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Forsmark site investigation

Boremap mapping of percussion boreholes HFM16-18

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May 2004

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

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Abstract

This report presents the Boremap mapping of three percussion drilled boreholes: HFM16, HFM17 and HFM18. This activity is one of many performed within the site investigation program in Forsmark.

HFM16 was drilled in order to provide the flushing water for drilling the core drilled borehole KFM06A, while HFM17 and HFM18 were drilled in order to check up two lineaments. The percussion drilled boreholes were investigated with several logging methods, for example, conventional geophysical logging, borehole radar and TV-logging. This report includes interpretations of BIPS-images from TV-loggings, supported by geophysical logs. As requested by SKB no investigations of drill cuttings were performed, although this was included in the original activity plan.

In HFM16 a medium grained metagranite-granodiorite dominates (64.5%). This is cut by several thin rock occurrences; several generations of fine- to medium grained granitoid rocks (26.6%), pegmatites and amphibolites. One densely fractured section was observed between 16.8 and 18.0 m. Six thin crushed sections were observed at following borehole depths: 24.27–24.36 m, 35.11–35.20 m, 41.30–41.40 m, 59.05–60.15 m, 69.19–69.52 m and 70.35–70.52 m.

In HFM17 a medium grained metagranite-granodiorite dominates (91.9%), cut by pegmatites, thin fine- to medium grained granitoids and amphibolites. One crushed section was observed at 31.02–31.55 m, but no densely fractured section was observed.

Also in HFM18 a medium grained metagranite-granodiorite dominates (67.6%), cut by pegmatites (10.5%), amphibolites (7.6%) and different generations of fine- to medium grained granitoid rocks (11.5%). Three densely fractured sections occur at 10.0–10.8 m, 140.5–141.7 m and 144.3–146.7 m, while two crushed sections were observed at 37.57–37.79 m and 46.72–46.91 m.

Sammanfattning

I denna rapport presenteras Boremapkartering av tre hammarborrade hål: HFM16, HFM17 och HFM18. Denna aktivitet är en av många som utförs inom ramen för platsundersökningar i Forsmark.

HFM16 borrades för att tillgodose vattenförsörjningen vid kärnborrningen av teleskopborrhålet KFM06A, medan HFM17 och HFM18 borrades för att kontrollera två lineament. De hammarborrade borrhålen undersöktes med flera loggningsmetoder, bl.a. konventionell geofysisk loggning, borrhålsradar och TV-loggning. Denna rapport innefattar tolkningarna av BIPS-bilderna från TV-loggningarna med stöd av geofysikloggar. Enligt önskemål från SKB utfördes ingen kaxkartering även om detta inkluderades i den ursprungliga aktivitetsplanen.

HFM16 domineras av metagranit-granodiorit (64,5 %) som skärs av flera tunna bergartsinslag, främst av olika generationers fint-medelkorniga granitoida bergarter (26,6 %), men också av pegmatiter och amfiboliter. En sprickrik sektion observerades mellan 16,8 och 18,0 m. Sex tunna krossektioner observerades vid följande borrhålsdjup: 24,27–24,36 m, 35,11–35,20 m, 41,30–41,40 m, 59,05–60,15 m, 69,19–69,52 m och 70,35–70,52 m.

HFM17 domineras av metagranit-granodiorit (91,9 %) som skärs av pegmatiter, tunna fint-medelkorniga granitoider och amfiboliter. En krossad sektion observerades vid 31,02–31,55 m, medan inga sprickrika sektioner observerades.

Även HFM18 domineras av metagranit-granodiorit (67,6 %) som skärs av pegmatiter (10,5 %), amfiboliter (7,6%) och olika generationers fint-medelkorniga granitoida bergarter (11,5 %). Tre sprickrika sektioner förekommer på djupen 10,0–10,8 m, 140,5–141,7 m, samt 144,3–146,7 m medan två krossade sektioner observerades på 37,57–37,79 m och 46,72–46,91 m.

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1 Introduction

This document reports the data gained by the Boremap mapping of three percussion boreholes, drilled within the site investigation at Forsmark. The work was carried out in April and May 2004 in accordance with activity plan SKB PF 400-03-102. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

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

Activity plan	Number	Version
Boremapkartering av hammarborrhålen HFM 16–18	AP PF 400-03-102	1.0
Method descriptions	Number	Version
Metodbeskrivning för Boremap-kartering	SKB MD 143.006	1.0

HFM16 is located at drill site 6 (DS 6, Figure 1-1). The purpose was mainly to provide flushing water for the core drilling, but also the occurrence of a gently dipping fracture zone (A2) was investigated. HFM17 is drilled to study the possible gentle dip of a north-easterly oriented lineament (code XFM0062A0/B0) located northwest of the borehole. HFM18 is drilled to study a north-easterly oriented lineament (code XFM0065A0/B0) located north of the borehole, as well as the occurrence of a gently dipping possible fracture zone (A4). The percussion drillholes HFM16–18 will also be used for groundwater level monitoring and to gain hydrogeochemical data.

The percussion drilled boreholes were after completion of drilling investigated with several logging methods, for example, conventional geophysical logging, borehole radar and TV-logging. The latter method implies logging with a colour TV-camera to produce images of the borehole wall, so called BIPS-images (Borehole Image Processing System). The method is described in SKB MD 222.006 Metodbeskrivning för TV-loggning med BIPS (SKB, internal controlling document).

Mapping of percussion boreholes according to the Boremap method is based on the use of BIPS-images of the borehole wall, supported by, for example, the study of drill cuttings, drilling penetration rate and geophysical logs. In this work the mapping was supported with drilling penetration rate and geophysical logs.

The BIPS-images enable the study of the distribution of fractures along the borehole. Fracture characteristics like aperture, colour of fracture minerals etc are possible to study as well. Furthermore, since the BIPS software has the potential of calculating strike and dip of planar structures such as foliations, rock contacts and fractures intersecting the borehole, also the orientation of each planar structure is documented with the Boremap method. Important to keep in mind is that the mappings only represent the thin lines of boreholes that intersect the rock body.

Figure 1-1 *Locations of HFM16–18, Forsmark. DS2 = drill site 2, DS6 = drill site 6.*

2 Objective and scope

The aim of this activity was to document lithologies, ductile structures and the occurrence and character of fractures and fracture zones in the bedrock penetrated by the three percussion drilled boreholes HFM16–18. Data were collected in order to obtain a foundation for a preliminary assessment of the bedrock conditions adjacent to the telescopic drilled borehole KFM06A and to study some lineaments (code XFM0062A0/B0 and XFM0065A0/B0). Other data obtained from the percussion drilled boreholes, such as thickness of soil cover, soil stratigraphy, groundwater level and groundwater flow, will not be treated in this paper.

3 Equipment

3.1 Description of interpretation tools

Mapping of BIPS-images was performed with the software Boremap v. 3.4.2. The Boremap software calculates actual directions (strike and dip) of planar structures penetrated by the borehole (foliations, fractures, fracture zones, rock contacts etc). Data on inclination, bearing and diameter of the borehole are used as in-data for the calculations (Table 4-1). The BIPS-image lengths were calibrated (see Chapter 4.2). The Boremap software is loaded with the bedrock and mineral standard used for surface mapping at the Forsmark investigation site to enable correlation with the surface geology.

Stereographic projections were plotted in StereoNet, while schematic presentations of the boreholes were presented in WellCad.

3.1.1 BIPS-image quality

The BIPS-image quality of HFM16 is excellent.

The BIPS-image of HFM17 is excellent to good. In the end of the borehole a thin layer of mud covers approximately 40% of the borehole wall, but most geological features are still visible through the mud layer.

The BIPS-image of HFM18 is generally good. In HFM18 there are some suspensions in the borehole water that have precipitated on the lower side of the borehole wall. From about 149 m borehole length the precipitated mud is so thick that it covers approximately 50% of the borehole wall. This does slightly disturb the mapping.

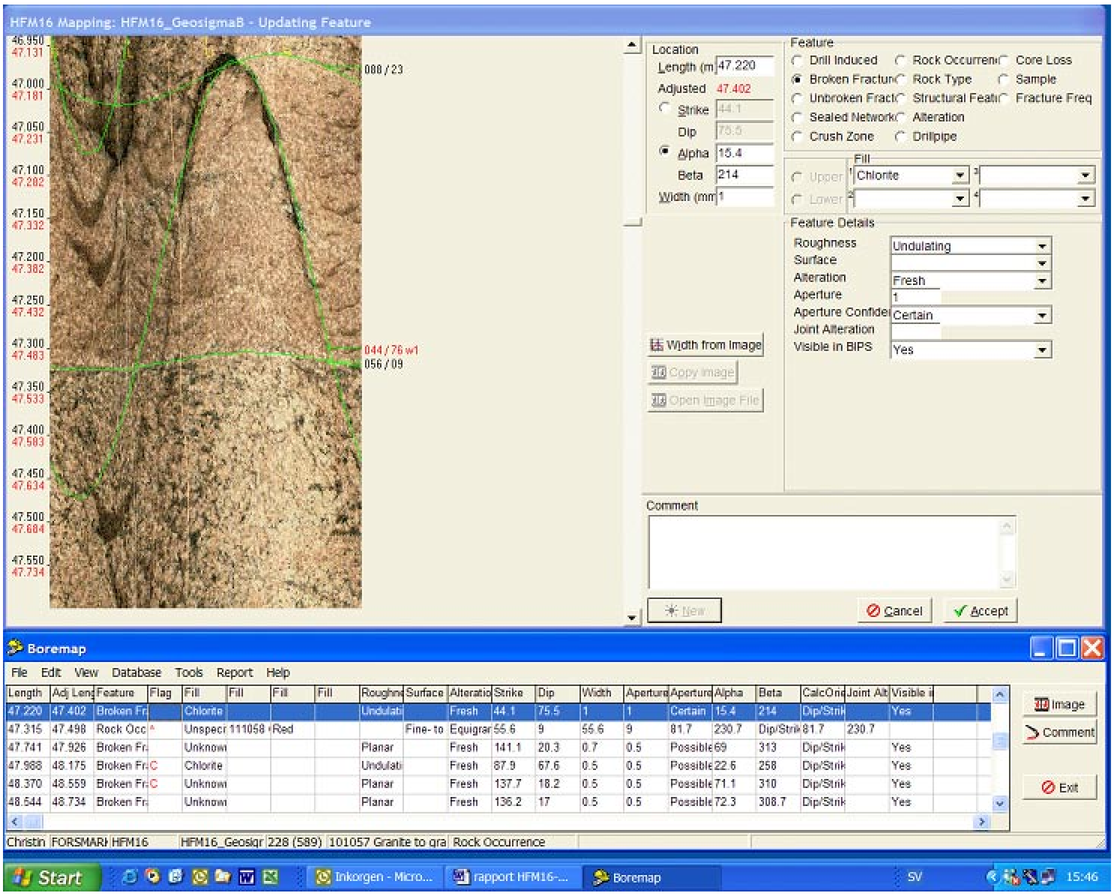

Figure 3-1. Example of interpretation of BIPS-images with the software Boremap v. 3.4.2.

4 Execution

4.1 General

Boremap mapping of the percussion drilled boreholes HFM16–18 was performed and documented according to activity plan AP PF 400-03-102 (SKB, internal document), with the exception that the drill cuttings were not investigated. Instead, geophysical logs of the boreholes were available. The mapping was performed in accordance with the SKB method description for Boremap mapping (SKB MD 143.006, Version 1.0, Metodbeskrivning för Boremap-kartering, SKB, internal controlling document).

4.2 Preparations

The lengths of the boreholes are listed in Table 4-1. Length corrections of the BIPS-images were made for all the boreholes. The BIPS-image of HFM16 was originally 128.88 m long but was corrected to 129.47 m long. The corresponding corrections for HFM17 and HFM18 were 208.23 to 209.21 m and 179.44 m to 180.34 m, respectively. The corrections were made since it is known that the registered length in the BIPS-images in general deviates with approximately 0.5 m per 100 m from the real length, and that the last 30 cm of the boreholes cannot be logged with BIPS.

Background data collected from SICADA prior to the Boremap mapping included:

- borehole diameter (Appendix 8),
- total borehole length (Appendix 8),
- borehole deviation data (Appendix 9),
- drilling penetration rate (Appendix 10).

Geophysical logs from Geovista AB were used as supporting data for the boreholes HFM16–18 (Appendix 11).

Measurements of borehole directions were refined using deviation data from the SKB SICADA database (field note no Forsmark 216, 256, 257). Geometric data for boreholes HFM16–18 are given in Table 4-1.

Table 4-1. Borehole data for HFM16–18 (values from starting point).

ID-code	Northing	Easting	Bearing (degrees)	Inclina-tion (degrees)	Diameter (mm)	Borehole length (m)	BIPS-image interval (adj. length in m)	End of casing	Appr. depth to bedrock surface (m)
HFM16	6699721	1632466	327.9	-84.2	140	132.50	12.0-129.47	12.0	2.6
HFM17	6699462	1633261	318.6	-84.1	137	210.65	8.0-209.21	8.0	0.5
HFM18	6698327	1634037	313.3	-59.4	139	180.65	8.0-180.34	9.0	1.7

4.3 Execution of measurements

Available geological information is more limited for Boremap mapping of percussion drilled boreholes than core drilled boreholes, where the drill core can be directly compared with BIPS-images of the borehole wall. During mapping of percussion boreholes, fractures and rock types can only be seen on the BIPS-images. As solid rock samples are not accessible, certain assumptions and simplifications have to be made during mapping. These are described below.

4.3.1 Fractures

As fractures could be studied only in the BIPS-image they could not be confidently classified as rough, smooth or slickensided, nor could their mineralogy or alteration be reliably determined. Hence, classifications of fracture minerals in the percussion boreholes should be treated with caution. The following assumptions were made:

- Width of very thin fractures (< 1 mm) were impossible to measure accurately and was therefore, as a rule, interpreted as 0.7–1 mm thick or, if only partly or vaguely observed, as 0.5 mm thick.
- Fractures were assumed to be open if not clearly observed to be sealed.
- Dark coloured fractures were interpreted to contain some amount of chlorite (such colouration may, however, also be caused by shadows in the fracture walls or by other dark coloured minerals).
- Bright white (commonly sealed) fracture fillings were interpreted to contain calcite.
- White to slightly greyish fracture material was interpreted as quartz.
- Light green or grey fracture fillings were interpreted as prehnite or epidote.
- The fracture minerals in fractures that were only indicated by shadows were mapped as unknown mineral.
- Fractures with reddish rims were mapped as “oxidized walls”.

4.3.2 Rock colour and oxidation

Rock colours in the BIPS-images appear somewhat modified and bleached, and the classifications of the colours are therefore likely to be less accurate.

The varying exposure of the BIPS-camera as well as suspensions in the borehole water complicates the interpretation of oxidized sections, since sections with higher exposure are less reddish than sections with lower exposure and sections rich in suspensions look more brownish/reddish in BIPS than other sections.

4.3.3 Rock contacts

Orientation of irregular or diffuse rock contacts may be difficult to observe and measure with the Boremap method, since only planar and discrete features can be accurately measured.

4.3.4 Lithologies

Lithological classifications were sometimes difficult, since the boreholes consist mostly of different granitic rocks. From the BIPS-image and the geophysical logs it is not easy to determine whether fine- to medium grained granites are "granite, granodiorite and tonalite, metamorphic, fine- to medium grained" (C-type, code 101051) or "granite, metamorphic, aplitic" (C-type, code 101058). If the granitic occurrence is thin it is not certain that "granite, fine- to medium grained" (D-type, code 111058) is indicated by higher gamma-radiation and then it can be difficult to separate it from the others. Even very thin occurrences of pegmatite (code 101061) can sometimes be difficult to separate from the rock occurrences mentioned earlier. Therefore some misinterpretations must be accounted for.

Some medium-grained white rock occurrences with biotite could not be determined for sure, and were therefore mapped as metagranitoid (code 111051) (HFM18, 168–172 m).

No drill cuttings were used for classification of rocks.

4.3.5 Grain size

Classification of grain size can be difficult, especially for minor rock occurrences of fine- or medium grain size. This is due to the pixel resolution of the BIPS-image and the difficulty to measure the width of grains less than 2 mm. When the rock is composed of minerals of similar colours, the grain size can be overestimated when relying too much on the BIPS-images, since single grains are hard to distinguish.

4.3.6 Foliation and lineation

Foliation and lineation are difficult to separate from each other in the BIPS-image, unless the deformation is strong. Some attempts have been made to separate the two in the Boremap mapping, but usually moderately dipping deformation has been interpreted as lineation, while steeply dipping deformation has been interpreted as foliation. This relation has been observed during regional mapping but the relationship is not definite and therefore some misinterpretations may occur.

The Boremap software does not yet calculate trend and plunge of linear features. Therefore the strike in Boremap for lineations should be recalculated with +90 in order to get the trend of the lineation. The dip in Boremap is equal to the plunge of the lineation.

4.3.7 Supporting data

Schematic presentations of geophysical logs (Appendix 11) were used to support the classifications of rock types. Silica density is good for separating tonalites from granites, while natural gamma radiation is good for recognizing younger granitic occurrences. P-reports of the bedrock mapping in Forsmark /1, 2/ were also helpful when interpreting the lithologies.

Drilling penetration rate was used as supporting data for the geological interpretation (Appendix 10). For example, faster drilling penetration correlates well with crush zones, densely fractured sections and pegmatites, while slower drilling penetration rate correlates with amphibolites.

4.4 Data handling

The Boremap mappings of HFM16–18 were performed on a local computer disk, while a back-up of the Boremap mapping was saved on Geosigma's network before each break exceeding 15 minutes. When the mappings were finished and quality checked by the author and by a computer routine in Boremap, the data was submitted to SKB for exportation to SICADA.

All data are stored in the SKB database SICADA under field note no Forsmark 321.

4.5 Nonconformities

Investigations of drill cuttings were not performed because this was not requested for in the order from SKB, even though it was requested for in the activity plan.

No other nonconformities exist.

5 Results

The Boremap mapping of HFM16–18 are stored in SICADA (field note no Forsmark 321) and it is only these data that shall be used for further interpretation and modelling. The interpreter should be aware of the assumptions mentioned in Chapter 4.

Results from the Boremap mapping are briefly described in Sections 5.1–5.3 below and the graphical presentations of the data are given in Appendices 1–6 (WellCad- and BIPS-images). Equal area stereo diagrams showing fractures are shown in Appendix 7.

5.1 HMF16

Lithologies

The dominant rock type of HFM16 is a medium-grained, lineated, reddish grey to greyish red, metagranite-granodiorite (64.5%). This is cut by several minor rock occurrences of pegmatite (5.7%), amphibolite (3.3%), fine- to medium grained aplitic metagranite (10.8%), fine- to medium grained granite (13.1%) and a fine- to medium grained metagranite, -granodiorite to -tonalite (2.7%).

Fractures

Frequency of interpreted *open fractures* in HFM16 is calculated to c 2.2 open fractures/m from BIPS-images of the borehole (available between 12.0–129.3 m). 44% of the mapped open fractures have very uncertain apertures and were only indicated by shadows or mapped as having a possible aperture of 0.5 mm. One densely fractured interval was observed: 16.8–18.0 m (7.5 fractures/m). The dominating fracture set has an orientation of 005°/15° while the less pronounced fracture sets strikes 235°/80° and 030°/80°. The orientation pattern for one of the two dominating sets of interpreted *sealed fractures* coincides with one of the open fracture sets (030°/80°), the other sealed fracture set has an orientation of 030°/30°. The orientations of fractures are shown in Appendix 7.

Six crushed sections were observed; the first at 24.27–24.36 m having the orientation 220°/25°, the second at 35.11–35.20 m having the orientation 115°/10° and the third at 41.30–41.40 m having the orientation 020°/15°. The fourth crush zone is situated next to a cavity; this cavity is visible between 59.05 m and 59.80 m and the crush is visible between 59.80 m and 60.15 m. It is not known how large the cavity originally was, and how much crushed material has fallen out into the borehole. The orientation of this fourth crushed section is uncertain. The fifth crushed section is situated at 69.19–69.52 m having an uncertain strike though a dip between 20–30°, while the sixth crushed section is observed at 70.35–70.52 m striking 000°/25°.

5.2 HMF17

Lithologies

The dominant rock type of HFM17 is the same medium-grained, lineated, light pinkish grey to greyish red, metagranite-granodiorite (91.9%) as in HFM16. This is cut by several minor rock occurrences of pegmatite (4.4%), amphibolite (0.7%), fine- to medium grained aplitic metagranite (0.8%), fine- to medium grained granite (0.5%) and a fine- to medium-grained metagranite, -granodiorite to –tonalite (1.7%).

Fractures

Frequency of interpreted *open fractures* in HFM17 has been calculated to c 1.0 open fractures/m from BIPS images of the borehole (available between 8.0–210.6 m). 25% of the mapped open fractures have very uncertain apertures and were only indicated by shadows or mapped as having a possible aperture of 0.5 mm. No densely fractured intervals were observed. Five sets of open fractures were observed. The two dominating orientations are 230°/80° and 130°/30°. Less pronounced sets of open fractures are orientated 190°/85°, 350°/35° and 295°/75°. The dominating sets of interpreted *sealed fractures* have the orientations, in order of abundance, 225°/80°, 210°/10°, 175°/80° and 285°/75°. Less pronounced sets of sealed fractures are orientated 130°/50° and 120°/30°. Fracture orientations are shown in Appendix 7.

One crushed section was observed at 31.02–31.55 m with the orientation ~220°/05°.

The conclusion of the mapping is that the borehole has probably not reached the lineament it was supposed to intersect.

5.3 HMF18

Lithologies

The dominant rock type of HFM18 is a medium-grained, lineated, light pinkish grey to reddish grey, metagranite-granodiorite (67.6%). This is cut by several minor rock occurrences of pegmatite (10.5%), amphibolite (7.6%), fine- to medium grained aplitic metagranite (4.4%), fine- to medium grained granite (4.5%), metatonalite to –granodiorite (2.8%) and a fine- to medium grained metagranite, - granodiorite to -tonalite (2.6%). Less than 0.1% of the borehole consists of a possible metagranitoid.

Fractures

Frequency of interpreted *open fractures* in HFM18 has been calculated to about 2.1 open fractures/m. 36% of the mapped open fractures have very uncertain apertures and were only indicated by shadows or mapped as having a possible aperture of 0.5 mm. Three densely fractured intervals were observed: 10.0–10.8 m (17.6 fractures/m), 140.5–141.7 m (10 fractures/m) and 144.3–146.7 m (8.9 fractures/m). In the last densely fractured interval downward directed red coloured outflow from the fractures can be observed, although most fracture apertures are too thin to be visible in the BIPS-image (see Figure 5-1). Two dominating fracture sets were observed having the orientations 030°/90° and 050°/20°. The mapped *sealed fractures* show the following preferred orientations: 175°/80°, 030°/90°, 035°/20° and 030°/50°. The orientations of fractures are shown in Appendix 7.

Two crushed sections were observed: one at 37.57–37.79 m having the orientation 025°/10° and one at 46.72–46.91 m having the orientation 040°/20°.

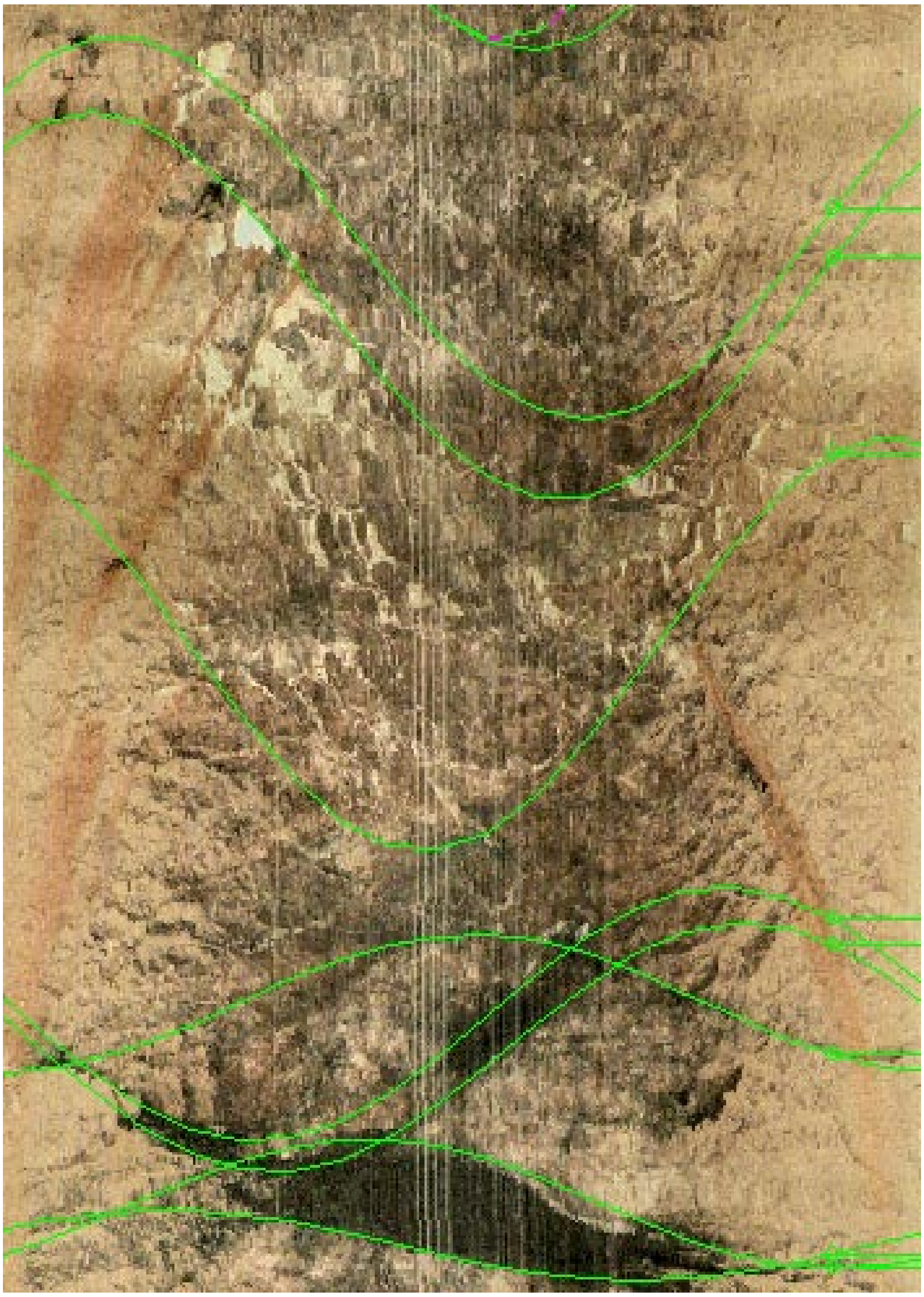

Figure 5-1. *Downward directed outflow from fractures in HFM18, ca 146 m borehole length.*

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/1/ Stephens M B, Lundqvist S, Bergman T, Andersson J, Ekström M, 2003. 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. SKB P-03-75. Svensk Kärnbränslehantering AB.

/2/ Stephens M B, Bergman T, Andersson J, Hermansson T, Petersson J. Zetterström E L, Nordman C, Albrecht L, Ekström M, 2004. Forsmark site investigation. Bedrock mapping – Stage 2 (2003) – Bedrock data from outcrops and the basal parts of trenches and shallow boreholes through the Quaternary cover. SKB P-04-91. Svensk Kärnbränslehantering AB.

Appendix 1

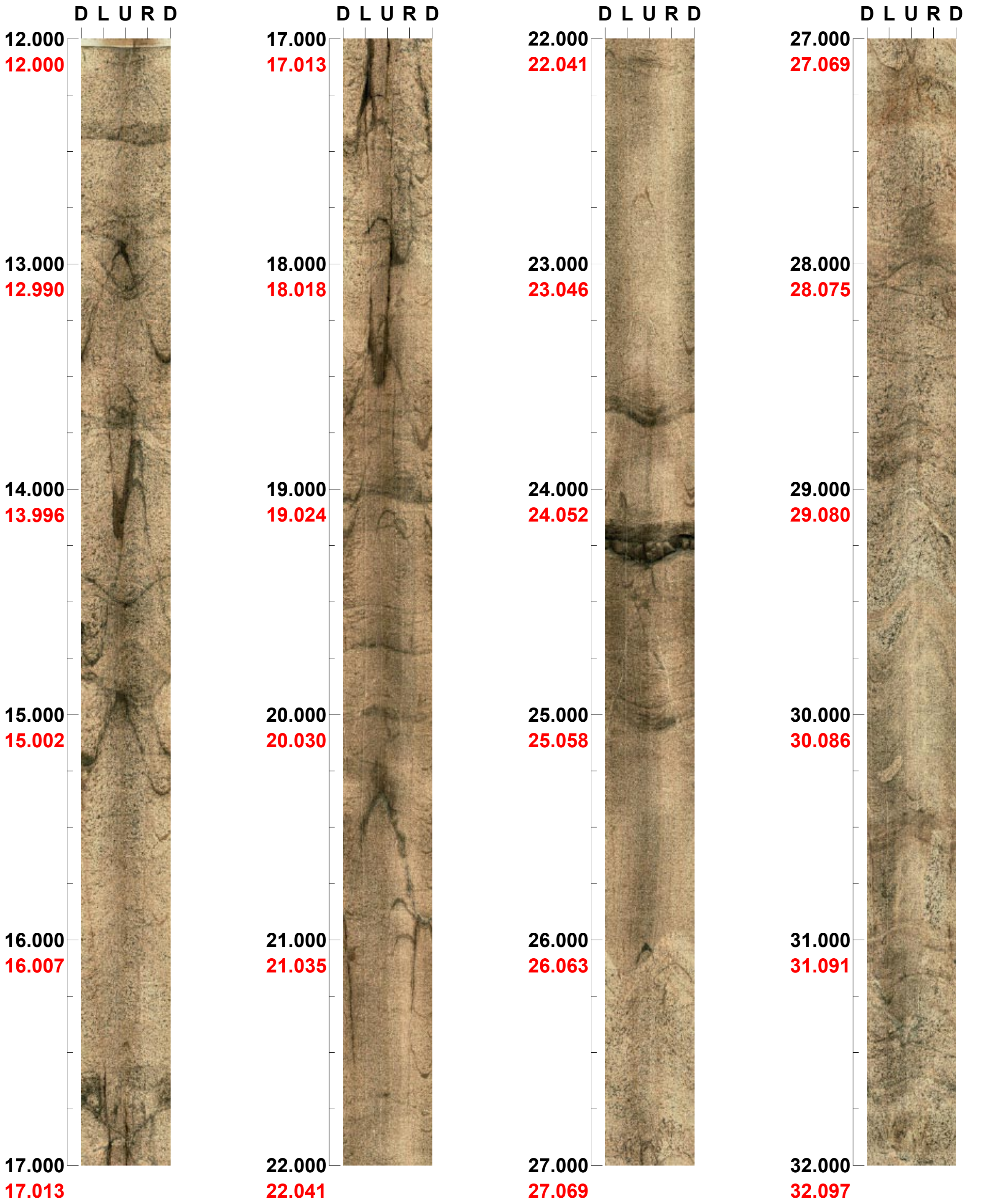
BIPS-images of HFM16

Project name: Forsmark

Image file	: c:\304224~1\hfm16.bip
BDT file	: c:\304224~1\hfm16.bdt
Locality	: FORSMARK
Bore hole number	: HFM16
Date	: 03/12/04
Time	: 10:50:00
Depth range	: 12.000 - 128.879 m
Azimuth	: 325
Inclination	: -85
Diameter	: 140.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 90 %
Pages	: 6
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: HFM16 **Azimuth: 325** **Inclination: -85**

Depth range: 12.000 - 32.000 m



(1 / 6) **Scale: 1/25** **Aspect ratio: 90 %**

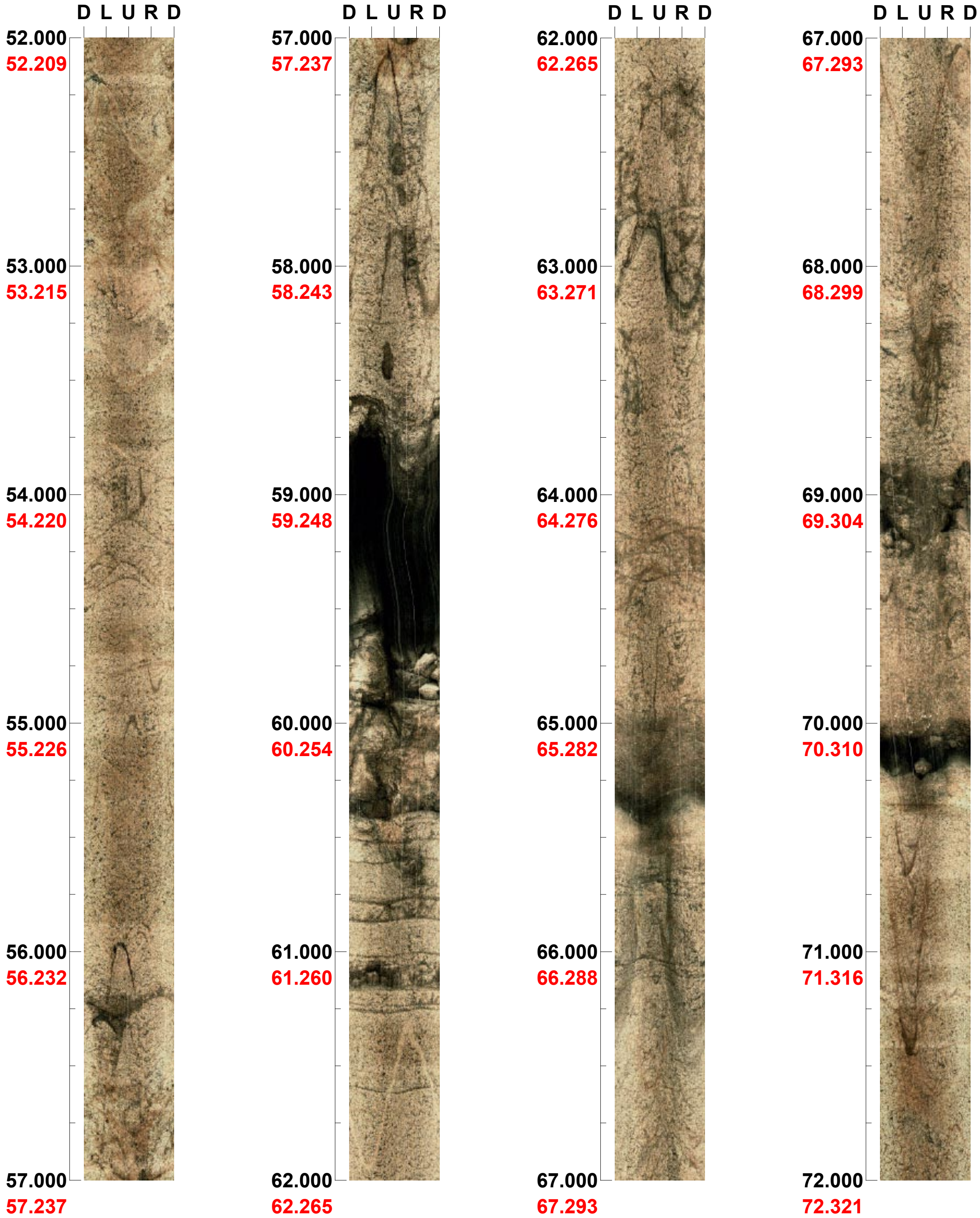
Project name: Forsmark
Bore hole No.: HFM16 **Azimuth: 311** **Inclination: -86**

Depth range: 32.000 - 52.000 m

(2 / 6) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM16 **Azimuth: 175** **Inclination: -88**

Depth range: 52.000 - 72.000 m



(3 / 6) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM16 Azimuth: 151 Inclination: -87

Depth range: 72.000 - 92.000 m

(4 / 6) Scale: 1/25 Aspect ratio: 90 %

Project name: Forsmark
Bore hole No.: HFM16 **Azimuth: 136** **Inclination: -85**

Depth range: 92.000 - 112.000 m

(5 / 6) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark

Bore hole No.: HFM16 **Azimuth: 131** **Inclination: -80**

Depth range: 112.000 - 128.879 m

(6 / 6) **Scale: 1/25** **Aspect ratio: 90 %**

Appendix 2

BIPS-images of HFM17

Project name: Forsmark

Image file	: c:\304224~1\hfm17.bip
BDT file	: c:\304224~1\hfm17.bdt
Locality	: FORSMARK
Bore hole number	: HFM17
Date	: 04/03/10
Time	: 16:43:00
Depth range	: 7.000 - 208.225 m
Azimuth	: 316
Inclination	: -85
Diameter	: 137.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 90 %
Pages	: 11
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: HFM17 **Azimuth: 316** **Inclination: -85**

Depth range: 7.000 - 27.000 m

D L U R D

7.000
7.000

8.000
8.000
9.000
9.005
10.000
10.010
11.000
11.016
12.000
12.021

D L U R D

12.000
12.021

13.000
13.026
14.000
14.031
15.000
15.036
16.000
16.042
17.000
17.047

D L U R D

17.000
17.047

18.000
18.052
19.000
19.057
20.000
20.062
21.000
21.068
22.000
22.073

D L U R D

22.000
22.073

23.000
23.078
24.000
24.083
25.000
25.088
26.000
26.094
27.000
27.099

(1 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark

Bore hole No.: HFM17 **Azimuth: 324** **Inclination: -85**

Depth range: 27.000 - 47.000 m

(2 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM17 **Azimuth: 333** **Inclination: -85**

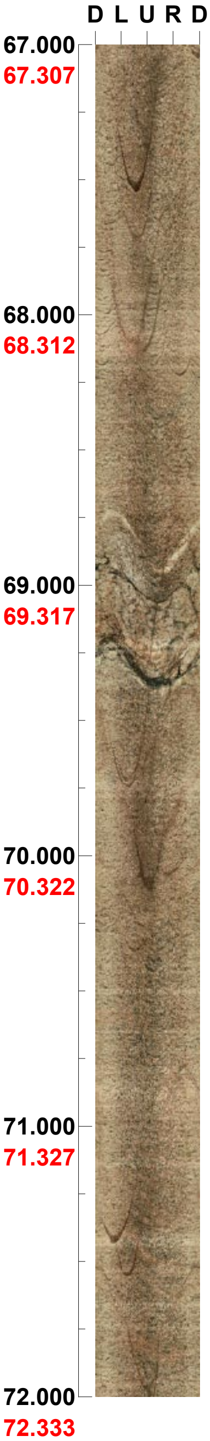
Depth range: 47.000 - 67.000 m

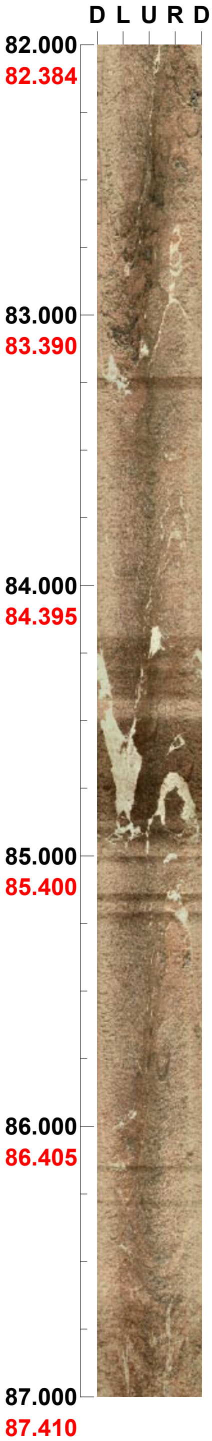
(3 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark

Bore hole No.: HFM17 **Azimuth: 10** **Inclination: -84**

Depth range: 67.000 - 87.000 m

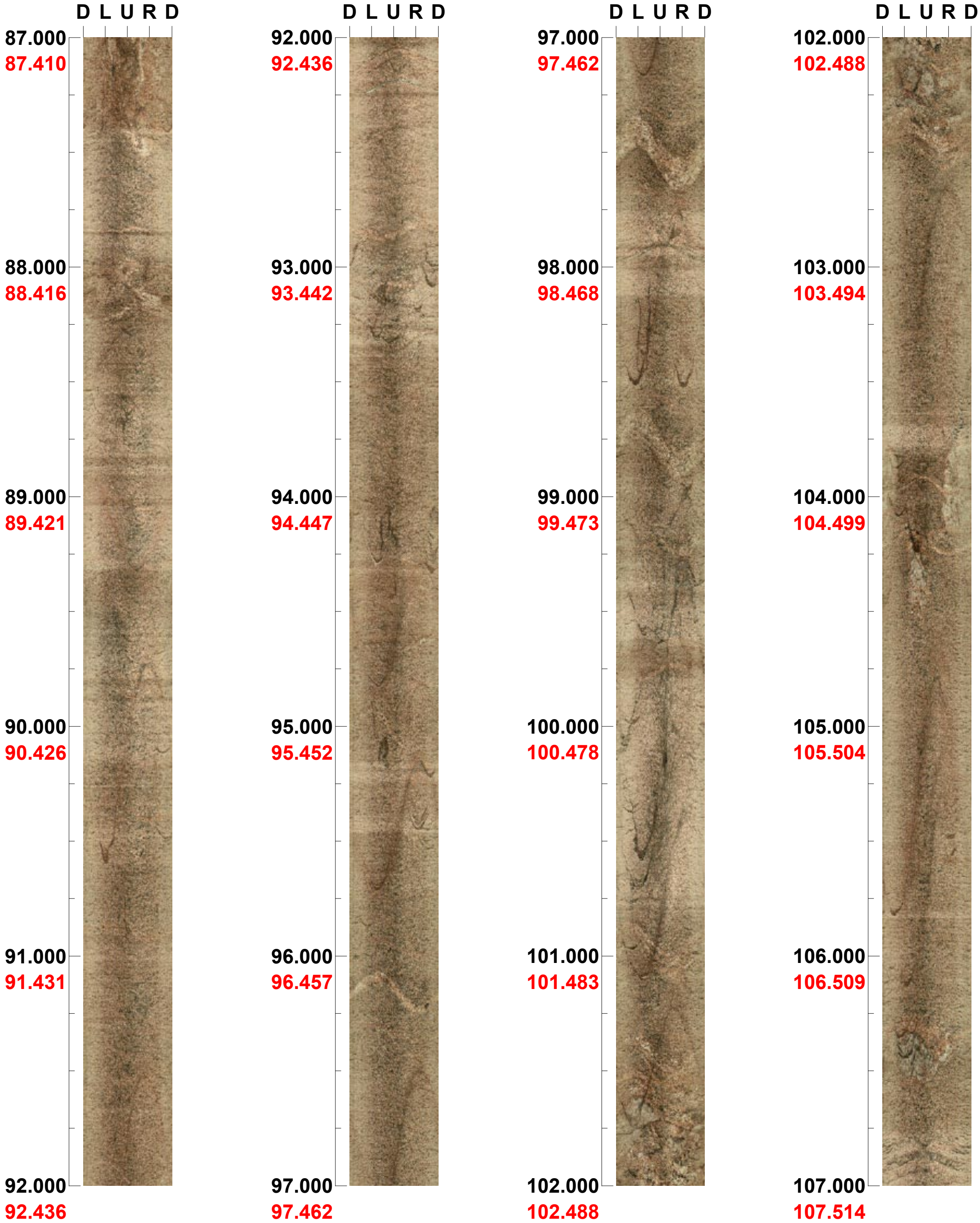




(4 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM17 **Azimuth: 34** **Inclination: -82**

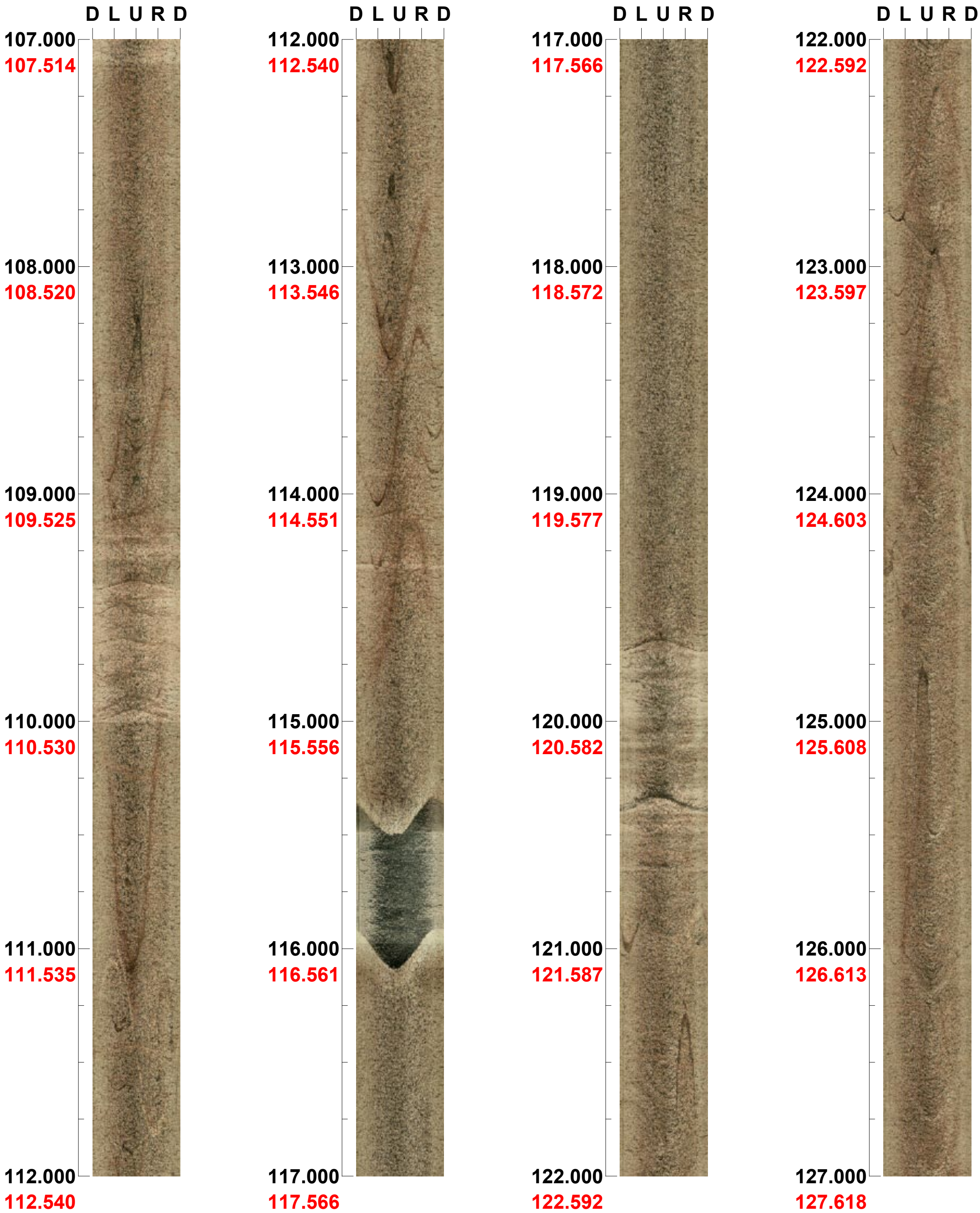
Depth range: 87.000 - 107.000 m



(5 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM17 **Azimuth: 42** **Inclination: -81**

Depth range: 107.000 - 127.000 m



(6 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM17 Azimuth: 49 Inclination: -79

Depth range: 127.000 - 147.000 m

D L U R D

127.000
127.618
128.000
128.623
129.000
129.629
130.000
130.634
131.000
131.639
132.000
132.644

D L U R D

132.000
132.644
133.000
133.649
134.000
134.655
135.000
135.660
136.000
136.665
137.000
137.670

D L U R D

137.000
137.670
138.000
138.675
139.000
139.681
140.000
140.686
141.000
141.691
142.000
142.696

D L U R D

142.000
142.696
143.000
143.701
144.000
144.707
145.000
145.712
146.000
146.717
147.000
147.722

(7 / 11) Scale: 1/25 Aspect ratio: 90 %

Project name: Forsmark

Bore hole No.: HFM17 **Azimuth: 55** **Inclination: -78**

Depth range: 147.000 - 167.000 m

(8 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM17 Azimuth: 57 Inclination: -77

Depth range: 167.000 - 187.000 m

(9 / 11) Scale: 1/25 Aspect ratio: 90 %

Project name: Forsmark

Bore hole No.: HFM17 **Azimuth: 61** **Inclination: -77**

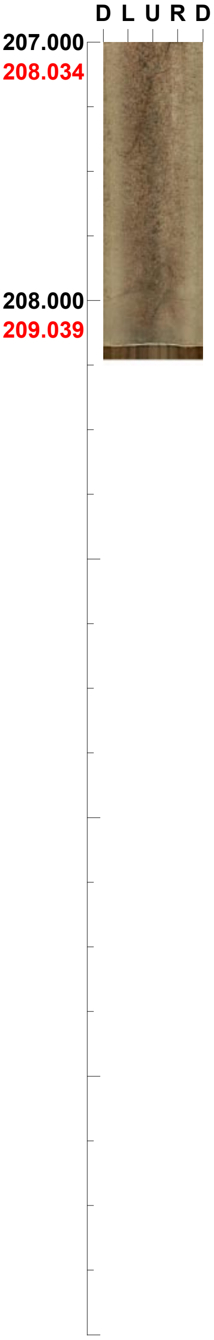
Depth range: 187.000 - 207.000 m

(10 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark

Bore hole No.: HFM17 **Azimuth: 63** **Inclination: -76**

Depth range: 207.000 - 208.225 m



(11 / 11) **Scale: 1/25** **Aspect ratio: 90 %**

BIPS-images of HFM18

Project name: Forsmark

Image file	: c:\304224~1\hfm18.bip
BDT file	: c:\304224~1\hfm18.bdt
Locality	: FORSMARK
Bore hole number	: HFM18
Date	: 04/01/15
Time	: 09:07:00
Depth range	: 8.000 - 179.441 m
Azimuth	: 315
Inclination	: -58
Diameter	: 139.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 90 %
Pages	: 9
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: HFM18 **Azimuth: 315** **Inclination: -58**

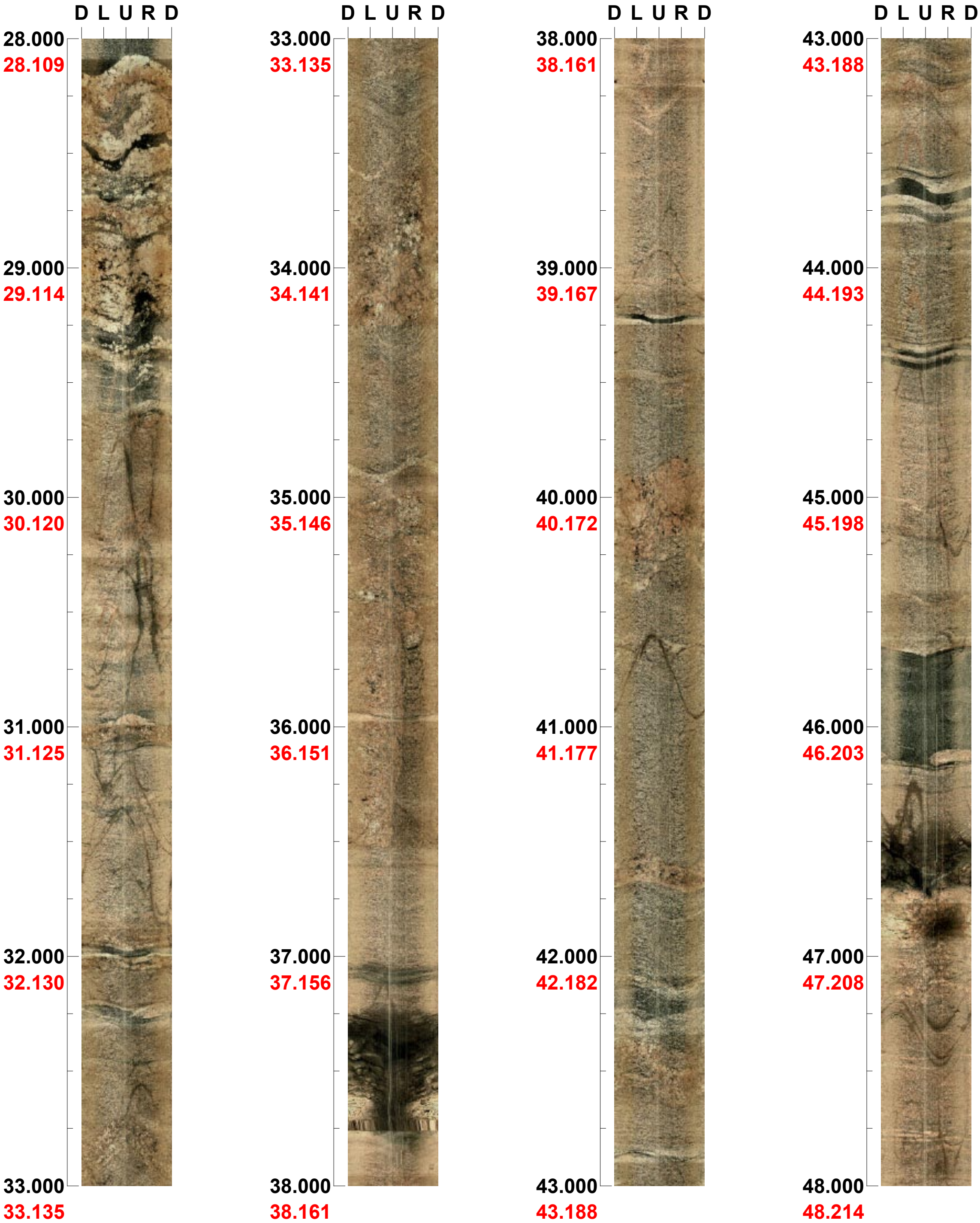
Depth range: 8.000 - 28.000 m

(1 / 9) Scale: 1/25 Aspect ratio: 90 %

Project name: Forsmark

Bore hole No.: HFM18 **Azimuth: 310** **Inclination: -57**

Depth range: 28.000 - 48.000 m



(2 / 9) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM18 **Azimuth: 307** **Inclination: -57**

Depth range: 48.000 - 68.000 m

(3 / 9) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM18 Azimuth: 306 Inclination: -56

Depth range: 68.000 - 88.000 m

(4 / 9) Scale: 1/25 Aspect ratio: 90 %

Project name: Forsmark
Bore hole No.: HFM18 **Azimuth: 304** **Inclination: -55**

Depth range: 88.000 - 108.000 m

(5 / 9) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM18 Azimuth: 305 Inclination: -54

Depth range: 108.000 - 128.000 m

(6 / 9) Scale: 1/25 Aspect ratio: 90 %

Project name: Forsmark
Bore hole No.: HFM18 **Azimuth: 305** **Inclination: -54**

Depth range: 128.000 - 148.000 m

(7 / 9) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark

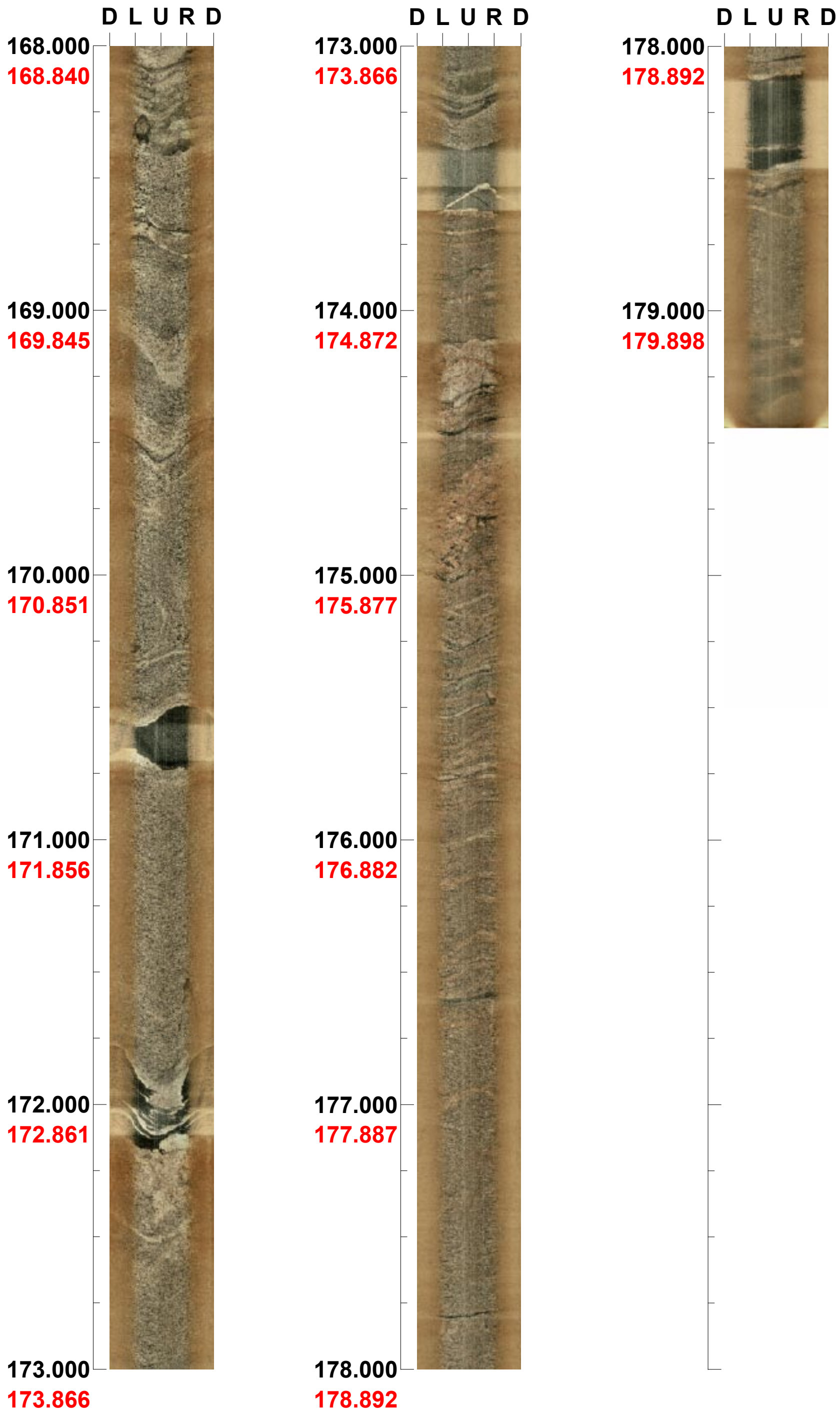
Bore hole No.: HFM18 **Azimuth: 305** **Inclination: -52**

Depth range: 148.000 - 168.000 m

(8 / 9) **Scale: 1/25** **Aspect ratio: 90 %**

Project name: Forsmark
Bore hole No.: HFM18 **Azimuth: 303** **Inclination: -50**

Depth range: 168.000 - 179.441 m



(9 / 9) **Scale: 1/25** **Aspect ratio: 90 %**

Appendix 4

WellCad diagram of HFM16

Title Geological legend for the percussion drilled borehole HFM16 at Forsmark

Site	FORSMARK
Borehole	HFM16
Plot Date	2004-06-20 21:01:56

ROCKTYPE FORSMARK

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

ROCK ALTERATION

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

MINERAL

- Epidote
- Calcite
- Chlorite
- Quartz
- Unknown
- Prehnite
- Oxidized Walls

STRUCTURE

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

TEXTURE

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

GRAINSIZE

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

STRUCTURE ORIENTATION

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

INTENSITY

- No intensity
- Faint
- Weak
- Medium
- Strong

ROUGHNESS

- Planar
- Undulating
- Stepped
- Irregular

SURFACE

- Rough
- Smooth
- Slickensided

CRUSH ALTERATION

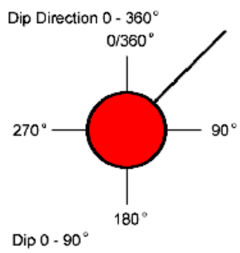
- Slightly Altered
- Moderately Altered
- Highly Altered
- Completley Altered
- Gouge
- Fresh

FRACTURE ALTERATION

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

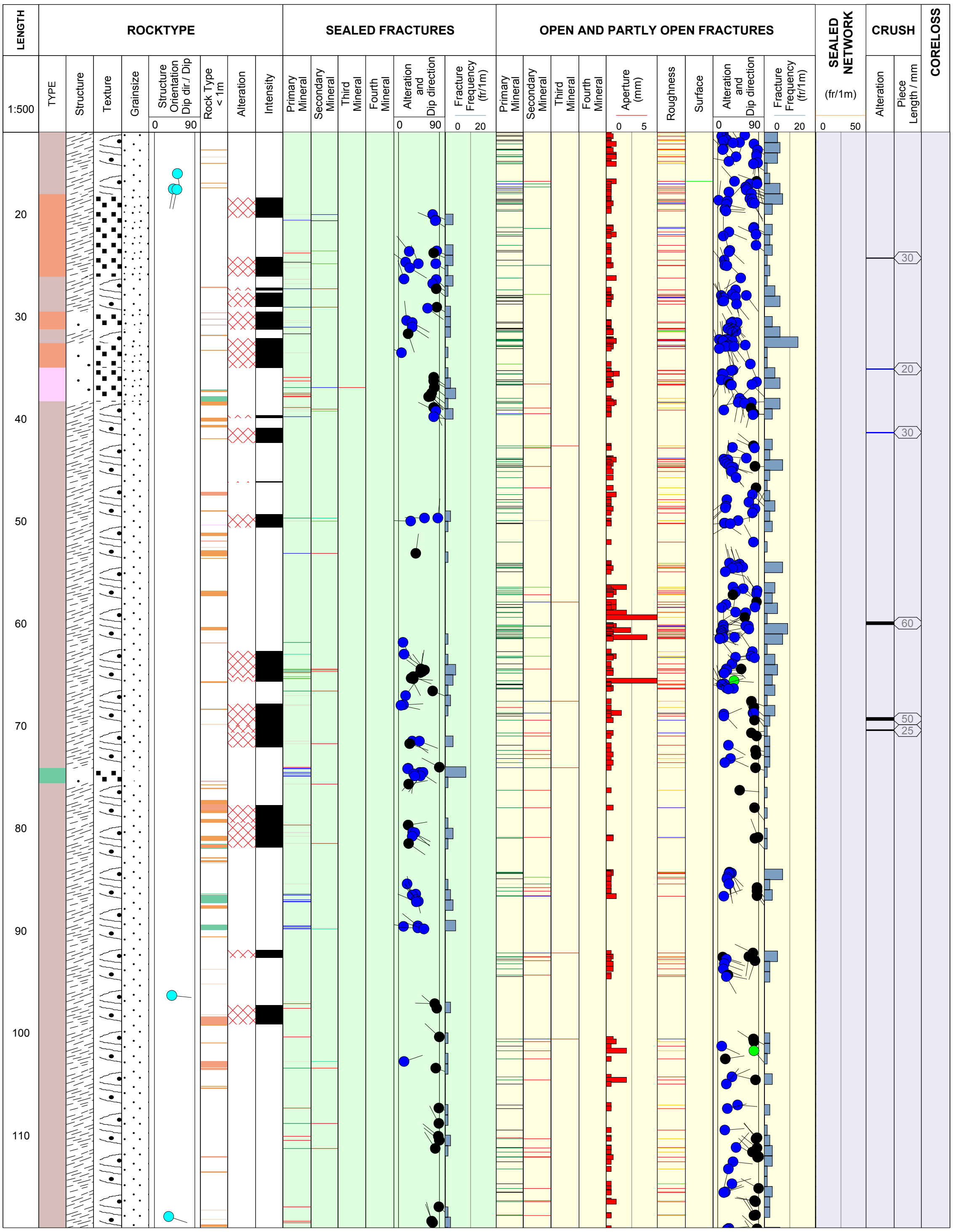
FRACTURE DIRECTION

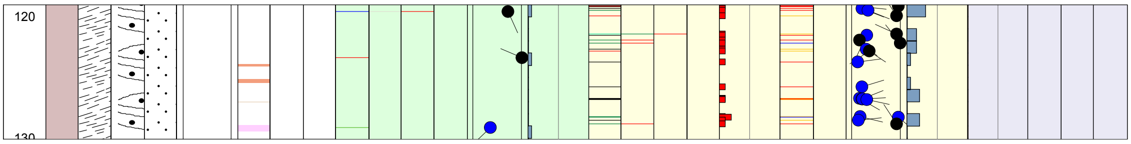
STRUKTURE ORIENTATION



Title **Geological mapping of the percussion drilled borehole HFM16 at Forsmark**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM16	**Northing [m]**	6699721.10
Diameter [mm]	139	**Easting [m]**	1632466.18
Length [m]	132.500	**Elevation [m.a.s.l.]**	3.21
Bearing [°]	327.96	**Drilling Start Date**	2003-11-04 07:00:00
Inclination [°]	-84.21	**Drilling Stop Date**	2003-11-11 16:00:00
Date of mapping	2004-06-14 13:55:00	**Plot Date**	2004-06-20 21:01:56
Rocktype data from	p_rock_XXXXX	**Fracture data from**	p_fract_core




120
130

Appendix 5

WellCad diagram of HFM17

Title	Geological legend for the percussion drilled borehole HFM17 at Forsmark
Site	FORSMARK
Borehole	HFM17
Plot Date	2004-06-20 21:01:56

ROCKTYPE FORSMARK

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

ROCK ALTERATION

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

MINERAL

- Epidote
- Calcite
- Chlorite
- Quartz
- Unknown
- Oxidized Walls

STRUCTURE

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

TEXTURE

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

GRAINSIZE

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

STRUCTURE ORIENTATION

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

INTENSITY

- No intensity
- Faint
- Weak
- Medium
- Strong

ROUGHNESS

- Planar
- Undulating
- Stepped
- Irregular

SURFACE

- Rough
- Smooth
- Slickensided

CRUSH ALTERATION

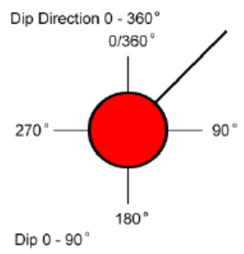
- Slightly Altered
- Moderately Altered
- Highly Altered
- Completley Altered
- Gouge
- Fresh

FRACTURE ALTERATION

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

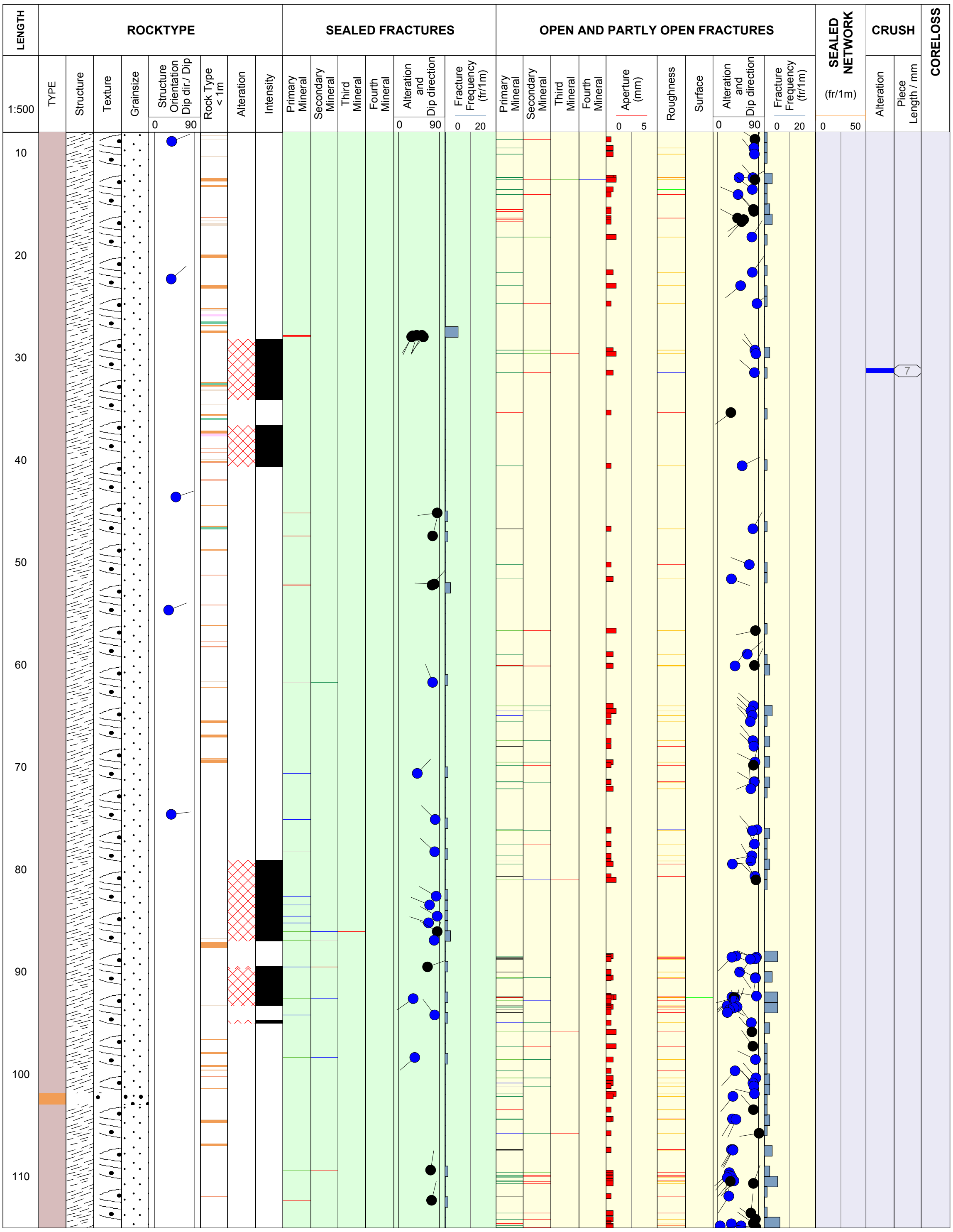
FRACTURE DIRECTION

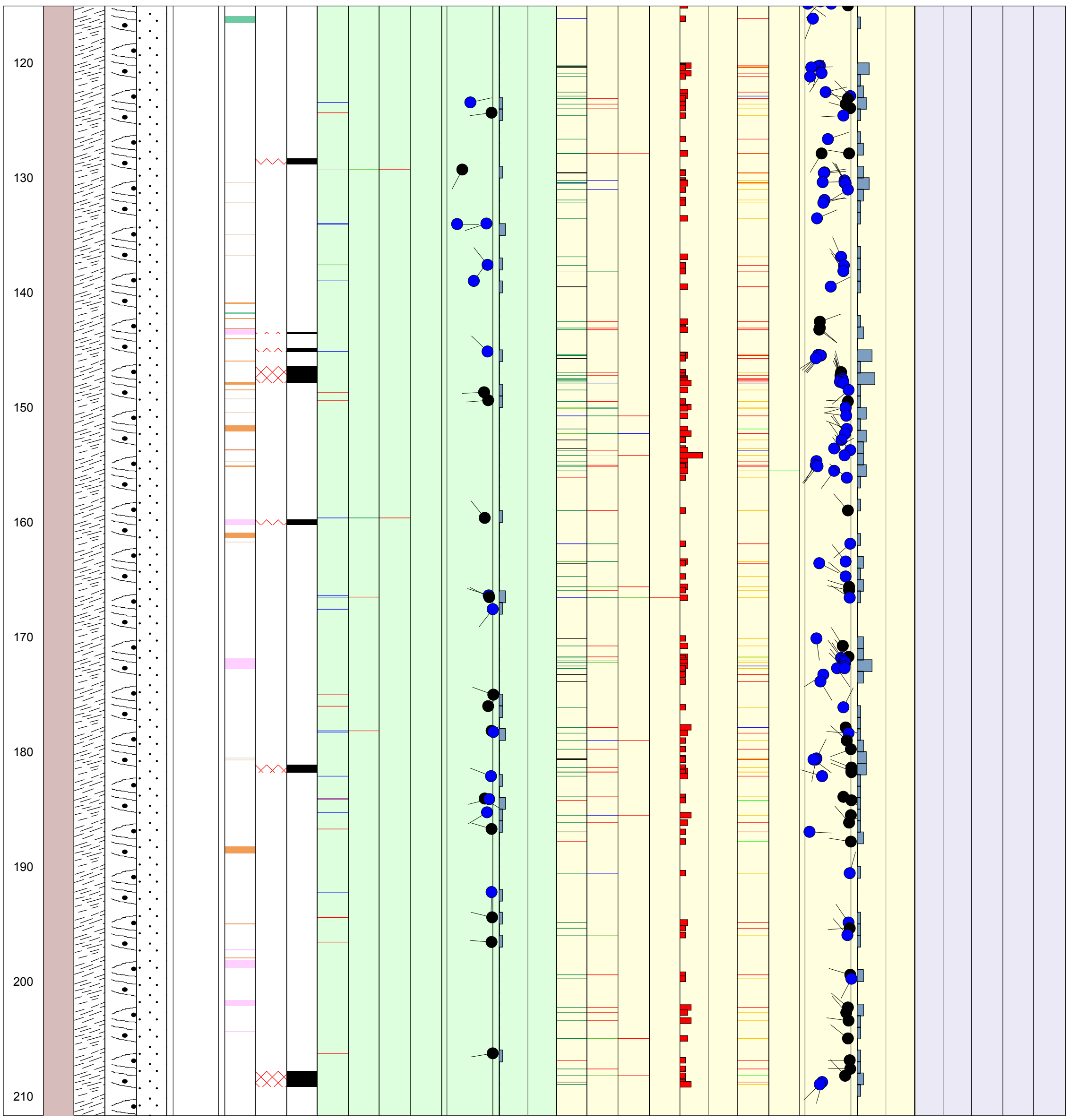
STRUKTURE ORIENTATION



Title Geological mapping of the percussion drilled borehole HFM17 at Forsmark

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM17	**Northing [m]**	6699461.95
Diameter [mm]	136	**Easting [m]**	1633261.31
Length [m]	210.650	**Elevation [m.a.s.l.]**	3.75
Bearing [°]	318.58	**Drilling Start Date**	2003-12-01 14:30:00
Inclination [°]	-84.18	**Drilling Stop Date**	2003-12-08 19:00:00
Date of mapping	2004-06-14 13:59:00	**Plot Date**	2004-06-20 21:01:56
Rocktype data from	p_rock_XXXXX	**Fracture data from**	p_fract_core





120
130
140
150
160
170
180
190
200
210

Appendix 6

WellCad diagram of HFM18

Title	Geological legend for the percussion drilled borehole HFM18 at Forsmark
Site	FORSMARK
Borehole	HFM18
Plot Date	2004-06-20 21:01:56

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

ROCK ALTERATION
- Oxidized
- Chloritisized
- Epidotisized
- Weathered
- Tectonized
- Sericitisized
- Quartz dissolution
- Silicification
- Argillization
- Albitization
- Carbonatization
- Saussuritization
- Steatitization
- Uralitization

MINERAL
- Calcite
- Chlorite
- Quartz
- Unknown
- Prehnite
- Oxidized Walls

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

TEXTURE
- Hornfelsed
- Porphyritic
- Ophitic
- Equigranular
- Augen-Bearing
- Non_equigranular
- Metamorphic

GRAINSIZE
- Aphanitic
- Fine grained
- Fine to Medium Grained
- Medium coarse
- Coarse grained
- Medium grained

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

INTENSITY
- No intensity
- Faint
- Weak
- Medium
- Strong

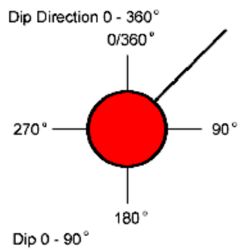
ROUGHNESS
- Planar
- Undulating
- Stepped
- Irregular

SURFACE
- Rough
- Smooth
- Slickensided

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

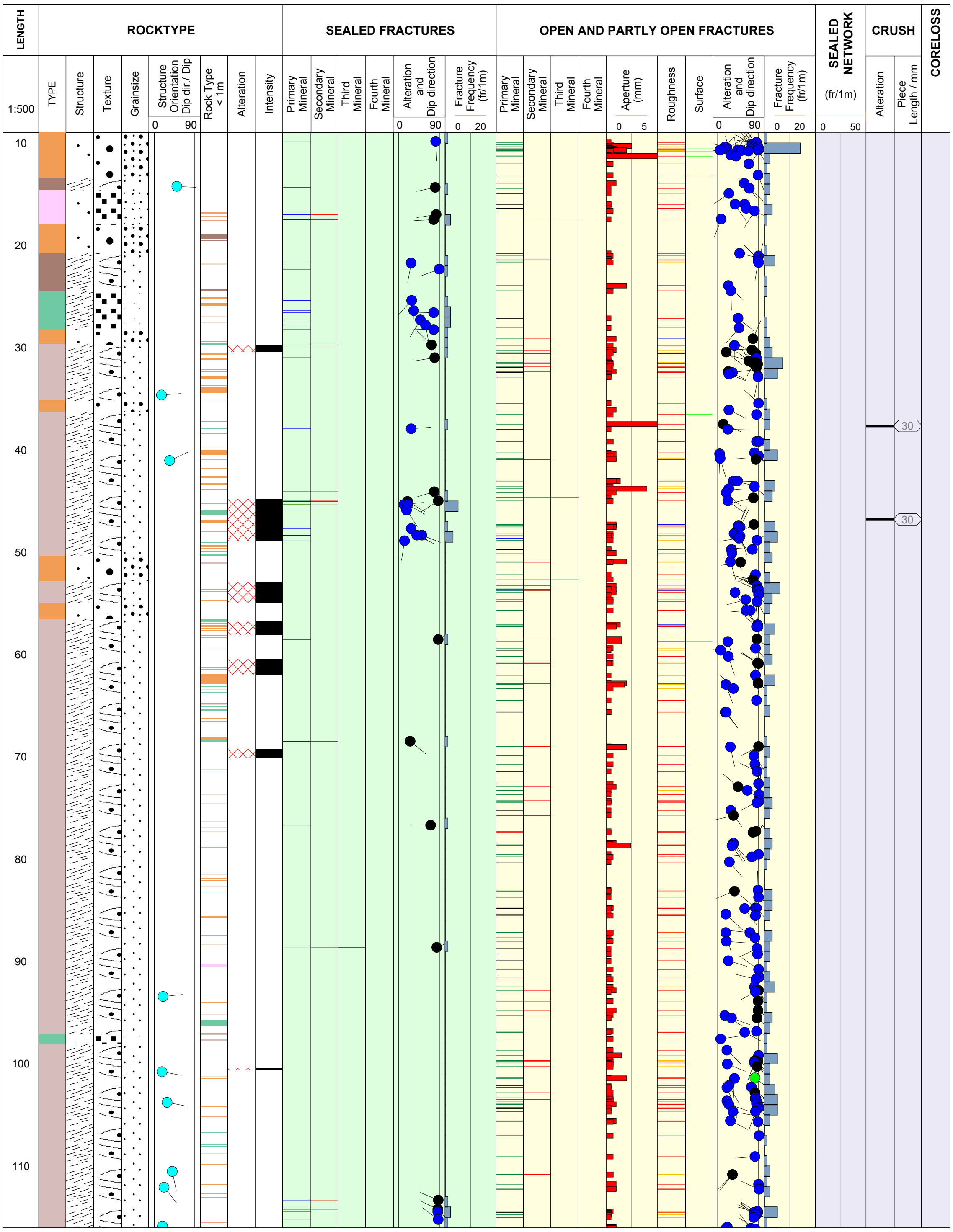
FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered
- Highly Altered
- Completely Altered
- Gouge
- Fresh

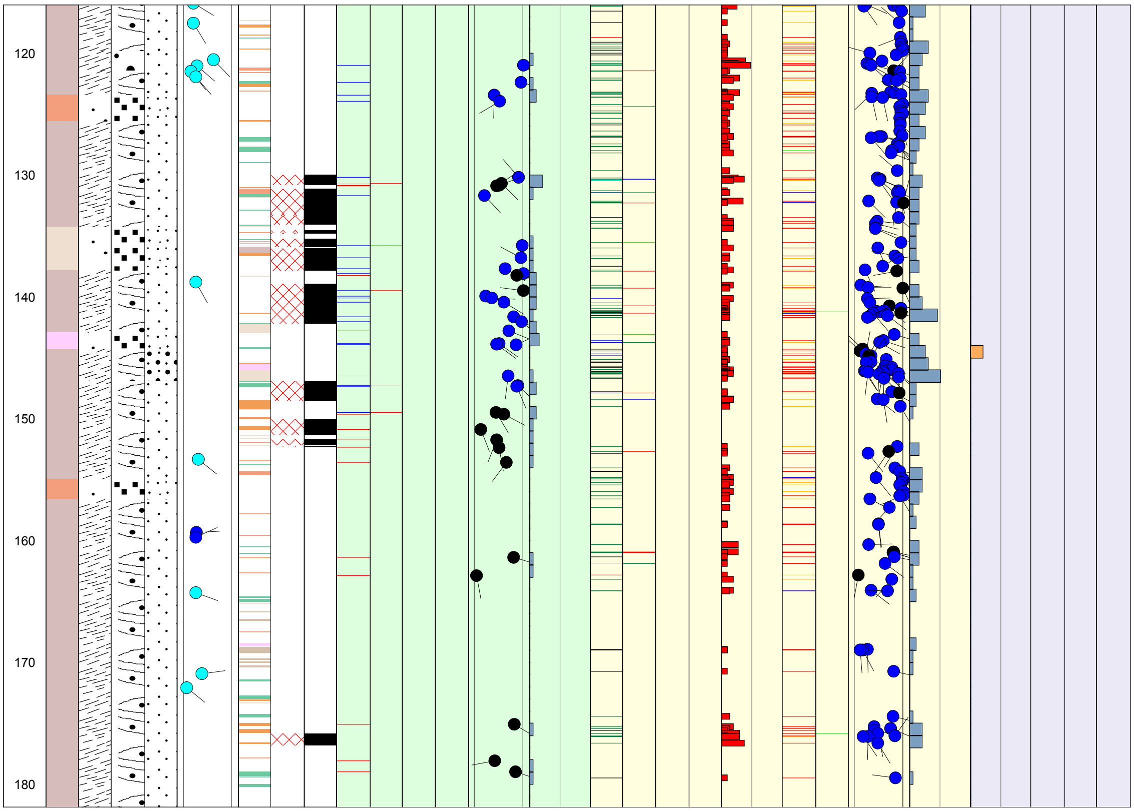
FRACTURE DIRECTION
STRUKTURE ORIENTATION



Title **Geological mapping of the percussion drilled borehole HFM18 at Forsmark**

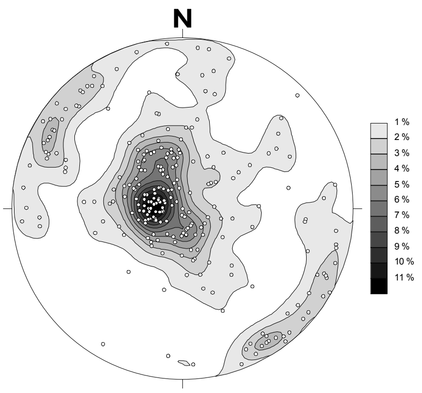
Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM18	**Northing [m]**	6698326.86
Diameter [mm]	138	**Easting [m]**	1634037.37
Length [m]	180.650	**Elevation [m.a.s.l.]**	5.04
Bearing [°]	313.30	**Drilling Start Date**	2003-12-10 12:30:00
Inclination [°]	-59.35	**Drilling Stop Date**	2003-12-16 20:00:00
Date of mapping	2004-06-14 13:57:00	**Plot Date**	2004-06-20 21:01:56
Rocktype data from	p_rock_XXXXX	**Fracture data from**	p_fract_core



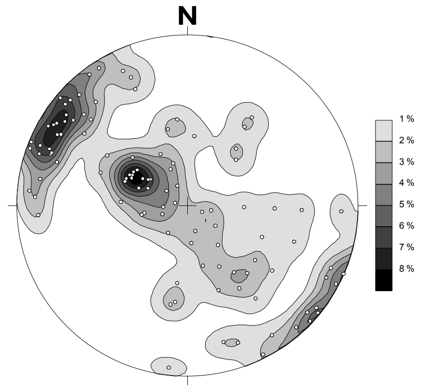

120
130
140
150
160
170
180

Appendix 7

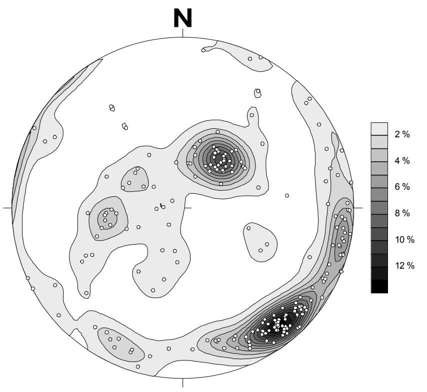
Stereographic projections showing fractures, HFM16–18



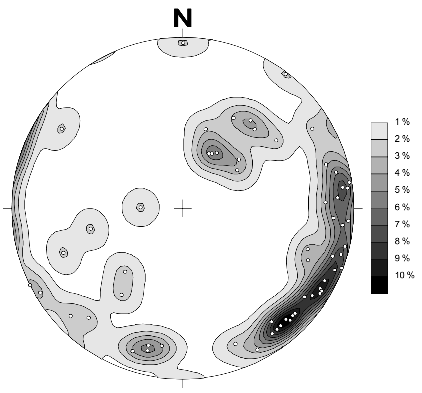
HFM16 - Contoured pole to plane diagram showing *open fractures* (N = 257)



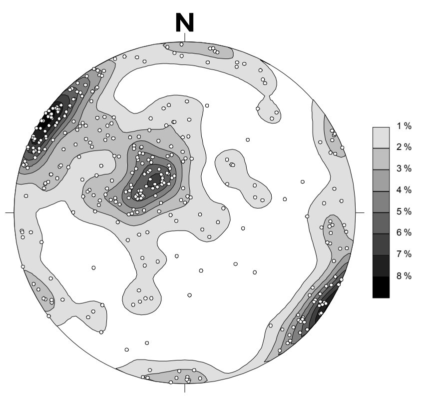
HFM16 - Contoured pole to plane diagram showing *sealed fractures* (N = 106)



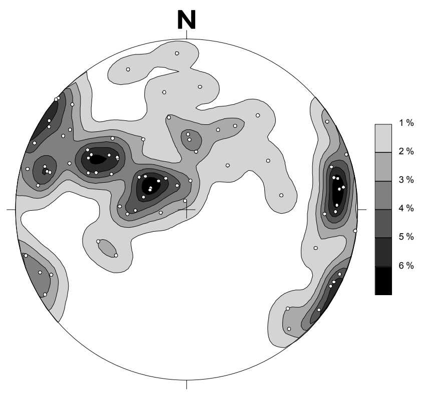
HFM17 - Contoured pole to plane diagram showing *open fractures* (N = 203)



HFM17 - Contoured pole to plane diagram showing *sealed fractures* (N = 60)



HFM18 - Contoured pole to plane diagram showing *open fractures* (N = 358)



HFM18 - Contoured pole to plane diagram showing *sealed fractures* (N = 78)

In data: Borehole length and diameter, HFM16–18

Hole Diam T - Drilling: Borehole diameter

HFM16, 2003-11-04 07:00:00 - 2003-11-11 16:00:00 (0.000 - 132.500 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	12.020	0.195	RX-drilling
12.020	82.000	0.140	59-61m;krosszon,risk för ras
82.000	132.500	0.139	

Printout from SICADA 2004-03-17 10:54:51.

Hole Diam T - Drilling: Borehole diameter

HFM17, 2003-12-01 14:30:00 - 2003-12-08 19:00:00 (0.000 - 210.650 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	8.000	0.180	RX 140
8.000	120.500	0.137	0,1382 at 8.0m,0,137 at 120.5m
120.500	210.650	0.136	

Printout from SICADA 2004-03-17 10:56:28.

Hole Diam T - Drilling: Borehole diameter

HFM18, 2003-12-10 12:30:00 - 2003-12-16 20:00:00 (0.000 - 180.650 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	9.000	0.179	Tabex 140
9.000	120.500	0.140	
120.500	180.650	0.138	

Printout from SICADA 2004-03-04 07:54:47.

Appendix 9

In data: Deviation data for HFM16–18

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM16, 2003-11-18 14:22:00 - 2003-11-18 14:45:00 (0.000 - 132.500 m)

Bhlen (m)	Magnetic Bearing (degrees)	Dip (degrees)	Northing (m)	Easting (m)	Elevation (m)	Locala (m)	Localb (m)	Localc (m)
0.00	0.0	0.0						
15.00	325.8	-85.8						
18.00	319.9	-85.8						
21.00	315.7	-86.1						
24.00	312.7	-86.6						
27.00	311.7	-86.8						
30.00	307.9	-88.0						
33.00	301.6	-88.0						
36.00	285.9	-88.7						
39.00	280.3	-88.9						
42.00	190.3	-89.7						
45.00	188.2	-89.5						
48.00	182.5	-89.0						
51.00	175.1	-88.2						
54.00	172.7	-87.6						
57.00	159.7	-87.8						
60.00	158.1	-86.9						
63.00	151.7	-87.6						
66.00	163.4	-87.0						
69.00	162.9	-86.8						
72.00	161.7	-85.7						
75.00	155.2	-86.8						
78.00	149.2	-86.2						
81.00	144.9	-85.9						
84.00	141.3	-85.2						
87.00	136.6	-85.0						
90.00	136.3	-84.5						
93.00	138.1	-83.9						
96.00	137.9	-83.2						
99.00	135.3	-82.7						
102.00	135.6	-82.2						
105.00	133.3	-81.9						
108.00	134.1	-81.4						
111.00	131.4	-80.7						
114.00	129.9	-80.1						
117.00	126.9	-79.6						
120.00	124.8	-79.2						
123.00	125.9	-79.0						
126.00	124.4	-78.0						
129.00	124.3	-77.5						
132.00	124.3	-77.5						

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Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM17, 2003-12-11

Bhlen (m)	Magnetic Bearing (degrees)	Dip (degrees)	Northing (m)	Easting (m)	Elevation (m)	Locala (m)	Localb (m)	Localc (m)
12.00	316.1	-85.1						
15.00	318.6	-85.4						
18.00	320.9	-85.7						
21.00	325.7	-85.7						
24.00	324.8	-85.5						
27.00	329.1	-85.3						
30.00	329.0	-85.1						
33.00	331.4	-85.0						
36.00	333.1	-85.1						
39.00	337.1	-85.1						
42.00	342.7	-85.3						
45.00	344.6	-85.2						
48.00	349.7	-85.1						
51.00	357.5	-84.9						
54.00	2.1	-84.9						
57.00	5.1	-84.7						
60.00	10.5	-84.6						
63.00	14.4	-84.1						
66.00	18.4	-84.1						
69.00	23.2	-83.5						
72.00	26.2	-83.3						
75.00	24.8	-83.1						
78.00	32.6	-82.6						
81.00	33.9	-82.3						
84.00	34.7	-82.2						
87.00	36.8	-81.7						
90.00	39.6	-81.5						
93.00	39.4	-81.2						
96.00	42.8	-81.1						
99.00	43.1	-81.2						
102.00	43.1	-80.9						
105.00	44.6	-80.8						
108.00	45.3	-80.5						
111.00	47.7	-80.6						
114.00	47.1	-80.1						
117.00	47.4	-80.0						
120.00	49.8	-79.8						
123.00	50.4	-79.6						
126.00	50.4	-79.4						
129.00	52.8	-79.1						
132.00	52.3	-78.9						
135.00	53.5	-78.8						
138.00	54.9	-78.4						
141.00	55.1	-78.3						
144.00	55.3	-78.1						
147.00	55.4	-77.9						
150.00	56.5	-77.5						
153.00	56.3	-77.7						
156.00	57.0	-77.8						
159.00	56.8	-77.5						
162.00	58.7	-77.7						
165.00	59.0	-77.5						
168.00	59.4	-77.5						
171.00	59.3	-77.4						
174.00	59.6	-77.2						
177.00	60.1	-77.0						
180.00	61.7	-77.0						
183.00	62.2	-76.9						
186.00	62.9	-76.7						
189.00	62.6	-76.6						
192.00	62.4	-76.6						
195.00	63.2	-76.2						
198.00	63.3	-76.1						
201.00	63.8	-76.2						
204.00	64.3	-76.1						
207.00	63.6	-75.8						
210.00	59.1	-74.8						

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Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM18, 2004-01-12 00:00:00

Bhlen (m)	Magnetic Bearing (degrees)	Dip (degrees)	Northing (m)	Easting (m)	Elevation (m)	Locala (m)	Localb (m)	Localc (m)
12.00	315.2	-58.3						
15.00	311.9	-58.0						
18.00	311.3	-57.9						
21.00	311.1	-57.6						
24.00	310.3	-57.5						
27.00	309.7	-57.4						
30.00	310.0	-57.4						
33.00	309.8	-57.3						
36.00	304.3	-57.2						
39.00	308.3	-57.5						
42.00	306.9	-57.2						
45.00	307.2	-57.3						
48.00	307.7	-57.0						
51.00	308.0	-57.0						
54.00	306.7	-57.0						
57.00	306.5	-56.8						
60.00	306.7	-56.8						
63.00	306.5	-56.6						
66.00	305.9	-56.3						
69.00	305.4	-56.2						
72.00	304.8	-56.0						
75.00	305.7	-55.9						
78.00	305.9	-55.8						
81.00	304.9	-55.8						
84.00	304.6	-55.6						
87.00	305.2	-55.5						
90.00	304.7	-55.2						
93.00	304.7	-55.1						
96.00	305.5	-54.9						
99.00	305.2	-54.8						
102.00	305.0	-54.6						
105.00	305.4	-54.6						
108.00	305.7	-54.5						
111.00	304.4	-54.4						
114.00	305.1	-54.3						
117.00	304.2	-54.2						
120.00	305.5	-54.0						
123.00	305.1	-53.8						
126.00	304.8	-53.7						
129.00	305.5	-53.5						
132.00	304.5	-53.3						
135.00	305.0	-53.2						
138.00	304.0	-53.1						
141.00	304.9	-52.9						
144.00	305.0	-52.6						
147.00	305.1	-52.4						
150.00	304.2	-52.1						
153.00	303.9	-51.9						
156.00	304.1	-51.7						
159.00	304.1	-51.3						
162.00	303.9	-51.0						
165.00	303.7	-50.8						
168.00	303.3	-50.6						
171.00	303.2	-50.3						
174.00	302.5	-50.1						
177.00	301.8	-49.9						
180.00	302.9	-49.6						

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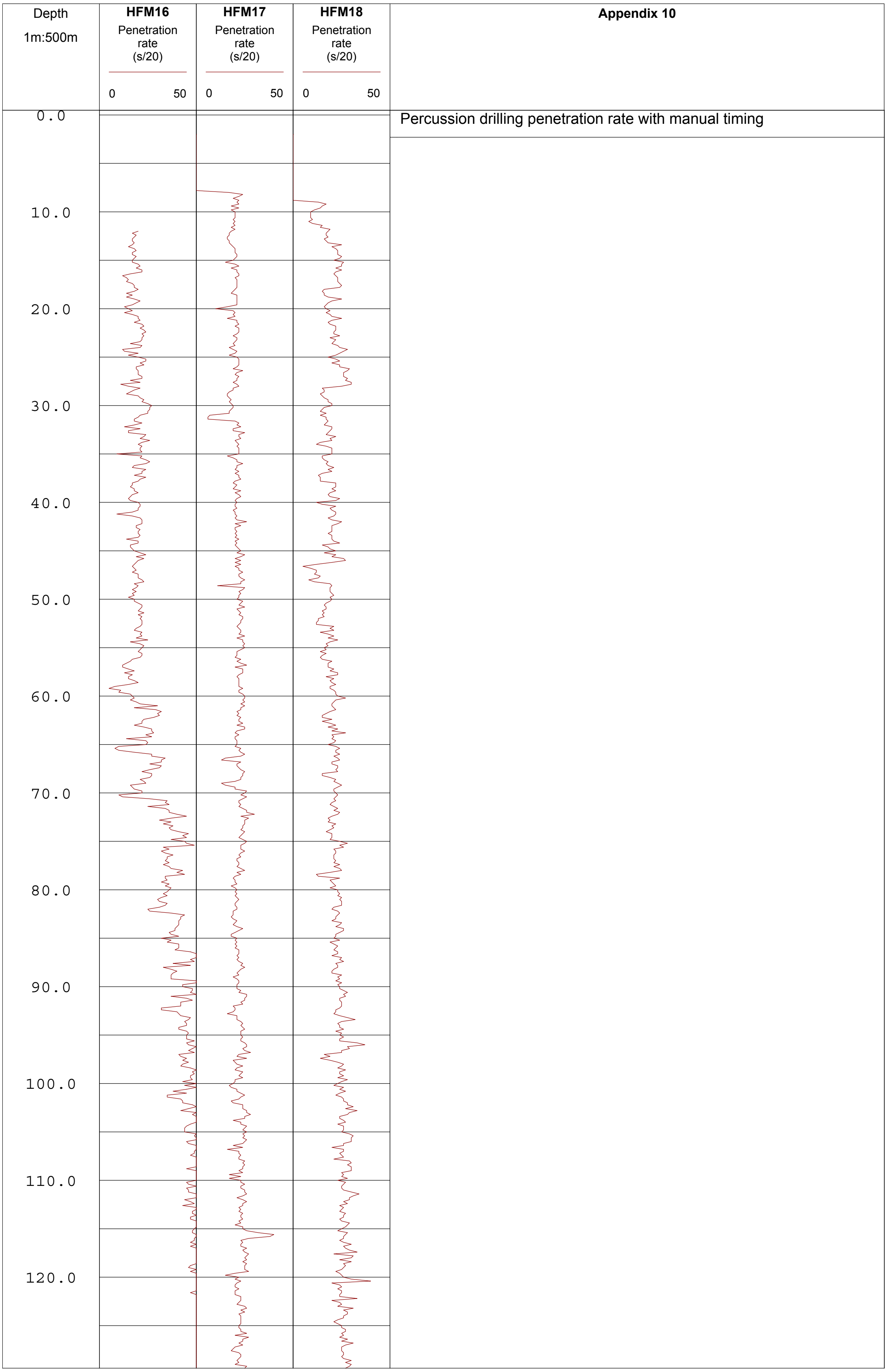
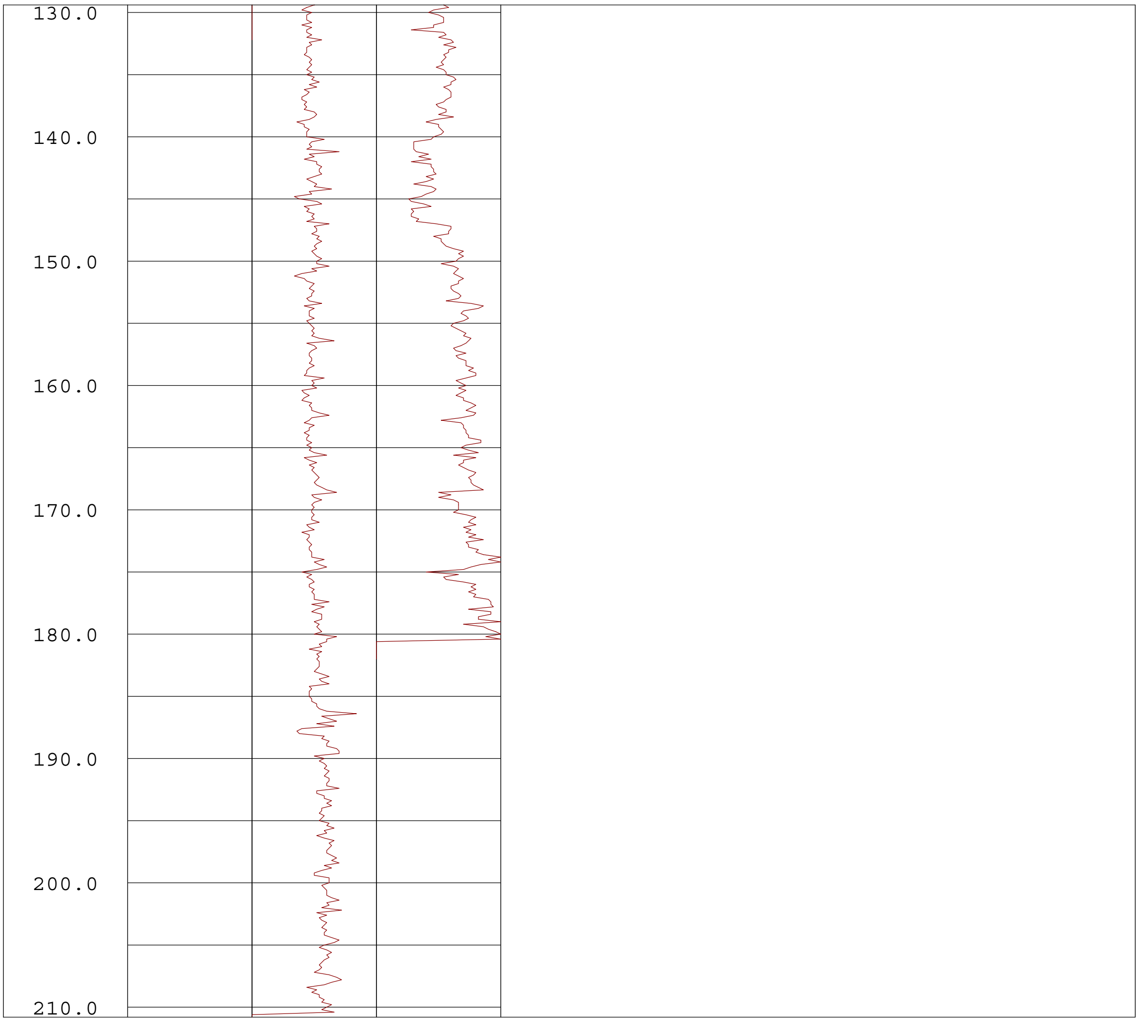
Appendix 10

In data: Drilling penetration rate, HFM16–18

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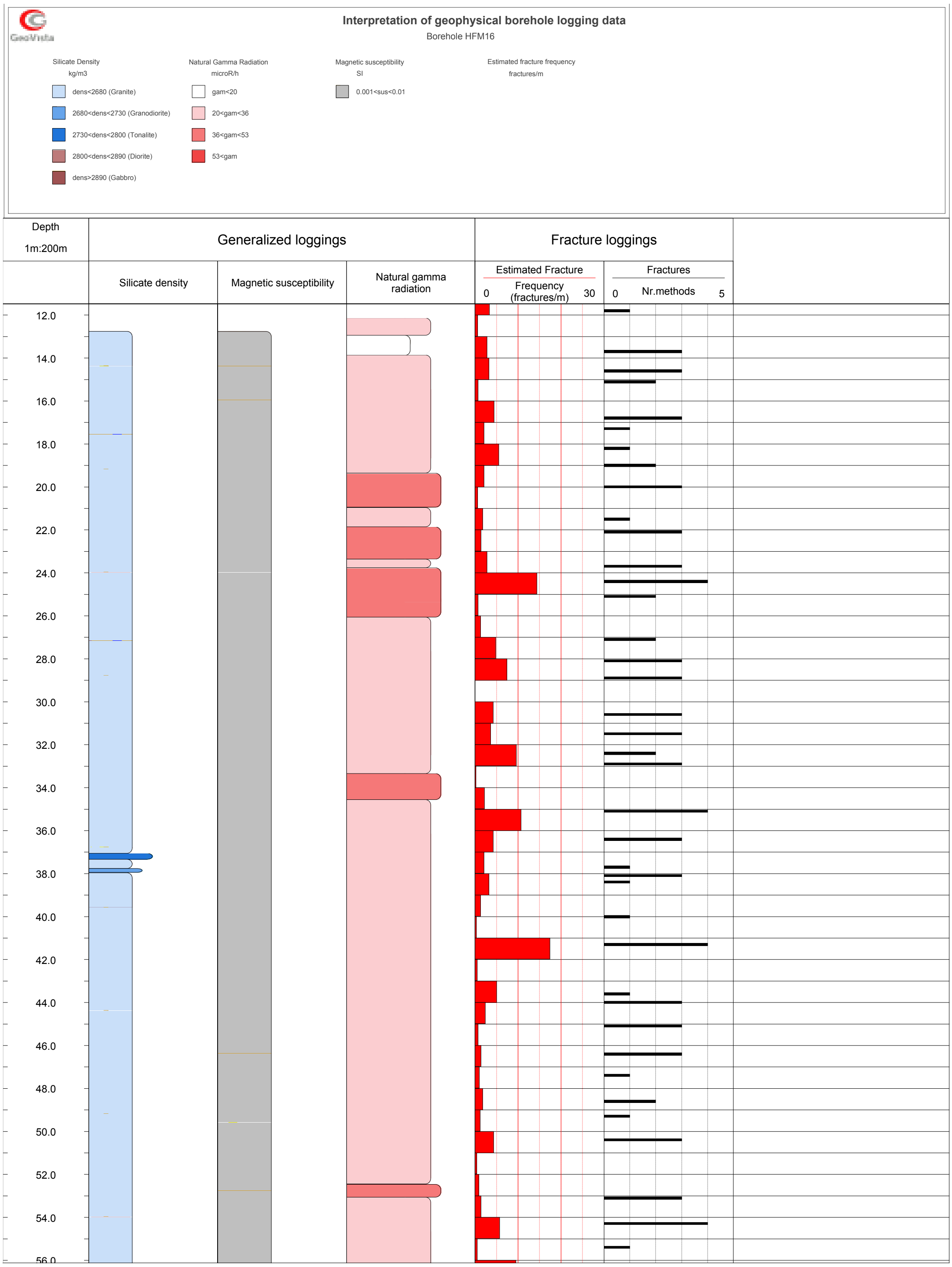
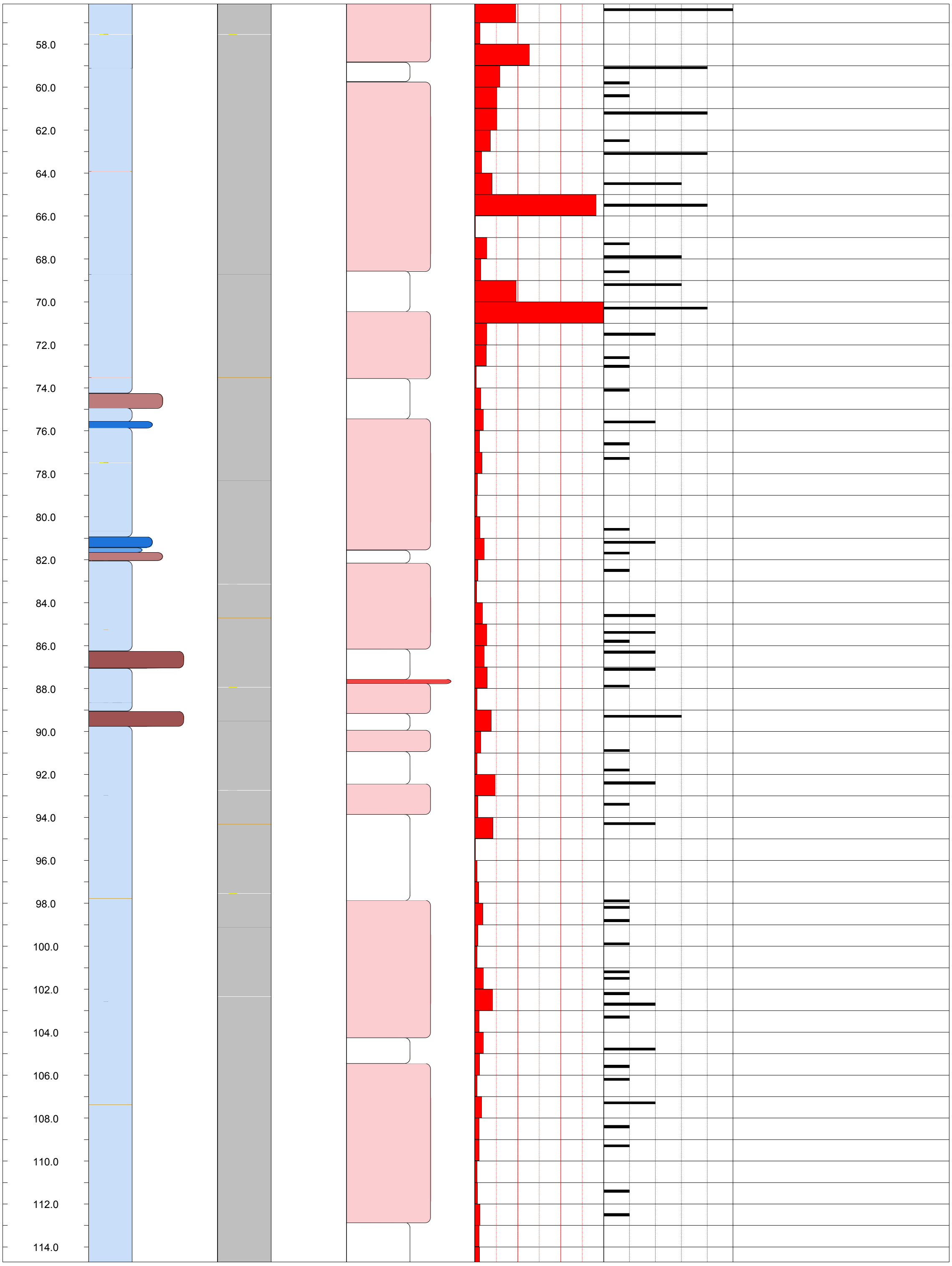
Appendix 11

In data: Geophysical logs, HFM16–18

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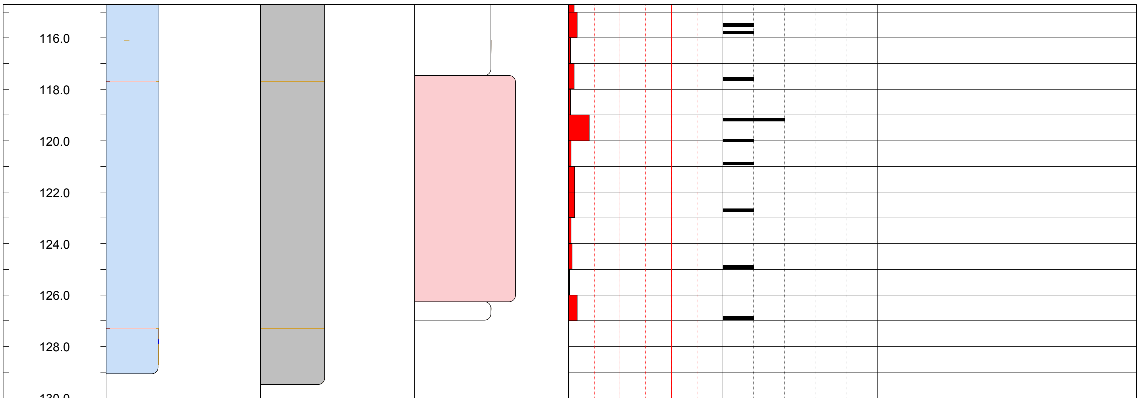
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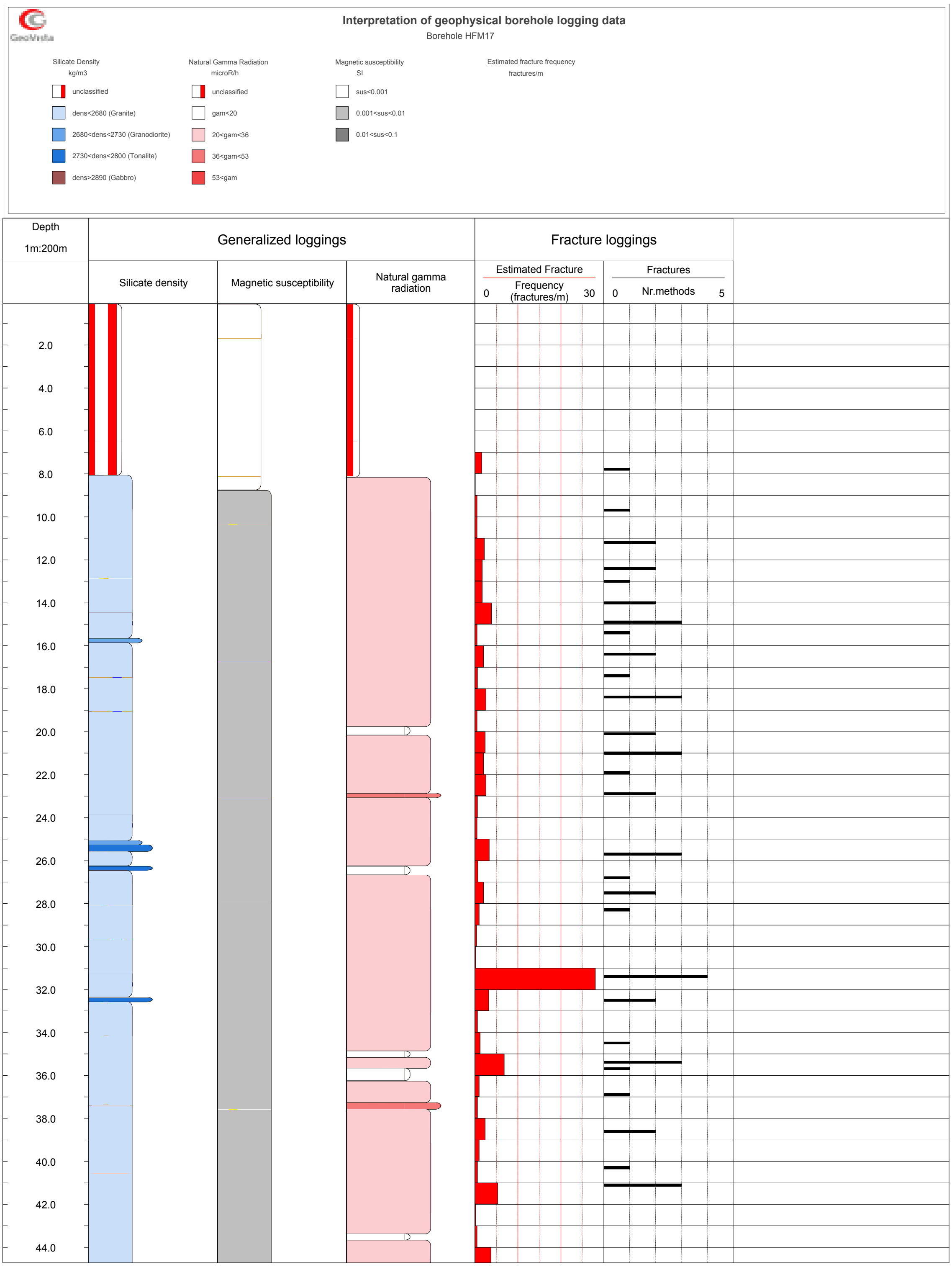
Interpretation of geophysical borehole logging data
Borehole HFM17
Silicate Density
kg/m3
unclassified
dens<2680 (Granite)
2680<dens<2730 (Granodiorite)
2730<dens<2800 (Tonalite)
dens>2890 (Gabbro)
Natural Gamma Radiation
microR/h
unclassified
gam<20
20<gam<36
36<gam<53
53<gam
Magnetic susceptibility
SI
sus<0.001
0.001<sus<0.01
0.01<sus<0.1
Estimated fracture frequency
fractures/m
Depth
1m:200m
Generalized loggings
Fracture loggings
Silicate density
Magnetic susceptibility
Natural gamma radiation
Estimated Fracture Frequency (fractures/m)
0
30
Fractures
Nr.methods
0
5
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
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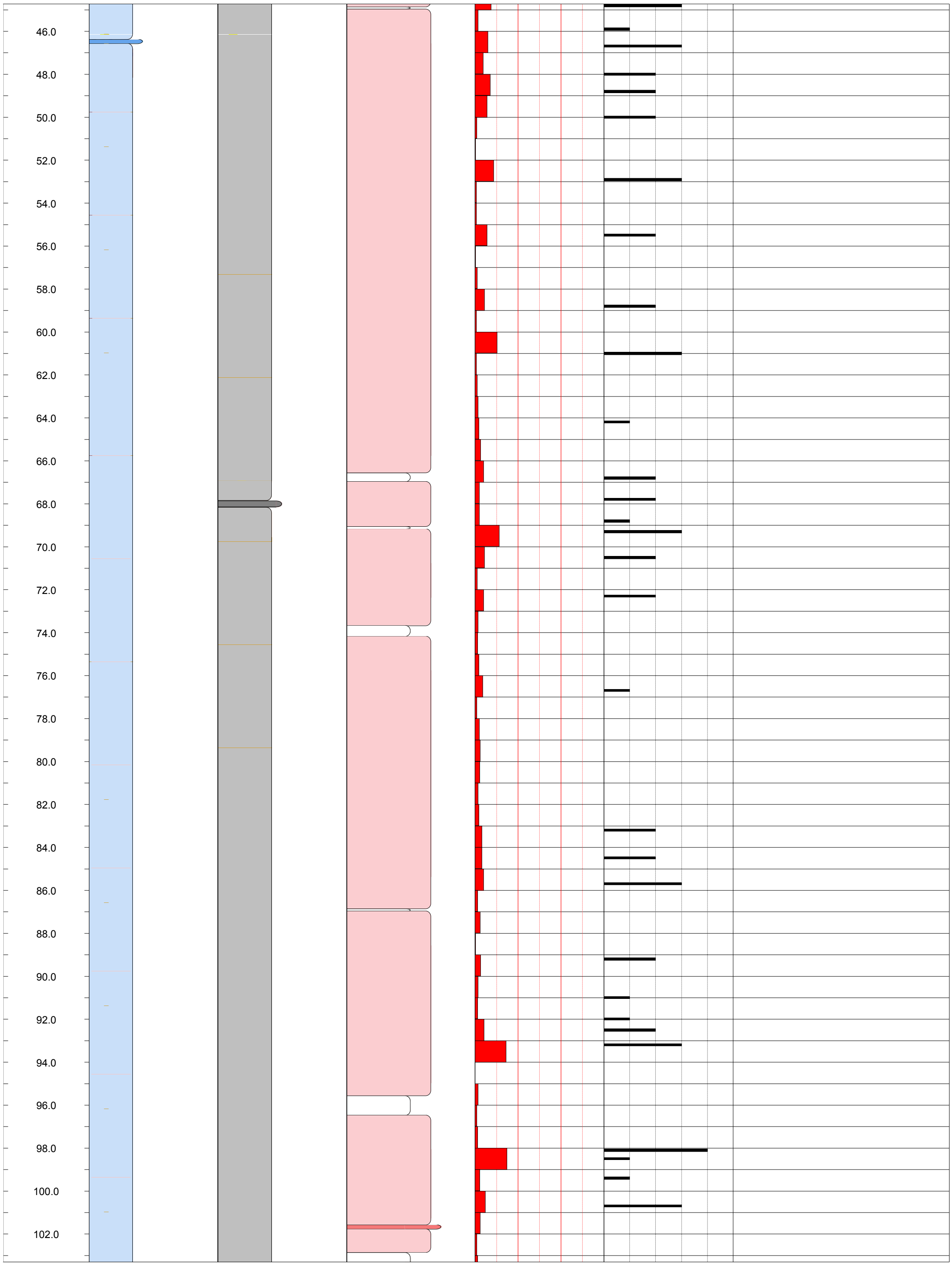
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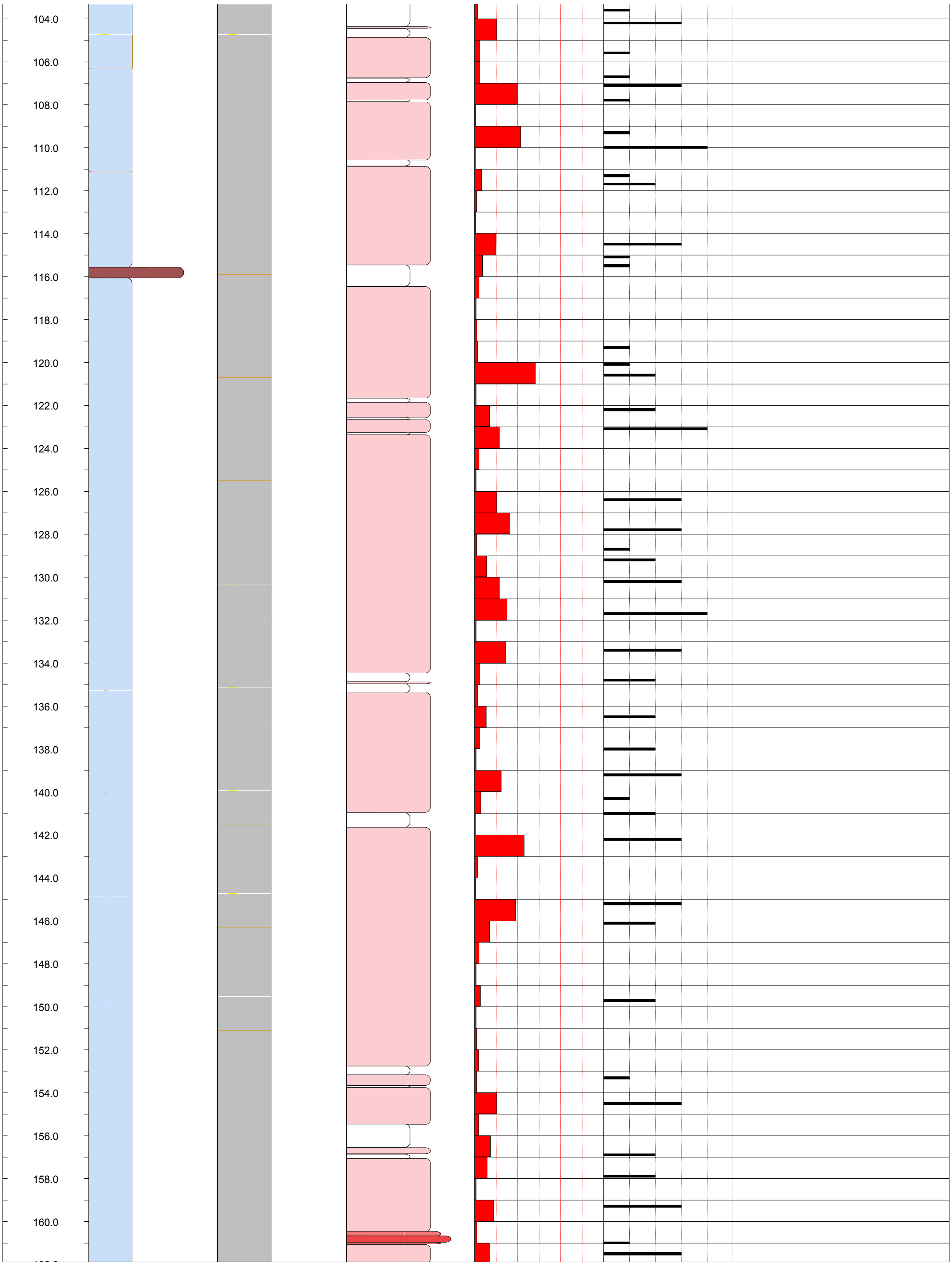
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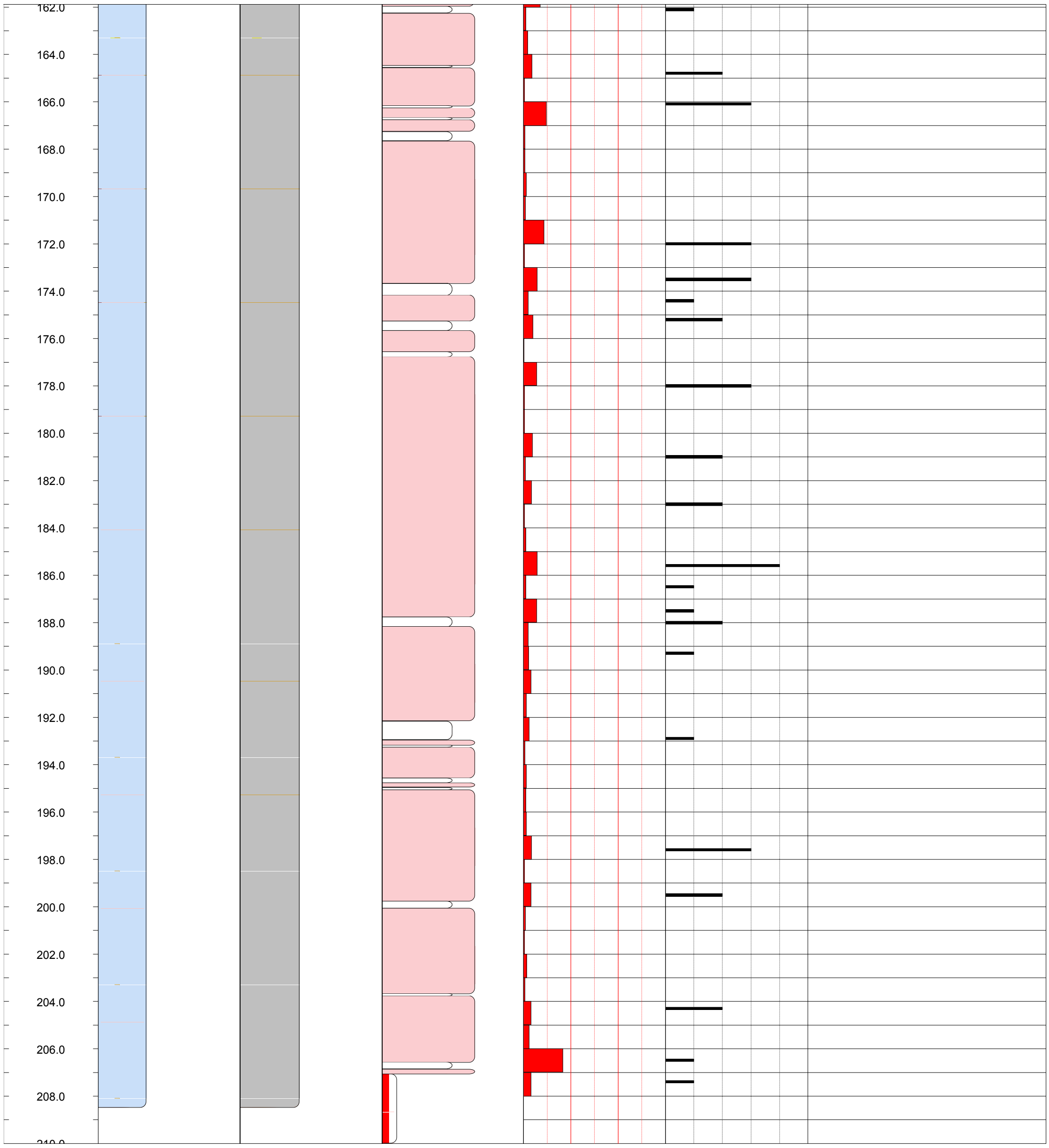
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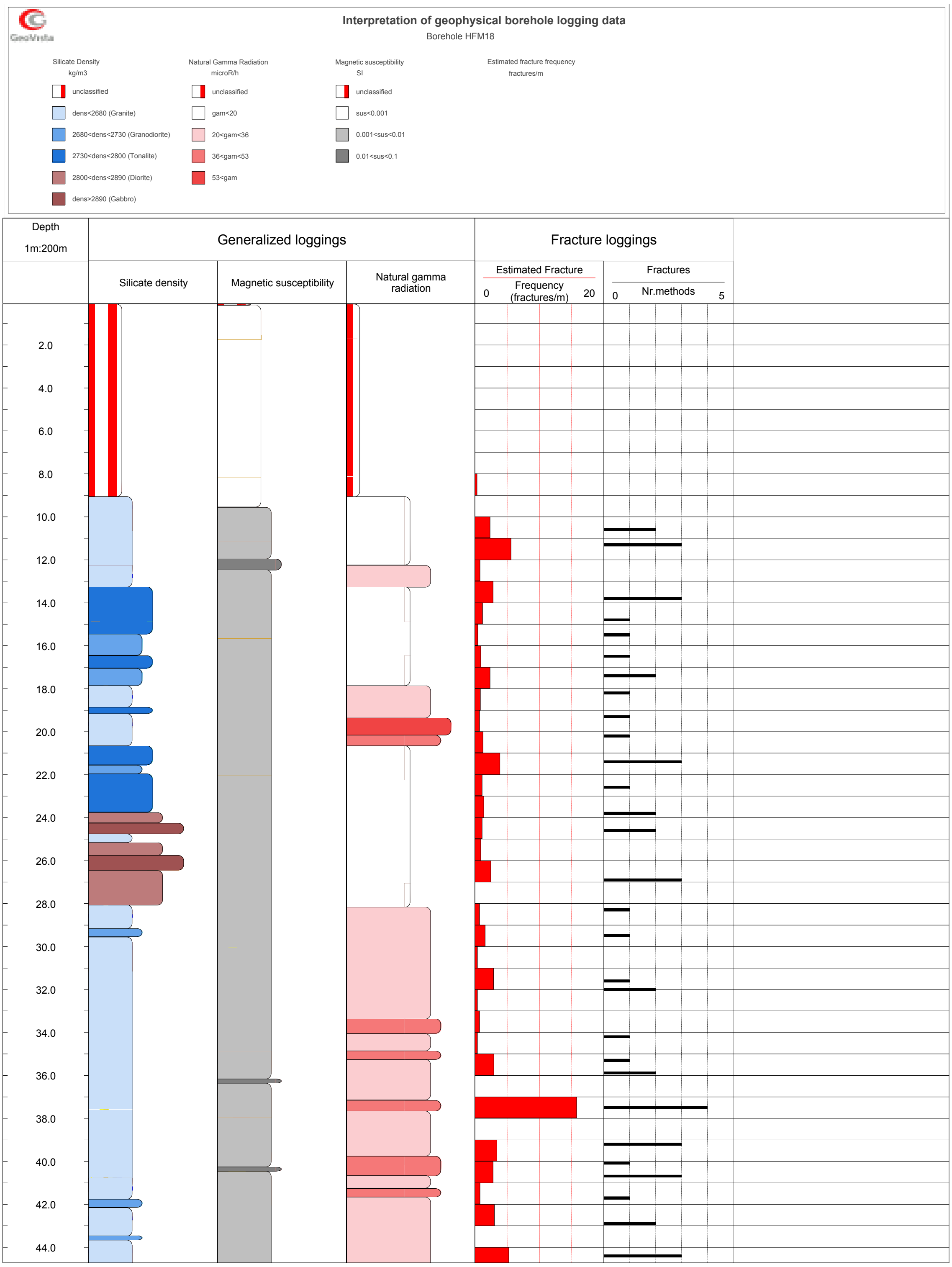
Interpretation of geophysical borehole logging data
Borehole HFM18
Silicate Density
kg/m3
unclassified
dens<2680 (Granite)
2680<dens<2730 (Granodiorite)
2730<dens<2800 (Tonalite)
2800<dens<2890 (Diorite)
dens>2890 (Gabbro)
Natural Gamma Radiation
microR/h
unclassified
gam<20
20<gam<36
36<gam<53
53<gam
Magnetic susceptibility
SI
unclassified
sus<0.001
0.001<sus<0.01
0.01<sus<0.1
Estimated fracture frequency
fractures/m
Depth
1m:200m
Generalized loggings
Fracture loggings
Silicate density
Magnetic susceptibility
Natural gamma radiation
Estimated Fracture Frequency (fractures/m)
0
20
Fractures
Nr.methods
0
5
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
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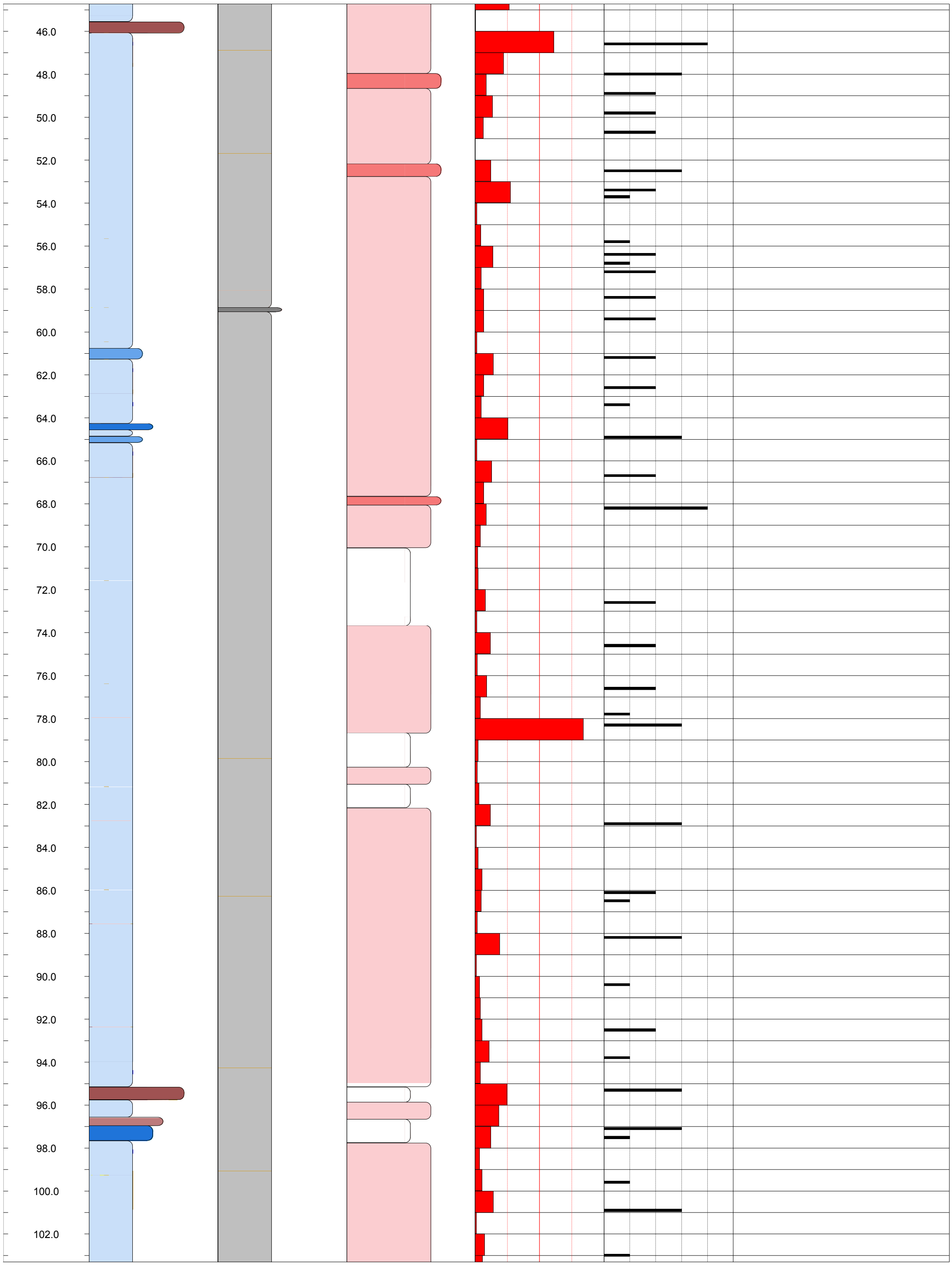
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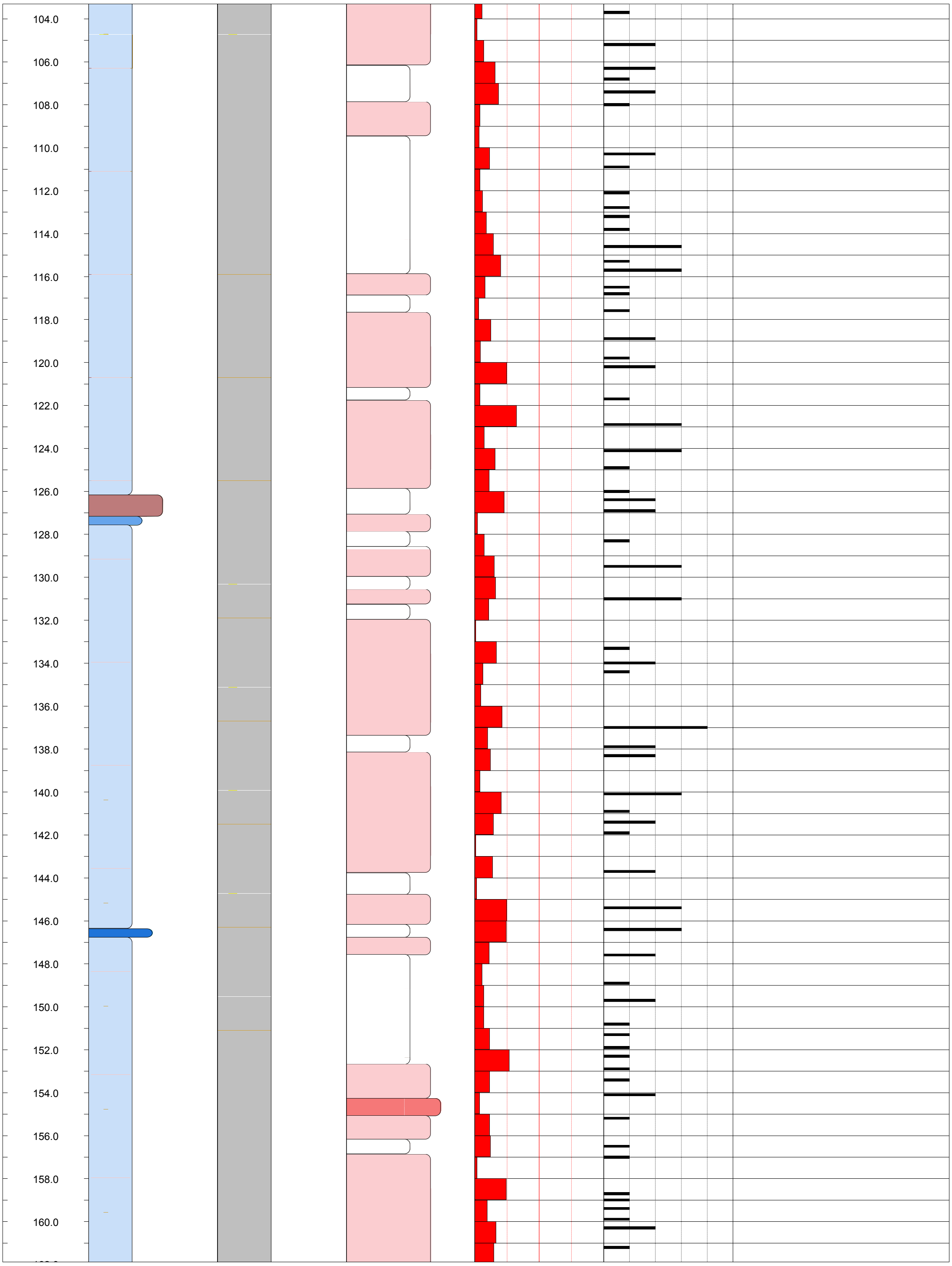
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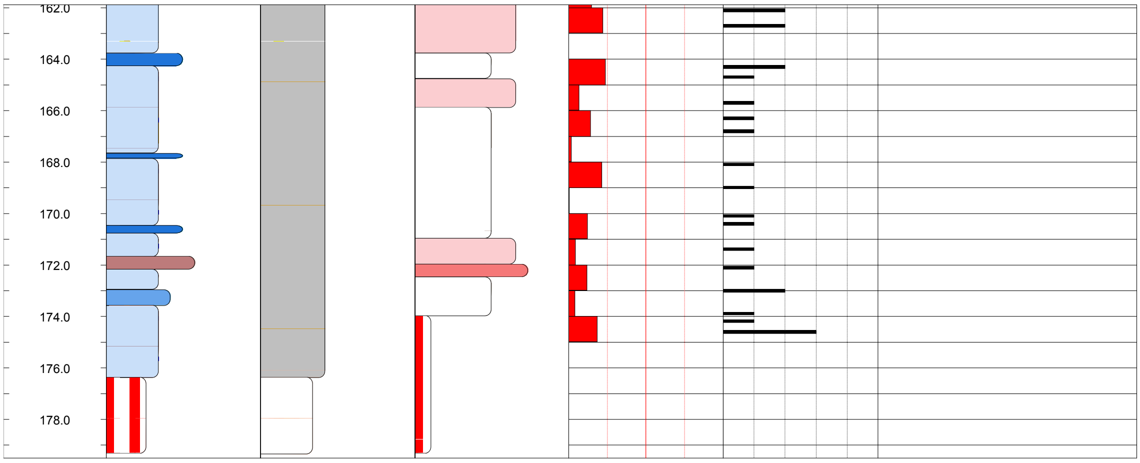
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