained metagabbro/metadiorite (101033) and amphibolite (102017). Confidence level = 3.

415–489 m

DZ3: Increased frequency of sealed fractures and sealed fracture networks. Increased frequency of open fractures with apertures up to 6 mm in the uppermost part of the interval. Locally faint to weak oxidation and an interval of vuggy aplitic metagranite at 451.4–452.2 m. Most fractures strike SW and dip variably to the NW. A subordinate set of steeply dipping sealed fractures strikes NNW. The most frequent fracture filling minerals in the order of decreasing abundance include calcite, chlorite, adularia and hematite. The interval c 419–426 m is characterized by a large number of distinct low resistivity anomalies, decreased P-wave velocity and some caliper anomalies. The interval c 442–460 m is characterized by a large number of distinct low resistivity anomalies and partly decreased P-wave velocity. Twenty-for non-oriented and eight oriented radar reflectors are identified. The oriented radar reflectors occur at 425.9 m (091/46 or 161/38), 430.0 m (160/39 or 090/45), 444.9 m (084/57), 449.0 m (048/89 or 213/75), 449.4 m (084/45 or 163/43), 453.8 m (089/48 or 167/41), 460.8 m (094/32) and 480.1 m (144/64 or 077/20). One persistent non-oriented radar reflector intersects the borehole at 477 m with the angle 50 degrees and can be traced at least 50 m away from the borehole. Decreased radar amplitude at the interval 420–435 m, 450–460 m and 470 m. DZ3 consists of aplitic metagranite (101058) generally affected by faint to medium albitization, subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amphibolite (102017). Confidence level = 3.

502–555 m

DZ4: Increased frequency of sealed fractures, sealed fracture networks and, in the central part (534–540 m), open fractures and crush zones (3, 3, 5 and 40 cm wide). Fracture apertures are typically less than 1 mm, with some up to 3 mm. Most open/partly open fractures strike ESE and dip moderately to the SSW. However, fractures that strike NNE and are steeply dipping, that strike NW and dip steeply to the NE and that are gently dipping are also present. A similar pattern for the orientation of sealed fractures is apparent. However, the fractures within the different orientation sets are more evenly distributed.

The most frequent fracture filling minerals in the order of decreasing abundance include calcite, chlorite, adularia and hematite. There is a large number of distinct low resistivity anomalies along the entire section. The interval c 531–540 m is characterized by a major decrease in the bulk resistivity, a large decrease in P-wave velocity and several distinct caliper anomalies. Five oriented radar reflectors occur at 507.4 m (340/89 or 014/37), 509.8 m (150/56 or 085/29), 533.8 m (171/38 or 097/51), 537.3 m (223/88) and at 540.2 m (090/62). Sixteen non-oriented radar reflectors are identified. One persistent non-oriented radar reflector intersects the borehole at 538 m and can be traced at least 40 m away from the borehole. Decreased radar amplitude at the interval 530–540 m. Locally faint to weak oxidation. DZ4 consists of aplitic metagranite (101058) generally affected by faint to medium albitization, subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amphibolite (102017). Confidence level = 3.

623–677 m

DZ5: Increased frequency of sealed fractures, sealed fracture networks and open fractures. Sealed fractures dominate. Fracture apertures are typically less than 1 mm, with two > 10 mm. Most fractures fall into four orientation sets. The steeply dipping sets strike NE, WNW and SSE (dip to WSW). The fourth set is gently dipping. The most frequent fracture filling minerals in the order of decreasing abundance include calcite, chlorite, adularia and hematite. There are increased occurrences of low resistivity anomalies, partly a slight decrease in the bulk resistivity and a few minor caliper anomalies. 28 identified radar reflectors, of which 11 are oriented. Five of them are oriented in the interval 203–222/67–81 and two of them 200–230/6–13. Other orientations are 106/74 or 211/27, 354/65 and 059/84. Two persistent radar reflectors intersect the borehole at 644 m and 664 m with intersection angle 56 degrees and orientation 052/69, respectively. They can be traced at least 25 m away from the borehole. Decreased radar amplitude at 620 m, 640 m, 650 m, 665–670 m and 675 m. Locally faint to weak oxidation. DZ5 consists of aplitic metagranite (101058) generally affected by faint to medium albitization, subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amphibolite (102017). Confidence level = 2.

6 Comments

The result from the geological single-hole interpretation of KFM06C is presented in a WellCad plot (Appendix 1). The WellCad plot consists of the following columns:

1: Depth (Length along the borehole).

2: Rock type.

3: Rock alteration.

4: Sealed fractures.

5: Open and partly open fractures.

6: Crush zones.

7: Silicate density.

8: Magnetic susceptibility.

9: Natural gamma radiation.

10: Estimated fracture frequency.

11: Description: Rock unit.

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

13: Stereogram for open and partly open fractures in rock unit (red symbols).

14: Description: Possible deformation zone.

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

16: Stereogram for open and partly open fractures in possible deformation zone (red symbols).

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Appendix 1

Geological single-hole interpretation of KFM06C

Title SINGLE HOLE INTERPRETATION KFM06C

SKB

Site	FORSMARK	**Inclination [°]**	-60.11	**Elevation [m.a.s.l.]**	4.09	**Signed data**
Borehole	KFM06C	**Date of mapping**	2005-08-29 08:00:00	**Drilling Start Date**	2005-03-09 08:30:00	
Diameter [mm]	51	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2005-04-13 12:15:00	
Length [m]	1000.430	**Northing [m]**	6699740.96	**Surveying Date**		
Bearing [°]	26.07	**Easting [m]**	1632437.03	**Plot Date**	2006-04-04 21:14:45	

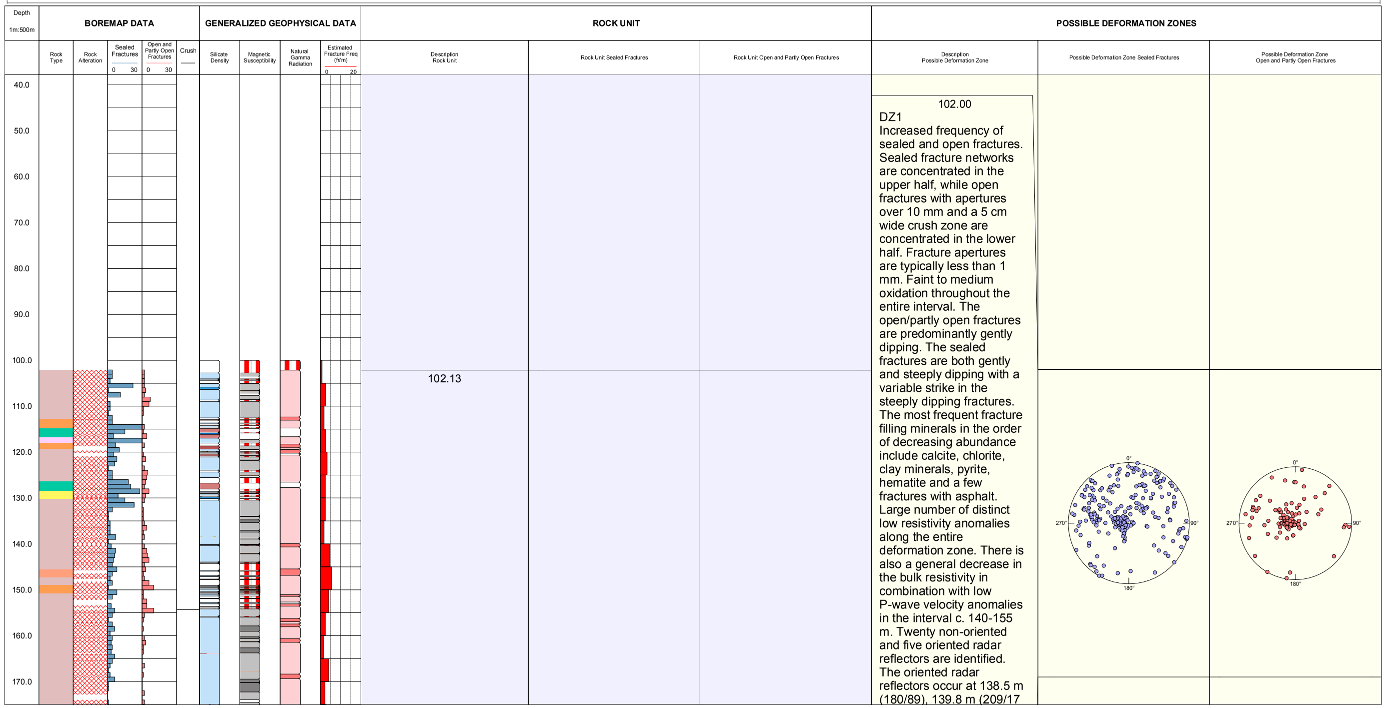
ROCKTYPE FORSMARK
- Granite, fine- to medium-grained
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained
- Granite, metamorphic, aplitic
- Granite to granodiorite, metamorphic, medium-grained
- Diorite, quarts diorite and gabbro, metamorphic
- Amphibolite
- Felsic to intermediate volcanic rock, metamorphic

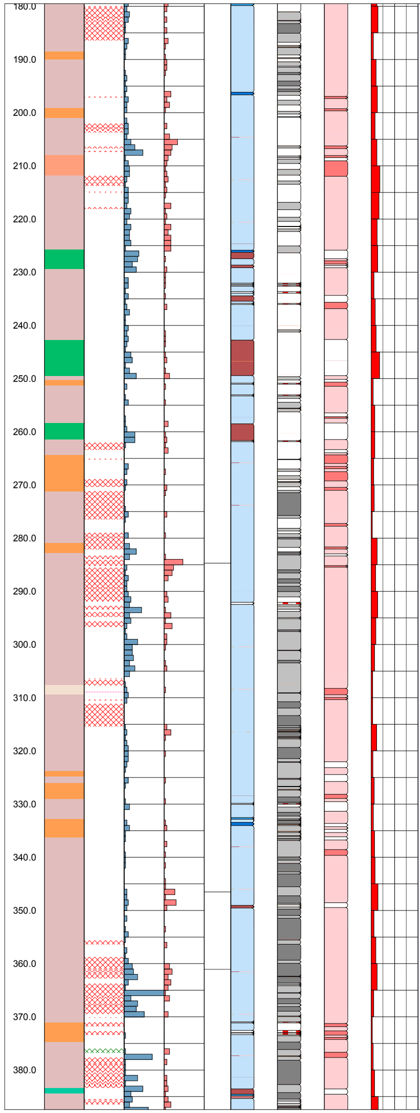
ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Quartz dissolution
- Argillization
- Albitization
- Saussuritization

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

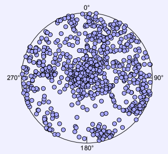
SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

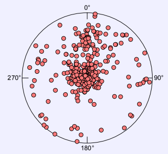
NATURAL GAMMA
- unclassified
- gam<20
- 20<gam<36
- 36<gam<53





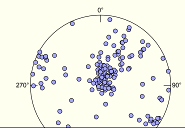
RU1
Medium-grained metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), fine- to medium-grained metagabbro/metadiorite (101033) and amphibolite (102017). In addition, a few occurrences of felsic to intermediate metavolcanic rock (103076), fine- to medium-grained metagranitoid (101051) and aplitic metagranite (101058). Anomalously high frequency of open and sealed fractures in two intervals (205-230 and 284-305 m) relative to the bedrock outside possible deformation zones. The lower interval also includes a 10 cm wide crush zone. Anomalously low magnetic susceptibility (5-20×10-5 SI) in the interval 200-270 m, which corresponds to a greyish variety of the medium-grained metagranite-granodiorite (101057). Uncertainty = 3.

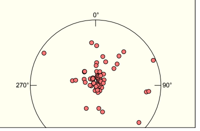




(104/67), 151.9 m (112/64 or 020/3) and at 152.6 m (183/82). Decreased radar amplitude at 105 m, 115-120 m, 125-130 m, 140-150 m and 155 m. DZ1 consists of medium-grained metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061), fine- to medium-grained metagabbro/metadiorite (101033) and amphibolite (102017). Uncertainty= 3.
169.00

359.00
DZ2
Increased frequency of sealed fract. and sealed fract. networks, especially in the lower part. Two crush zones (4 and 5 cm wide), one at the top and one near the bottom of DZ2. Fract. apertures are typically less than 1 mm, with a few that ranges up to 2 mm. Faint to medium oxidation throughout DZ2. The open/partly open fract. are pred. gently dipping. The sealed fract. are both gently and steeply dipping. One set strikes NE or NNE. Other sealed steeply dipping fractures strike SE and dip variably to the SW. The most frequent fract. filling minerals in the order of decreasing abundance include calcite and chlorite. There is a general decr. in the bulk resistivity in combination with a large number of distinct low resistivity anomalies along the interval 385-400 m. There is also a thin but distinct low P-wave vel.





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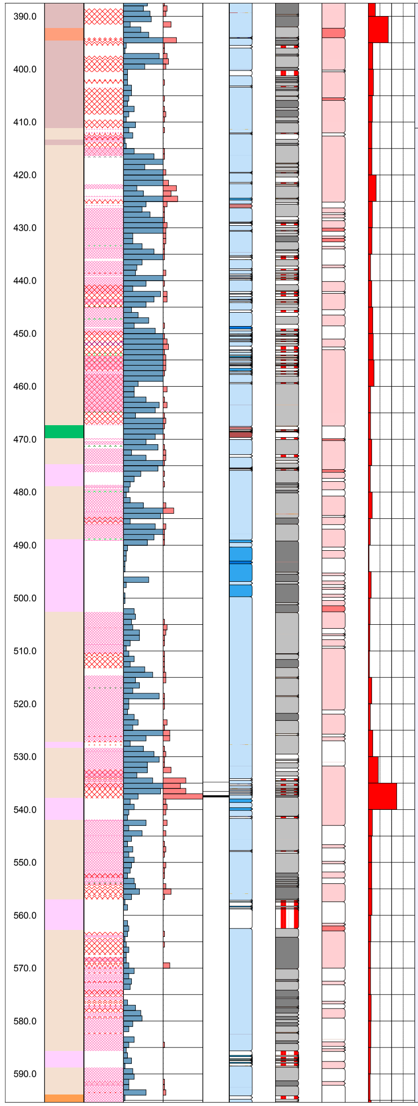
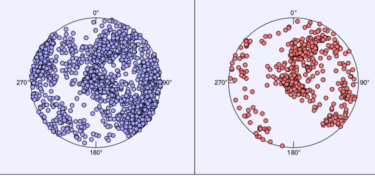


411.15

411.15

RU2a
Aplitic metagranite (101058) generally affected by faint to medium albitization, which in part corresponds to decreased natural gamma radiation. Subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amphibolite (102017). In addition, one occurrence of fine- to medium-grained quartz-bearing metadiorite (101033) and one of felsic to intermediate metavolcanic rock (103076). Anomalously

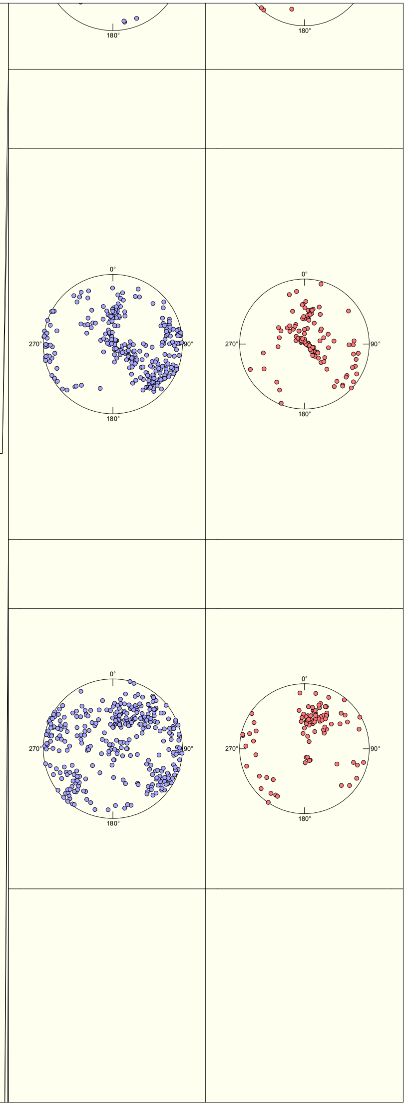


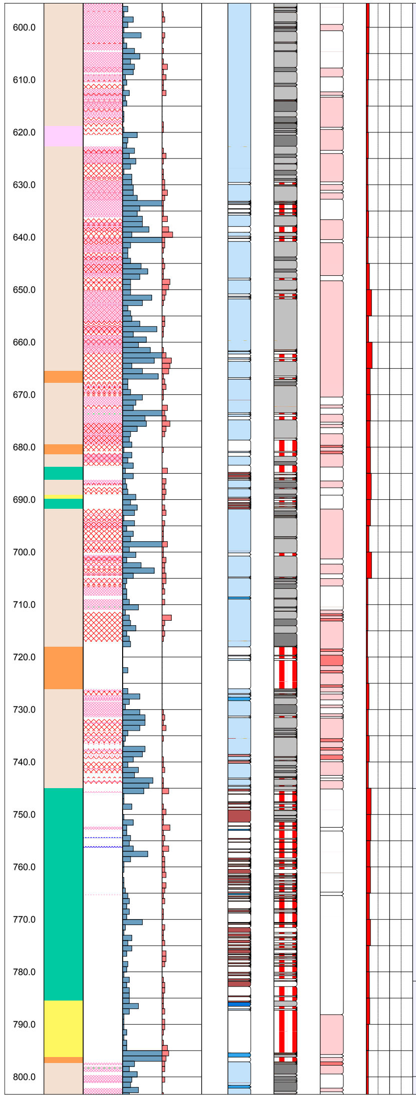
anomaly and caliper anomaly at 394.5 m. Nine non-oriented and five oriented radar refl. are identified. Oriented occur at 361.7 m (190/9 or 109/68), 376.6 m (135/79 or 002/19), 380.9 m (140/90), 388.4 m (115/66 or 161/5) and 392.9 m (262/11 or 111/79). One persistent non-oriented reflector intersects the borehole at 394 m with the angle 38 degrees and can be traced at least 80 m away from the borehole. Decr. radar ampl. at 360 m and 395 m. DZ2 consists of medium-grained metagranite-granodiorite (101057) with subord. occurrences of pegmatitic granite (101061), fine- to medium-grained metagabbro/metadiorite (101033) and amphibolite (102017). Uncertainty = 3

400.00

415.00

DZ3
Increased freq. of sealed fract. and sealed fract. networks. Incr. freq. of open fract. with apertures up to 6 mm in the uppermost part of the interval. Locally faint to weak oxidation and an interval of vuggy aplitic metagranite at 451.4-452.2 m. Most fract. strike SW and dip variably to the NW. A subordinate set of steeply dipping sealed fract. strikes NNW. The most frequent fract. filling minerals in the order of decreasing abundance include calcite, chlorite, adularia and hematite. The interval c. 419-426 m is charact. by a large number of distinct low resistivity anomalies, decr. P-wave vel. and some caliper anomalies. The interval c. 442-460 m is charact. by a large number of distinct low res. anomalies and partly decr. P-wave vel. Twenty-for non-oriented and eight oriented radar reflectors are identified. The oriented refl. occur at 425.9 m (091/46 or 161/38), 430.0 m (160/39 or 090/45), 444.9 m (084/57), 449.0 m (048/89 or 213/75), 449.4 m (084/45 or 163/43), 453.8





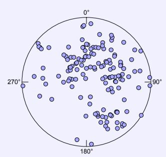
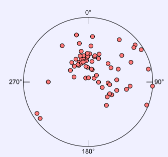
high frequency of sealed fractures and locally faint to weak oxidation below 560 m relative to the upper part of the borehole outside possible deformation zones. Uncertainty = 3.

745.05

745.05

RU3
Amphibolite (102017) with subordinate occurrences of pegmatitic granite (101061). Uncertainty = 3.

785.47

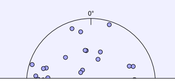
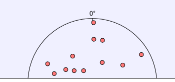



785.47

RU4
Felsic to intermediate metavolcanic rock (103076). Uncertainty = 3.

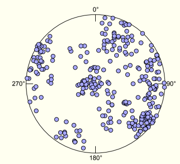
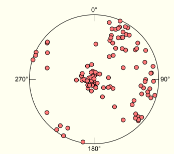
796.30

796.30

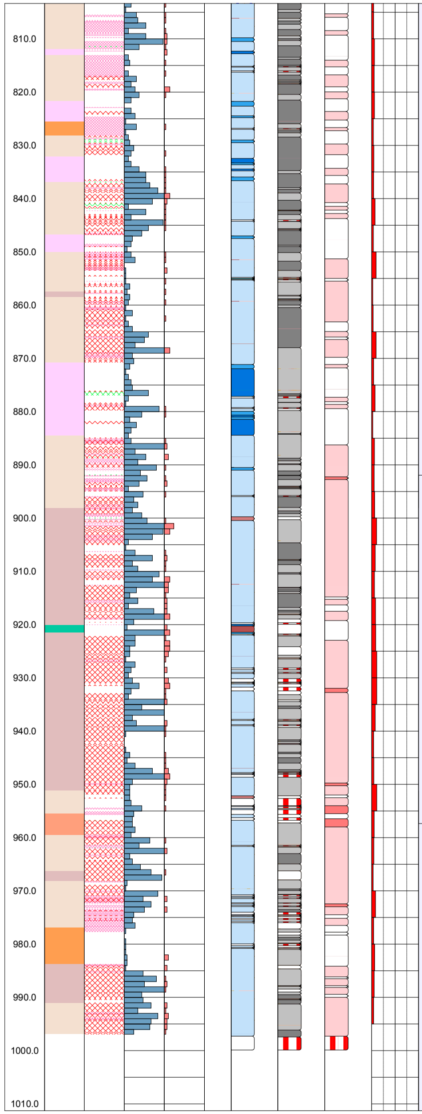
... m (089/48 or 167/41), 460.8 m (094/32) and 480.1 m (144/64 or 077/20). One persistent non-oriented refl. intersects at 477 m with the angle 50 degrees and can be traced at least 50 m away from the borehole. Decr. radar amplitude at 420-435 m, 450-460 m and 470 m. DZ3 consists of aplitic metagranite (101058) generally affected by faint to medium albitization, subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amphibolite (102017). Uncert. = 3.

489.00

502.00

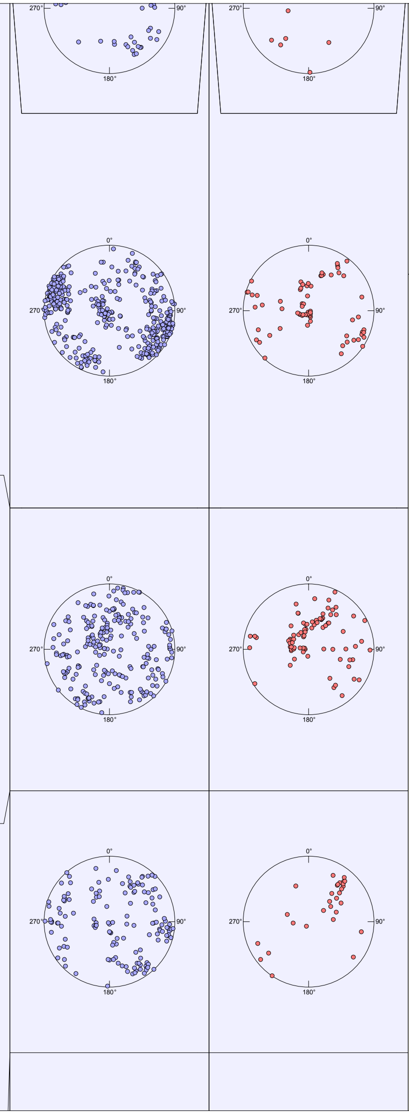
DZ4
Incr. freq. of sealed fract., sealed fract. networks and, in the central part (534-540 m), open fract. and crush zones (3, 3, 5 and 40 cm wide). Fract. apertures are typically less than 1 mm, with some up to 3 mm. Most open/partly open fract. strike ESE and dip moderately to the SSW. However, fract. that strike NNE and are steeply dipping, that strike NW and dip steeply to the NE and that are gently dipping are also present. A similar pattern for the orientation of sealed fract. is apparent. However, the fract. within the diff. orientation sets are more evenly distr. The most freq. fract. filling minerals in the order of decr. abundance incl. calcite, chlorite, adularia and hematite. There is a large number of distinct low res. anomalies along the entire section. The interval c. 531-540 m is charact. by a major decr. in the bulk res., a large decr. in P-wave vel. and several dist. caliper anomalies. Five oriented radar refl. occur at 507.4 m (340/89 or 014/37), 509.8 m (150/56 or 085/29), 533.8 m (171/38 or 097/51), 537.3 m (223/88) and at 540.2 m (090/62). Sixteen non-oriented refl. are identified. One persistent



RU2b
Aplitic metagranite (101058) generally affected by faint to medium albitization, which in part corresponds to decreased natural gamma radiation and slightly increased density. Subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061), medium-grained metagranite-granodiorite (101057) and amphibolite (102017). In addition, a few metre wide interval dominated by calc-silicate rock (108019). Anomalously high frequency of sealed fractures, sealed fracture networks and locally faint to weak oxidation relative to the upper part of the borehole outside possible deformation zones. Uncertainty = 3.
898.13

898.13
RU5
Foliated, fine- to medium-grained metagranite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061) and amphibolite (102017). Anomalously high frequency of sealed fractures, sealed fracture networks and faint to weak oxidation relative to the upper part of the borehole outside possible deformation zones. Partly decreased magnetic susceptibility (<0.001 SI) in the interval c. 919-940 m. Uncertainty = 3.
951.23

951.23
RU6
Aplitic metagranite (101058), generally affected by faint to medium albitization, foliated, fine- to medium-grained metagranite-granodiorite (101057) and pegmatitic granite (101061). Subordinate occurrences of amphibolite (102017). Anomalously high frequency of sealed fractures, sealed fracture networks and faint to weak oxidation relative to the upper part of the borehole



non-oriented refl. inters. at 538 m, can be traced at least 40 m from the borehole. Decr. radar ampl. at the interval 530-540 m. Loc. faint to weak oxid. DZ4 consists of aplitic metagranite (101058) gen. affected by faint to medium albitization, sub. occur. of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amph. (102017). Unc.= 3.
555.00

623.00
DZ5
Increased frequency of sealed fractures, sealed fracture networks and open fractures. Sealed fractures dominate. Fracture apertures are typically less than 1 mm, with two >10 mm. Most fractures fall into four orientation sets. The steeply dipping sets strike NE, WNW and SSE (dip to WSW). The fourth set is gently dipping. The most frequent fracture filling minerals in the order of decreasing abundance include calcite, chlorite, adularia and hematite. There are increased occurrences of low resistivity anomalies, partly a slight decrease in the bulk resistivity and a few minor caliper anomalies. 28 identified radar reflectors, of which 11 are oriented. Five of them are oriented in the interval 203-222/67-81 and two of them 200-230/6-13. Other orientations are 106/74 or 211/27, 354/65 and 059/84. Two persistent radar reflectors intersect the borehole at 644 m and 664 m with intersection angle 56 degrees and orientation 052/69, respectively. They can be traced at least 25 m away from the borehole. Decreased radar amplitude at 620 m, 640 m, 650 m, 665-670 m and 675 m. Locally faint to weak oxidation. DZ5 consists of aplitic metagranite (101058) generally affected by faint to medium albitization,

1020.0 1030.0									outside possible deformation zones. Partly decreased magnetic susceptibility (<0.001 SI) and natural gamma radiation (<20 μR/h) in the interval c. 974-984 m. Uncertainty = 3. 1000.43			subordinate occurrences of fine- to medium-grained metagranitoid (101051), pegmatitic granite (101061) and amphibolite (102017). Uncertainty = 2. 677.00		