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Forsmark site investigation

Boremap mapping of percussion boreholes HFM23–32 and HFM38

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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.

Abstract

This report presents the result from the Boremap mapping of the percussion drilled boreholes HFM23–32 and HFM38. The boreholes were drilled in autumn 2005 – summer 2006. The boreholes are drilled both within and outside the tectonic lens, which has been selected as a candidate area for deposition of nuclear waste. Most of the boreholes are drilled in order to verify and characterize lineaments, while some are drilled to supply water for the core drilling. HFM32 was drilled in order to characterize the ground water flow pattern in the upper part of the bedrock.

The mapping of the boreholes started in January 2006 and was finished in September 2006. The mappings are based on the borehole image (BIPS), generalized geophysical logs and drilling penetration rate. In some cases the drill cuttings were investigated to support the mapping.

The boreholes HFM23–29, HFM32 and HFM38 are dominated by the typical rock types in the candidate area; medium-grained metagranite-granodiorite, pegmatite and amphibolite. HFM30 is drilled in the Eckarfjärden deformation zone and is dominated by metatonalite-granodiorite, with the typical rock types of the candidate area as subordinate rock types. HFM31 is drilled west of reactor 3, and is dominated by younger pegmatite and metadiorite-gabbro.

Oxidation of the bedrock is frequently occurring in the boreholes. Albitization is generally sporadic and associated with amphibolite, but in HFM38 almost all of the rock seems to be albitized. Epidotization occurs sporadically in HFM30.

The boreholes commonly show mean fracture frequencies of 1.3–2.1 interpreted open fractures/m (crush excluded), 0–0.7 interpreted partly open fractures/m and 0.8–3.2 interpreted sealed fractures/m (sealed network excluded). HFM26 and HFM30 are relatively rich in fractures with 2.4, respectively 3.2 interpreted open fractures/m and 3.9, respectively 5.4 sealed fractures/m.

Crushed rock occurs in HFM23, HFM26, HFM27, HFM29–32 and HFM38. Most frequently are horizontal to sub-horizontal crushed sections, with the exception of HFM30, which is characterized by as many as eight crushed sections, of which six are moderately to steeply dipping, striking E –SSE. Steeply dipping crushed sections also occur in HFM31 (323/75) and in HFM38 (185/77), and moderately dipping crushed sections occur in HFM26 (074/47 and 049/43).

Sammanfattning

Denna rapport redovisar resultatet från Boremapkartering av de hammarborrade borrhålen HFM23–32 och HFM38. Borrhålen borrades under hösten 2005–sommaren 2006. Borrhålen är borrade både inom och utanför den tektoniska linsen, vilken har valts som kandidatområde för deponering av högaktivt kärnavfall. De flesta av borrhålen är borrade för att verifiera och karaktärisera lineament, medan några är borrade för att förse kärnborrningen med vatten. HFM32 borrades för att karaktärisera grundvattenflödet i den övre delen av berggrunden.

Karteringen av borrhålen påbörjades i januari 2006 och avslutades i september 2006. Karteringarna är baserade på borrhålsbilden (BIPS), generaliserade geofysiska loggar och borrsjunkningshastighet. I några fall har borrkaxet undersökts för att ge stöd åt karteringen.

Borrhålen HFM23–29, HFM32 och HFM38 domineras av de typiska bergarterna för kandidatområdet; medelkornig metagranit-granodiorit, pegmatit och amfibolit. HFM30 är borrad i Eckarfjärden deformationszon och domineras av metatonalit-granodiorit, med de typiska bergarterna för kandidatområdet som underordnade bergarter. HFM31 är borrat väster om reaktor 3 och domineras av yngre pegmatiter och metadiorit-gabbro.

Oxidation är vanligt förekommande i borrhålen. Albitisering förekommer vanligen sporadiskt och i anslutning till amfiboliter, men i HFM38 är bergarterna i så gott som hela borrhålet albitiserade. Epidotisering förekommer sporadiskt i HFM30.

Borrhålen uppvisar vanligen sprickfrekvenser på 1,3–2,1 tolkade öppna sprickor/m (kross exkluderat), 0–0,7 tolkade delvis öppna sprickor/m och 0,8–3,2 tolkade läkta sprickor/m (läkta spricknätverk exkluderade). HFM26 och HFM30 är relativt sprickrika med 2,4, respektive 3,2 tolkade öppna sprickor/m och 3,9, respektive 5,4 läkta sprickor/m.

Sektioner med kross förekommer i HFM23, HFM26, HFM27, HFM29–32 och HFM38. Vanligast är horisontella till sub-horisontella krossade intervall, med undantag av HFM30 som karaktäriseras av så många som åtta krossade sektioner av vilka sex är moderat till brant stupande, strykande O-SSO. Brant stupande krossar förekommer även i HFM31 (323/75) och i HFM38 (185/77) och moderat stupande krossar i HFM26 (074/47 och 049/43).

Contents

1 Introduction

This document reports the data gained by the Boremap mapping of eleven percussion boreholes, drilled within the site investigation at Forsmark. The work was carried out during 2006 in accordance with activity plan SKB AP PF 400-05-128. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

Locations of the percussion drilled boreholes are presented in Figure 1-1. The boreholes were drilled in connection with core drilled boreholes, or with the aim to identify lineaments. HFM32 was drilled in order to investigate the hydrology in the area.

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

Activity plan	Number	Version
Boremapkartering av borrhålen HFM23–32 och HFM38	SKB AP PF 400-05-128	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för Boremapkartering	SKB MD 143.006	2.0
Mätsystembeskrivning för Boremap	SKB MD 146.001	1.0
Nomenklatur vid Boremapkartering	SKB MD 143.008	1.0
Instruktion: Regler för bergarters benämningar vid platsundersökningen i Forsmark	SKB MD 132.005	1.0

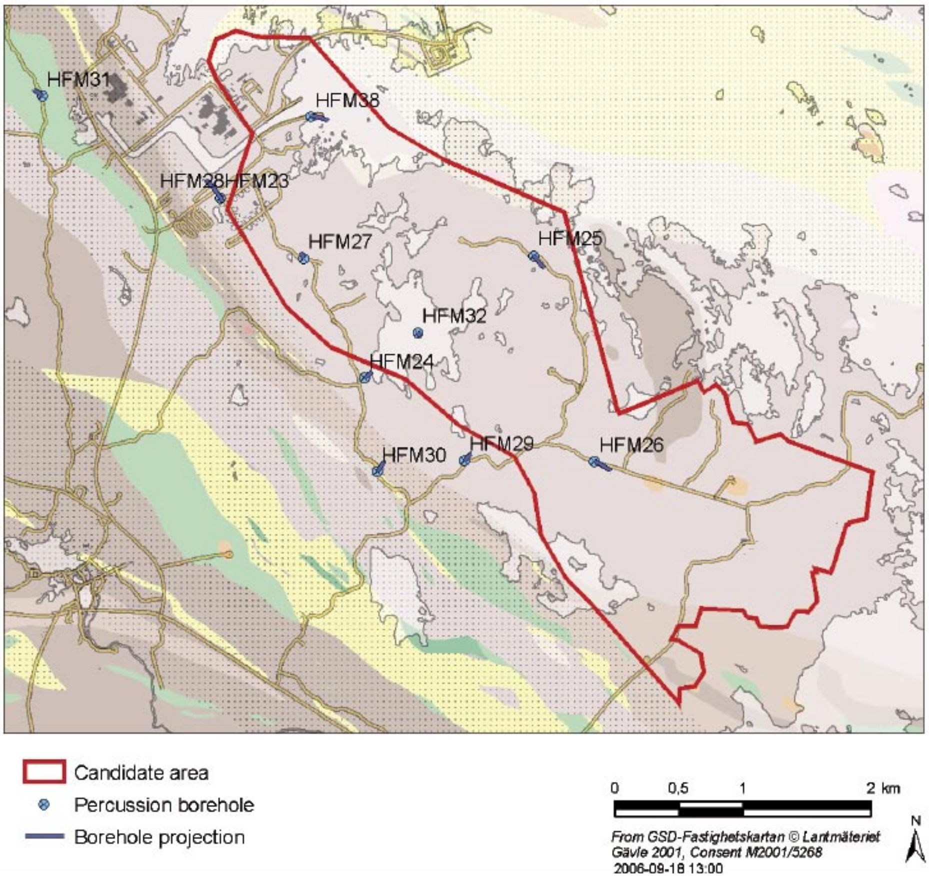

Figure 1-1. Locations of HFM23–32 and HFM38, Forsmark.

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).

The boreholes were mapped during the period January–September 2006. Mapping of percussion boreholes, according to the Boremap method, is based on the use of BIPS-images of the borehole wall supported by study of drill cuttings (Appendix 3), drilling penetration rate (Appendix 6) and generalised geophysical logs (Appendix 7).

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.

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

- borehole diameter (Appendix 4),
- total borehole length (Appendix 4),
- deviation data (Appendix 5),
- drilling penetration rate (Appendix 6).

Background data from Geovista AB was generalized geophysical logs from the boreholes HFM24–32 and HFM38 (Appendix 7).

Geometric data for boreholes HFM23–32 and HFM38 are given in Table 4-1.

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 percussion drilled boreholes HFM23–32 and HFM38. 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 report.

3 Equipment

3.1 Description of interpretation tools

Mapping of the boreholes based on BIPS-images was performed with the software Boremap v. 3.7.5. The Boremap software calculates actual directions (strike and dip) of planar structures penetrated by the borehole (foliations, fractures, fracture zones, rock contacts etc). Inclination, bearing and diameter of the borehole are used as in-data for the calculations (Table 4-1). The BIPS-image lengths were calibrated (Table 4-2). The Boremap software is loaded with the rock types and mineral standard used for surface mapping at the Forsmark investigation site, to enable correlation with the surface geology.

Schematic presentations of the boreholes are presented in WellCAD-diagrams (Appendix 1a–k).

When investigating the drill cuttings, see Figures 3-1 and 3-2, a tap of water, an ordinary kitchen strainer, a hand lens or stereo microscope and 10% hydrochloric acid was used.

3.1.1 BIPS-image quality

The BIPS-image qualities of the boreholes are listed in Appendix 2. The results from the BIPS-loggings are presented in P-reports /1, 2, 3, 4, 5/.

Figure 3-1. *Unwashed drill cutting sample, HFM30, 23 m.*

Figure 3-2. *Washed drill cutting sample, HFM30, 23 m.*

4 Execution

4.1 General

Boremap mapping of the percussion drilled boreholes HFM23–32 and HFM38 was performed and documented according to activity plan AP PF 400-05-128 (SKB, internal document). Geophysical logs of the boreholes and drilling penetration rate supported the mapping and the drill cuttings were investigated when considered necessary. The mapping was performed in accordance with the SKB method description for Boremap mapping SKB MD 143.006, v.2, as well as SKB MD 146.001, v.1.0 (SKB internal controlling documents) and R-01-19 /6/. Information from earlier performed investigations in the area were also helpful in the interpretations /7, 8, 9/.

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.

Length 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 (SKB MD 143.006, v. 2.0, SKB internal controlling document), and that the last 30 cm of the boreholes cannot be logged with BIPS. The end of casing has also been used for length correction. All length corrections made are listed in Table 4-2.

In HFM24 the recorded length is longer than the adjusted. This is very rare, and the authors have only observed the phenomenon in this borehole. This may be explained by the fact that the borehole was logged in winter time, and consequently snow and ice disturbed the accuracy of the measuring wheel /10/.

Table 4-1. Borehole data for HFM23–32 and HFM38.

ID-code	Northing	Easting	Bearing (degrees)	Inclination (degrees)	Diameter (mm)	Borehole length (m)	Mapping interval (m)	End of casing
HFM23	6700067.69	1630595.43	337.3	–67.8	139	211.50	20.8–180.202	20.8
HFM24	6698662.37	1631719.64	047.3	–59.6	139	151.35	18.03–151.05	18.03
HFM25	6699616.18	1633039.37	140.8	–57.8	139	187.50	9.04–187.20	9.04
HFM26	6698008.93	1633516.39	109.8	–52.2	140	202.70	12.03–162.43	12.03
HFM27	6699595.26	1631245.94	337.3	–67.8	139	127.50	12.03–127.20	12.03
HFM28	6700068.84	1630597.24	146.8	–84.8	138	151.20	12.00–148.404	12.00
HFM29	6698018.65	1632502.81	030.1	–58.7	139	199.70	9.03–199.40	9.03
HFM30	6697930.95	1631819.57	28.8	–55.5	139.5	200.75	18.03–200.424	18.03
HFM31	6700860.44	1629207.28	309.6	–69.3	140	200.75	9.03–200.45	9.03
HFM32	6699015.04	1632137.07	117.4	–86.3	138	202.65	12.03–202.35	12.03
HFM38	6700701.28	1631301.71	89.6	–53.5	139	200.75	9.05–194.6	9.05

Table 4-2. Length adjustments for BIPS images.

BIPS-image	Rec. length (m)	Adj. length (m)	Difference (m)
HFM23	20.739	20.803	+0.064
	179.993	180.89	+0.897
HFM24	18.035	18.030	–0.005
	151.218	151.050	–0.168
HFM25	8.998	9.040	+0.042
	186.350	187.200	+0.850
HFM26	12.037	12.03	–0.007
	161.624	162.432	+0.808
HFM27	12.035	12.035	0
	126.992	127.627	+0.635
HFM28	12.000	12.000	0
	135.119	135.855	0.736
HFM29	9.050	9.030	–0.020
	199.110	199.400	+0.290
HFM30	18.011	18.03	+0.019
	200.25	200.451	+0.201
HFM31	8.996	8.996	0
	199.843	200.45	+0.607
HFM32	6.030	6.030	0
	201.737	202.351	+0.614
HFM38	9.06	9.05	–0.010
	194.376	194.97	+0.594

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

- borehole diameter (Appendix 4),
- total borehole length (Appendix 4),
- borehole deviation data (Appendix 5),
- drilling penetration rate (Appendix 6).

Generalized geophysical logs from Geovista AB were used as supporting data for the mapping of all boreholes, except for HFM23 (Appendix 7).

Geometric data for boreholes HFM23–32 and HFM38 are given in Table 4-1.

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 in 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 determined. The following assumptions were made:

- Width of very thin fractures (< 1.5 mm) were impossible to measure accurately and was therefore, as a rule, interpreted as 1 mm thick or, if only partly or vaguely observed, as 0.7 mm thick.
- Fractures were assumed to be open, if not clearly observed to be sealed.
- Fractures that were only indicated by shadows were mapped as open with a possible aperture of 0.7 mm.
- Fractures with reddish rims were mapped as "oxidized walls". No other fracture mineral was generally documented.

4.3.2 Rock colour and alteration

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

The varying exposure of the BIPS-camera, as well as drill cutting in suspension 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.

Albitization /11/ is relatively easy to recognize when it occurs adjacent to amphibolitic veins, but if not, this type of alteration is hard to distinguish from metamorphic pegmatites.

Other rock alterations are probably missed in the interpretation of the percussion drilled boreholes, due to the somewhat bleached colour and the resolution of the image.

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 contain different types of granitic rocks. From the BIPS-image and the geophysical logs it is not easy to determine whether fine- to medium-grained metagranites are metagranite-granodiorite-tonalite (C-generation, code 101051) or aplitic metagranite, (B-generation, code 101058). If the granitic occurrence is narrow, it is not certain that fine- to medium-grained granite (D-generation, code 111058) is indicated by higher gamma-radiation, and then it can be difficult to separate it from the others. Even very narrow occurrences of pegmatite (code 101061) can sometimes be difficult to separate from the rock occurrences mentioned earlier, especially if the pegmatitic veins are metamorphic. Therefore some misinterpretations must be accounted. When it is impossible to determine what generation the fine-grained granite belongs to with some probability, the granitic vein is mapped simply as granite (code 1058).

In order to save time, drill cutting samples were investigated to classify the rock types and/or alterations only when it was considered necessary (see Appendix 3).

4.3.4 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.

4.3.5 Foliation and lineation

Foliation and lineation are difficult to separate from each other in the BIPS-image, unless the structure is clearly developed. Intersection angle of the structures also affect the possibility to distinguish the two. Some attempts have been made to separate them in the Boremap mapping. A structure that looks like foliation or lineation in BIPS, is interpreted as foliation when it is steeply dipping or vertical and as lineation when it is sub-horizontal to gently dipping. This relation has been observed during regional mapping but the relationship is not definite and therefore some misinterpretations may occur.

4.3.6 Supporting data

Schematic presentations of generalized geophysical logs (Appendix 7) were used to support the classifications of rock types. Silica density is useful for separating tonalites from granites, while natural gamma radiation is useful for recognizing younger granitic occurrences. Reports of the bedrock mapping in Forsmark /7, 8, 9/ were also helpful when interpreting the lithologies.

Drilling penetration rate was used as supporting data for the geological interpretation (Appendix 6). 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 HFM23–32 and HFM38 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 authors and by a computer routine in Boremap, the data was submitted to SKB for exportation to SICADA.

All data are stored in the SKB SICADA database, and it is only these data that should be used for further interpretation.

4.5 Nonconformities

4.5.1 Lacking geophysical data

No generalized geophysical logs were available for HFM23 and all interpretations in the mapping are solely based on the BIPS-image and drilling penetration rate. The reason for this is that the borehole is drilled with a low inclination and deviates upwards resulting in higher risk for borehole collapse. In order not to risk the geophysical equipment, the borehole was not logged at all.

4.5.2 Missing in-data in SICADA

Data for borehole diameter and borehole length were missing for the boreholes HFM30 and HFM31. These data were received straight from the persons responsible for the drilling (AP-PF-400-06-046). Drilling penetration rate for HFM31 is missing in the SICADA database, and the borehole is mapped without this information.

4.5.3 Albitization versus pegmatites

Interpretation of rock type in albitized areas is treacherous, since the albitized metagranite-granodiorite gets a pegmatitic appearance in BIPS. In the first mapping of HFM38, too many sections with pegmatites were interpreted. In the revised mapping, geophysical data was more relied on and areas with low gamma radiation were interpreted as albitized metagranite-granodiorite if there were no other proof for pegmatite. Still, the mapping is only to consider as an interpretation and not as clear facts.

4.5.4 Deviations from activity plan

Soil depth and soil stratigraphy are not documented in the Boremap mapping. Fracture minerals were not documented on the request of SKB.

5 Results

The Boremap mapping of HFM23–32 and HFM38 are stored in SICADA, and it is only these data that shall be used for further interpretation and modelling. The user of this data should be aware of the assumptions mentioned in chapter 4.

Results from the Boremap mapping are briefly described in Sections 5.1–5.12 below and the graphical presentations of the data are given as WellCAD-diagrams in Appendix 1.

5.1 General lithology

The boreholes HFM23–32 and HFM38 show the same lithology, although there are small variations between the boreholes. Two exceptions are HFM30 and HFM31 which are situated outside the candidate area. Apart from HFM30 and HFM 31, the boreholes are dominated by a foliated and/or lineated metagranite-granodiorite (~ 80%, code 101057) followed by massive or lineated pegmatite or pegmatitic granite (~ 10%, code 101061) and weakly foliated amphibolite (~ 7%, code 102017) (Table 5-1). Less frequently occurring rock types are not found in all the boreholes. They include minor occurrences of fine- to medium-grained granites of different ages (codes 101058, 111058 and 1058), metagranodiorite (101056), metatonalite-granodiorite (101054), fine- to medium-grained metagranite-granodiorite-tonalite (101051), felsic to intermediate volcanic rock (103076) as well as quartz dominated hydrothermal vein (8021) and breccia (6005). The different rock types are described in earlier SKB-reports /7, 8, 9/.

5.2 HFM23

HFM23 is drilled towards north-west at drill site 9 in the residence area (Figure 1-1). The borehole has an extreme deviation, starting with an inclination of –59.4° and ending with an inclination of + 9.35° (Appendix 5). The mapped rock types in HFM23 are the usual for the area: medium-grained metagranite-granodiorite (101057) dominates over pegmatite (101061) and amphibolite (102017, Table 5-1, Appendix 1a). The strain in the borehole increases from the beginning of the borehole to the end of the borehole. The metagranite-granodiorite appears lineated in the interval 20.80–143.40 m and becomes weakly foliated and richer in biotite at 144.67 m, where after the foliation intensity seems to vary and in one interval the rock type

Table 5-1. Rock type distribution in HFM23–32 and HFM38.

Borehole	101057	101056	101061	102017	101033	101054	101058	111058	101051	103076	other
HFM23	70		23	7							<1
HFM24	79		10	3			1	4	3		<1
HFM25	81		10	5			2	2	<1		<1
HFM26	79		7	12			<1	<1	1		<1
HFM27	79		8	12			<1	<1			<1
HFM28	69	4	12	4			<1	9	2		
HFM29	81		11	7			<1			0.8	<1
HFM30	24		20	8		42	<1	<1		4	<1
HFM31	2		48	5	45				<1		<1
HFM32	61		28	10			<1	<1			<1
HFM38	73		17	5					4	<1	<1

looks veined (170.78–178.67 m). The lineation is sub-horizontal with an average trend and plunge of 120/15 (Appendix 1a). The foliation is roughly 160/77 and is slightly steeper higher up in the borehole relative to the end of the borehole.

936 fractures were documented, of which 305 are considered open, 518 sealed and 113 partly open, giving a total fracture frequency of 5.8 fractures/m, or 1.9 open fractures/m, 3.2 sealed fractures/m and 0.7 partly open fractures/m (Table 5-2). One sub-horizontal crushed section is observed at 52.04–52.10 m. Three sections rich in fractures occur at 32–42 m and 82–94 m and 166–168 m.

5.3 HFM24

HFM24 is situated on the south-western shore of the Bolundsfjärden lake (Figure 1-1).The rock types observed in HFM24 corresponds well to the general geology in the area (Table 5-1, Appendix 1b). Other, less frequently observed rock types, are younger fine- to medium-grained granite (111058), which is observed in the beginning of the borehole at c. 20–26 m borehole length, and fine- to medium-grained metagranite-granodiorite-tonalite (101051), which is observed at c. 51 m and 59 m borehole length. The foliation in the metagranite-granodiorite (101057) is rather consistent (~ 130/70).

A total number of 496 fractures were documented in HFM24 (18.03–151.05 m), of which 198 are considered open, 197 sealed and 36 partly open. This results in an interpreted total fracture frequency of 3.2 fractures/m or 1.5 open fractures/m, 1.5 sealed fractures/m and 0.3 partly open fractures/m (Table 5-2). At 79.64 m there is one fracture with visible outflow in the BIPS-image, though no aperture is visible.

Three intervals are relatively rich in fractures: 18–30 m, 50–80 m and 87–98 m. The upper two are also correlated with oxidation and some larger apertures (Appendix 1b). No crushed sections were observed.

5.4 HFM25

HFM25 is located in the eastern part of the candidate area, between drill sites 2 (DS2) and 6 (DS6, Figure 1-1). The dominating rock type is metagranite-granodiorite (101057). The borehole is drilled sub-parallel to the foliation. The measured foliation is c. 320/55 in the intervals 9–105 m and 180–187 m and c. 290/65 in between. Subordinate rock types are pegmatite (101061), amphibolite (102017) and various fine- to medium-grained granites (Table 5-1, Appendix 1c).

Table 5-2. Fracture frequency in HFM23–32 and HFM38.

Borehole	Open fractures/m	Sealed fractures /m	Partly open fractures/m
HFM23	1.9	3.2	0.7
HFM24	1.5	1.5	0.3
HFM25	1.1	2.5	0.5
HFM26	2.4	3.9	< 0.1
HFM27	1.4	0.8	0
HFM28	1.7	2.2	0
HFM29	0.8	0.8	< 0.1
HFM30	3.2	5.4	0
HFM31	1.3	1.6	0.3
HFM32	1.9	1.4	0
HFM38	2.1	2.3	0.6

In total 733 fractures were documented in HFM25 (9.04–187.2 m) of which 190 are considered open, 454 sealed and 89 partly open. This result in an interpreted total fracture frequency of 4.1 fractures/m or 1.1 open fractures/m, 2.5 sealed fractures/m and 0.5 partly open fractures/m (Table 5-2).

In the beginning of the borehole, the fractures are mainly steeply dipping (Appendix 1c), which is rather unusual for Forsmark. Sections relatively rich in fractures occur at 80–96 m, 142–159 m and 161–187 m. These sections also correlate with oxidation of the wall-rock.

No crushed sections were observed.

5.5 HFM26

HFM26 is situated in between drill site 2 (DS 2) and 3 (DS 3, Figure 1-1). The borehole is predominantly composed of metagranite-granodiorite (101057), together with subordinate occurrences of amphibolite (102017) and pegmatites (101061, Table 5-1 and Appendix 1e). Minor occurrences of fine- to medium-grained granite of different age occur (rock codes 101058, 111058 and 1058), as well as quartz dominated hydrothermal veins. The latter constitute less than 1% of the borehole. The structure in the metagranite-granodiorite is interpreted as lineation. The general trend and plunge is 190/40.

A quite large amount of fractures were documented in HFM26 (940 in the interval 12.00–161.63 m borehole length). In total, 362 fractures are considered open and 578 sealed. The frequency of interpreted open fractures is 2.4 fractures/m (crush excluded) and of interpreted sealed fractures 3.9 fractures/m (sealed fracture networks excluded, Table 5-2). The overall fracture frequency is 6.3 fractures/m. HFM26 has a peak in fractures ~ 25–30 meters. This peak is mostly a result of a large number of open fractures, with a general aperture of 0.7 mm, except for two fractures with a 5 mm aperture. The frequency of sealed fractures increases between 65 and 80 m.

Three crushed sections have been observed in the following intervals: 13.02–13.42 m, 25.06–25.20 m and 27.54–27.85 m. They are gently dipping (34–47°) striking S-SE. There are 8 sealed networks in HFM26 (Appendix 1h).

The four interpreted narrow brecciated sections are striking E-SE and moderately dipping (44–55°), The width varies but is generally small, up to 10 cm. Three deformation bands have been interpreted as cataclasites. The possible cataclasite occurrences seem to be very fine-grained with a small number of clasts.

Albitization is present in contacts between amphibolite and metagranite-granodiorite. The altered rock has a bleached and spotted appearance.

Oxidation occurs in shorter intervals throughout the entire borehole.

5.6 HFM27

HFM27 is located at drill site 1 (DS 1, Figure 1-1). The borehole is in general composed of the same rock types as those in the candidate area, but the occurrence of amphibolite (102017) is slightly more frequent (~ 12%, Table 5-1, Appendix 1e). Minor occurrences of fine- to medium-grained granites of different ages occur (codes 101058, 111058 and 1058) as well as quartz dominated hydrothermal veins (8021), but they constitute less than 1% of the borehole. The ductile deformation is interpreted as foliation, although moderately dipping (~ 140/50).

The frequency of interpreted open fractures is 1.4 fractures/m and of interpreted sealed fractures 0.8 fractures/m (Table 5-2). One section rich in fractures occur at 43–67 m. The interpreted open fractures are mainly sub-horizontal, and they do also have apertures up to a few millimetres wide. Four crushed sections are observed and they occur in the following intervals: 19.90–19.94 m, 27.75–28.44 m, 49.30–49.45 m and 118.42–118.49 m. They are mostly sub-horizontal dipping 05–36°.

5.7 HFM28

HFM28 is located at drill site 9 (DS9) in the residence area, in the north-western part of the candidate area (Figure 1-1). HFM28 is clearly dominated by metagranite-granodiorite (101057) with subordinate dykes of amphibolite (102017) and pegmatite (101061, Table 5-1, Appendix 1f). In several sections in HFM28 the metagranite-granodiorite contains fragments of what is interpreted as amphibolites. A rock type interpreted as metagranodiorite (101056) is observed at ~ 23.95–27.58 m, supported by an increase in silica density relative to metagranite-granodiorite (Appendix 7). The structures in HFM28 are usually not clearly visible in BIPS, since they probably are very weak. Therefore have few observations been made. The mapped lineations show a general orientation of 165/23 and the foliation, which is the less dominating structure type, shows a general orientation of 147/57.

Relatively few fractures were documented in HFM28 (539 in the interval 12.00–135.86 m borehole length). In total are 238 fractures considered open and 301 sealed. This results in an interpreted fracture frequency of 1.7 open fractures/m and 2.2 sealed fractures/m (Table 5-2). An additional number of sealed fractures are mapped as sealed fracture network or as oxidized zones. There are 8 sealed networks in HFM28. The open fracture frequency shows a peak around 48 meters and the sealed fracture frequency has its peak around 53 meters. There are no crushed sections in HFM28.

A possible albitization is observed as bleached rims in the metagranite-granodiorite in contact with amphibolite, and in some cases as light coloured vein-like structures in the metagranite-granodiorite. The metagranite-granodiorite is oxidized in the section 115.50–115.71 m.

A very narrow brecciated zone is observed at 113.58–113.62 m.

5.8 HFM29

HFM29 is situated immediately to the west of the candidate area (Figure 1-1). Metagranite-granodiorite dominates HFM29 (Table 5-1, Appendix 1g). The borehole is characterized by a high frequency of narrow pegmatitic (101061) veins and also some amphibolitic (102017) veins, with associated felsic to intermediate volcanic rock (103076). The foliation in the metagranite-granodiorite is ~ 120/65 (Appendix 1g).

Relatively few fractures were documented in HFM29 (307 in the interval 9.03–199.4 m borehole length). In total, 155 fractures are considered open, 147 sealed and 5 partly open. This results in an interpreted total fracture frequency of 1.6 fractures/m or 0.8 open fractures/m, 0.8 sealed fractures/m and <0.1 partly open fractures/m (Table 5-2). It should though be remembered that especially in HFM29 only few fractures were clearly observed in BIPS and that most of the observed fractures are inferred by possible oxidation or shadows. This may be due to suspensions in the borehole fluid.

The interval 60–80 m is relatively rich in fractures (Appendix 1g) and this interval also coincides with oxidation and slightly higher apertures. Interpreted open fractures are also concentrated to the interval 163–177 m.

One narrow crushed section is documented at 16.38–16.40 m borehole length, having the orientation 275/11.

5.9 HFM30

HFM30 is drilled in the Eckarfjärden deformation zone, west of the central candidate area (Figure 1-1). The borehole is dominated by a metatonalite-granodiorite (101054, Table 5-1, Appendix 1h). The borehole begins with a metagranite-granodiorite (101057), which is oxidized and has low biotite content in the upper half (18.03–32.60 m), which is also reflected in a drop in density (Appendix 3 and 7g). Other rock types are amphibolite (102017), pegmatitic veins (101061) and fine- to medium-grained granites of different ages (codes 101058, 111058 and 1058). The general foliation in the metatonalite-granodiorite is 135/75.

The rock is weakly to strongly oxidized in the intervals 19–57 m, 76–119 m and 147–200 m. In the interval 30.31–37.08 m, the metagranite-granodiorite seems to be affected by epidotization. This is visible as greyish green irregular occurrences.

HFM30 is characterized by a large amount of fractures (1569 fractures in the interval 18.03–200.45 m borehole length). 581 fractures are considered open and 988 sealed. The open fracture frequency is 3.2 fractures/m (crush excluded), while the sealed fracture frequency is 5.4 fractures/m (sealed fracture networks excluded, Table 5-2). There are also 28 sealed fracture networks in HFM30 (Appendix 1h).

The interval 159–200 m has high frequency of open fractures, and all the observed crushed sections are also concentrated to this borehole interval. Of the eight observed crushed sections, six are moderately dipping striking E –SSE, while two are gently dipping striking west and east respectively. Four of them are less than 10 cm wide, while the rest are 20–40 cm wide (Appendix 7g).

Brecciation in the pegmatite has been observed in several sections in HFM30. These brecciated sections are generally narrow with a width ~ 10 cm, but a few extend up to 60 cm. The interval 158.72–159.83 m is strongly deformed and is interpreted as a cataclasite. It occurs together with sealed fractures with oxidized walls.

5.10 HFM31

HFM31 is situated outside the candidate area, west of reactor 3 (Figure 1-1). The lithology is different from the candidate area with younger D-generation pegmatite (101061) having anomalous gamma radiation and foliated metadiorite-gabbro (101033) as dominating rock types (Table 5-1, Appendix 1i). The foliation is almost vertical striking mostly 340°. Subordinate rock types are amphibolite (102017), metagranite–granodiorite (101057), granite (1058), fine- to medium-grained metagranite-granodiorite-tonalite (101051) and quartz-dominated hydrothermal vein (8021).

The rock is oxidized in shorter intervals in the borehole, and albitization is observed between 101 and 104 m.

Relatively few fractures are documented in HFM31; only 253 open, 66 partly open and 304 sealed fractures, resulting in fracture frequencies of 1.3 open fractures/m, 0.3 partly open fractures/m and 1.6 sealed fractures/m (Table 5-2). No section with increased fracture frequency has been observed in the borehole. Two crushed sections occur at 45.20–45.22 m and 108.36–108.54 m with the orientations 167/32 and 323/75 respectively.

5.11 HFM32

HFM32 is located on an island in Bolundsfjärden (Figure 1-1). It is relatively rich in pegmatite (101061, Table 5-1). A longer section with amphibolite (102017) occurs in the beginning of the borehole (6–20 m). The dominating rock type is metagranite-granodiorite (101057) covering approximately 60% of the borehole. Minor occurrences consist of fine- to medium-grained granites of different ages (codes 101058, 111058 and 1058). The structure in HFM32 is usually not clearly visible in BIPS and probably very weak, and therefore only few structural orientations have been measured (Appendix 1j).

A borehole section at 28.40 m is darker in colour lacking sharp contacts. That could be interpreted either as a crush zone or as a section with high fracture frequency. The section is mapped as rich in fractures, based upon the fact that the fractures in the section was possible to orientate. Two (~ 10 cm) crushed sections have been observed, the first one at 15.34 m with the orientation 312/15 and the second one at 18.09 m with the orientation 336/25.

The total number of fractures in HFM32 is 652. Of these 379 fractures are considered open and 273 sealed. The open fracture frequency is 1.9 fractures/m while the number of sealed fractures per meter is 1.4 (Table 5-2). An additional number of sealed fractures are mapped as sealed fracture network or as oxidized zones. There are 5 sealed networks in HFM32.

A peak in fracture frequency is observed at c. 28 m borehole length, almost entirely represented by open fractures. A less obvious peak in the frequency of open fractures is observed around 10 meters.

A possible albitization is observed as bleached rims along contacts between metagranite-granodiorite and amphibolite, and in some cases as light coloured vein-like structures in the metagranite-granodiorite. The metagranite-granodiorite is oxidized in the following sections: 60.30–60.60 m and 181.05–181.34 m.

Four narrow brecciated zones were observed in HFM32 and a possible occurrence of a brittle-ductile deformation zone with the orientation 236/84.

5.12 HFM38

HFM38 is located in the northern part of the candidate area close to drill site 8 (Figure 1-1). The borehole consists of the typical rock types in the candidate area, with metagranite-granodiorite (101057) as dominating rock type and pegmatite(101061), amphibolite (102017) and fine- to medium-grained metagranite-granodiorite-tonalite (101051) as subordinate rock types (Table 5-1).

The borehole is characterized by albitization with varying intensity almost throughout the entire borehole, and this has complicated the interpretation of rock types (Appendix 1k). Oxidized intervals occur mainly in the interval 21–58 m, but also in 157–164 m.

The structure of the metagranite-granodiorite is generally not visible in BIPS in the upper half of the borehole. From 147 m and downwards, an N-S striking steeply dipping foliation can be observed.

In total, 385 interpreted open, 110 partly open and 423 sealed fractures are observed in HFM38 giving fracture frequencies of 2.1 open fractures/m, 0.6 partly open fractures/m and 2.3 sealed fractures/m (Table 5-2). The upper part of the borehole, as well as the section 149–164 m, show increased fractures frequencies. One zone interpreted as a crush is observed at 30.04–30.53 m, having an orientation of 185/77.

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Appendix 1

WellCAD-diagrams

Title	LEGEND FOR FORSMARK	HFM23-32, 38	Appendix: 1a-k

Site FORSMARK
Borehole HFM23-32 and HFM38
Plot Date 2006-10-16 21:58:09
Signed data

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
- Laumontitization
- Fract zone alteration

MINERAL
- Oxidized Walls

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

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

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

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

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

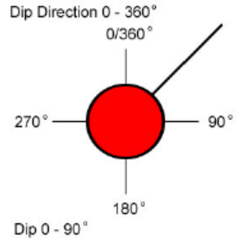
ROUGHNESS
- Planar
- Undulating
- Stepped
- Irregular

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 GEOLOGY IN HFM23 **Appendix: 1a**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM23	**Northing [m]**	6700067.69
Diameter [mm]	134	**Easting [m]**	1630595.43
Length [m]	211.500	**Elevation [m.a.s.l.]**	4.25
Bearing [°]	324.35	**Drilling Start Date**	2005-08-24 13:00:00
Inclination [°]	-58.47	**Drilling Stop Date**	2005-09-01 14:00:00
Date of coremapping	2006-08-23 15:29:00	**Plot Date**	2006-10-16 21:58:09
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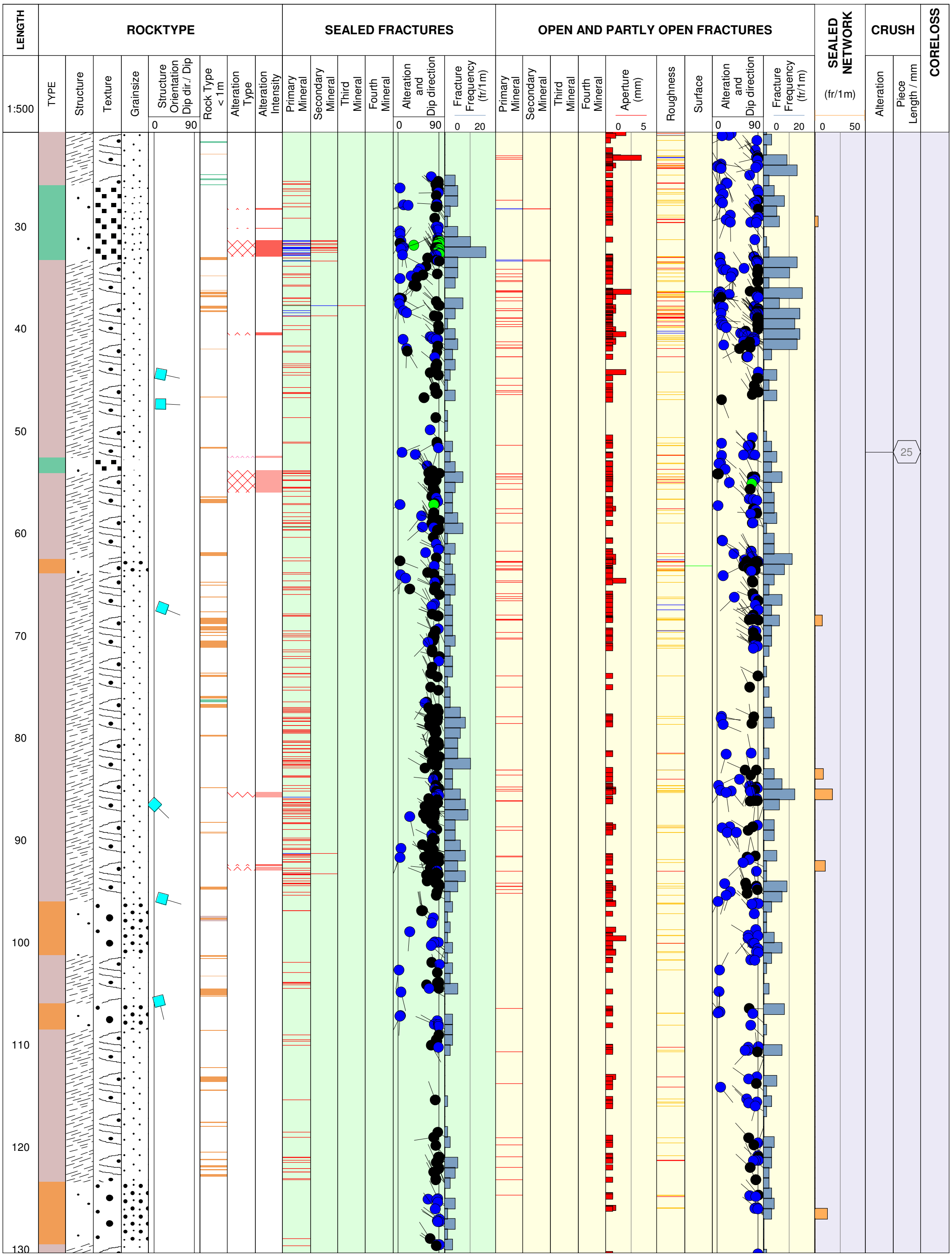

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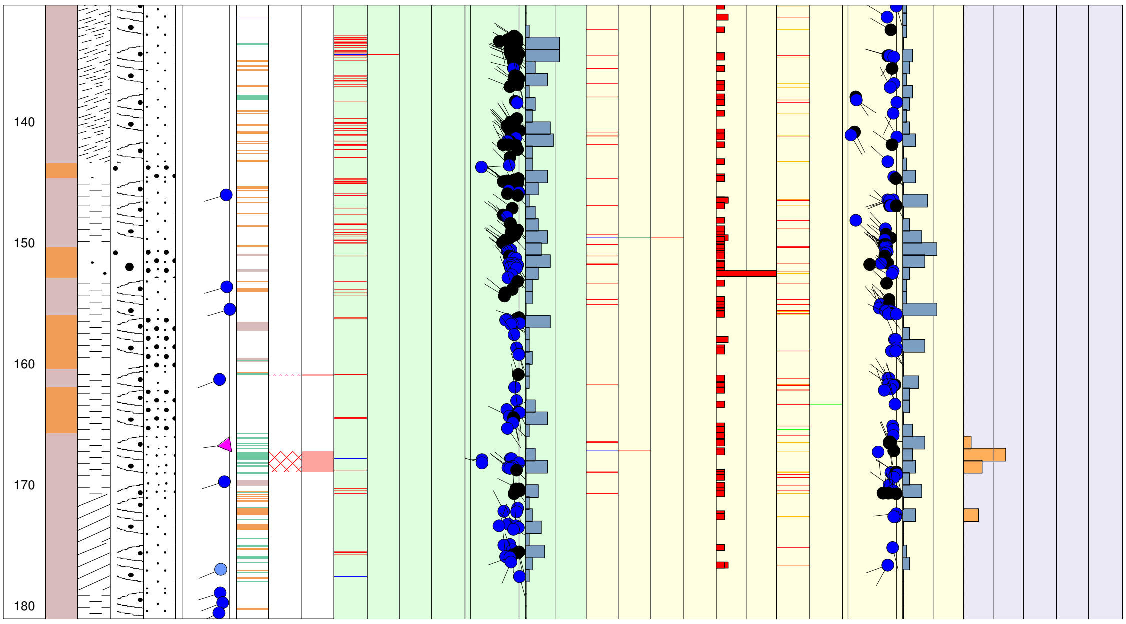
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Title GEOLOGY IN HFM24 **Appendix: 1b**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM24	**Northing [m]**	6698662.37
Diameter [mm]	138	**Easting [m]**	1631719.64
Length [m]	151.350	**Elevation [m.a.s.l.]**	3.68
Bearing [°]	47.29	**Drilling Start Date**	2005-11-22 10:00:00
Inclination [°]	-59.55	**Drilling Stop Date**	2005-11-22 11:00:00
Date of coremapping	2006-03-09 11:23:00	**Plot Date**	2006-10-16 21:58:09
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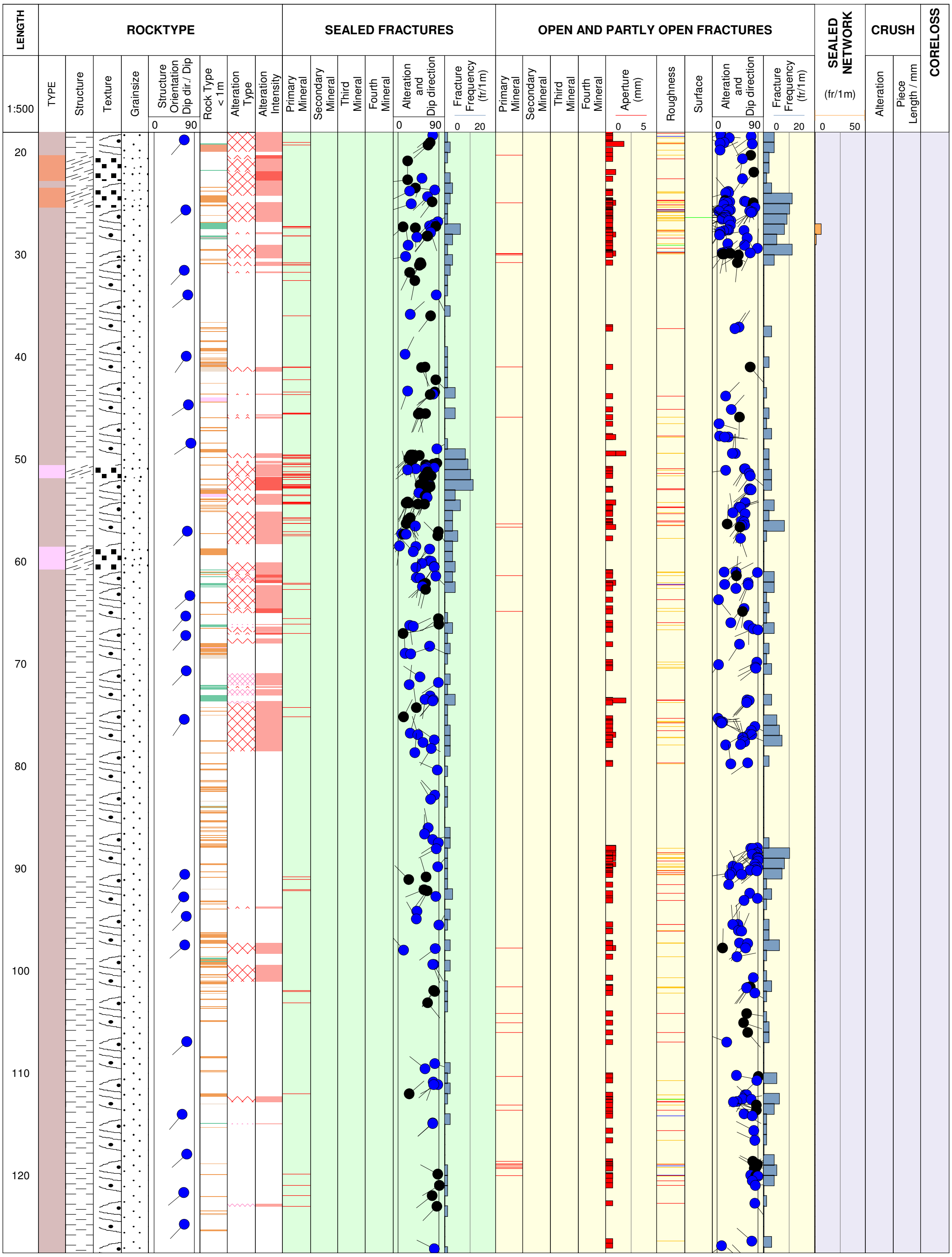

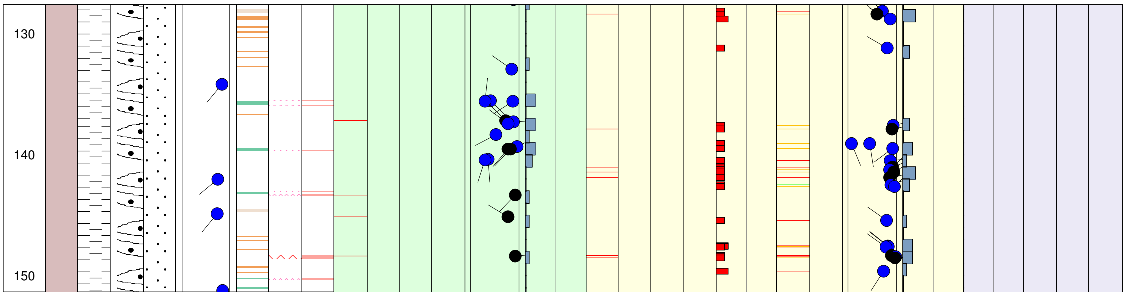

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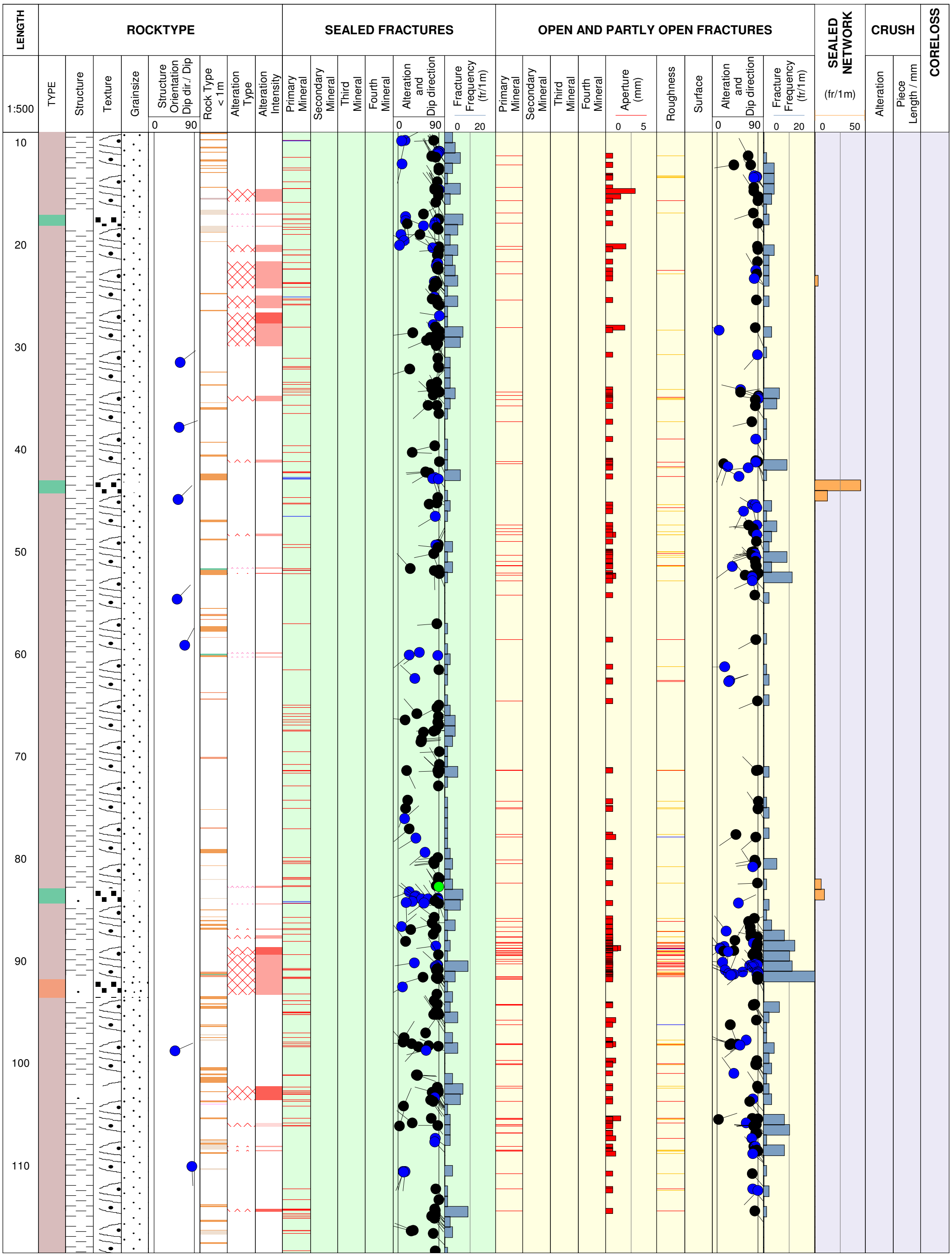
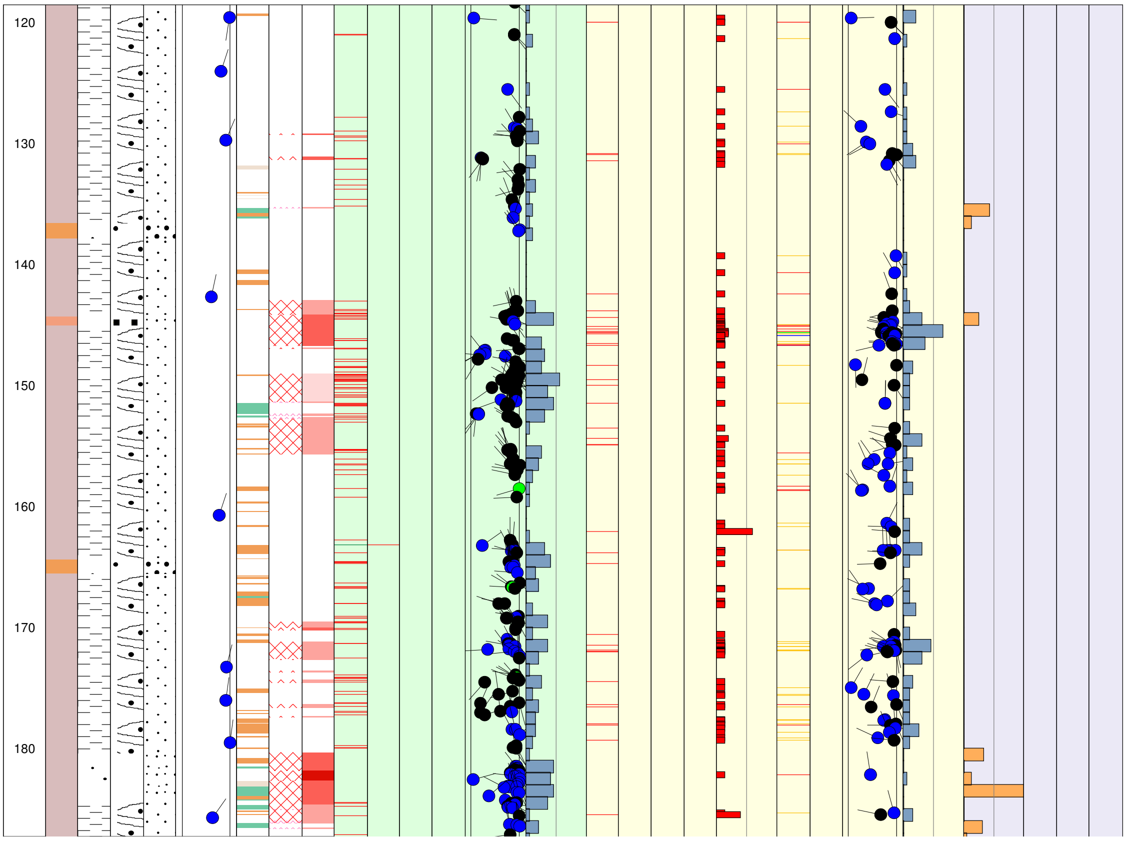
Title GEOLOGY IN HFM25 **Appendix: 1c**

Site	FORSMARK	Coordinate System	RT90-RHB70
Borehole	HFM25	Northing [m]	6699616.18
Diameter [mm]	139	Easting [m]	1633039.37
Length [m]	187.500	Elevation [m.a.s.l.]	3.86
Bearing [°]	140.84	Drilling Start Date	2005-09-05 14:00:00
Inclination [°]	-57.80	Drilling Stop Date	2005-09-08 12:15:00
Date of coremapping	2006-01-13 15:33:00	Plot Date	2006-10-16 21:58:09
Rocktype data from	p_rock	Signed data	





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Title **GEOLOGY IN HFM26** **Appendix: 1d**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM26	**Northing [m]**	6698008.93
Diameter [mm]	138	**Easting [m]**	1633516.39
Length [m]	202.700	**Elevation [m.a.s.l.]**	2.73
Bearing [°]	112.42	**Drilling Start Date**	2005-11-10 07:00:00
Inclination [°]	-53.74	**Drilling Stop Date**	2005-11-18 07:00:00
Date of coremapping	2006-09-25 12:02:00	**Plot Date**	2006-10-16 21:58:09
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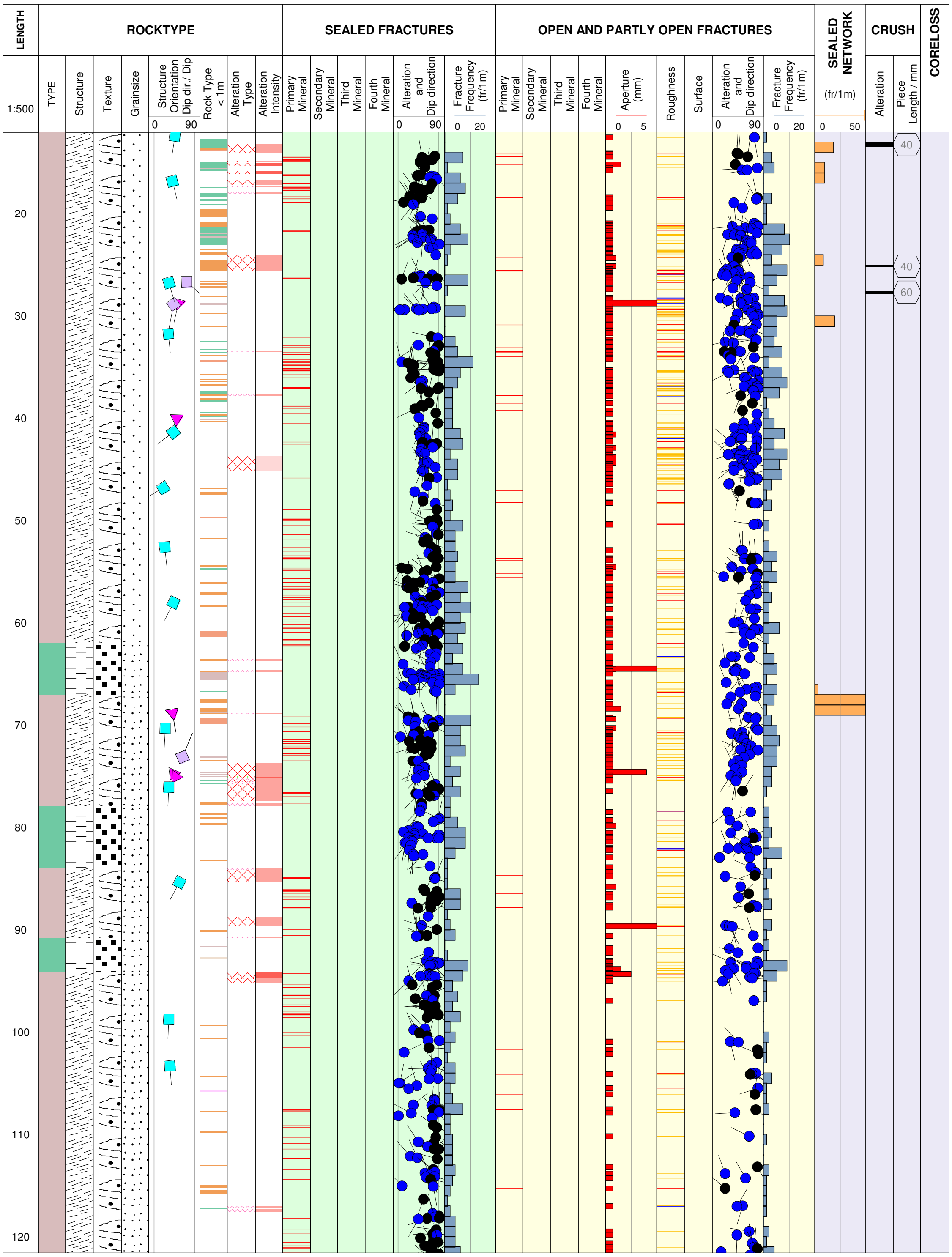

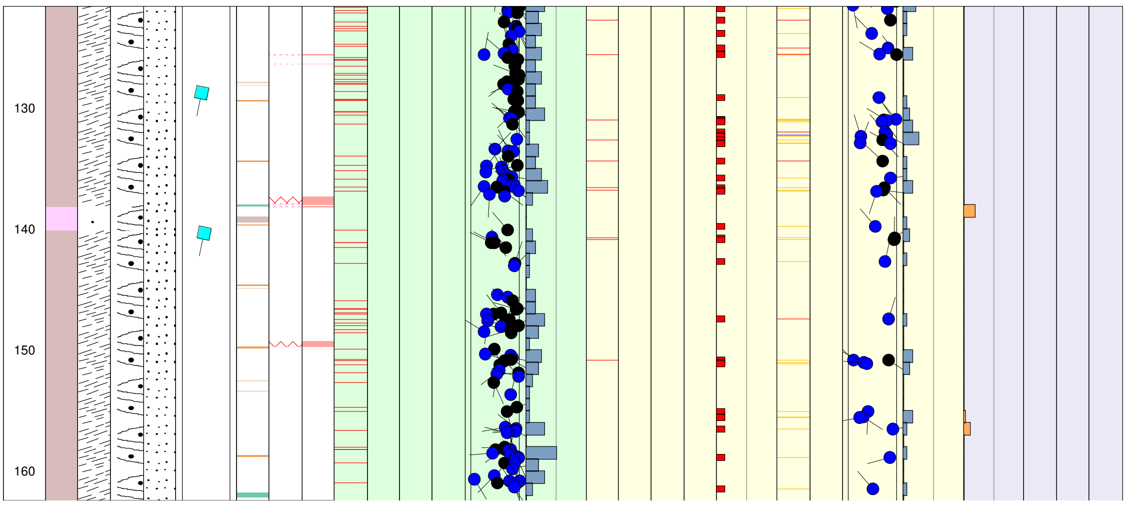

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Title **GEOLOGY IN HFM27** **Appendix: 1e**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM27	**Northing [m]**	6699595.26
Diameter [mm]	139	**Easting [m]**	1631245.94
Length [m]	127.500	**Elevation [m.a.s.l.]**	2.45
Bearing [°]	337.26	**Drilling Start Date**	2005-11-03 16:00:00
Inclination [°]	-67.82	**Drilling Stop Date**	2005-11-10 19:00:00
Date of coremapping	2006-02-22 12:47:00	**Plot Date**	2006-10-16 21:58:09
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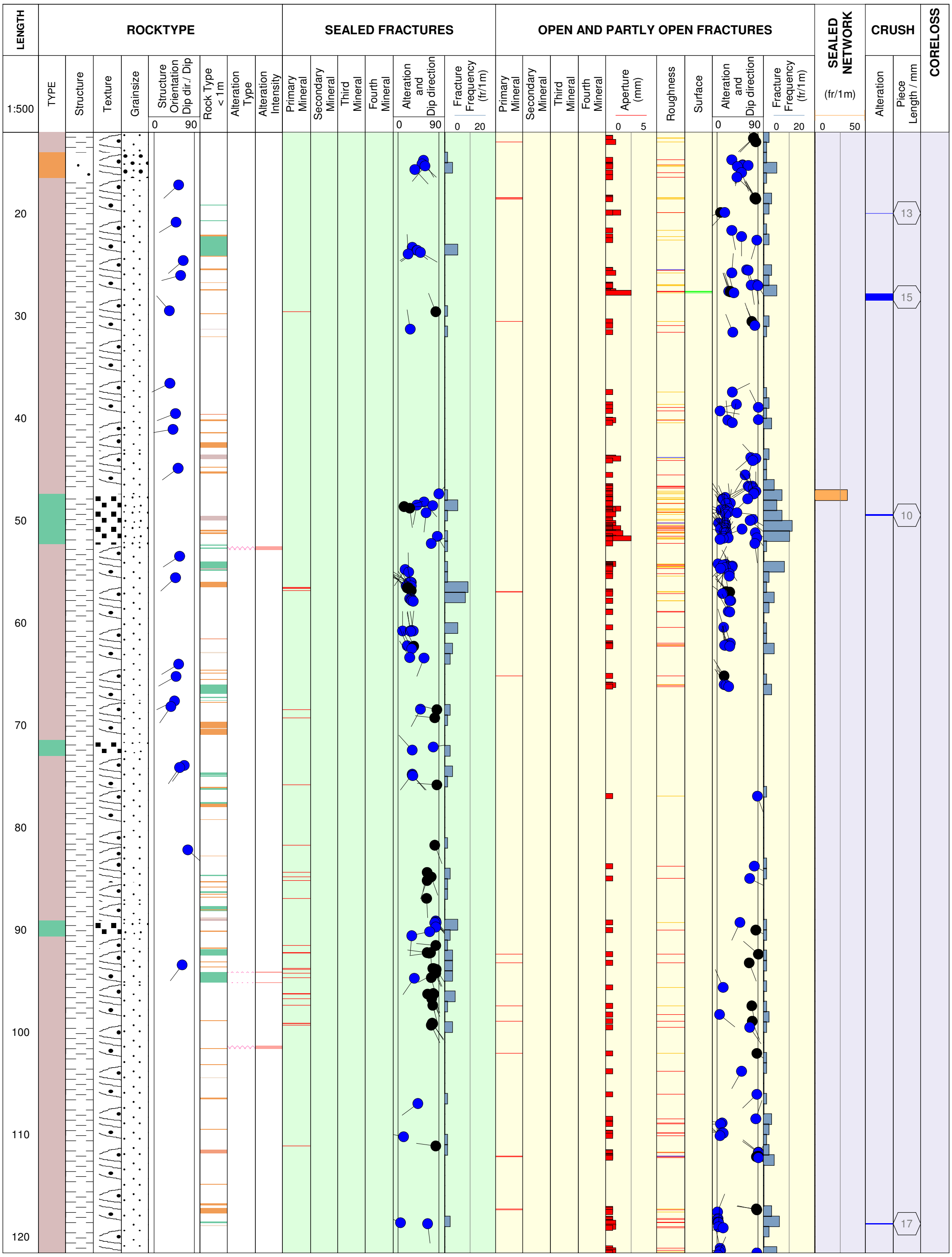

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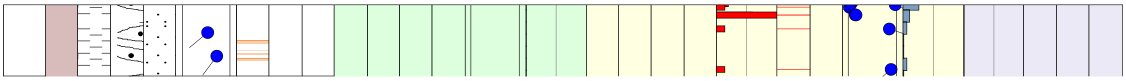

Title GEOLOGY IN HFM28 **Appendix: 1f**

Site	FORSMARK	Coordinate System	RT90-RHB70
Borehole	HFM28	Northing [m]	6700068.84
Diameter [mm]	135	Easting [m]	1630597.24
Length [m]	151.200	Elevation [m.a.s.l.]	4.27
Bearing [°]	146.78	Drilling Start Date	2005-09-12 13:30:00
Inclination [°]	-84.75	Drilling Stop Date	2005-09-14 19:00:00
Date of coremapping	2006-03-08 13:37:00	Plot Date	2006-10-16 21:58:09
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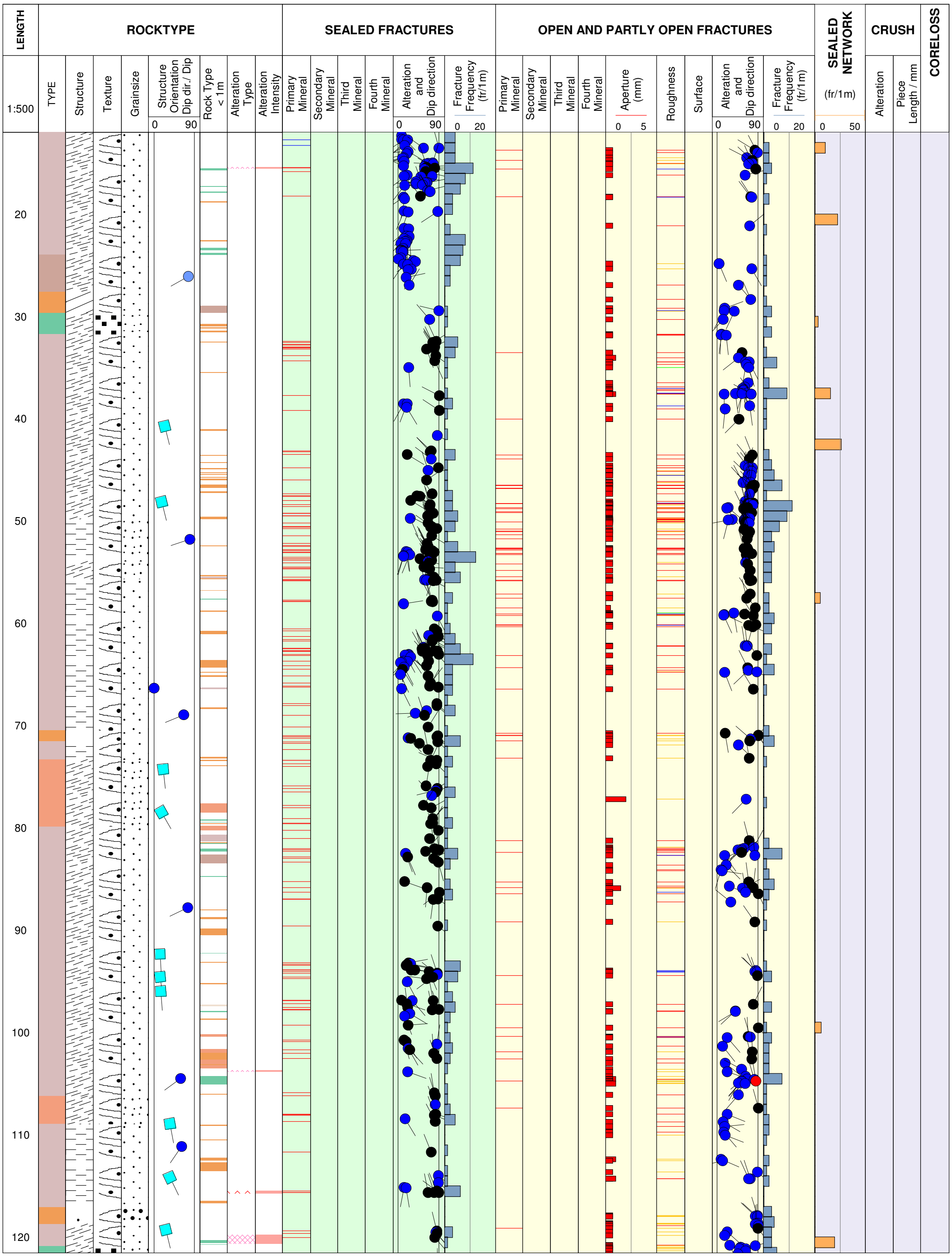

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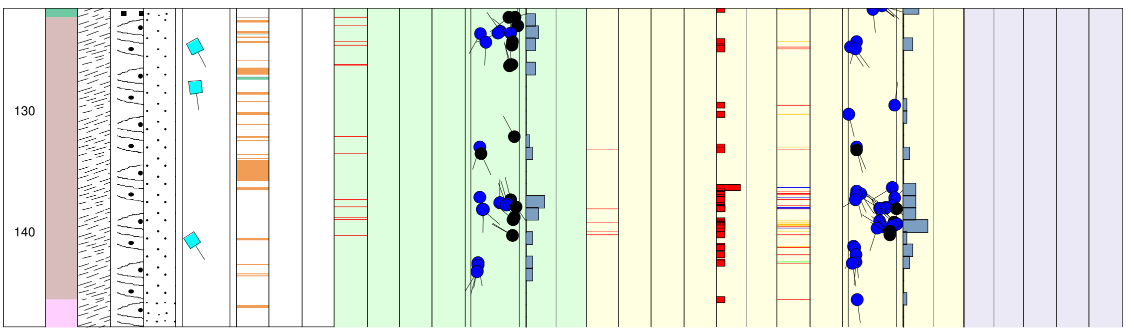

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Title GEOLOGY IN HFM29 **Appendix: 1g**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM29	**Northing [m]**	6698018.65
Diameter [mm]	138	**Easting [m]**	1632502.81
Length [m]	199.700	**Elevation [m.a.s.l.]**	4.47
Bearing [°]	29.95	**Drilling Start Date**	2005-12-12 07:00:00
Inclination [°]	-58.56	**Drilling Stop Date**	2005-12-19 12:30:00
Date of coremapping	2006-04-13 10:26:00	**Plot Date**	2006-10-16 21:58:09
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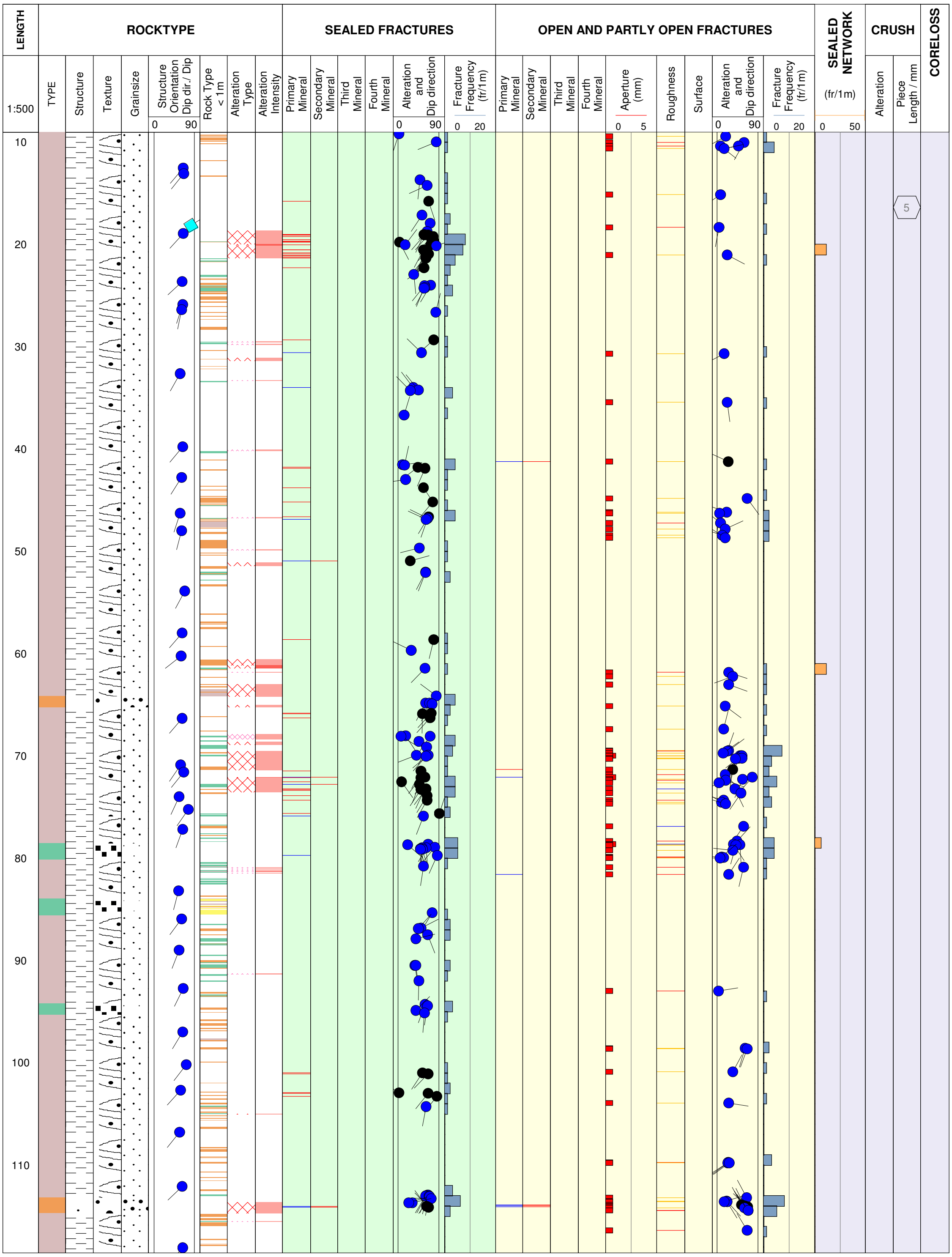

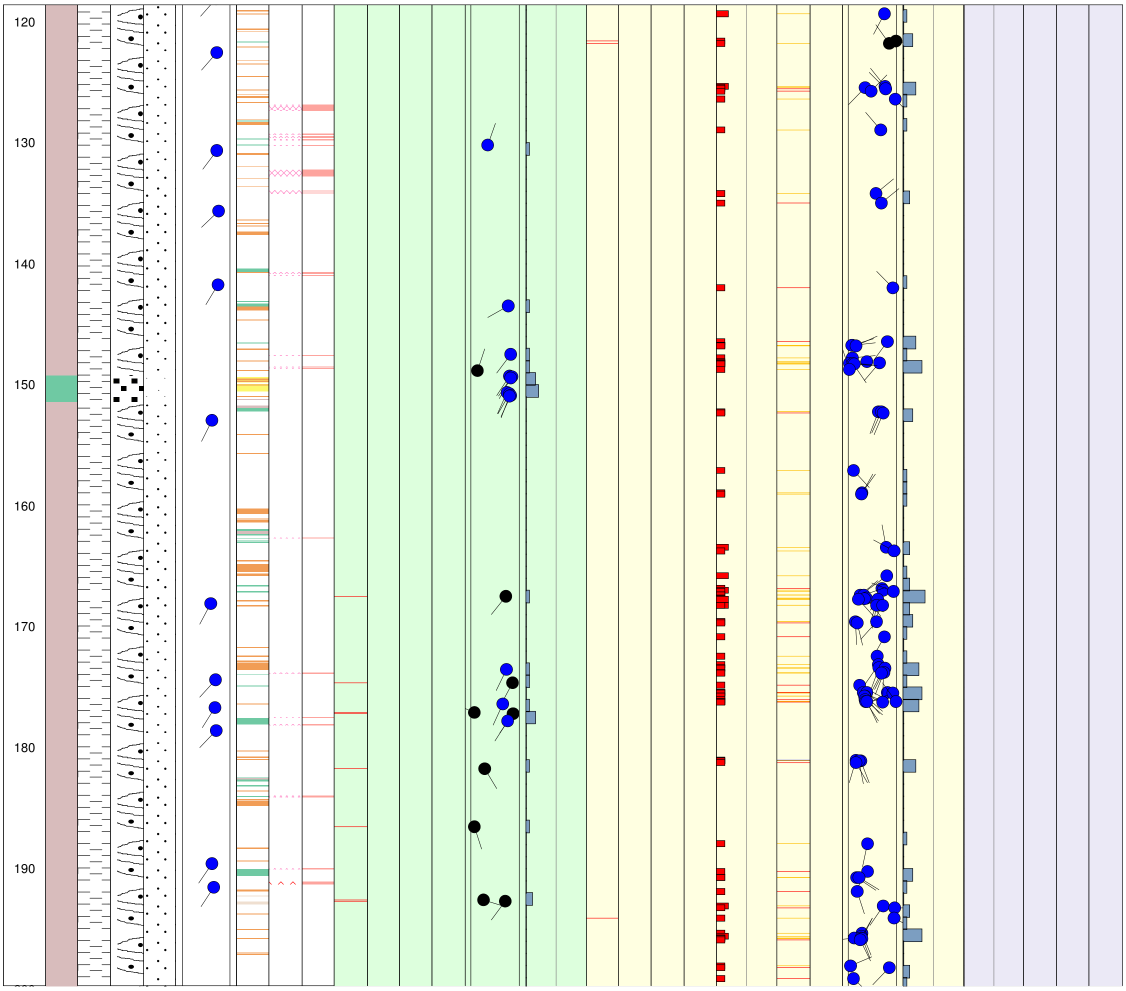
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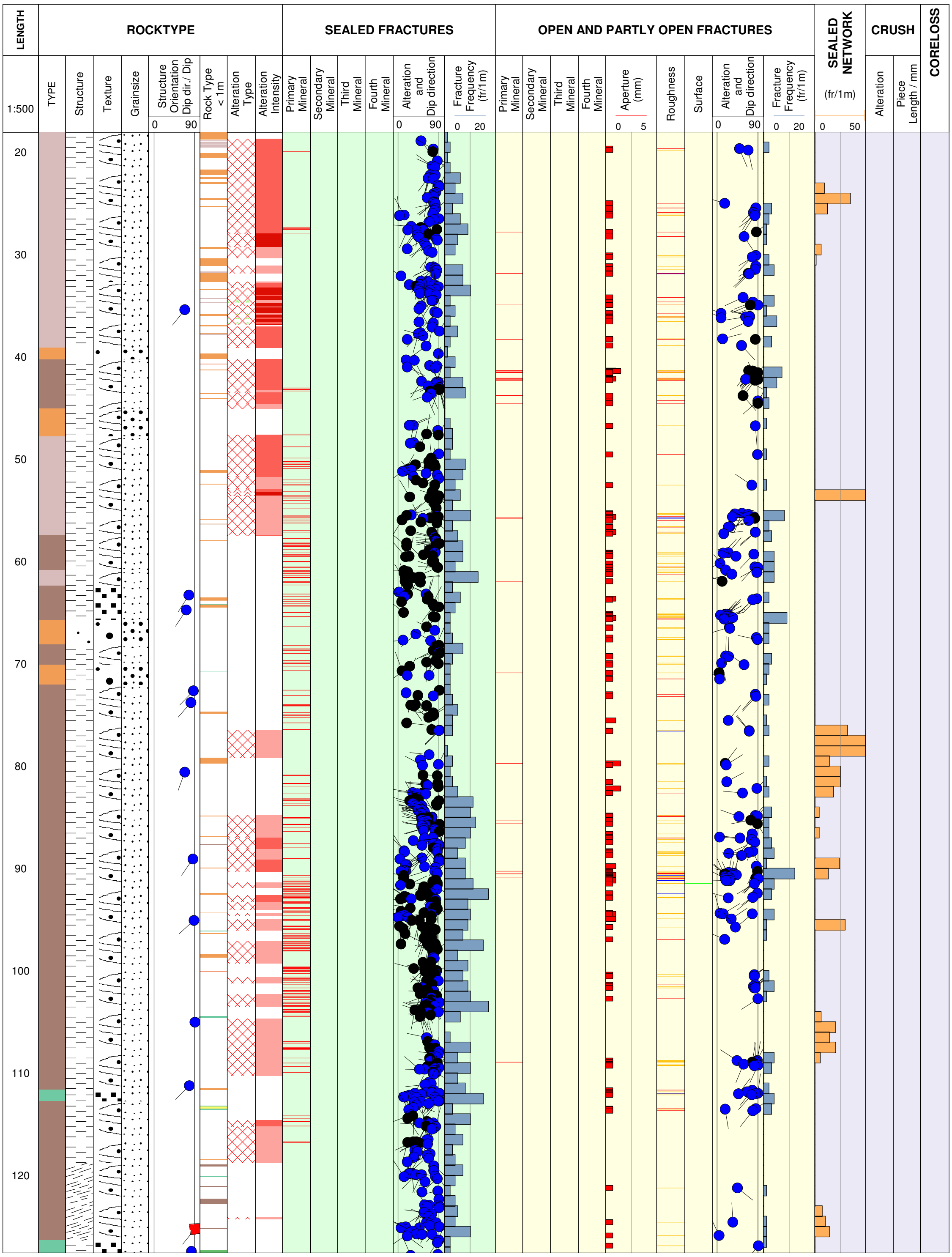
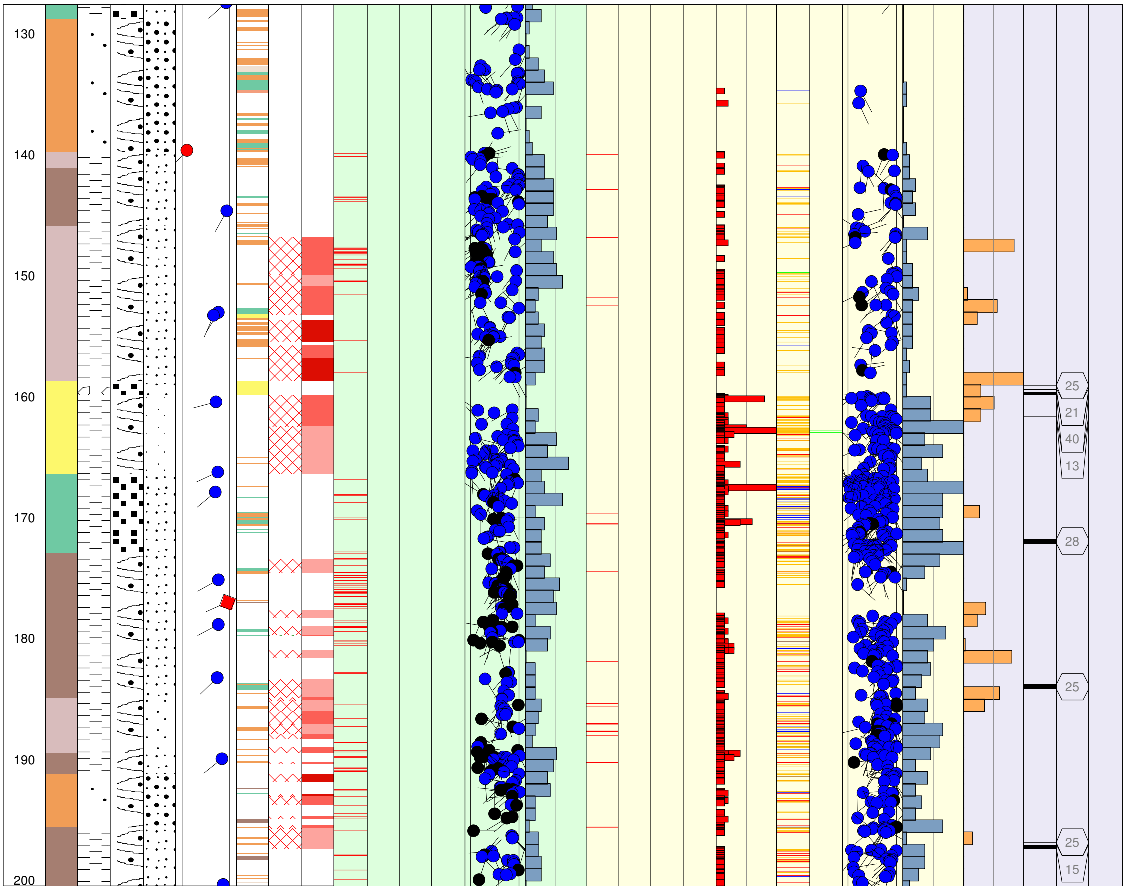
Title GEOLOGY IN HFM30 **Appendix: 1h**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM30	**Northing [m]**	6697930.95
Diameter [mm]	139	**Easting [m]**	1631819.57
Length [m]	200.750	**Elevation [m.a.s.l.]**	3.13
Bearing [°]	28.81	**Drilling Start Date**	2006-05-03 16:00:00
Inclination [°]	-55.49	**Drilling Stop Date**	2006-05-11 12:00:00
Date of coremapping	2006-09-05 20:16:00	**Plot Date**	2006-10-16 21:58:09
Rocktype data from	p_rock	**Signed data**	



Page 1



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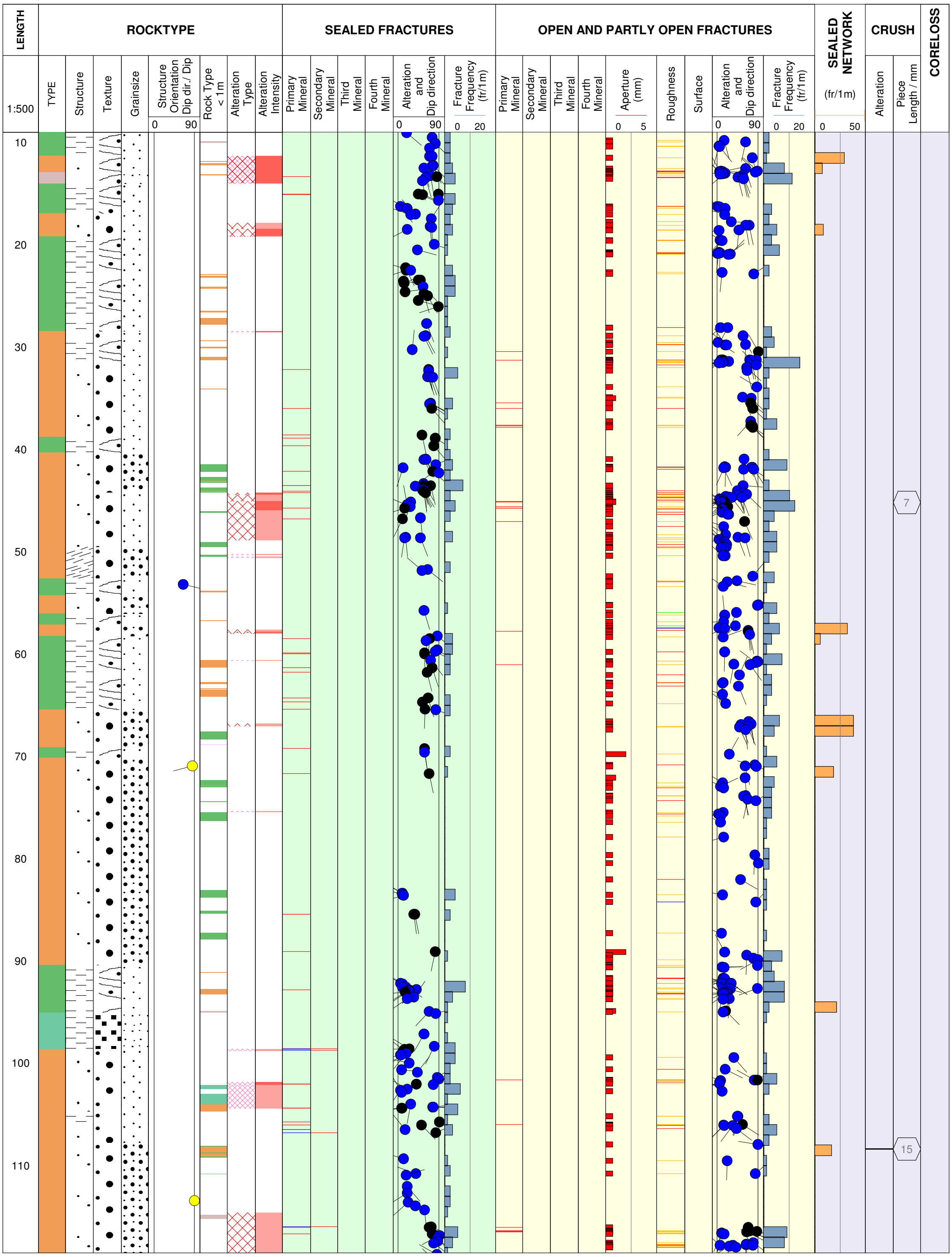
Title GEOLOGY IN HFM31 **Appendix: 1i**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM31	**Northing [m]**	6700860.44
Diameter [mm]	139	**Easting [m]**	1629207.28
Length [m]	200.750	**Elevation [m.a.s.l.]**	6.07
Bearing [°]	311.80	**Drilling Start Date**	2006-05-15 08:30:00
Inclination [°]	-69.22	**Drilling Stop Date**	2006-05-19 10:00:00
Date of coremapping	2006-06-09 10:46:00	**Plot Date**	2006-10-16 21:58:09
Rocktype data from	p_rock	**Signed data**	



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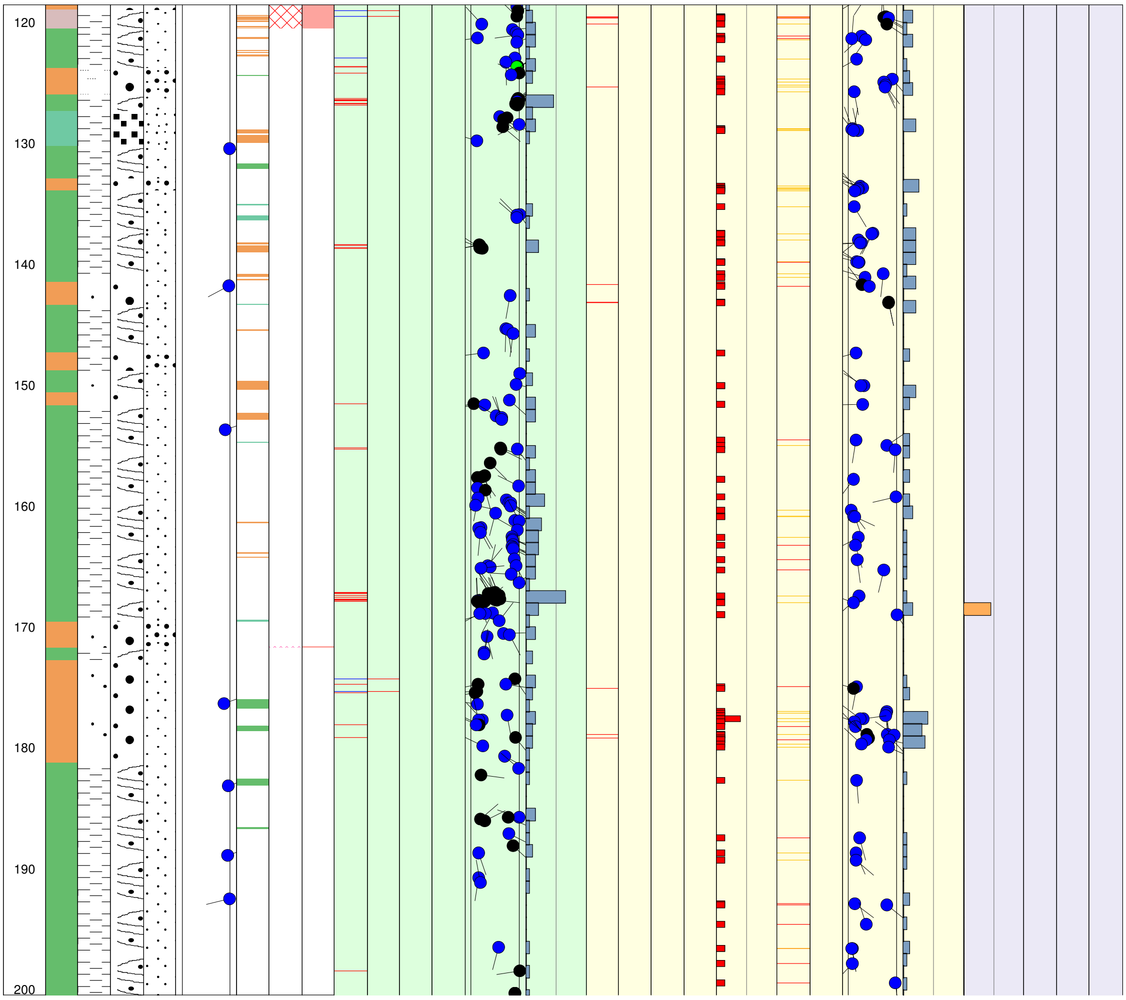

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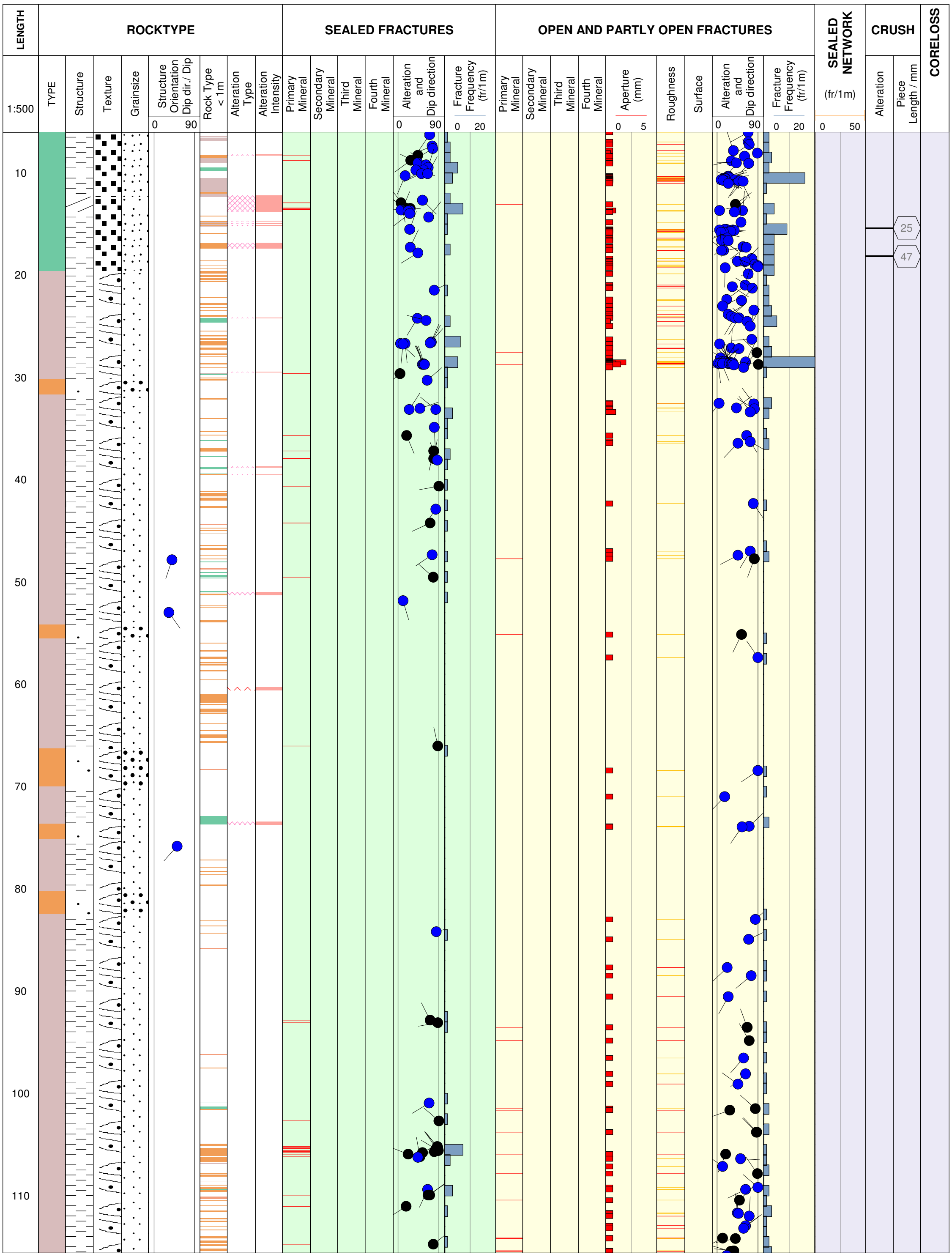
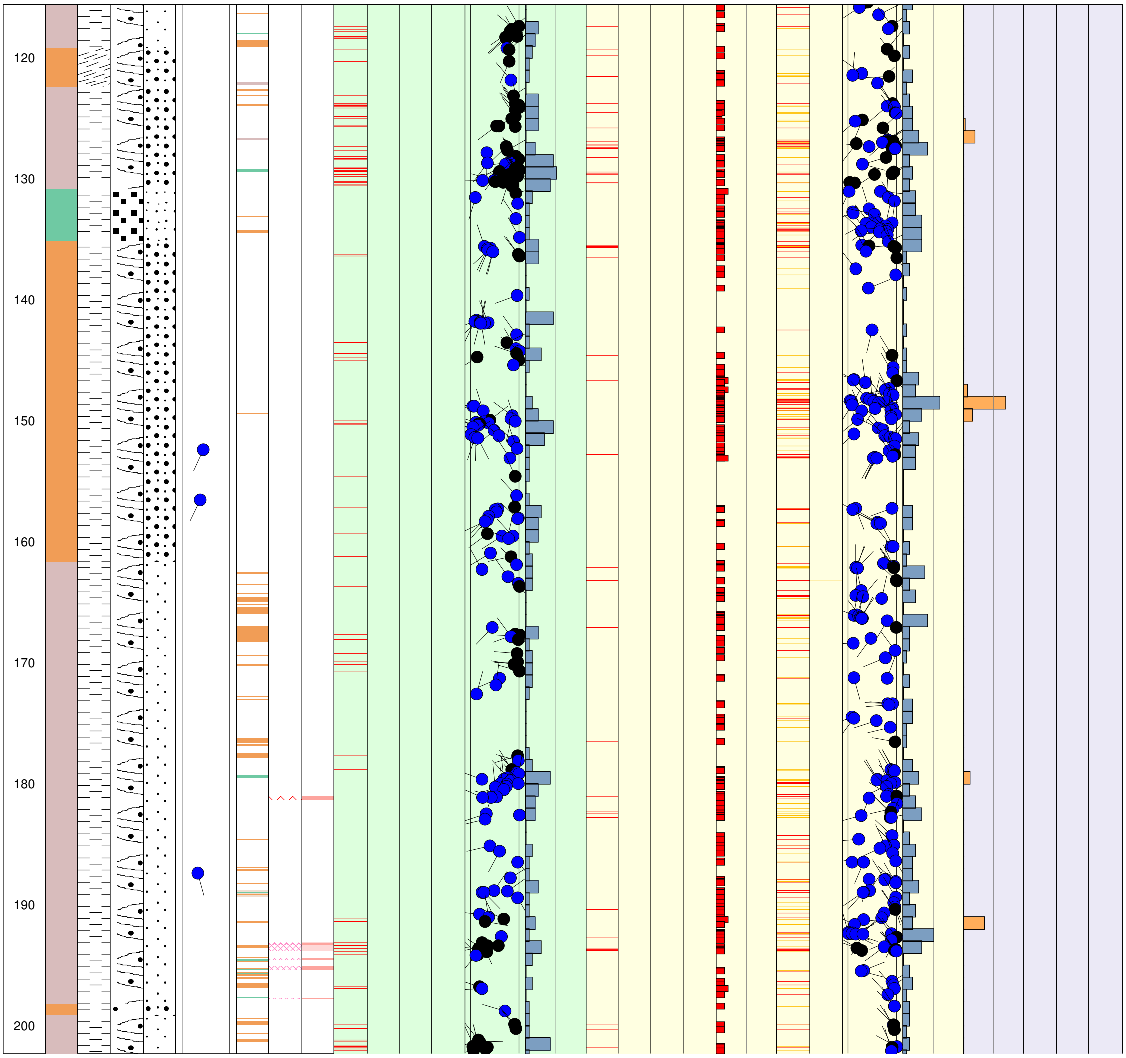
Title GEOLOGY IN HFM32 — Appendix: 1j

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	HFM32	**Northing [m]**	6699015.04
Diameter [mm]	132	**Easting [m]**	1632137.07
Length [m]	202.650	**Elevation [m.a.s.l.]**	0.97
Bearing [°]	116.15	**Drilling Start Date**	2006-01-11 08:30:00
Inclination [°]	-86.05	**Drilling Stop Date**	2006-01-14 16:00:00
Date of coremapping	2006-03-21 14:46:00	**Plot Date**	2006-10-16 21:58:09
Rocktype data from	p_rock	**Signed data**	





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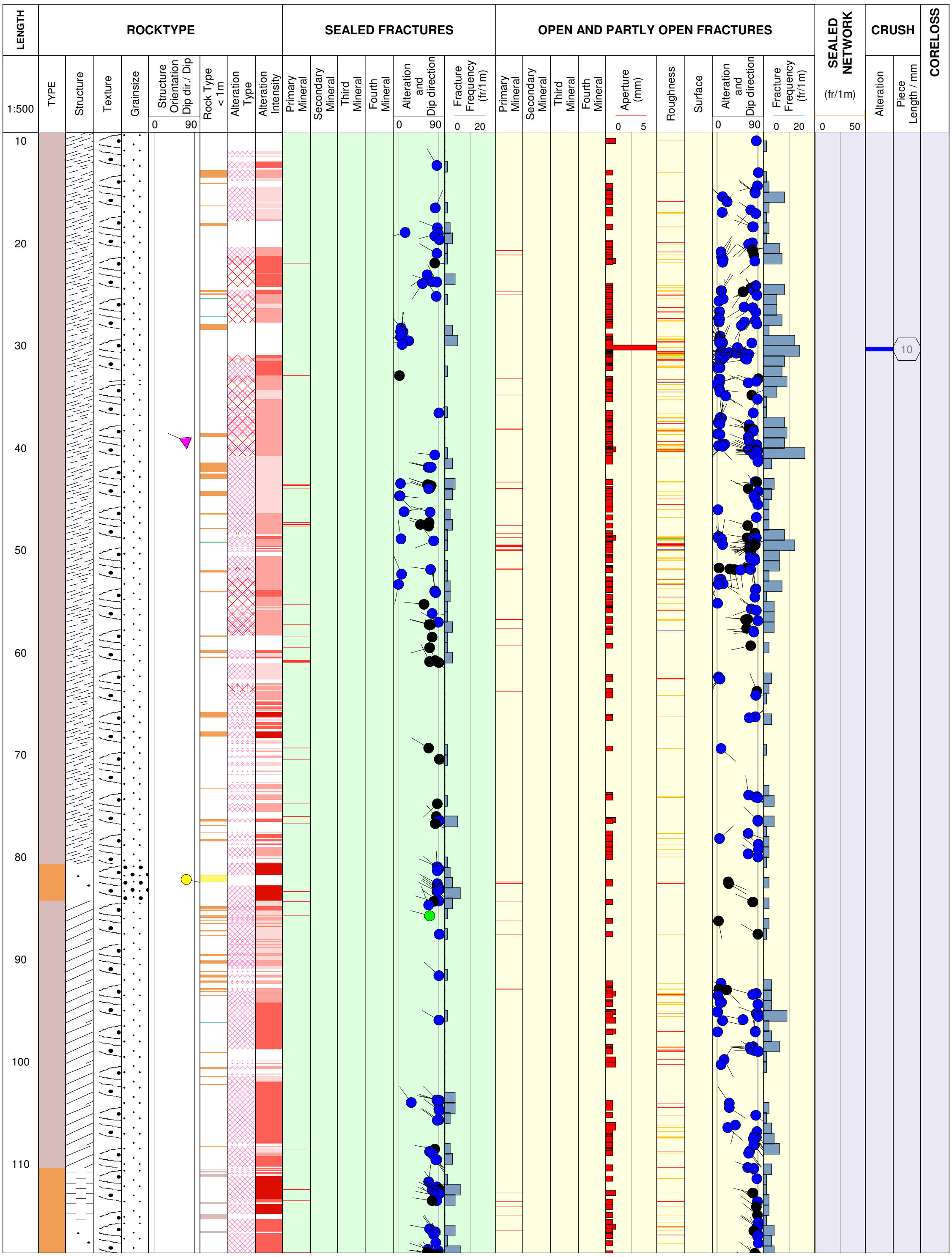
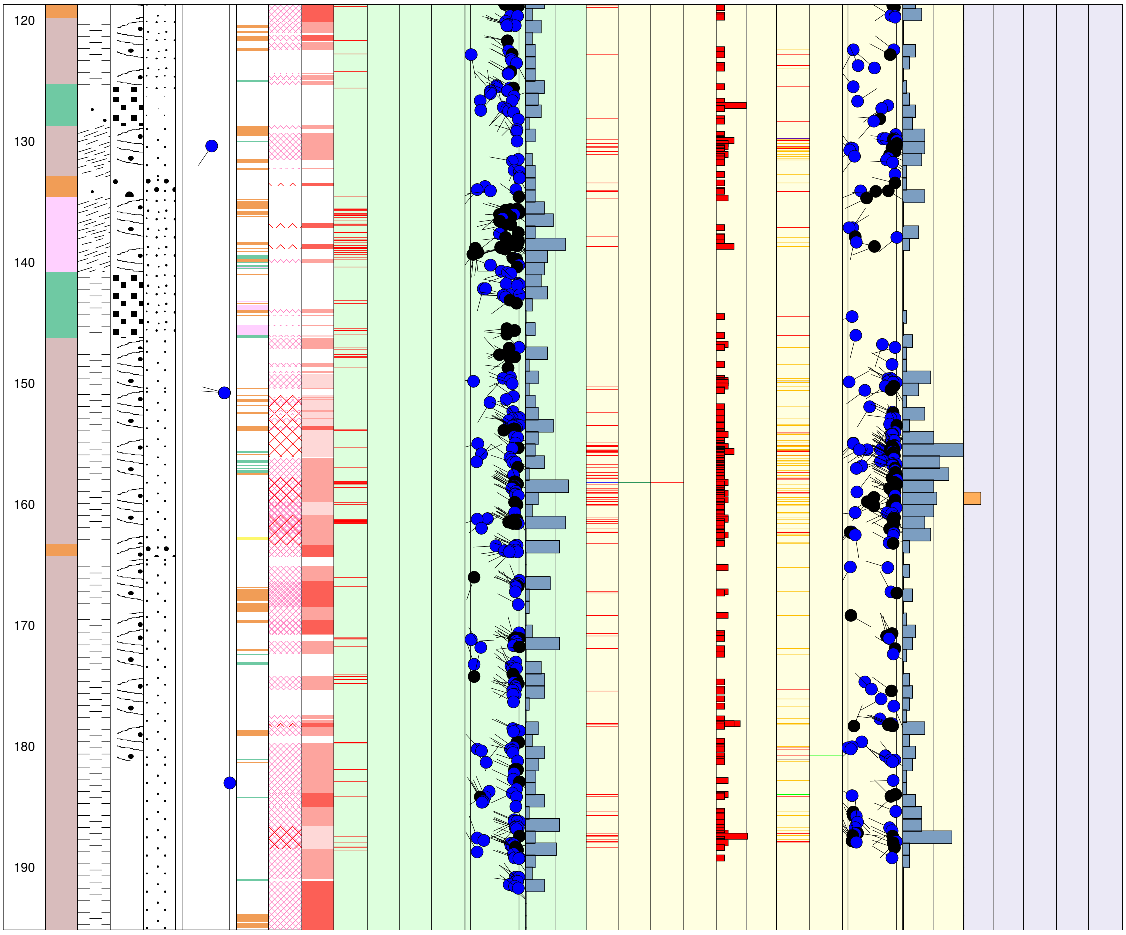
Title	GEOLOGY IN HFM38		Appendix: 1k
Site	FORSMARK	Coordinate System	RT90-RHB70
Borehole	HFM38	Northing [m]	6700701.28
Diameter [mm]	136	Easting [m]	1631301.71
Length [m]	200.750	Elevation [m.a.s.l.]	2.21
Bearing [°]	93.62	Drilling Start Date	2006-06-14 16:00:00
Inclination [°]	-54.44	Drilling Stop Date	2006-06-22 12:00:00
Date of coremapping	2006-09-05 15:29:00	Plot Date	2006-10-16 21:58:09
Rocktype data from	p_rock	Signed data	




120
130
140
150
160
170
180
190

Appendix 2

BIPS-image quality

Appendix 2a. BIPS Image Quality of HFM23

From	To	% visible	Comment
33.50	48.85	100	Good. Minor disturbances by mosaic pattern caused by stick-slip of the camera probe.
48.85	99.20	100	Relatively good. Mosaic pattern caused by stick-slip of the camera probe, approximatetly 2 cm stick-slip every meter.
79.20	100.50	100	Relatively good. Mosaic pattern caused by stick-slip of the camera probe.
108.40	153.60	75	Acceptable. Mud on lower side of borehole, partly transparent.
116.90	124.80	100	Good. Minor disturbances by mosaic pattern caused by stick-slip of the camera probe.
124.80	144.85	100	Relatively good. Mosaic pattern caused by stick-slip of the camera probe, approximatetly 2 cm stick-slip every meter.
144.85	147.20	100	Relatively good. Mosaic pattern caused by stick-slip of the camera probe.
147.20	179.49	100	Good. Minor disturbances by mosaic pattern caused by stick-slip of the camera probe.
179.49	179.74	100	Relatively good. Mosaic pattern caused by stick-slip of the camera probe.
179.74	180.70	100	Good. Minor disturbances by mosaic pattern caused by stick-slip of the camera probe.
180.70	180.90	100	Relatively good. Mosaic pattern caused by stick-slip of the camera probe.

Appendix 2b. BIPS Image Quality of HFM24

From	To	% visible	Comment
18.03	73.66	100	Good. Sporadic mosaic pattern caused by stick slip of the camera probe.
73.66	74.48	~100	Relatively good. Mosaic pattern due to stick slip of the camera probe, ca 1.5 mm long.
74.48	78.00	~100	Good. Very thin, mostly transparent cover of mud on lower side of borehole.
78.00	98.50	60	Acceptable. Mud on lower side of borehole, partly too thick to be transparent.
98.5	151.05	~90	Relatively good. Very thin cover of mud on lower side of borehole wall – covers approximately 50% but is almost transparent.

Appendix 2c. BIPS Image Quality of HFM25

From	To	% visible	Comment
9	11.44	100	Good
11.44	11.53	0	Bad. Very fast slipping of the camera while filming the borehole.
11.53	177.31	100	Good
177.31	180.10	100	Relatively good, but mosaic pattern due to stick-slip of the camera probe.
180.1	186.5	100	Good
186.5	187.20	70	Acceptable. Clay on lower side of borehole wall.

Appendix 2d. BIPS Image Quality of HFM26

From	To	% visible	Comment
12.03	79	100	Good
79	96	80	Relatively good. Thin cover of mud on lower side of borehole. Semitransparent.

96	115.5	75	Acceptable. Cover of mud on lower side of borehole.
115.5	161.63	60	Bad. Suspensions in the borehole fluid. Cover of mud on lower side of borehole.
161.63	~200	0-5	Clayey suspension and mud cover. Few features are sporadically visible. Not mapped.

Appendix 2e. BIPS Image Quality of HFM27

From	To	% visible	Comment
12.035	12.220	10	Bad. The image is covered by a greyish nontransparent material
12.220	127.627	100	Good. Somewhat diffuse, suspensions and uneven light

Appendix 2f. BIPS Image Quality of HFM28

From	To	% visible	Comment
12.015	124	100	Good. Lower side of borehole slightly over-exposed.
124	143	70-100	Good. Thin cover of mud on lower side of borehole.
143	145	70	Relatively good. Cover of mud on lower side of borehole.
145	148.41	50-60	Acceptable. Lower side of borehole almost black.

Appendix 2g. BIPS Image Quality of HFM29

From	To	% visible	Comment
9.03	18.32	100	Acceptable. Rough borehole wall surface. No water in borehole.
	18.32		Groundwater surface. Not horizontal (either 119/20 or 119/12) implying deviating maxibor measurement and/or orientation of BIPS image.
18.32	26	90	Acceptable. Rough borehole wall. White parallel streak on upper side of borehole
26	100	90	Good. White parallel streak on upper side of borehole
100	143	~75	Good. White parallel streak covering 10% on upper side of borehole. Thin cover of mud on right lower side of borehole. Debatable orientation quality.
143	199.4	80 (40)	Acceptable. White parallel streak covering 10% of upper side of borehole. Thin cover of mud covers 50% of lower side of borehole (possible to see through it) clay in suspension resulting in diffuse image.
192	199.4	80 (40)	Bad. Clay in suspension resulting in diffuse image.

Appendix 2h. BIPS Image Quality of HFM30

From	To	% visible	Comment
18.03	200.45	100	Good.

Appendix 2i. BIPS Image Quality of HFM31

From	To	% visible	Comment
101	180.90	70	Good. Thin cover of mud on the lower side of the borehole.

Appendix 2j. BIPS Image Quality of HFM32

From	To	% visible	Comment
6.03	201.70	100	Good.
201.70	202.35	50	Bad. The image is diffuse, probably due to clay in suspension.

Appendix 2k. BIPS Image Quality of HFM38

From	To	% visible	Comment
9.146	145.80	100	Good.
145.80	188.70	80	Good. Thin cover of mud on the lower side of the borehole.
188.70	194.791	50	Acceptable. Relatively thin cover of mud on the lower side of the borehole.

Appendix 3

Investigated drill cuttings

Borehole	Sample (m)	Colour treated sample	Rock type	Rock type ratio	Comment	Date
HFM24	19	Reddish brown	101057 + 101061	90/10	Biotite somewhat chlorite altered. Also some muscovite.	2006-03-23
HFM24	21	Greenish brown	101057	100	Relatively rich in biotite and chlorite. Biotite is chlorite-altered. Some very fine-grained greyish white grains - from deformation bands?	2006-03-23
HFM24	22	Greenish brown	101057	100	Relatively rich in biotite and chlorite. Biotite is chlorite-altered. Some very fine-grained greyish white grains - from deformation bands?	2006-03-23
HFM24	23	Red	101057		Biotite somewhat chlorite-altered. Some quartz-grains.	2006-03-23
HFM24	24	Red	101057 + 101061	95/05	Poor in biotite, which is somewhat chlorite-altered.	2006-03-23
HFM24	25	Greyish red	101057 + 101061	95/05	Chlorite on fracture surfaces. Biotite somewhat chlorite altered. Some larger fragments.	2006-03-23
HFM24	61	Red	101057 + 102017	95/05	strongly red 101057, biotite partly chlorite altered. Foliated. 102017 with epidote-bands (light green).	2006-03-23
HFM24	62	Greyish red	101057 + 102017 + 101061	80/15/05	Epidote rich bands, especially in 102017 but also in 101057.	2006-03-23
HFM26	156	Pinkish red	101057 + 101061	95/05	Sample taken because of very dark BIPS-image.	2006-03-23
HFM26	157	Pinkish red	101057 + 101061	95/05	Sample taken because of very dark BIPS-image.	2006-03-23
HFM26	158	Pinkish red	101057 + 101061	90/10	Sample taken because of very dark BIPS-image.	2006-03-23
HFM26	168	Red	101057	100	Traces of epidote-grains and aphanitic dark grains. Sample taken because of bad BIPS-image.	2006-03-23
HFM30	23	Reddish brown	101057 + 101061	70/30	Fine-medium grained. Relatively poor in biotite.	2006-09-26
HFM30	24	Brownish red	101057 + 101061	50/50	Fine-medium grained. Relatively poor in biotite.	2006-09-26
HFM30	25	Reddish brown	101057	100	Fine-medium grained. Relatively poor in biotite.	2006-09-26

Borehole	Sample (m)	Colour treated sample	Rock type	Rock type ratio	Comment	Date
HFM30	34	Dark brownish red	101057	100	Medium grained.	2006-09-26
HFM30	35	Brownish red	101057 + 101061	95/05	Medium grained.	2006-09-26
HFM30	36	Brownish red	101057 + 101061	100	Medium grained. Traces of epidote.	2006-09-26
HFM30	151	Red	101057	95/05	Fine-medium grained. Also epidote.	2006-09-26
HFM30	152	Red	101057 + 101061	100	Fine-medium grained. Also epidote.	2006-09-26
HFM30	196	Greyish red	101061 + 101054	95/05	Medium-grained. Epidote. Slickensided surface.	2006-09-26
HFM30	197	Greyish red	101061 + 101054	90/10	Medium-grained. Epidote.	2006-09-26
HFM32	10	Greenish black	102017	100	Some smooth chlorite-surfaces.	2006-03-23
HFM32	13	Grey	101057 + 102017	90/10	Bleached, grey to light grey. Deformed. Fracture surfaces with chlorite and some larger fragments.	2006-03-23
HFM32	16	Dark grey	102017	100	Foliated. Relatively big fragments.	2006-03-23
HFM32	19	Dark grey	102017	100	Also light green mineral - could be epidote or chlorite. Few larger fragments.	2006-03-23
HFM32	22	Light reddish grey	101057	100	Larger quartz fragment, possibly from quartz-vein. Fractures surface with calcite.	2006-03-23
HFM32	32	Light pinkish grey	101057	100		2006-03-23

In-data: Borehole length and diameter

Hole Diam T - Drilling: Borehole diameter

HFM23, 2005-08-24 13:00:00 - 2005-09-01 14:00:00 (0.000 - 211.500 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	20.800	0.1820	Tabex 140
20.800	115.000	0.1360	Styrd borrning 137.0/136.0
115.000	211.500	0.1340	Styrd borrning 136/ tre stift trasiga vid avslutad borrning

Printout from SICADA 2006-02-20 16:18:25.

Hole Diam T - Drilling: Borehole diameter

HFM24, 2005-11-22 10:00:00 - 2005-11-22 11:00:00 (0.000 - 151.350 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	18.030	0.1800	
18.030	100.350	0.1390	Omslipning vid 100.35 till 138.9 mm
100.350	151.350	0.1377	Vid borrslut

Printout from SICADA 2006-02-20 16:20:13.

Hole Diam T - Drilling: Borehole diameter

HFM25, 2005-09-05 14:00:00 - 2005-09-08 12:15:00 (0.000 - 187.500 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	9.100	0.1780	
9.100	187.500	0.1386	Krona 139.5 mm vid 115.2 m

Printout from SICADA 2005-12-20 09:20:37.

Hole Diam T - Drilling: Borehole diameter

HFM26, 2005-11-10 07:00:00 - 2005-11-18 07:00:00 (0.000 - 202.700 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	12.030	0.1800	
12.030	115.350	0.1400	Omslipning vid 115.35 m till 139.9 mm
115.350	202.700	0.1384	Vid borrslut

Printout from SICADA 2006-02-20 16:22:10.

Hole Diam T - Drilling: Borehole diameter

HFM27, 2005-11-03 16:00:00 - 2005-11-10 19:00:00 (0.000 - 127.500 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	12.030	0.1800	
12.030	110.000	0.1399	Omslipning vid 110 m till 139.8 mm
110.000	127.500	0.1386	Vid borrslut

Printout from SICADA 2006-02-20 16:24:21.

Hole Diam T - Drilling: Borehole diameter

HFM28, 2005-09-12 13:30:00 - 2005-09-14 19:00:00 (0.000 - 151.200 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
12.100	117.900	0.1368	Krona 138,3 mm vid 12,10 m
117.900	151.200	0.1351	Krona 136,8 mm vid 117,90 m

Printout from SICADA 2005-12-20 09:23:48.

Hole Diam T - Drilling: Borehole diameter

HFM29, 2005-12-12 07:00:00 - 2005-12-19 12:30:00 (0.000 - 199.700 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	9.030	0.1800	
9.030	85.700	0.1402	Omslipning vid 85.70 m till 140.1 mm
85.700	199.700	0.1381	vid borrslut

Printout from SICADA 2006-04-10 13:15:28.

Hole Diam T - Drilling: Borehole diameter

HFM30, 2006-05-03 16:00:00 - 2006-05-11 12:00:00 (0.000 - 200.750 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.300	18.030	0.1800	
18.030	122.250	0.1397	Omslipning vid 122,25 m till 139,5 mm
122.250	200.750	0.1387	Krona vid borrslut

Printout from SICADA 2006-11-24 12:59:12.

Hole Diam T - Drilling: Borehole diameter

HFM31, 2006-05-15 08:30:00 - 2006-05-19 10:00:00 (0.000 - 200.750 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.300	9.030	0.1800	
9.030	122.250	0.1399	Omslipning vid 122,25 m till 139,0 mm
122.250	200.750	0.1385	Krona vid borrslut

Printout from SICADA 2006-11-24 13:00:51.

Hole Diam T - Drilling: Borehole diameter

HFM32, 2006-01-11 08:30:00 - 2006-01-14 16:00:00 (0.000 - 202.650 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	6.030	0.1750	Tubex 140
6.030	106.600	0.1392	Ny krona vid borrstart har diameter 0,141 m. Vid upptag uppdagades trasig chuck och krona.
106.600	169.650	0.1358	Begagnad krona vid omstart har diameter 0,1375 m
169.650	202.650	0.1318	Omslipning vid 169,65 m till 135,5 mm. Kronan vid borrslut. (Kronan trasig)

Printout from SICADA 2006-02-20 16:26:10.

Hole Diam T - Drilling: Borehole diameter

HFM38, 2006-06-14 16:00:00 - 2006-06-22 12:00:00 (0.000 - 200.750 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.350	9.050	0.1800	Krona vid start 141,0mm.
9.050	122.250	0.1390	Omslip 122,25 till 138,4mm.
122.250	200.750	0.1360	Krona vid borrslut 136.0mm

Printout from SICADA 2006-08-23 15:46:58.

Appendix 5

In-data: Deviation data

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM23, 2006-06-15 08:00:00 - 2006-06-15 14:45:00 (3.000 - 204.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
3.00	-59.41	322.19
6.00	-58.92	322.03
9.00	-58.32	321.87
12.00	-57.64	321.71
15.00	-56.96	321.55
18.00	-56.28	321.39
21.00	-55.23	321.39
24.00	-54.28	321.41
27.00	-53.40	321.32
30.00	-52.42	320.96
33.00	-51.68	319.54
36.00	-50.27	320.08
39.00	-48.99	319.68
42.00	-47.66	319.12
45.00	-46.44	319.29
48.00	-45.21	319.20
51.00	-44.00	319.37
54.00	-42.93	319.48
57.00	-41.85	318.60
60.00	-40.75	319.05
63.00	-39.71	319.37
66.00	-38.78	319.69
69.00	-37.89	319.37
72.00	-36.67	319.70

75.00	-35.45	319.53
78.00	-34.00	319.58
81.00	-32.40	319.61
84.00	-30.54	319.84
87.00	-29.24	319.70
90.00	-27.70	319.92
93.00	-26.30	319.39
96.00	-24.86	320.61
99.00	-23.70	320.23
102.00	-22.60	319.84
105.00	-21.68	319.65
108.00	-20.49	319.47
111.00	-19.02	319.21
114.00	-17.71	319.06
117.00	-16.64	319.10
120.00	-15.58	319.13
123.00	-14.87	318.88
126.00	-13.71	318.64
129.00	-12.49	318.85
132.00	-11.18	318.85
135.00	-10.02	318.76
138.00	-9.00	318.67
141.00	-8.16	318.60
144.00	-7.26	318.56
147.00	-6.44	318.51
150.00	-5.47	318.48
153.00	-4.59	318.26
156.00	-3.55	318.26
159.00	-2.99	318.03
162.00	-2.54	317.98
165.00	-1.30	317.72
168.00	-0.46	317.67
171.00	0.38	317.62
174.00	1.09	317.53
177.00	1.74	317.34

180.00	2.77	317.39
183.00	3.61	318.01
186.00	4.44	317.62
189.00	5.43	318.42
192.00	6.13	316.85
195.00	7.21	316.64
198.00	7.90	316.78
201.00	8.64	316.71
204.00	9.35	317.26

Printout from SICADA 2006-09-15 09:51:32.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM24, 2006-01-25 10:00:00 - 2006-01-25 10:55:00 (21.000 - 150.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
21.00	-57.75	46.01
24.00	-57.80	46.19
27.00	-57.94	46.21
30.00	-58.14	46.33
33.00	-58.52	47.47
36.00	-58.84	47.38
39.00	-59.16	47.41
42.00	-59.45	47.68
45.00	-59.72	47.84
48.00	-59.91	48.12
51.00	-60.15	48.10
54.00	-60.30	48.28
57.00	-60.51	48.26
60.00	-60.65	48.49
63.00	-60.73	48.81
66.00	-60.94	48.44
69.00	-61.05	48.83
72.00	-61.17	48.86

75.00	-61.43	49.20
78.00	-61.66	49.37
81.00	-61.80	49.42
84.00	-61.98	49.65
87.00	-62.13	49.87
90.00	-62.36	49.82
93.00	-62.66	50.34
96.00	-62.89	50.03
99.00	-62.99	50.32
102.00	-63.09	50.53
105.00	-63.24	51.02
108.00	-63.40	51.11
111.00	-63.54	50.97
114.00	-63.75	51.12
117.00	-63.88	51.34
120.00	-64.05	51.79
123.00	-64.27	51.56
126.00	-64.41	51.46
129.00	-64.57	51.99
132.00	-64.75	52.38
135.00	-64.90	52.57
138.00	-65.03	52.55
141.00	-65.19	52.44
144.00	-65.34	52.68
147.00	-65.49	53.47
150.00	-65.73	53.87

Printout from SICADA 2006-02-20 16:13:38.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM25, 2005-09-12 13:03:00 - 2005-09-12 14:00:00 (12.000 - 186.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
12.00	-57.55	139.32
15.00	-57.27	138.84
18.00	-57.03	138.67
21.00	-56.53	139.01
24.00	-56.24	138.65
27.00	-55.76	138.74
30.00	-55.46	138.87
33.00	-54.95	138.93
36.00	-54.60	138.39
39.00	-54.15	139.09
42.00	-53.85	137.94
45.00	-53.37	137.85
48.00	-53.24	138.57
51.00	-52.91	137.76
54.00	-52.43	138.12
57.00	-52.01	138.80
60.00	-51.60	137.85
63.00	-51.08	137.73
66.00	-50.59	137.74
69.00	-50.10	137.93
72.00	-49.64	137.52
75.00	-49.12	137.28
78.00	-48.81	136.61
81.00	-48.42	137.45
84.00	-48.16	137.08
87.00	-47.73	136.84
90.00	-47.41	137.29
93.00	-46.92	137.77
96.00	-46.73	136.64

99.00	-46.42	136.61
102.00	-46.11	136.72
105.00	-45.76	136.67
108.00	-45.42	136.42
111.00	-45.11	136.60
114.00	-44.58	137.92
117.00	-44.34	136.63
120.00	-44.14	136.83
123.00	-43.89	136.30
126.00	-43.67	136.77
129.00	-43.46	136.71
132.00	-43.18	136.71
135.00	-42.96	136.91
138.00	-42.71	137.31
141.00	-42.41	136.33
144.00	-42.11	136.65
147.00	-41.89	136.33
150.00	-41.64	136.92
153.00	-41.38	136.89
156.00	-41.09	136.92
159.00	-40.85	137.13
162.00	-40.50	136.53
165.00	-40.22	136.61
168.00	-39.88	136.49
171.00	-39.68	136.41
174.00	-39.34	136.47
177.00	-39.05	135.71
180.00	-38.78	136.03
183.00	-38.56	135.68
186.00	-38.27	135.35

Printout from SICADA 2006-09-27 15:34:46.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM26, 2005-11-22 08:00:00 - 2005-11-22 09:00:00 (15.000 - 201.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
15.00	-52.19	109.76
18.00	-51.97	110.63
21.00	-51.75	108.99
24.00	-51.43	111.58
27.00	-51.19	111.26
30.00	-51.01	111.37
33.00	-50.91	112.59
36.00	-50.59	112.87
39.00	-50.22	111.77
42.00	-50.01	112.23
45.00	-49.85	112.92
48.00	-49.61	113.11
51.00	-49.43	113.89
54.00	-49.18	113.78
57.00	-48.93	113.69
60.00	-48.75	114.48
63.00	-48.63	114.82
66.00	-48.84	115.51
69.00	-48.45	116.23
72.00	-48.26	115.29
75.00	-48.05	116.52
78.00	-47.77	116.80
81.00	-47.52	117.56
84.00	-46.98	117.41
87.00	-46.79	117.62
90.00	-46.62	118.07
93.00	-46.46	118.05
96.00	-46.12	118.16
99.00	-45.84	118.20

102.00	-45.53	119.46
105.00	-45.18	119.02
108.00	-44.92	118.41
111.00	-44.48	118.52
114.00	-44.12	119.39
117.00	-44.00	118.52
120.00	-44.05	118.92
123.00	-43.99	118.57
126.00	-43.98	119.00
129.00	-43.93	118.96
132.00	-43.84	119.71
135.00	-43.76	118.57
138.00	-43.69	119.25
141.00	-43.65	119.42
144.00	-43.45	119.56
147.00	-43.40	119.35
150.00	-43.30	119.34
153.00	-43.26	120.25
156.00	-43.19	119.53
159.00	-43.20	120.28
162.00	-43.36	121.10
165.00	-43.28	120.80
168.00	-43.24	120.17
171.00	-43.11	120.81
174.00	-43.06	120.77
177.00	-43.01	120.83
180.00	-43.07	120.27
183.00	-43.02	120.40
186.00	-42.74	120.22
189.00	-42.66	120.38
192.00	-42.44	120.40
195.00	-42.23	120.23
198.00	-42.13	120.21
201.00	-42.12	120.92

Printout from SICADA 2006-09-27 10:38:01.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM27, 2005-11-15 07:50:00 - 2005-11-15 08:20:00 (15.000 - 126.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
15.00	-67.68	336.31
18.00	-67.85	336.04
21.00	-67.99	336.11
24.00	-67.94	334.97
27.00	-68.07	334.94
30.00	-67.77	335.14
33.00	-67.53	334.72
36.00	-67.33	334.17
39.00	-67.13	333.82
42.00	-66.94	333.79
45.00	-66.84	333.15
48.00	-66.75	332.76
51.00	-66.73	332.83
54.00	-66.69	332.17
57.00	-66.50	331.95
60.00	-66.40	331.45
63.00	-66.28	331.25
66.00	-66.23	330.87
69.00	-66.25	330.55
72.00	-66.36	330.63
75.00	-66.47	330.24
78.00	-66.57	329.41
81.00	-66.66	328.98
84.00	-66.81	328.42
87.00	-66.85	328.07
90.00	-66.89	327.57
93.00	-66.93	327.72
96.00	-66.98	326.69

99.00	-66.98	326.71
102.00	-67.03	326.60
105.00	-67.09	326.46
108.00	-67.14	326.35
111.00	-67.16	326.23
114.00	-67.15	326.06
117.00	-67.19	325.90
120.00	-67.20	325.92
123.00	-67.14	325.85
126.00	-67.13	325.66

Printout from SICADA 2006-03-23 15:20:31.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM28, 2006-01-19 08:30:00 - 2006-01-19 10:00:00 (15.000 - 149.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
15.00	-84.03	145.98
18.00	-83.83	146.49
21.00	-83.76	144.71
24.00	-83.59	145.12
27.00	-83.48	146.64
30.00	-83.23	147.51
33.00	-83.01	148.49
36.00	-82.74	151.59
39.00	-82.57	151.64
42.00	-82.32	152.72
45.00	-82.05	154.01
48.00	-81.87	155.43
51.00	-81.61	156.40
54.00	-81.36	157.69
57.00	-81.17	159.04
60.00	-80.90	158.77
63.00	-80.55	160.49

66.00	-80.26	161.27
69.00	-79.93	161.79
72.00	-79.56	161.93
75.00	-79.23	162.65
78.00	-78.92	163.12
81.00	-78.62	163.54
84.00	-78.39	163.84
87.00	-78.10	163.27
90.00	-77.70	164.76
93.00	-77.44	164.56
96.00	-77.25	164.80
99.00	-76.97	165.85
102.00	-76.74	166.21
105.00	-76.41	166.12
108.00	-76.02	166.37
111.00	-75.66	166.25
114.00	-75.35	167.18
117.00	-75.06	166.24
120.00	-74.74	167.12
123.00	-74.45	166.41
126.00	-73.99	167.20
129.00	-73.74	166.78
132.00	-73.52	165.70
135.00	-73.33	165.43
138.00	-73.00	166.12
141.00	-72.79	166.12
144.00	-72.43	166.71
147.00	-72.26	166.81
149.00	-72.15	166.93

Printout from SICADA 2006-02-20 16:15:05.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM29, 2006-01-25 08:30:00 - 2006-01-25 09:45:00 (12.000 - 198.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
12.00	-58.66	30.13
15.00	-58.91	31.29
18.00	-59.27	30.02
21.00	-59.58	30.45
24.00	-59.83	30.67
27.00	-60.09	31.76
30.00	-60.36	30.85
33.00	-60.73	31.70
36.00	-61.11	32.52
39.00	-61.55	32.90
42.00	-61.67	32.58
45.00	-62.06	33.54
48.00	-62.43	34.12
51.00	-62.67	34.73
54.00	-63.03	34.47
57.00	-63.40	35.91
60.00	-63.71	36.17
63.00	-64.04	36.28
66.00	-64.26	37.09
69.00	-64.47	37.32
72.00	-64.86	37.33
75.00	-65.22	38.39
78.00	-65.54	38.62
81.00	-65.73	38.62
84.00	-66.11	39.32
87.00	-66.44	39.69
90.00	-66.73	40.03
93.00	-67.05	41.21
96.00	-67.31	41.35

99.00	-67.54	43.18
102.00	-67.79	43.30
105.00	-67.97	44.25
108.00	-68.20	44.03
111.00	-68.36	44.07
114.00	-68.33	44.79
117.00	-68.54	45.77
120.00	-68.68	46.52
123.00	-69.01	47.08
126.00	-69.33	48.35
129.00	-69.41	48.08
132.00	-69.55	49.78
135.00	-69.80	50.29
138.00	-69.82	49.84
141.00	-69.93	52.09
144.00	-70.12	52.51
147.00	-70.13	53.99
150.00	-70.24	54.22
153.00	-70.28	55.04
156.00	-70.40	56.86
159.00	-70.51	57.54
162.00	-70.53	57.86
165.00	-70.62	56.26
168.00	-70.68	58.54
171.00	-70.81	60.08
174.00	-70.81	61.74
177.00	-70.93	62.04
180.00	-71.14	63.14
183.00	-71.23	63.75
186.00	-71.29	64.88
189.00	-71.33	66.02
192.00	-71.41	66.62
195.00	-71.44	67.82
198.00	-71.58	68.54

Printout from SICADA 2006-04-10 13:17:32.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM30, 2006-05-11 13:45:00 - 2006-05-11 14:30:00 (3.000 - 198.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
3.00	-55.68	27.56
6.00	-55.51	28.31
9.00	-55.55	29.06
12.00	-55.88	29.81
15.00	-55.88	30.56
18.00	-55.97	31.31
21.00	-55.71	31.31
24.00	-55.70	31.53
27.00	-55.89	31.36
30.00	-55.95	30.81
33.00	-56.04	30.94
36.00	-56.23	30.73
39.00	-56.42	30.72
42.00	-56.62	30.92
45.00	-56.89	30.92
48.00	-57.03	31.04
51.00	-57.24	31.33
54.00	-57.48	31.73
57.00	-57.65	32.14
60.00	-57.92	31.96
63.00	-58.15	31.74
66.00	-58.33	31.95
69.00	-58.60	32.16
72.00	-58.77	31.44
75.00	-59.07	31.85
78.00	-59.39	31.09
81.00	-59.59	32.11
84.00	-59.84	31.22

87.00	-60.08	31.39
90.00	-60.31	31.54
93.00	-60.48	31.59
96.00	-60.70	31.58
99.00	-60.92	31.31
102.00	-61.13	31.61
105.00	-61.32	31.32
108.00	-61.56	31.59
111.00	-61.76	30.92
114.00	-61.91	31.57
117.00	-62.14	30.93
120.00	-62.27	30.81
123.00	-62.40	30.61
126.00	-62.49	30.43
129.00	-62.53	30.47
132.00	-62.50	30.35
135.00	-62.51	30.44
138.00	-62.54	30.45
141.00	-62.62	30.39
144.00	-62.74	30.34
147.00	-62.86	30.20
150.00	-63.00	30.08
153.00	-63.06	30.01
156.00	-63.06	29.92
159.00	-63.12	29.84
162.00	-62.86	29.76
165.00	-62.59	30.02
168.00	-62.50	30.02
171.00	-62.47	30.15
174.00	-62.42	30.09
177.00	-62.45	30.48
180.00	-62.47	29.86
183.00	-62.56	30.08
186.00	-62.60	30.12
189.00	-62.72	29.93

192.00	-62.79	30.02
195.00	-62.78	30.41
198.00	-62.84	29.84

Printout from SICADA 2006-09-11 09:49:58.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM31, 2006-05-24 08:00:00 - 2006-05-24 09:00:00 (3.000 - 198.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
3.00	-69.34	309.60
6.00	-69.04	309.39
9.00	-68.96	309.19
12.00	-68.55	308.98
15.00	-68.57	308.78
18.00	-68.46	308.57
21.00	-68.48	308.37
24.00	-68.51	308.16
27.00	-68.47	307.96
30.00	-68.35	307.75
33.00	-68.34	307.55
36.00	-68.24	307.35
39.00	-68.16	307.14
42.00	-67.99	306.94
45.00	-67.84	306.73
48.00	-67.66	306.53
51.00	-67.55	306.32
54.00	-67.43	306.12
57.00	-67.44	305.91
60.00	-67.63	305.71
63.00	-67.58	305.51
66.00	-67.49	305.30
69.00	-67.54	305.10
72.00	-67.43	304.89

75.00	-67.38	304.69
78.00	-67.22	304.48
81.00	-67.08	304.28
84.00	-66.89	304.07
87.00	-66.67	303.87
90.00	-66.58	303.66
93.00	-66.50	303.46
96.00	-66.31	303.46
99.00	-65.90	303.47
102.00	-65.75	303.25
105.00	-65.52	302.52
108.00	-65.39	302.08
111.00	-65.25	301.55
114.00	-65.15	301.29
117.00	-65.06	301.16
120.00	-64.96	300.70
123.00	-64.90	300.65
126.00	-64.85	300.73
129.00	-64.65	300.46
132.00	-64.59	299.52
135.00	-64.43	300.85
138.00	-64.19	299.96
141.00	-64.08	300.90
144.00	-64.00	299.82
147.00	-63.85	299.29
150.00	-63.66	299.27
153.00	-63.65	299.77
156.00	-63.59	299.35
159.00	-63.53	299.41
162.00	-63.45	298.22
165.00	-63.36	297.29
168.00	-63.26	299.20
171.00	-63.12	298.43
174.00	-63.00	298.20
177.00	-62.85	297.85

180.00	-62.65	297.83
183.00	-62.52	297.73
186.00	-62.44	297.74
189.00	-62.32	297.66
192.00	-62.27	297.57
195.00	-62.13	297.54
198.00	-61.97	297.58

Printout from SICADA 2006-06-13 11:33:23.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM32, 2006-01-15 10:00:00 - 2006-01-15 11:00:00 (9.000 - 201.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
9.00	-86.31	117.41
12.00	-86.31	116.20
15.00	-86.28	118.44
18.00	-86.22	117.91
21.00	-85.94	121.54
24.00	-85.77	122.84
27.00	-85.50	125.68
30.00	-85.34	127.15
33.00	-85.09	130.31
36.00	-84.85	132.41
39.00	-84.59	136.61
42.00	-84.26	138.14
45.00	-84.00	140.09
48.00	-83.65	142.13
51.00	-83.31	143.00
54.00	-82.94	144.87
57.00	-82.68	146.29
60.00	-82.33	147.51
63.00	-81.98	147.55
66.00	-81.66	147.60

69.00	-81.52	147.75
72.00	-81.23	148.88
75.00	-80.98	149.11
78.00	-80.67	149.46
81.00	-80.50	149.17
84.00	-80.28	149.92
87.00	-79.98	149.52
90.00	-79.69	150.16
93.00	-79.48	151.38
96.00	-79.14	152.41
99.00	-78.93	153.27
102.00	-78.73	153.82
105.00	-78.58	154.81
108.00	-78.71	154.16
111.00	-78.43	156.41
114.00	-78.27	156.07
117.00	-78.30	155.46
120.00	-78.29	155.44
123.00	-78.21	155.80
126.00	-78.02	158.17
129.00	-78.18	156.78
132.00	-78.14	157.07
135.00	-78.15	156.93
138.00	-78.15	157.30
141.00	-78.18	157.22
144.00	-78.11	157.87
147.00	-77.84	158.57
150.00	-77.92	159.03
153.00	-77.84	160.26
156.00	-77.76	161.04
159.00	-77.74	161.36
162.00	-77.65	162.85
165.00	-77.75	162.32
168.00	-77.49	161.88
171.00	-77.56	162.98

174.00	-77.51	162.95
177.00	-77.31	163.35
180.00	-77.09	164.31
183.00	-76.87	164.52
186.00	-76.45	165.23
189.00	-76.08	165.83
192.00	-75.77	166.61
195.00	-75.29	167.12
198.00	-74.97	167.37
201.00	-74.45	167.87

Printout from SICADA 2006-02-20 16:16:18.

Magnetic Acc Dev T - Magnetic accelerometer deviation measurement

HFM38, 2006-06-22 09:40:00 - 2006-06-22 10:50:00 (3.000 - 192.000 m)

Bhlen (m)	Dip (degrees)	Magnetic Bearing (degrees)
3.00	-54.66	90.96
6.00	-54.32	90.29
9.00	-53.54	89.63
12.00	-54.06	89.63
15.00	-54.12	88.75
18.00	-53.82	88.76
21.00	-53.45	88.82
24.00	-53.21	89.09
27.00	-52.97	89.34
30.00	-52.72	89.72
33.00	-52.05	90.34
36.00	-51.49	90.55
39.00	-50.89	92.10
42.00	-50.79	92.07
45.00	-50.54	94.18
48.00	-50.34	92.83
51.00	-50.11	93.26

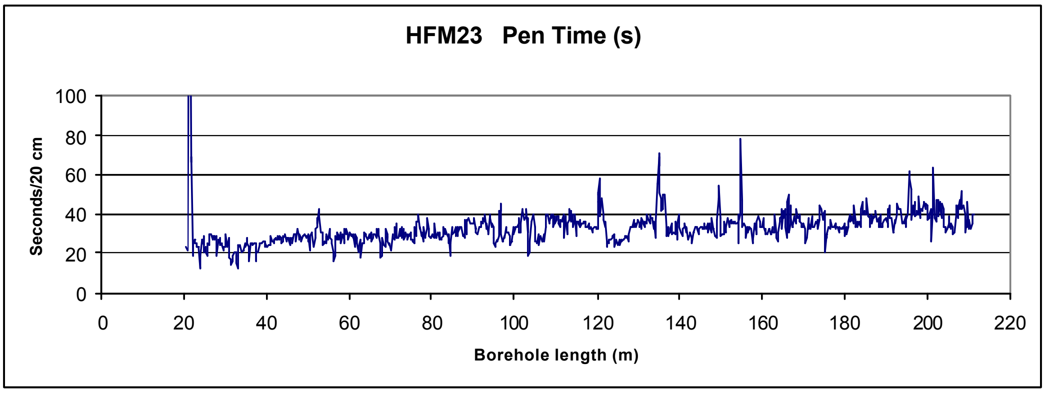
54.00	-49.80	94.88
57.00	-49.65	93.61
60.00	-49.33	94.76
63.00	-49.01	96.20
66.00	-48.71	96.75
69.00	-48.22	97.76
72.00	-47.78	98.42
75.00	-47.50	98.50
78.00	-47.24	98.45
81.00	-47.03	99.01
84.00	-46.85	99.24
87.00	-46.67	99.90
90.00	-46.50	100.03
93.00	-46.19	102.13
96.00	-45.93	101.18
99.00	-45.62	101.84
102.00	-45.23	102.92
105.00	-44.94	102.82
108.00	-44.70	104.08
111.00	-44.47	103.83
114.00	-44.23	104.87
117.00	-43.87	105.86
120.00	-43.61	105.12
123.00	-43.18	105.46
126.00	-42.83	105.69
129.00	-42.52	105.33
132.00	-42.30	105.31
135.00	-42.23	106.52
138.00	-42.16	106.34
141.00	-42.03	105.65
144.00	-41.86	105.72
147.00	-41.56	106.86
150.00	-41.54	105.48
153.00	-41.29	105.58
156.00	-41.12	106.83

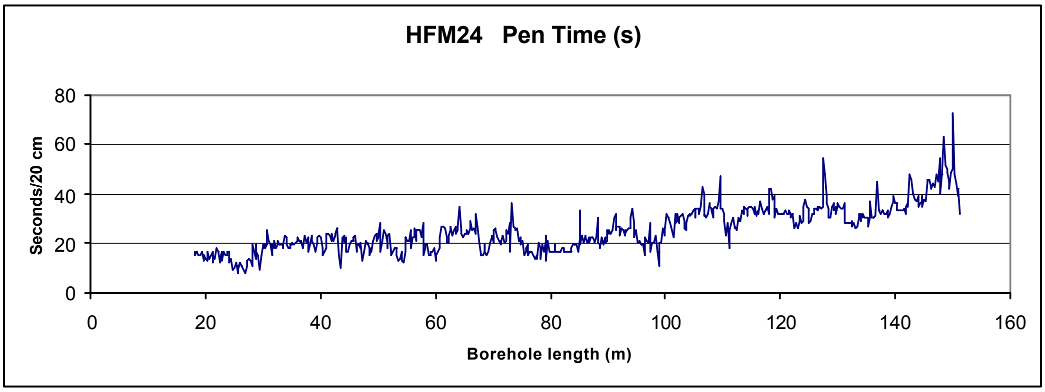
159.00	-40.96	105.86
162.00	-40.71	106.18
165.00	-40.33	106.18
168.00	-40.00	105.25
171.00	-39.58	105.80
174.00	-39.14	105.91
177.00	-38.88	105.75
180.00	-38.45	106.47
183.00	-38.03	106.17
186.00	-37.63	106.37
189.00	-37.00	106.14
192.00	-36.41	106.79

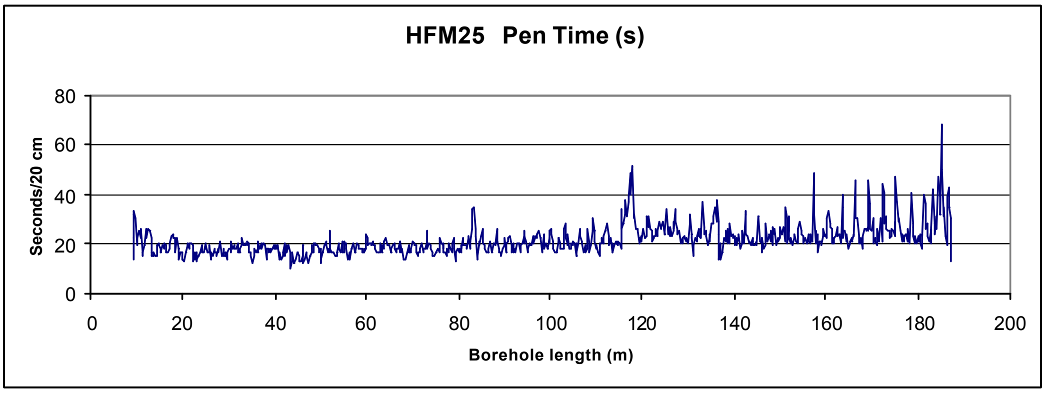
Printout from SICADA 2006-08-23 15:47:59.

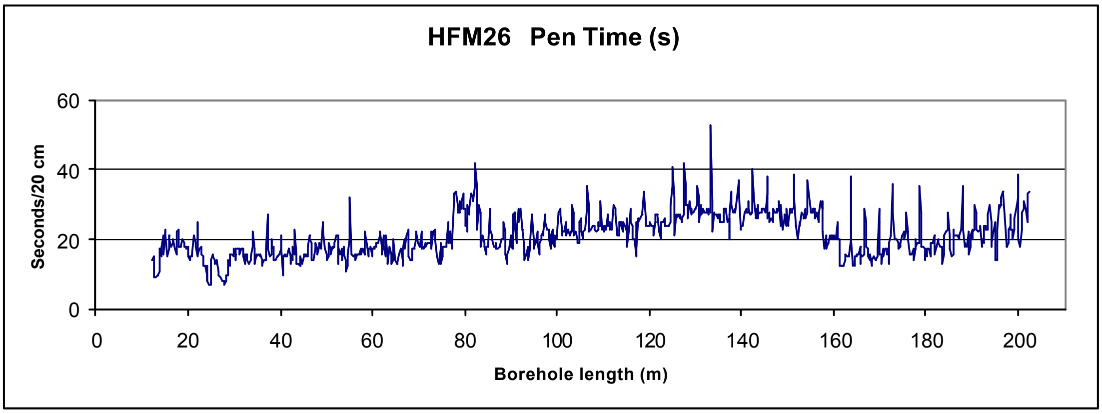
Appendix 6

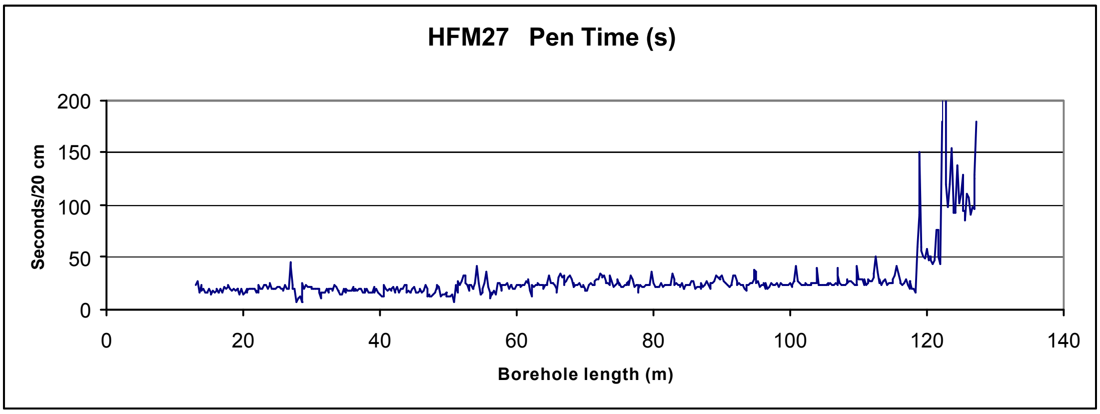
In-data: Drilling penetration rate

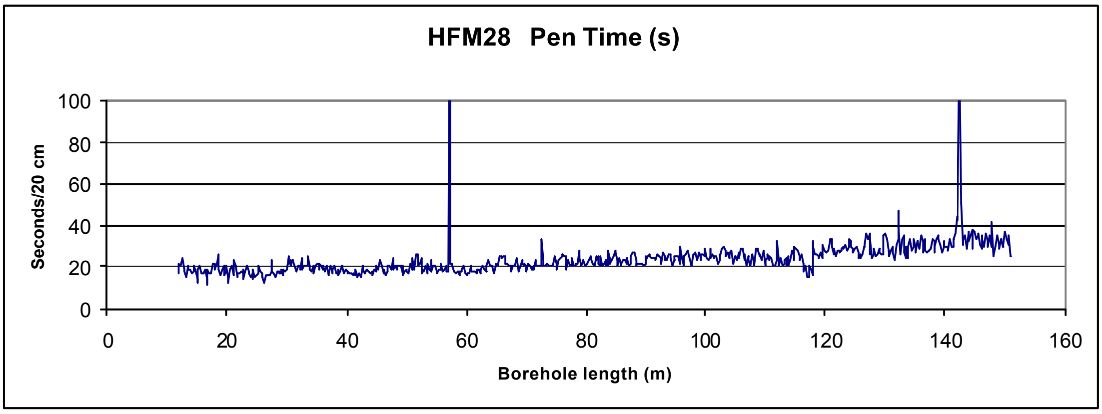


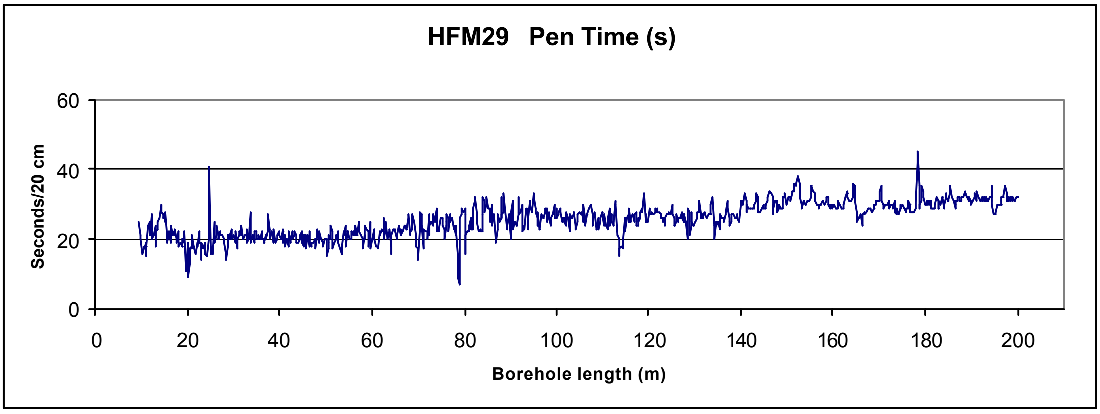


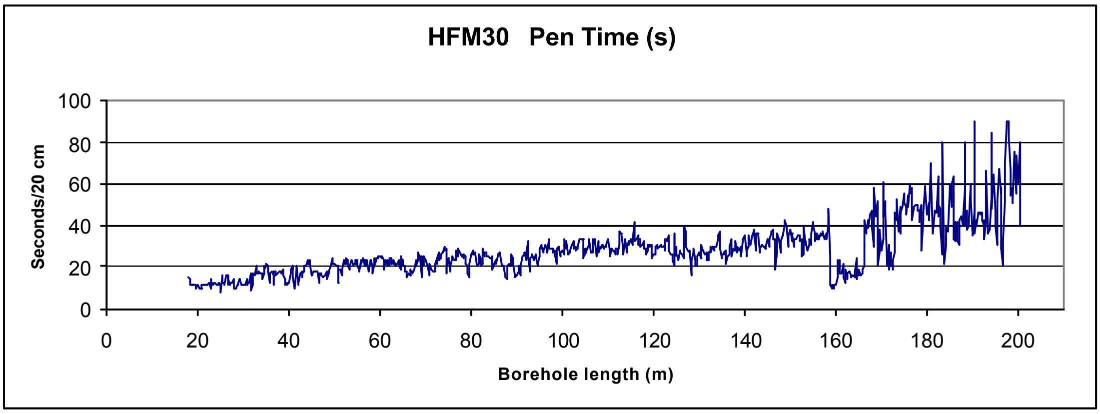



HFM26 Pen Time (s)
Seconds/20 cm
60
40
20
0
0
20
40
60
80
100
120
140
160
180
200
Borehole length (m)

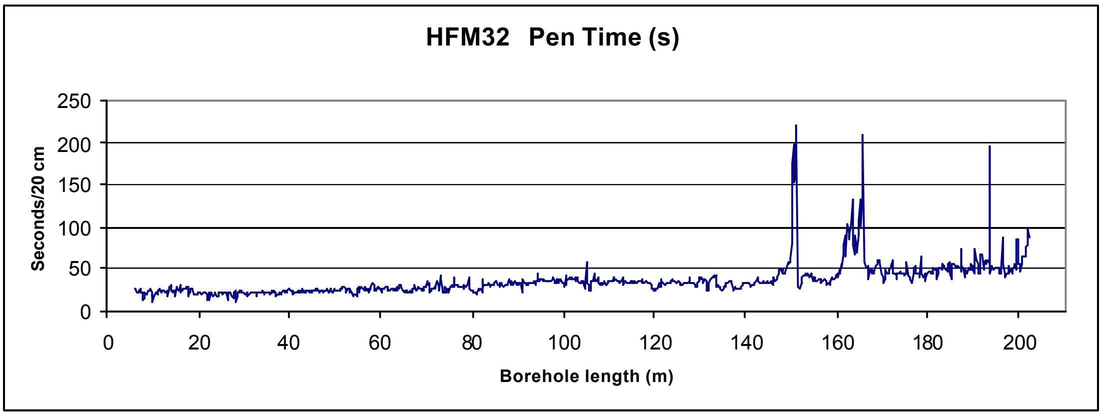

HFM27 Pen Time (s)
Seconds/20 cm
200
150
100
50
0
0
20
40
60
80
100
120
140
Borehole length (m)

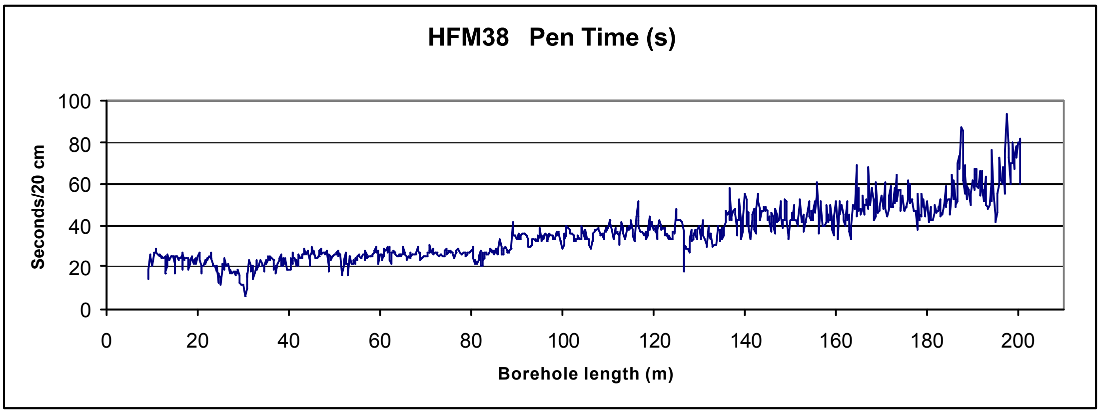

HFM28 Pen Time (s)
Seconds/20 cm
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
Borehole length (m)


HFM29 Pen Time (s)
Seconds/20 cm
60
40
20
0
0
20
40
60
80
100
120
140
160
180
200
Borehole length (m)



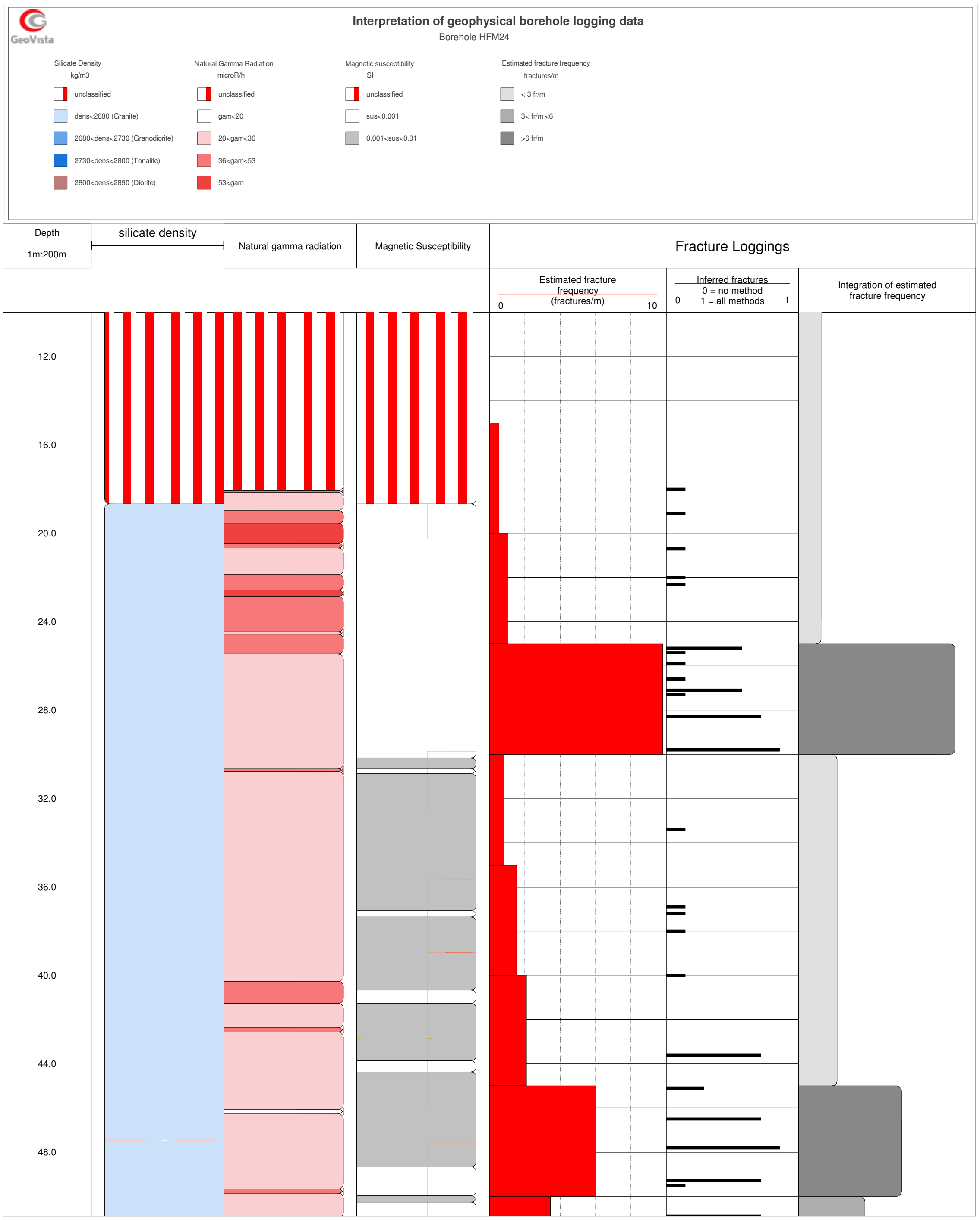
Data for HFM31 is missing in SICADA 2006-08-27



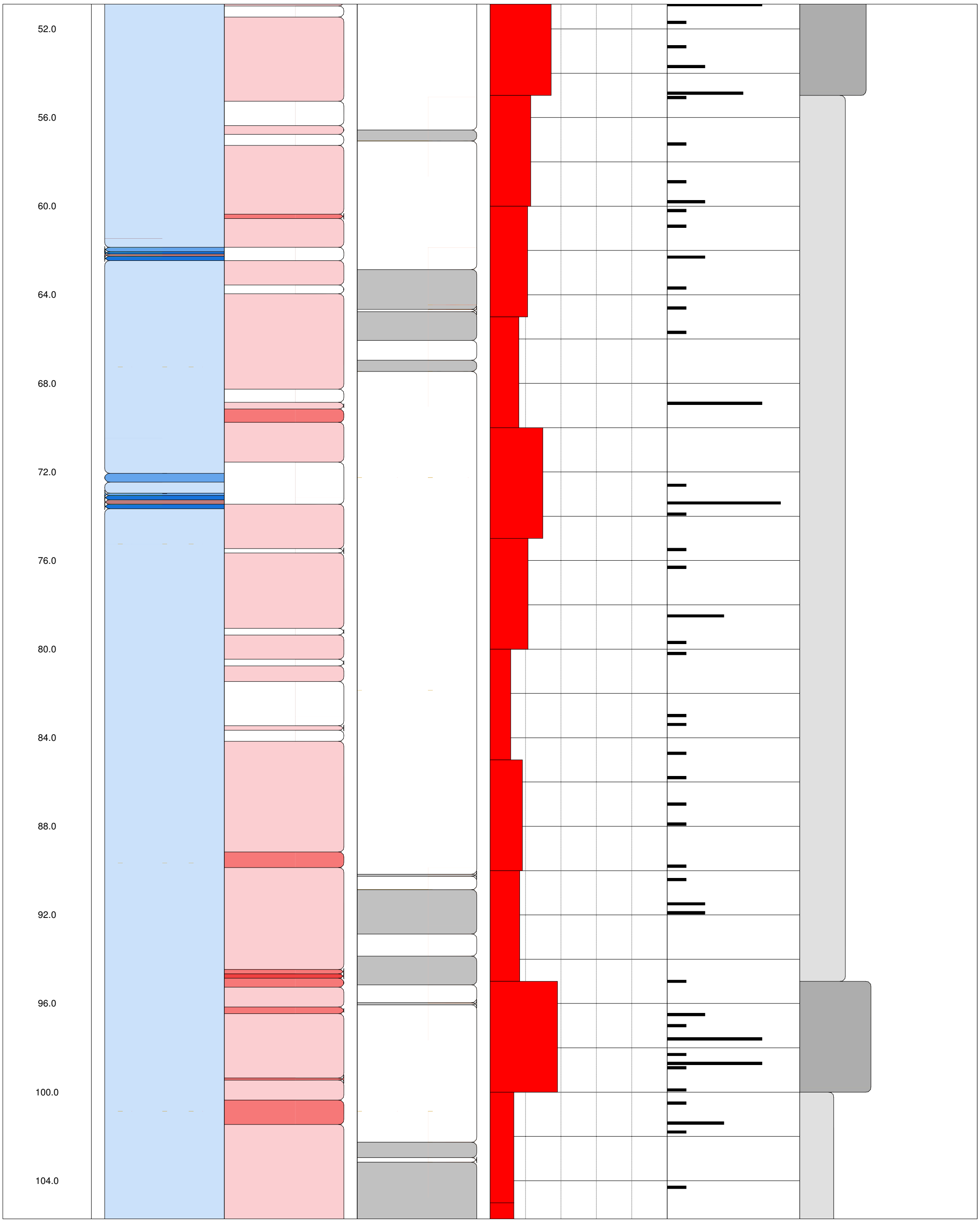


Appendix 7

In-data: Generalized geophysical logs



Page 1



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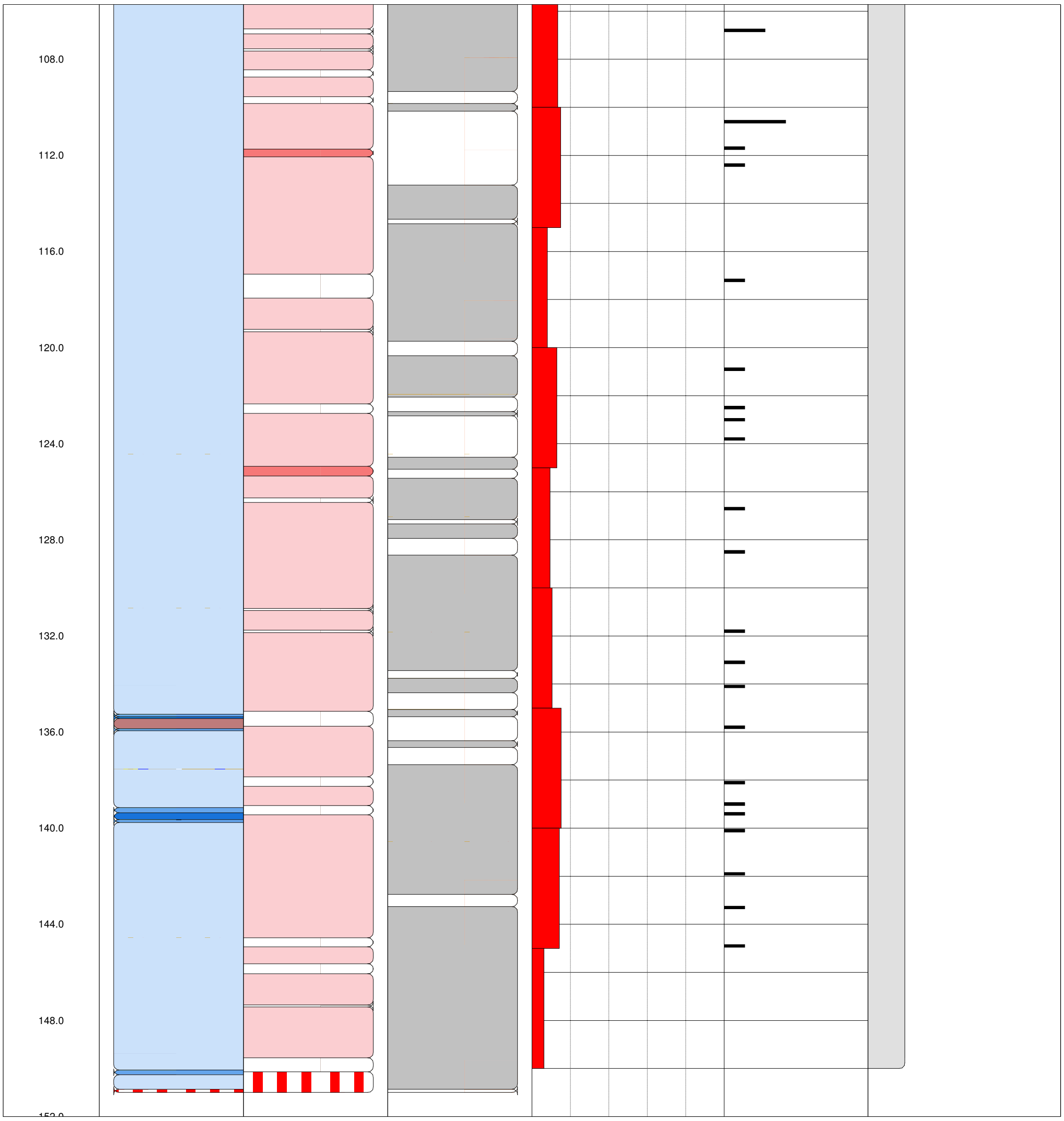
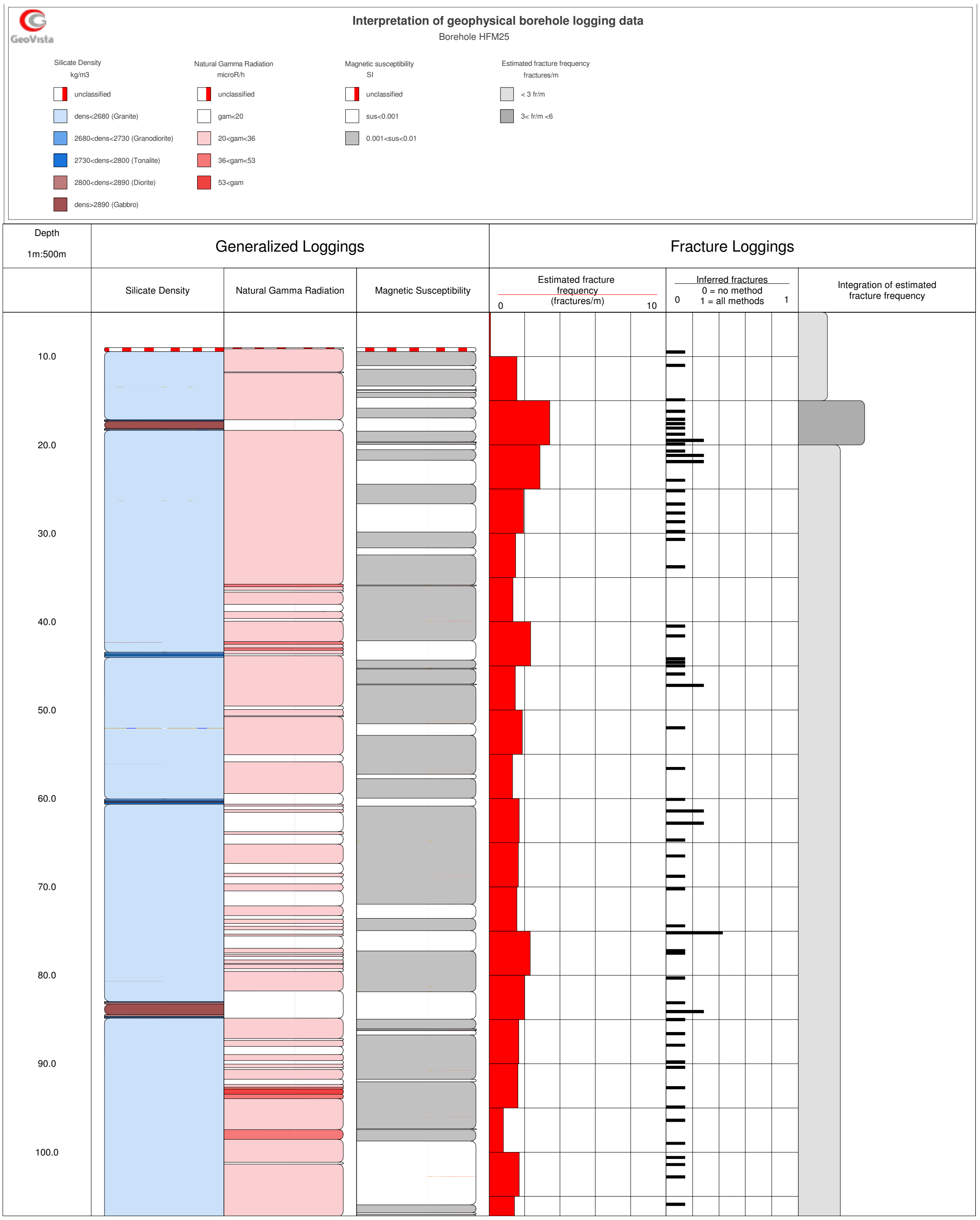
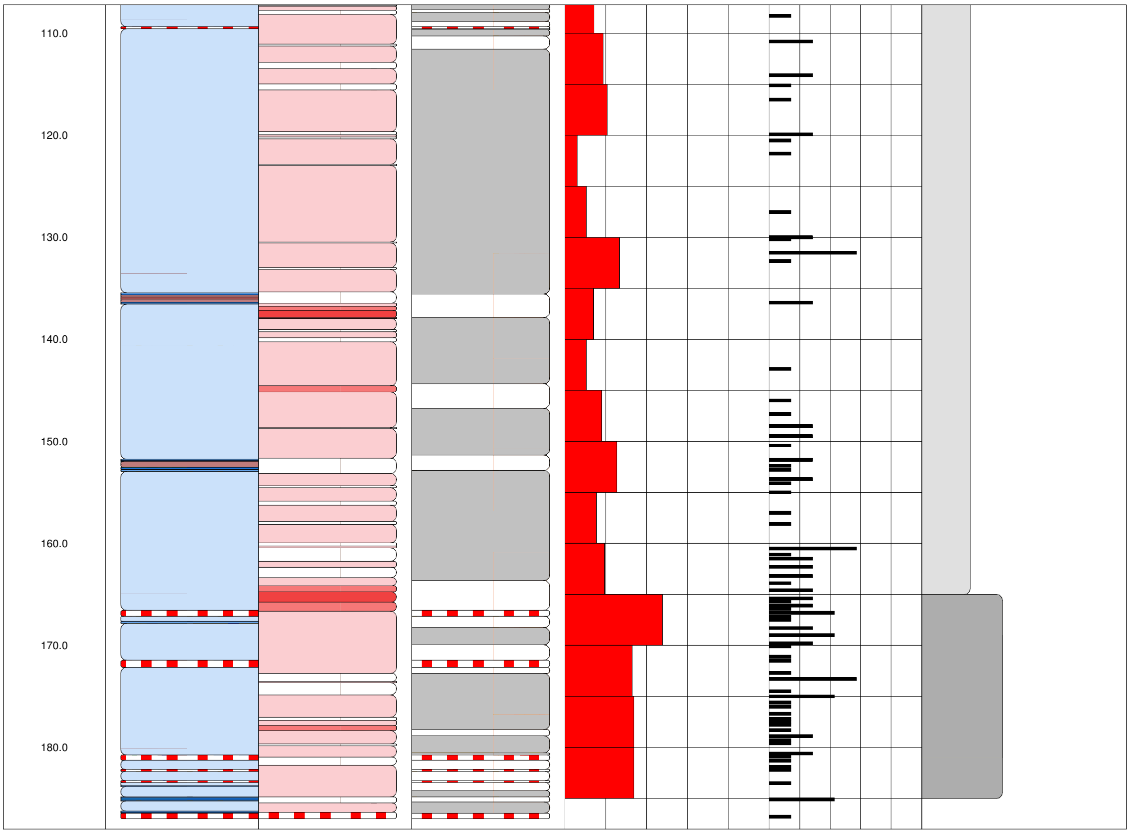
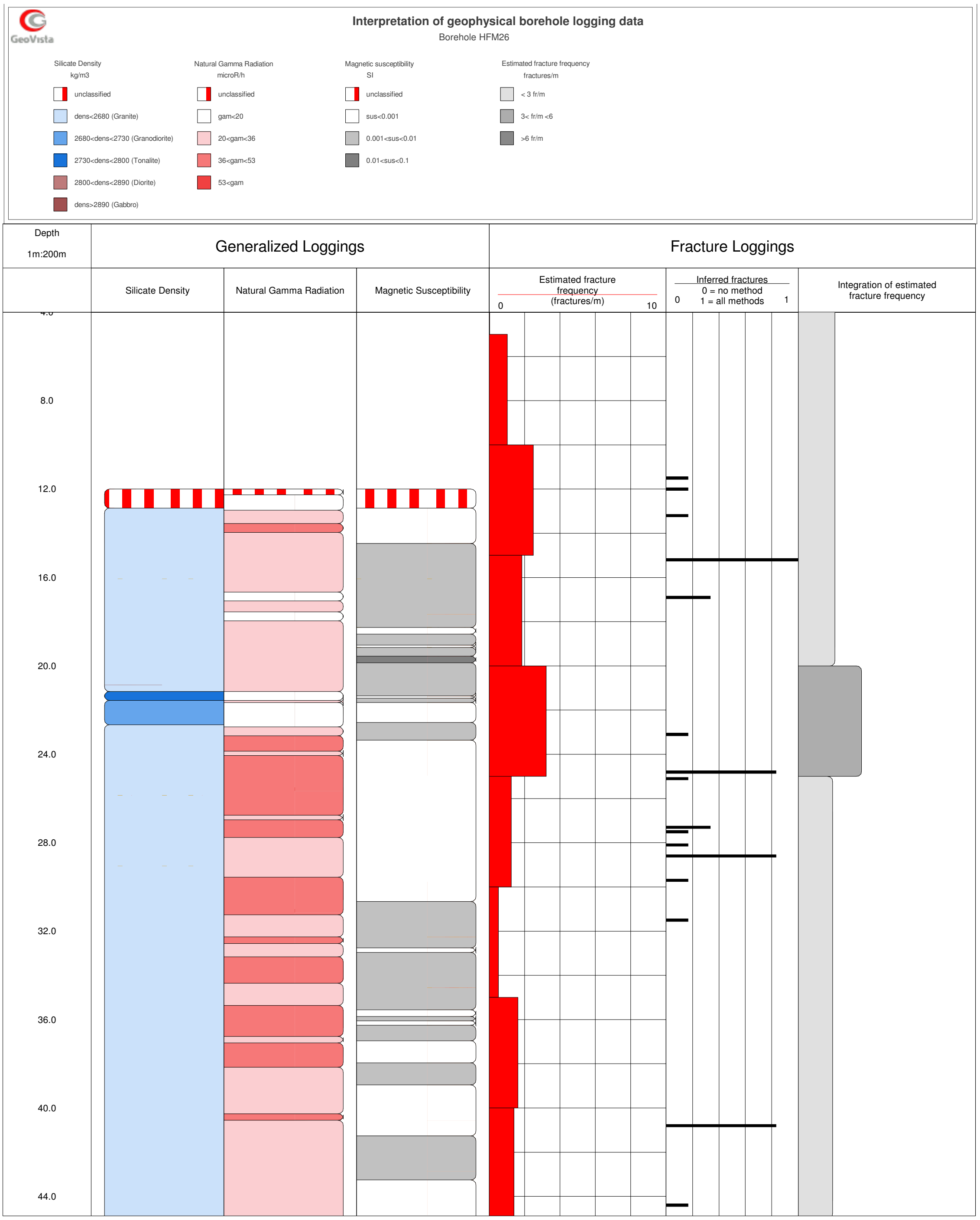


Page 3

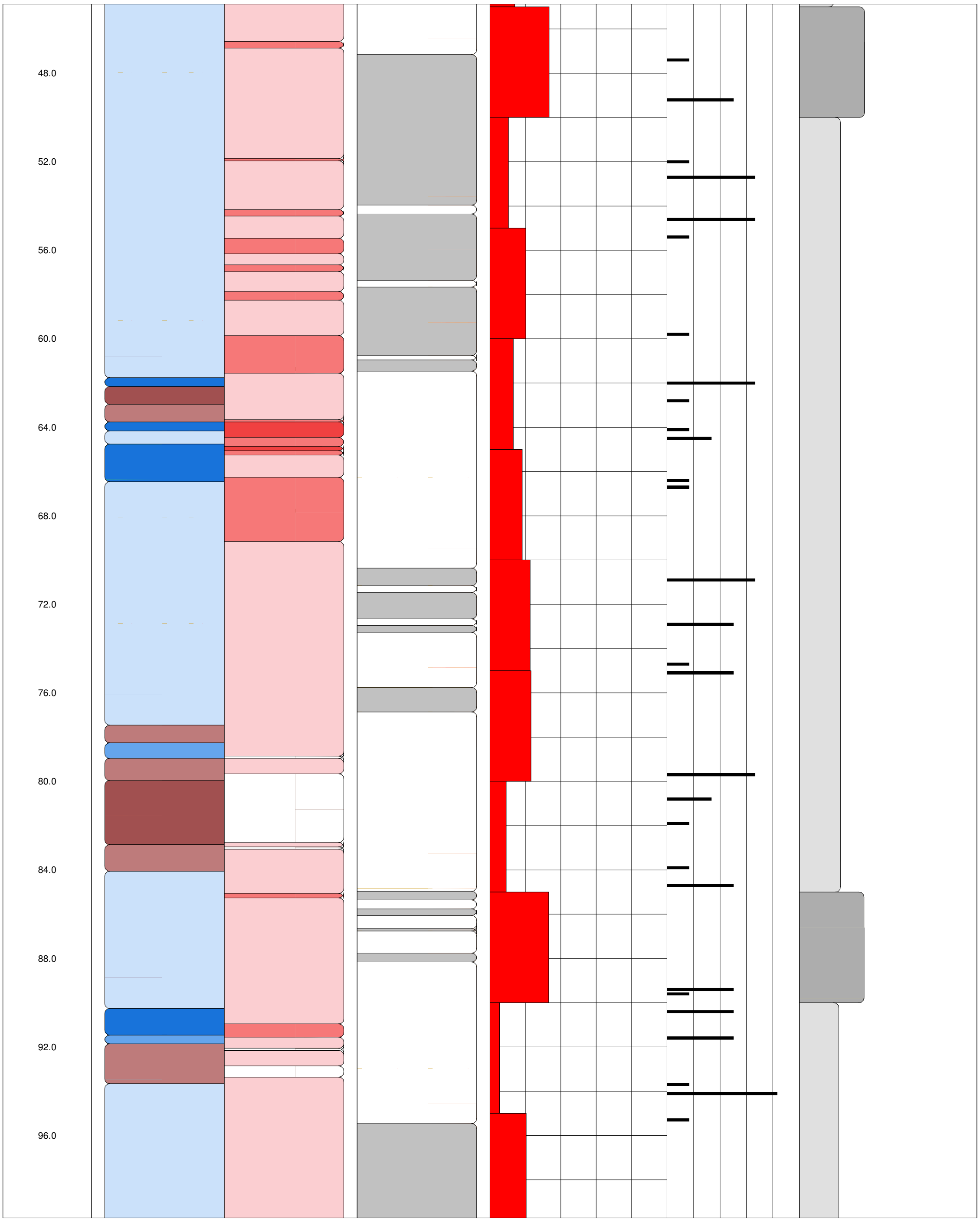

Interpretation of geophysical borehole logging data
Borehole HFM25
Silicate Density kg/m3
unclassified
dens<2680 (Granite)
2680<dens<2730 (Granodiorite)
2730<dens<2800 (Tonalite)
2800<dens<2890 (Diorite)
dens>2890 (Gabbro)
Natural Gamma Radiation microR/h
unclassified
gam<20
20<gam<36
36<gam<53
53<gam
Magnetic susceptibility SI
unclassified
sus<0.001
0.001<sus<0.01
Estimated fracture frequency fractures/m
< 3 fr/m
3< fr/m <6
Depth
1m:500m
Generalized Loggings
Fracture Loggings
Silicate Density
Natural Gamma Radiation
Magnetic Susceptibility
Estimated fracture frequency (fractures/m)
0
10
Inferred fractures
0 = no method
1 = all methods
0
1
Integration of estimated fracture frequency
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0



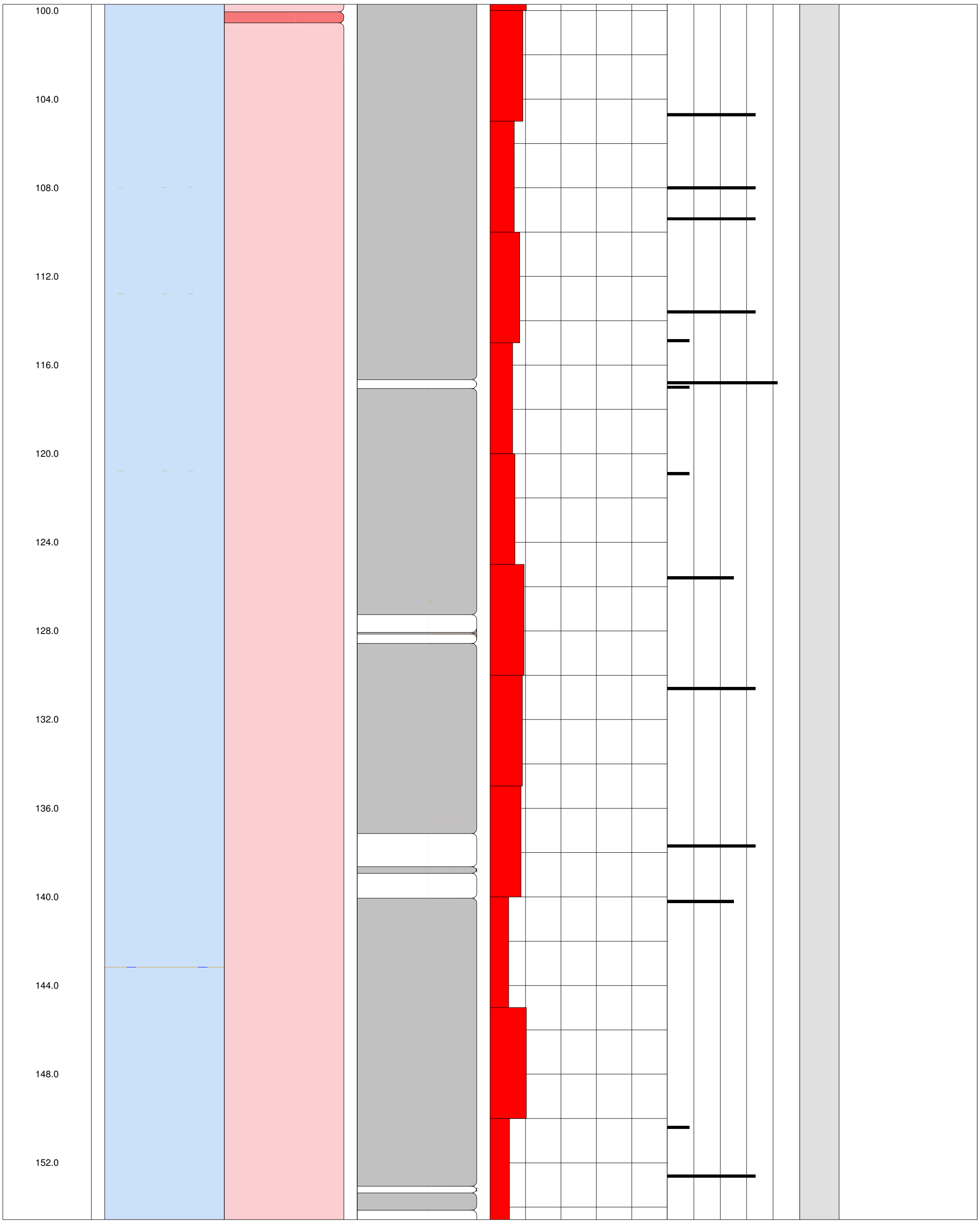
Page 2

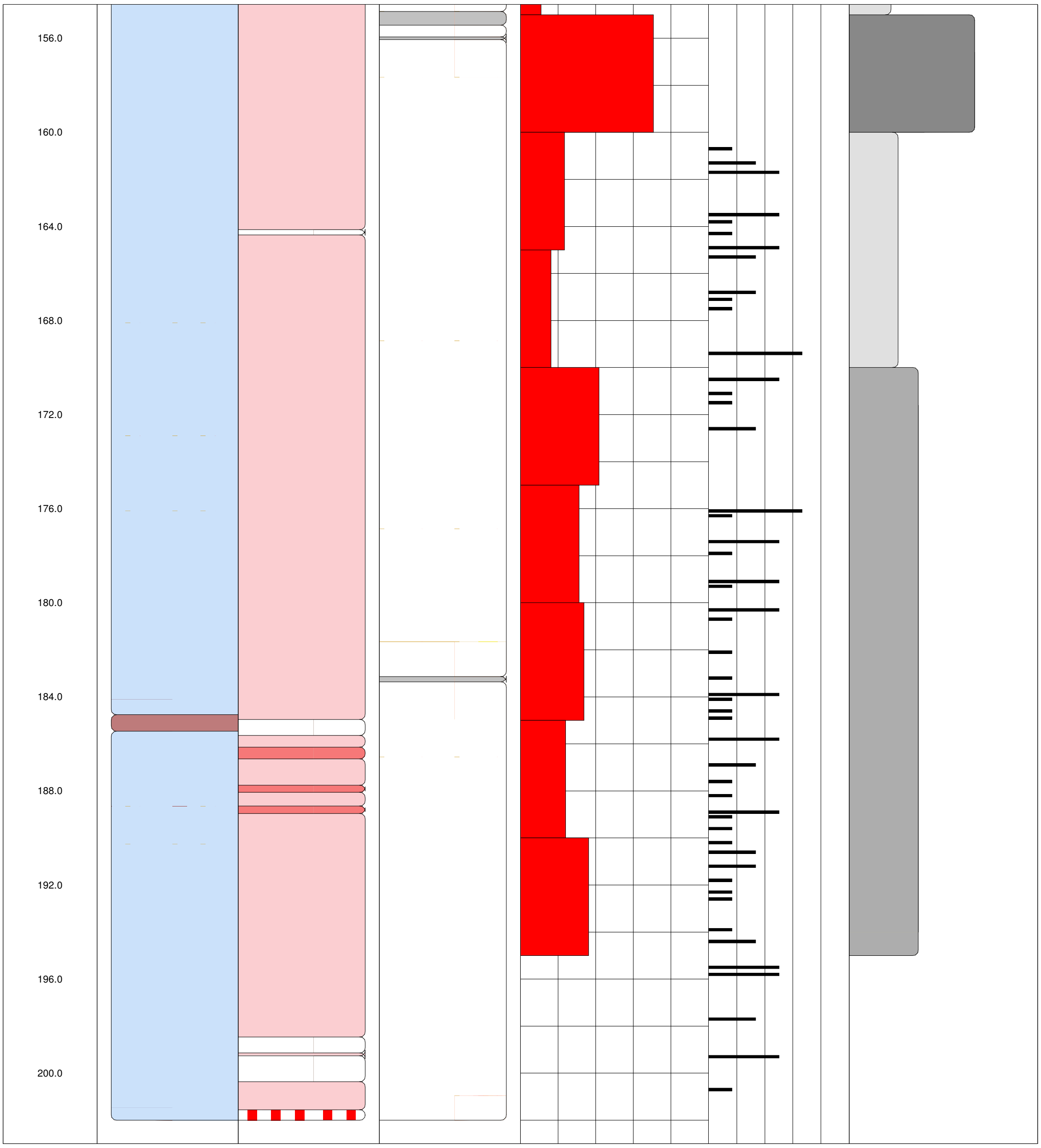

GeoVista
Interpretation of geophysical borehole logging data
Borehole HFM26
Silicate Density
kg/m3
unclassified
dens<2680 (Granite)
2680<dens<2730 (Granodiorite)
2730<dens<2800 (Tonalite)
2800<dens<2890 (Diorite)
dens>2890 (Gabbro)
Natural Gamma Radiation
microR/h
unclassified
gam<20
20<gam<36
36<gam<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
< 3 fr/m
3< fr/m <6
>6 fr/m
Depth
1m:200m
Generalized Loggings
Fracture Loggings
Silicate Density
Natural Gamma Radiation
Magnetic Susceptibility
Estimated fracture frequency (fractures/m)
0
10
Inferred fractures
0 = no method
1 = all methods
0
1
Integration of estimated fracture frequency
8.0
12.0
16.0
20.0
24.0
28.0
32.0
36.0
40.0
44.0

Page 1

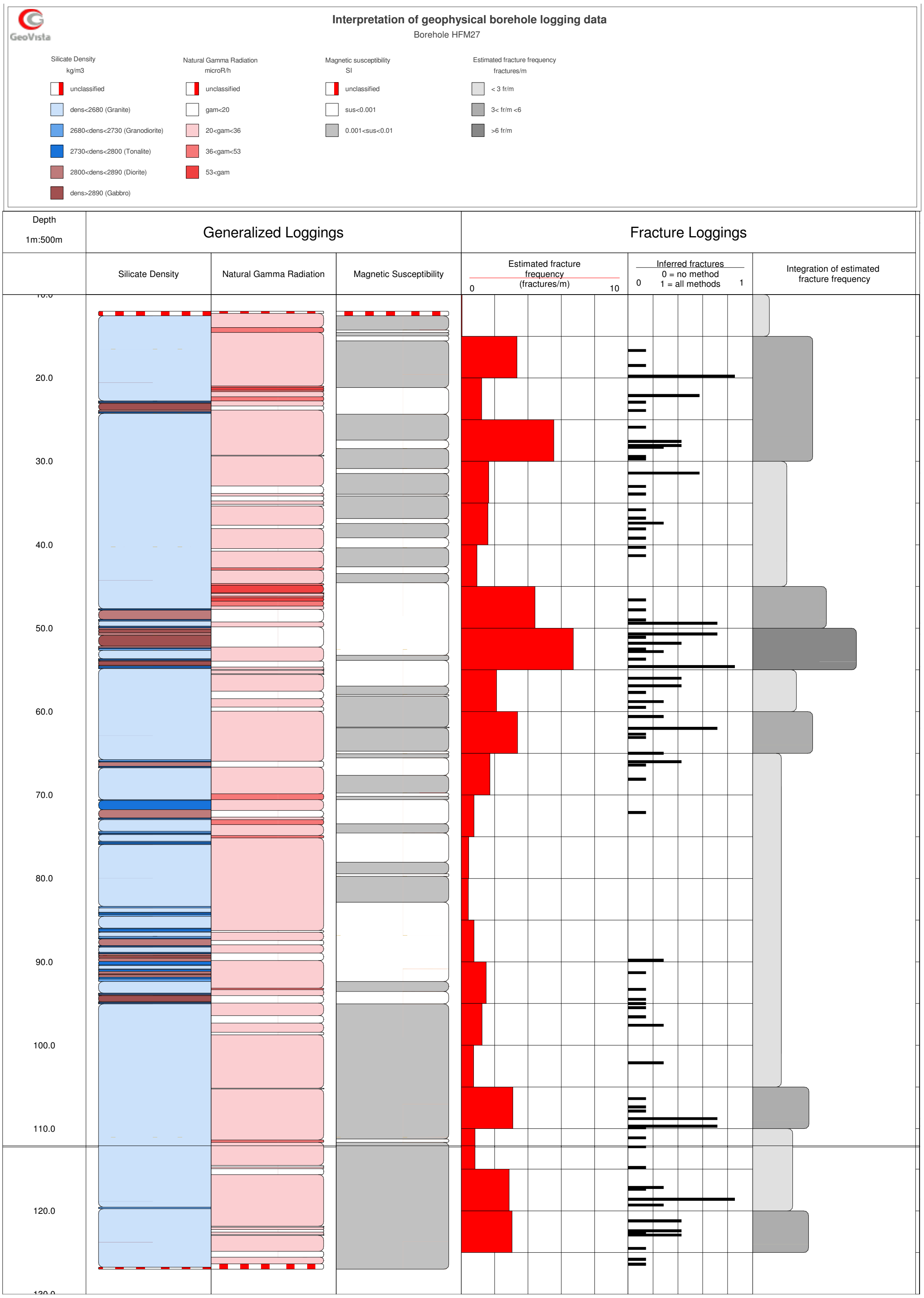


Page 2

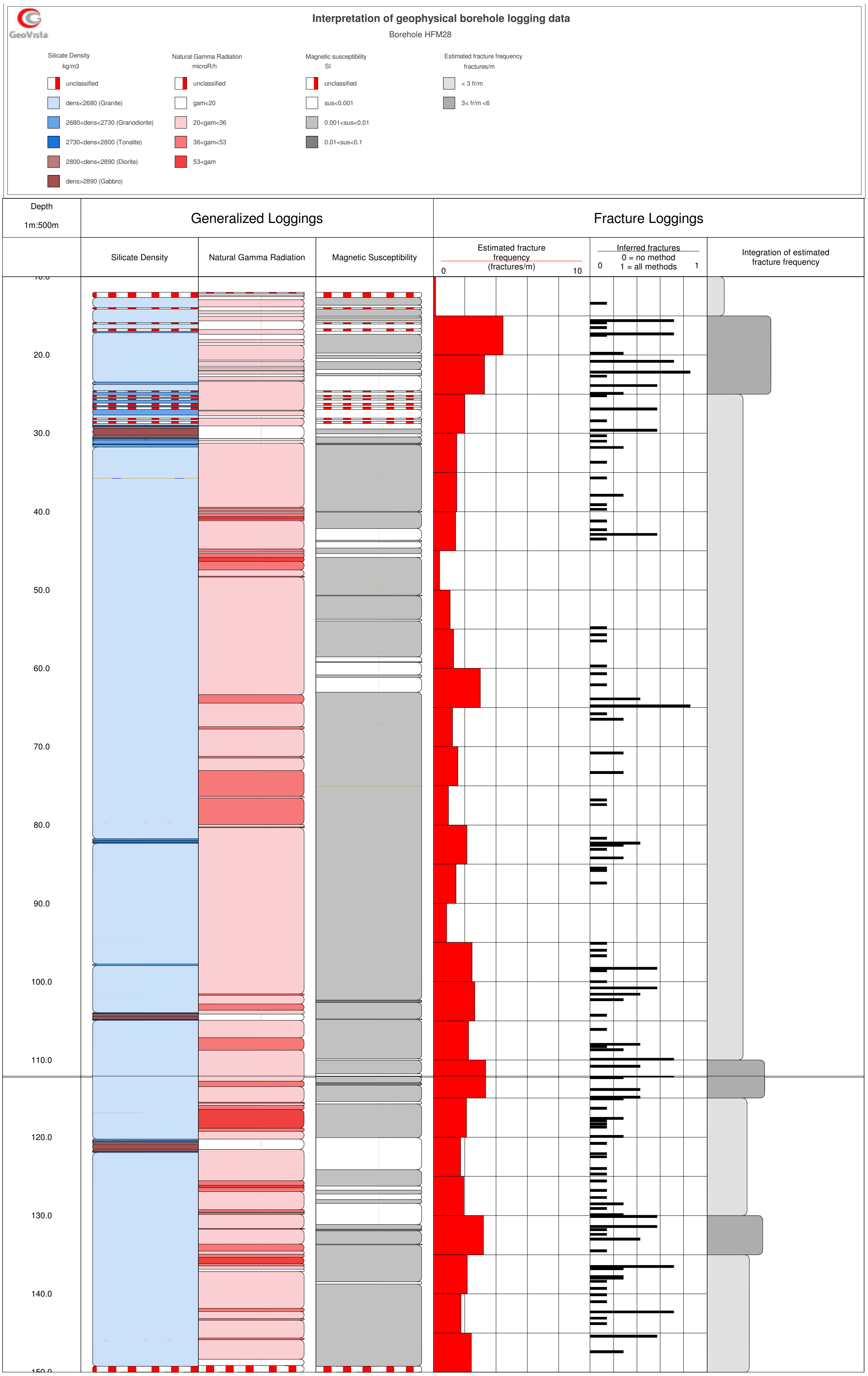

100.0
104.0
108.0
112.0
116.0
120.0
124.0
128.0
132.0
136.0
140.0
144.0
148.0
152.0
Page 3



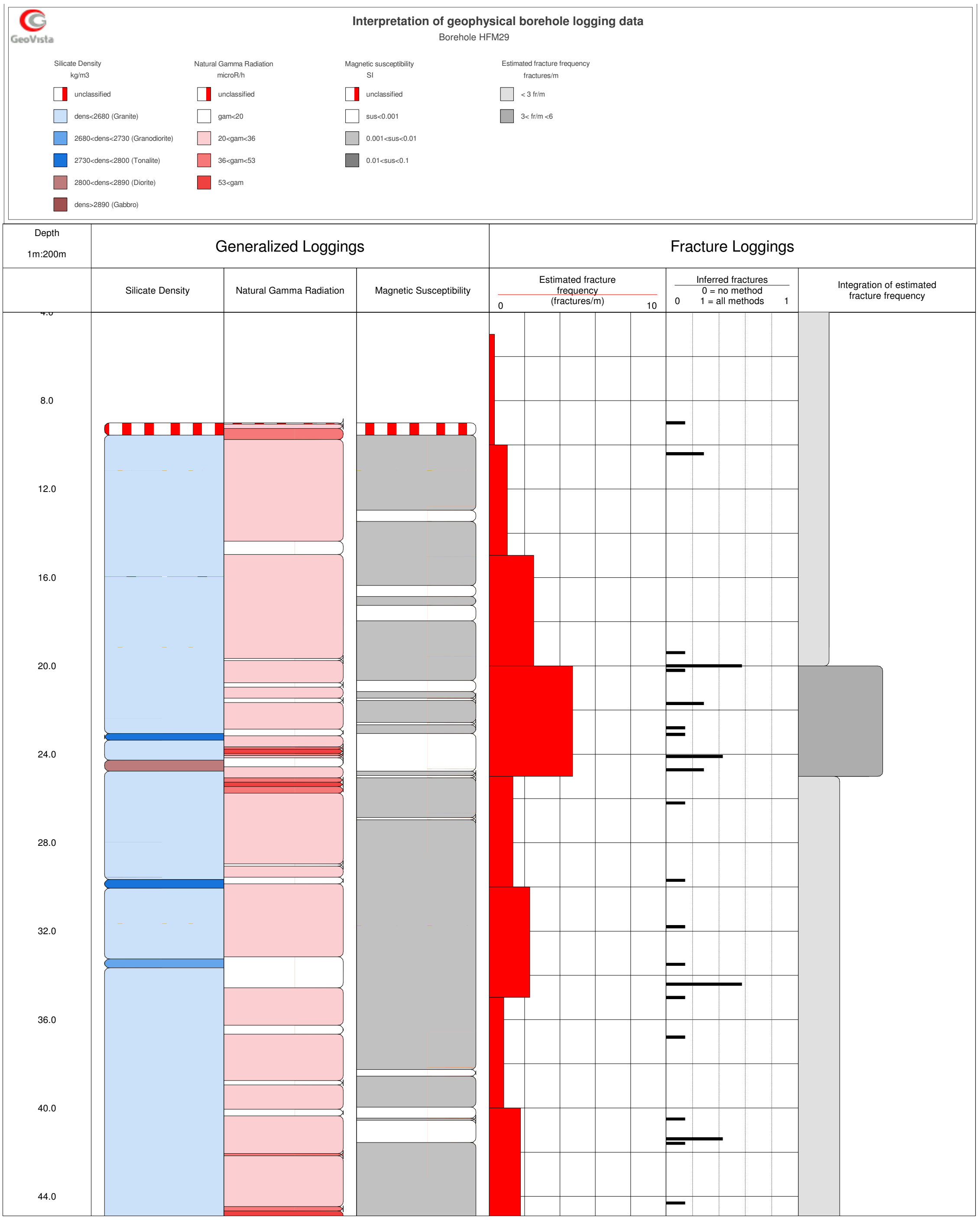
Page 4

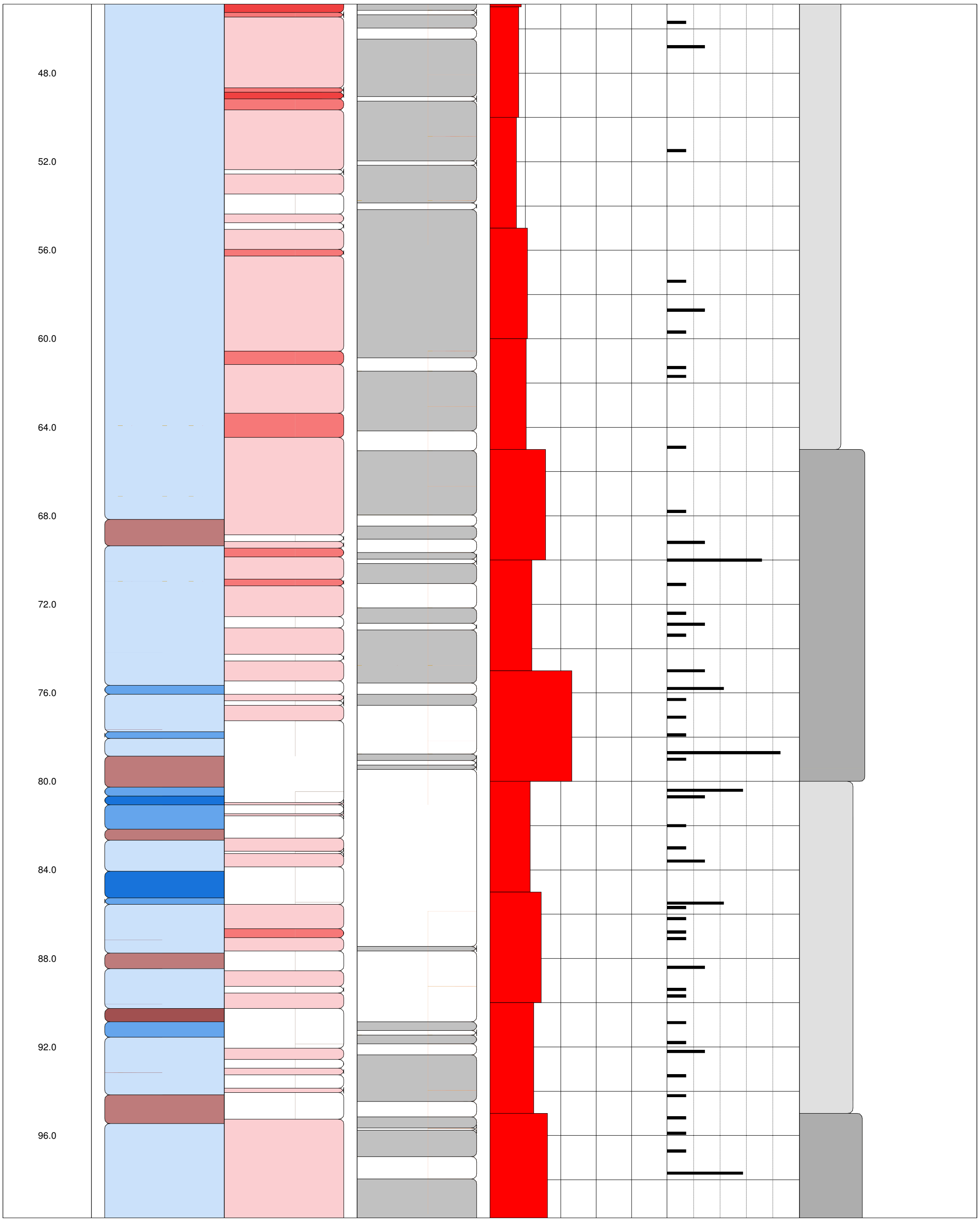


GeoVista
Interpretation of geophysical borehole logging data
Borehole HFM27
Silicate Density
kg/m3
unclassified
dens<2680 (Granite)
2680<dens<2730 (Granodiorite)
2730<dens<2800 (Tonalite)
2800<dens<2890 (Diorite)
dens>2890 (Gabbro)
Natural Gamma Radiation
microR/h
unclassified
gam<20
20<gam<36
36<gam<53
53<gam
Magnetic susceptibility
SI
unclassified
sus<0.001
0.001<sus<0.01
Estimated fracture frequency
fractures/m
< 3 fr/m
3< fr/m <6
>6 fr/m
Depth
1m:500m
Generalized Loggings
Fracture Loggings
Silicate Density
Natural Gamma Radiation
Magnetic Susceptibility
Estimated fracture frequency (fractures/m)
0
10
Inferred fractures
0 = no method
1 = all methods
0
1
Integration of estimated fracture frequency
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0



GeoVista
Interpretation of geophysical borehole logging data
Borehole HFM28
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
< 3 fr/m
3< fr/m <6
Depth
1m:500m
Generalized Loggings
Fracture Loggings
Silicate Density
Natural Gamma Radiation
Magnetic Susceptibility
Estimated fracture frequency (fractures/m)
0
10
Inferred fractures
0 = no method
1 = all methods
0
1
Integration of estimated fracture frequency
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0


GeoVista
Interpretation of geophysical borehole logging data
Borehole HFM29
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
< 3 fr/m
3< fr/m <6
Depth
1m:200m
Generalized Loggings
Fracture Loggings
Silicate Density
Natural Gamma Radiation
Magnetic Susceptibility
Estimated fracture frequency (fractures/m)
0
10
Inferred fractures
0 = no method
1 = all methods
0
1
Integration of estimated fracture frequency
8.0
12.0
16.0
20.0
24.0
28.0
32.0
36.0
40.0
44.0



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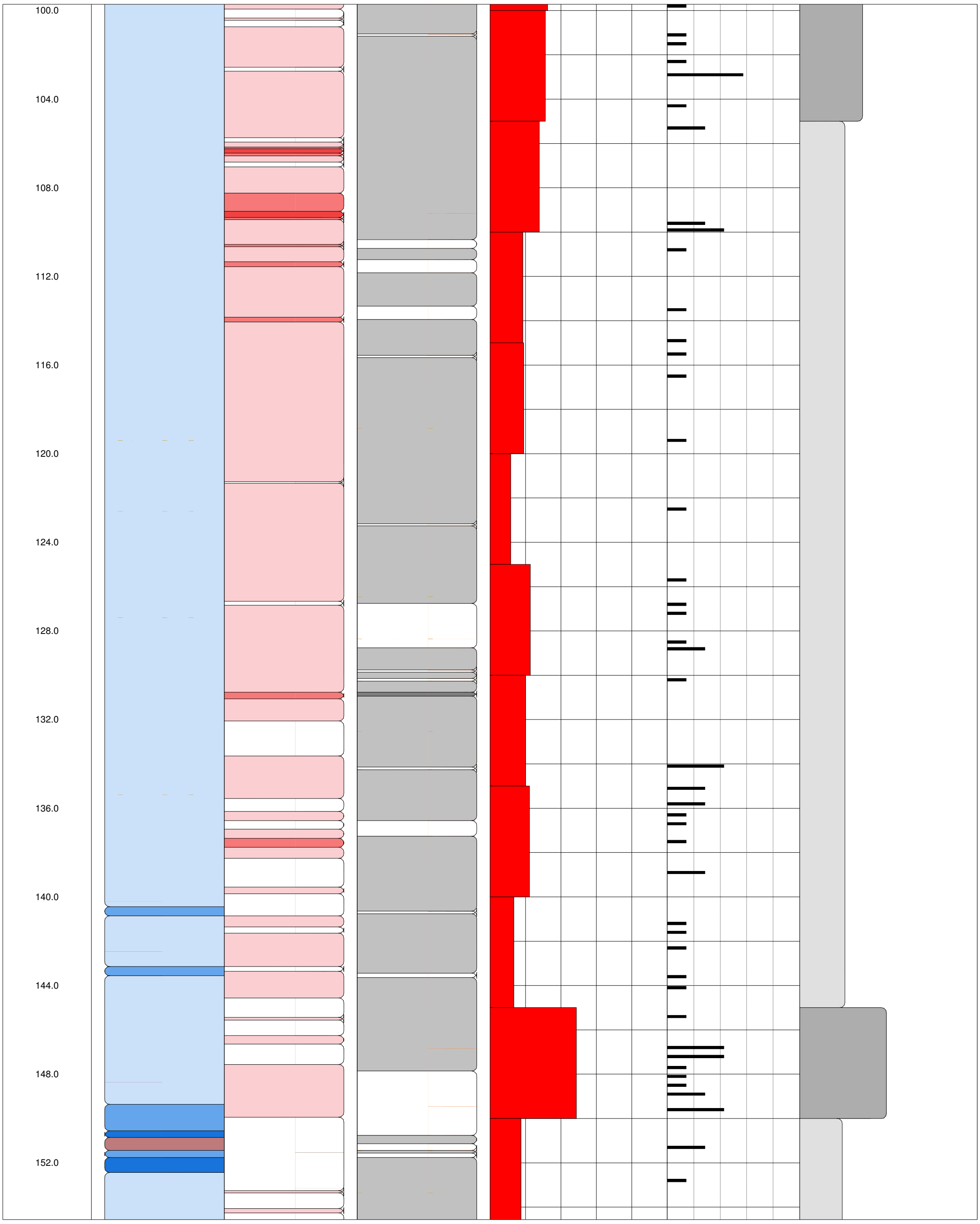
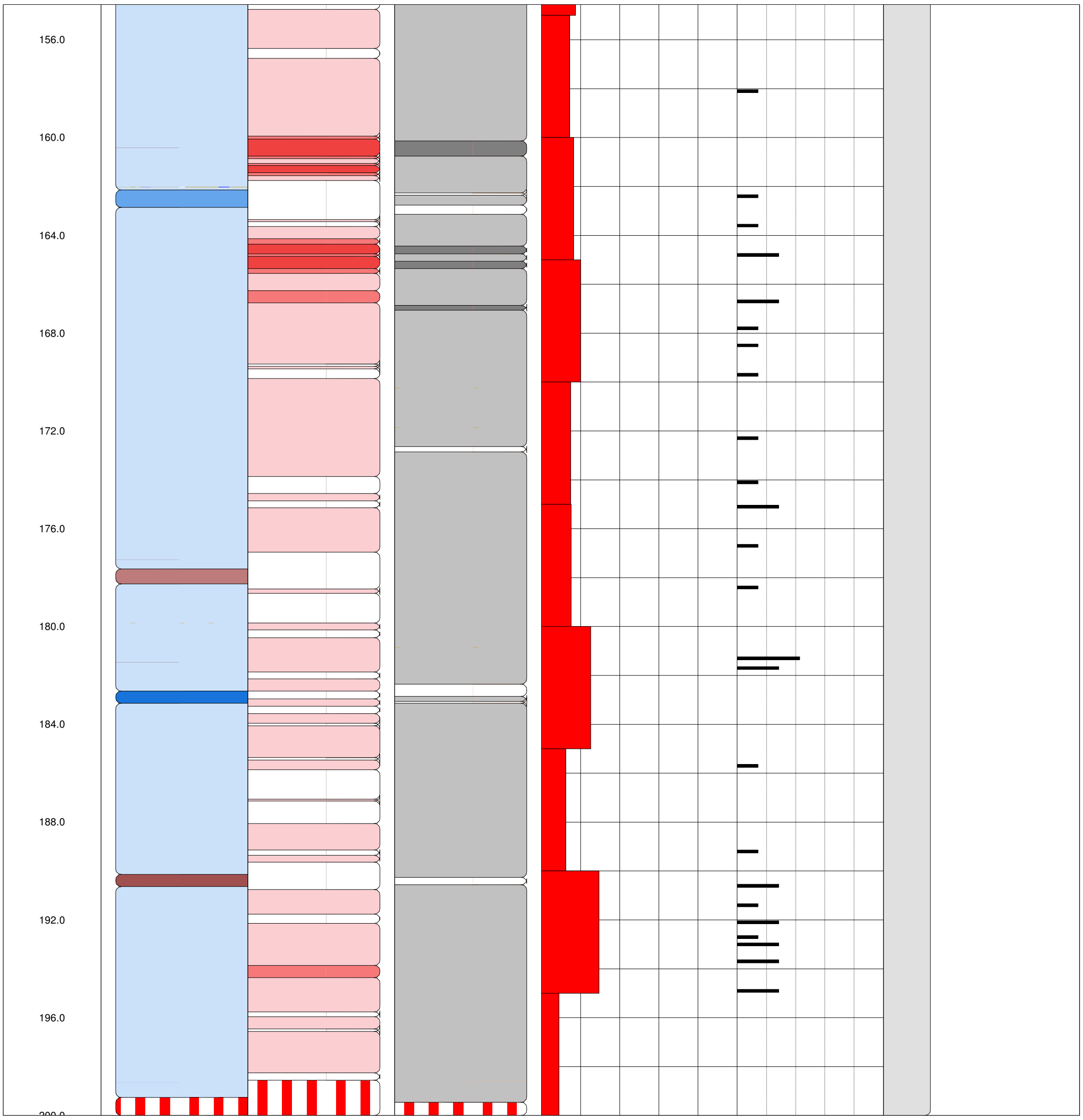

100.0
104.0
108.0
112.0
116.0
120.0
124.0
128.0
132.0
136.0
140.0
144.0
148.0
152.0

Page 3


156.0
160.0
164.0
168.0
172.0
176.0
180.0
184.0
188.0
192.0
196.0

GeoVista

Interpretation of geophysical borehole logging data

Borehole HFM30

Silicate Density kg/m3	Natural Gamma Radiation microR/h	Magnetic Susceptibility SI	Estimated Fracture Frequency fractures/m
unclassified	unclassified	unclassified	< 3 fr/m
dens<2680 (Granite)	gam<20	sus<0.001	3< fr/m <6
2680<dens<2730 (Granodiorite	20<gam<36	0.001<sus<0.01	
2730<dens<2800 (Tonalite)	36<gam<53	0.01<sus<0.1	
2800<dens<2890 (Diorite)	53<gam		
dens>2890 (Gabbro)			

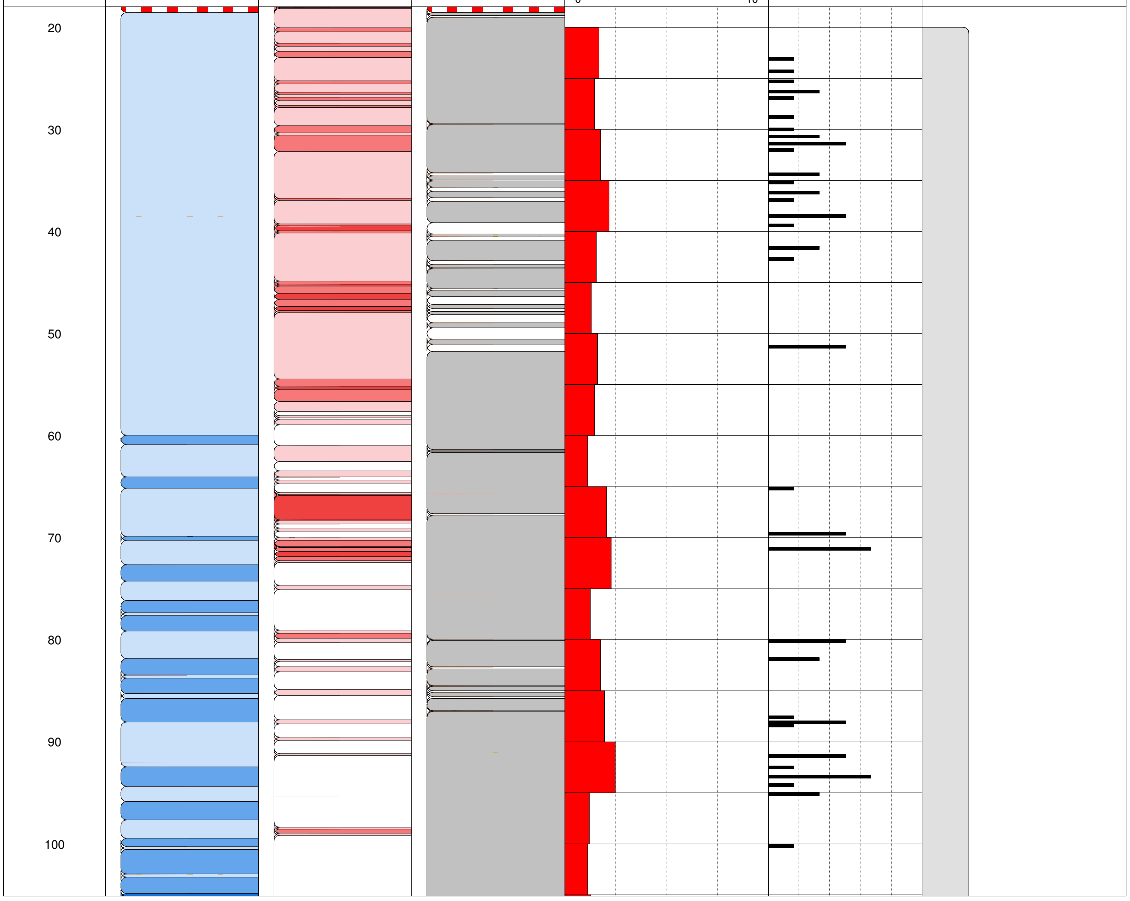
Silicate number of rows	Nat Gamma number of rows	Mag Sus number of rows	Est Frac Freq number of rows
90	154	123	6

Depth 1m:500m

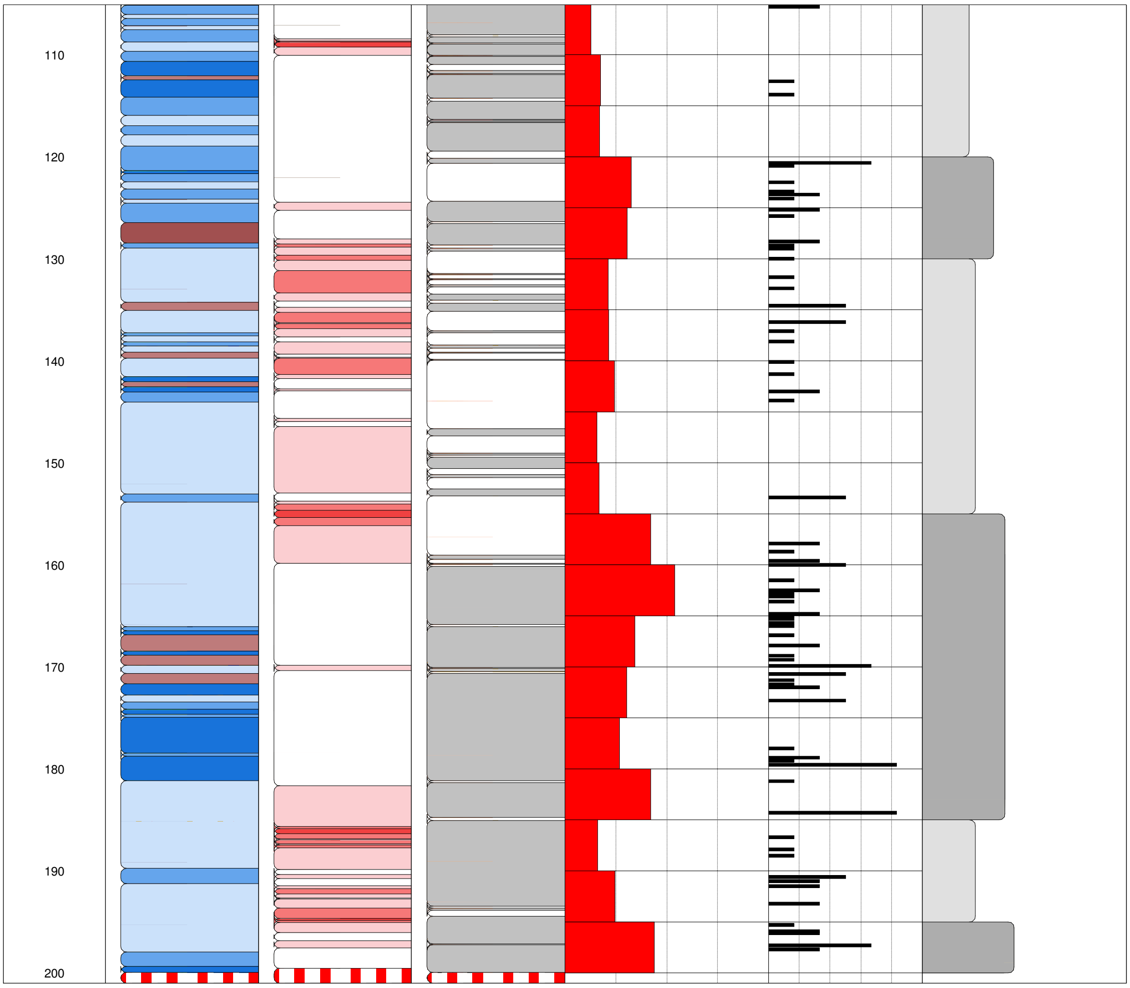
Generalized Loggings

Fracture Loggings

Silicate Density | Natural Gamma Radiation | Magnetic Susceptibility | Estimated fracture frequency (fractures/m) 0 10 | Inferred fractures 0 = no method 1 = all methods 0 1 | Integration of estimated fracture frequency



Page 1



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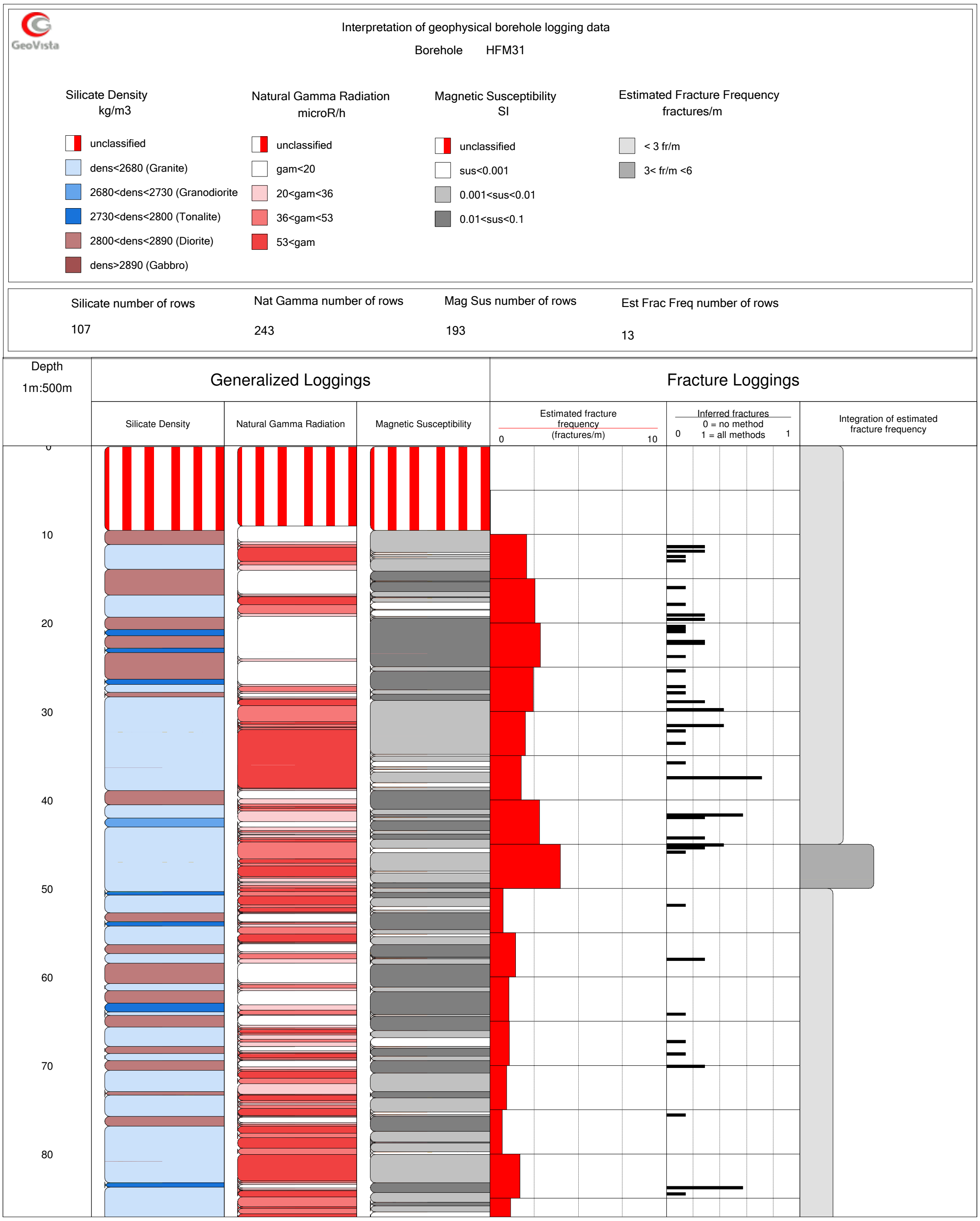
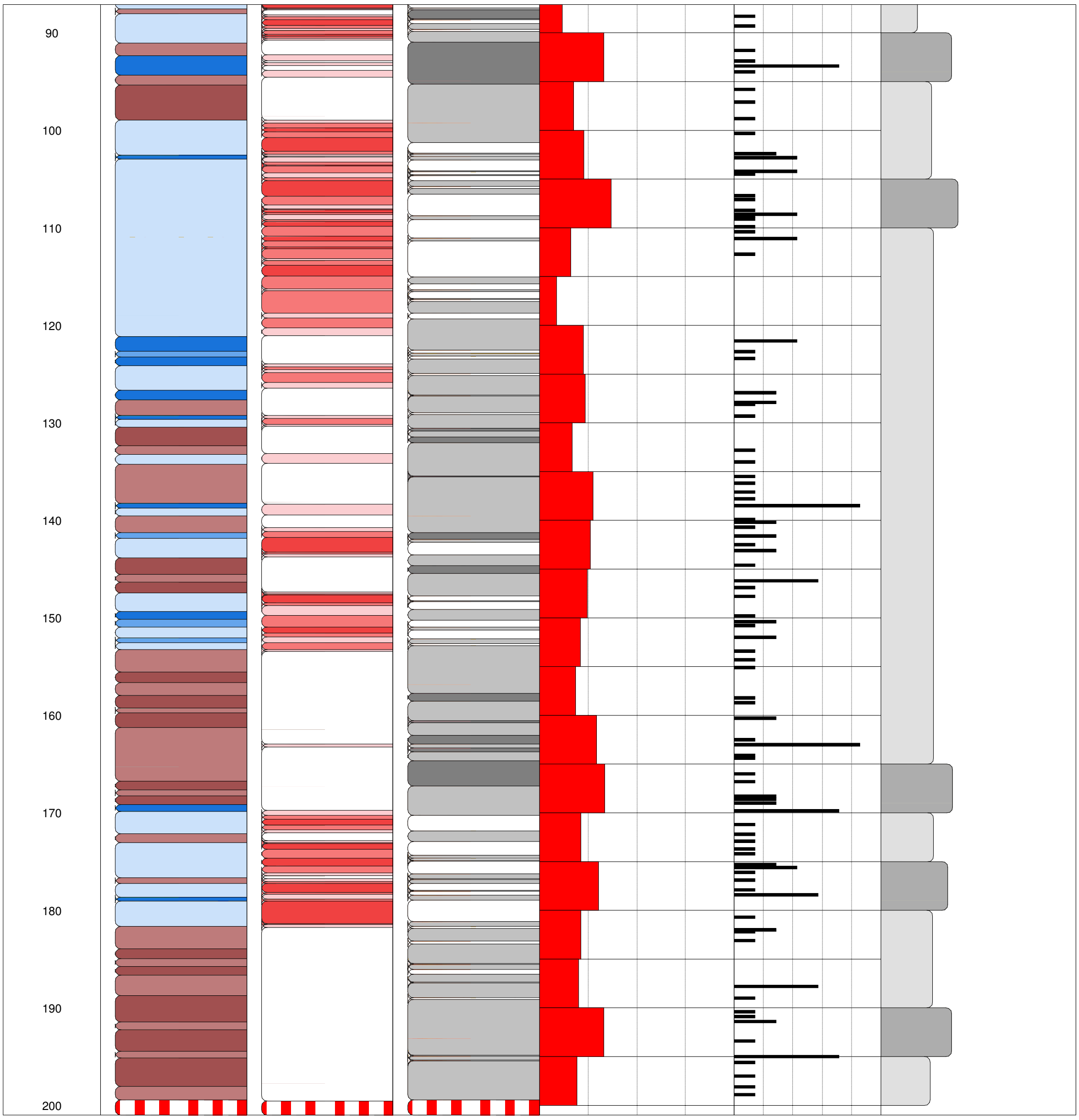
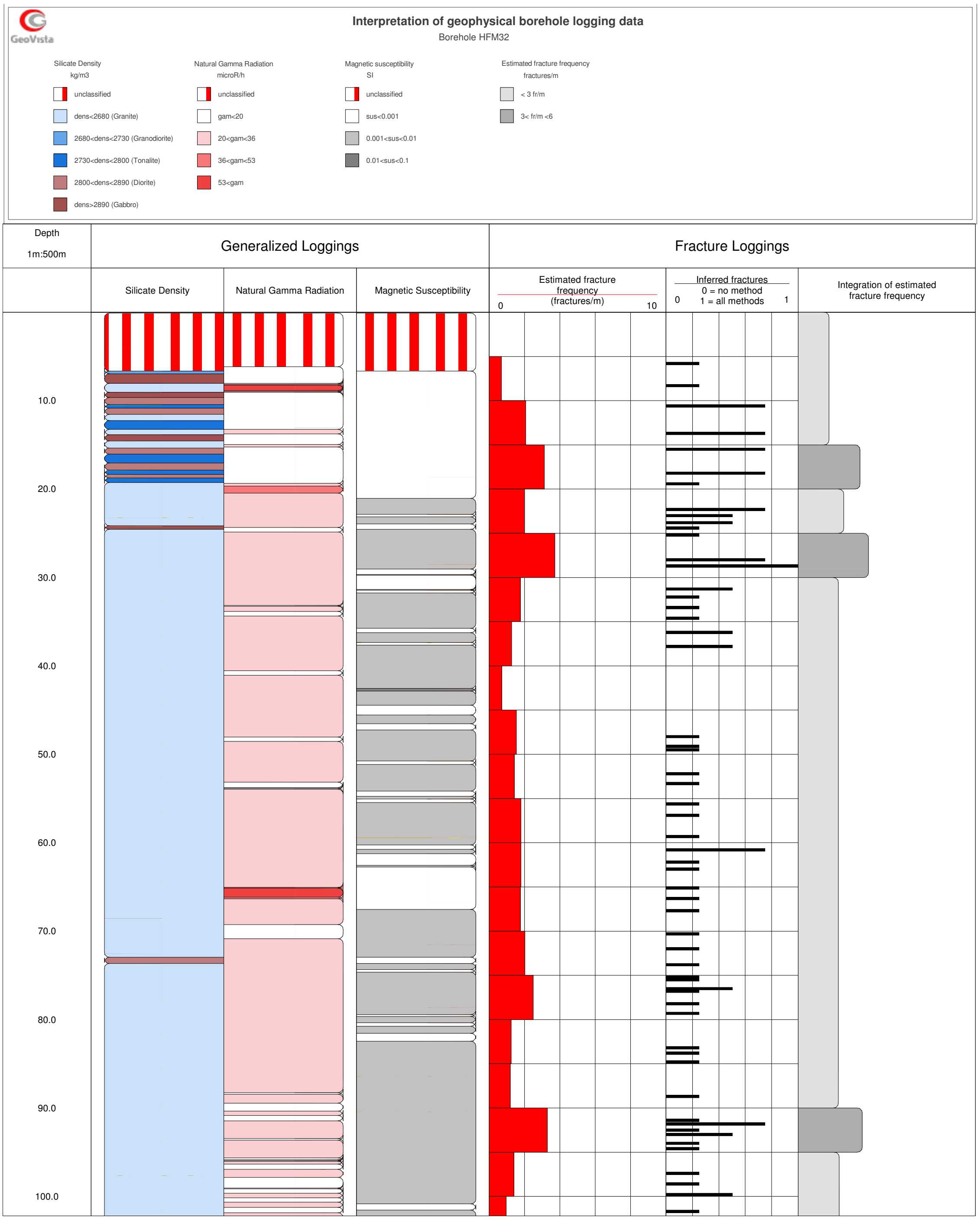
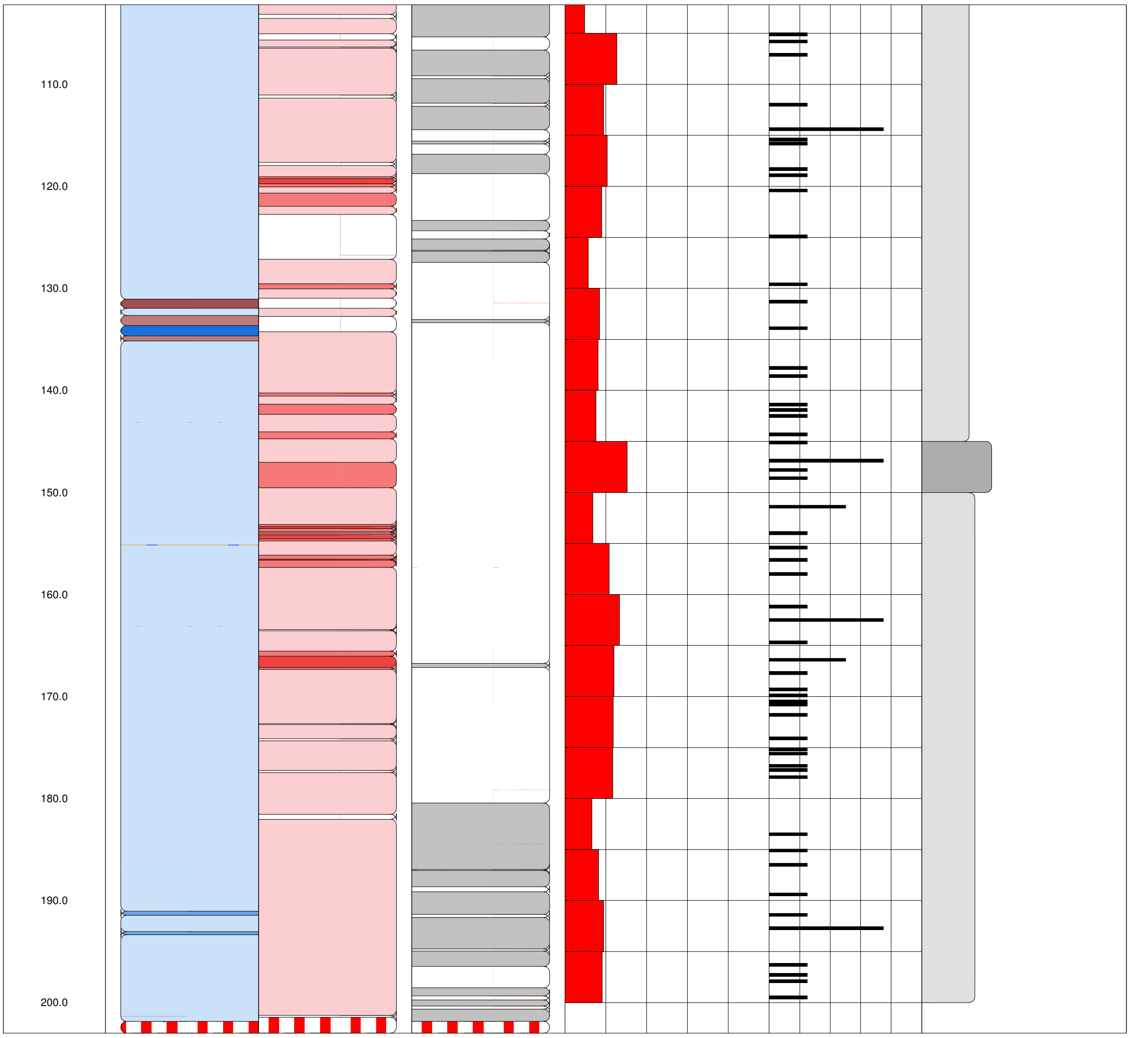

GeoVista
Interpretation of geophysical borehole logging data
Borehole HFM31
Silicate Density
kg/m3
unclassified
dens<2680 (Granite)
2680<dens<2730 (Granodiorite
2730<dens<2800 (Tonalite)
2800<dens<2890 (Diorite)
dens>2890 (Gabbro)
Natural Gamma Radiation
microR/h
unclassified
gam<20
20<gam<36
36<gam<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
< 3 fr/m
3< fr/m <6
Silicate number of rows
107
Nat Gamma number of rows
243
Mag Sus number of rows
193
Est Frac Freq number of rows
13
Depth
1m:500m
Generalized Loggings
Fracture Loggings
Silicate Density
Natural Gamma Radiation
Magnetic Susceptibility
Estimated fracture frequency (fractures/m)
0
10
Inferred fractures
0 = no method
1 = all methods
0
1
Integration of estimated fracture frequency
0
10
20
30
40
50
60
70
80



Page 2


GeoVista
Interpretation of geophysical borehole logging data
Borehole HFM32
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
< 3 fr/m
3< fr/m <6
Depth
1m:500m
Generalized Loggings
Fracture Loggings
Silicate Density
Natural Gamma Radiation
Magnetic Susceptibility
Estimated fracture frequency (fractures/m)
0
10
Inferred fractures
0 = no method
1 = all methods
0
1
Integration of estimated fracture frequency
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0



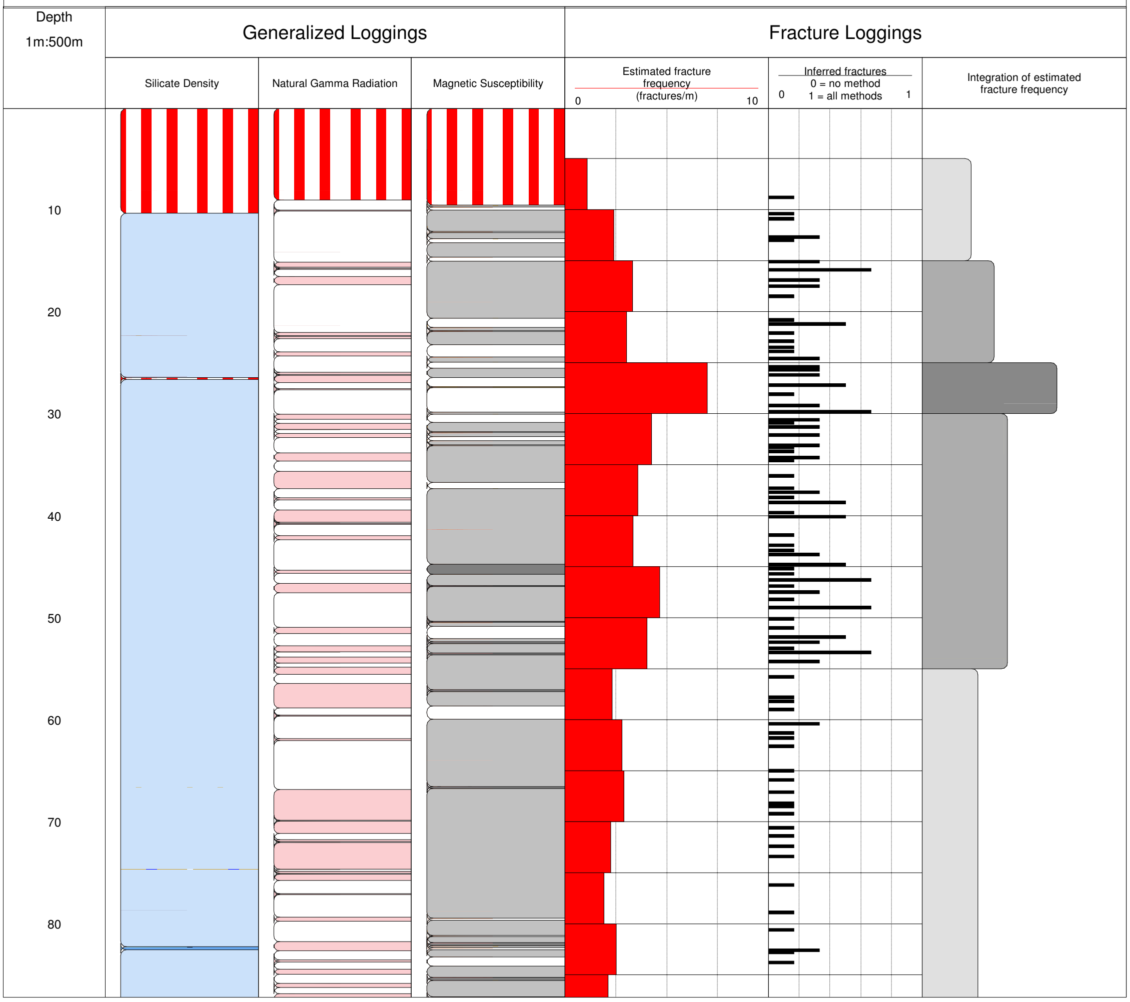
Page 2

Interpretation of geophysical borehole logging data

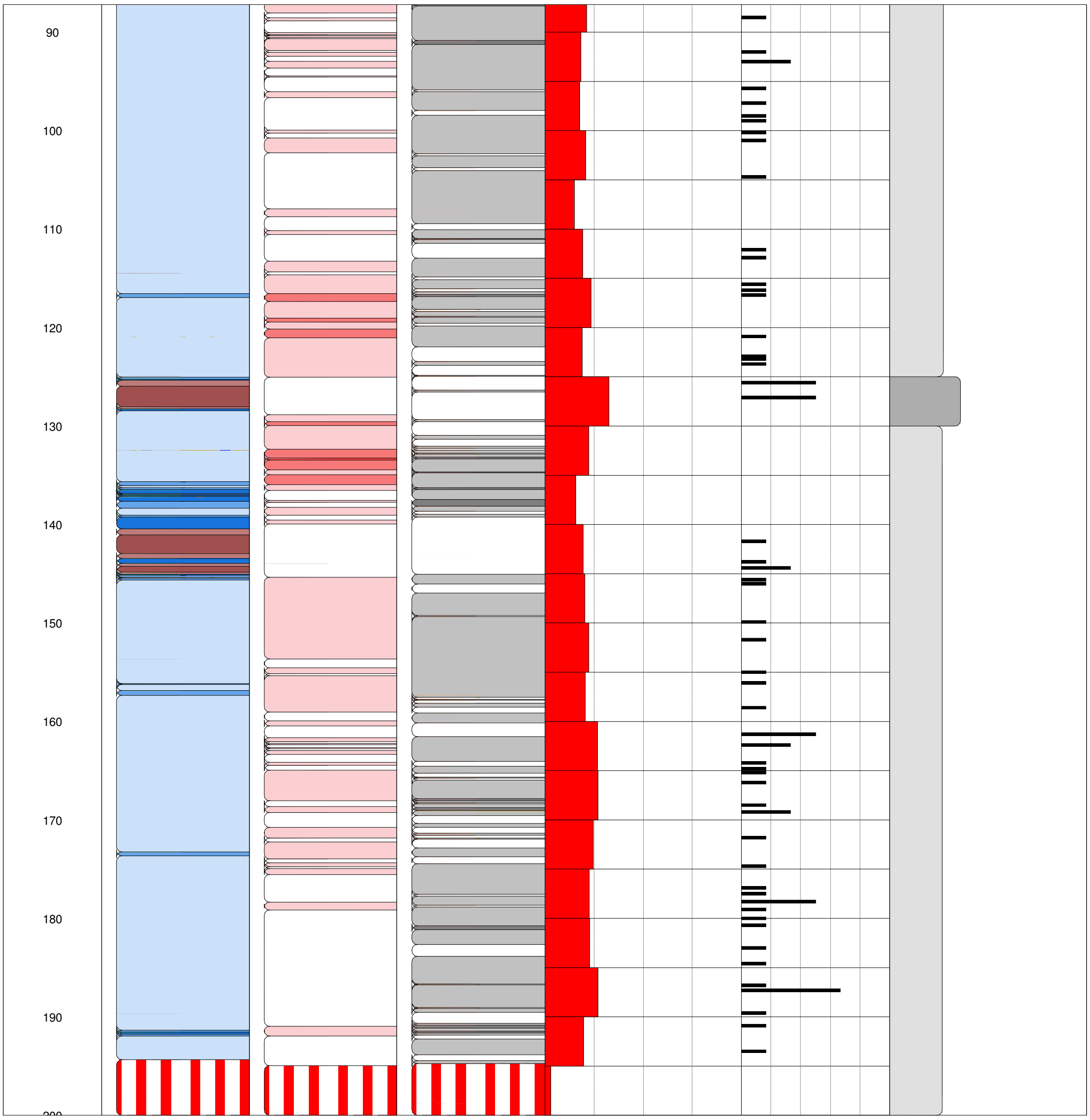
Borehole HFM38

Silicate Density kg/m3	Natural Gamma Radiation microR/h	Magnetic Susceptibility SI	Estimated Fracture Frequency fractures/m
unclassified	unclassified	unclassified	< 3 fr/m
dens<2680 (Granite)	gam<20	sus<0.001	3< fr/m <6
2680<dens<2730 (Granodiorite	20<gam<36	0.001<sus<0.01	>6 fr/m
2730<dens<2800 (Tonalite)	36<gam<53	0.01<sus<0.1	
2800<dens<2890 (Diorite)	53<gam		
dens>2890 (Gabbro)			

Silicate number of rows	Nat Gamma number of rows	Mag Sus number of rows	Est Frac Freq number of rows
50	169	177	7



Page 1



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