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Abstract

This report presents the results from the Boremap logging of telescopic drilled borehole KFM08A and core drilled borehole KFM08B. The boreholes are located at the western shore of Asphällsfjärden, in the northern part of Forsmark site investigation area, and plunges 60° towards northwest and west, respectively. The main purposes for the location of these boreholes were to (1) define the northern margin of the tectonic lens that largely coincides with the site investigation area, and (2) investigate the possible existence of minor deformation zones in the area. The full length of KFM08A is 1,001.19 metres, and the BIPS-image usable for mapping covers the interval 102.46–950 metres after length adjustment. The lowermost 51.19 metres of the borehole, for which no BIPS-image was available, were mapped conventionally. KFM08B has a total length of 200.54 metres, and the BIPS-image covers an interval between 5.72 and 200.06 metres after adjustment. All intersected structures and lithologies have been documented in detail by integrating information from the drill core and the BIPS-image.

The two boreholes are located in the hinge area of an inferred fold structure, which plunges moderately towards southeast. KFM08A is drilled, more or less, perpendicular to the fold hinge, from the tectonic lens into a belt of aplitic metagranite at 780–876 metres length and a subsequent sequence of metavolcanic rocks with intercalated amphibolite at 876–925 metres length. At 925 metres length, the borehole enters a structurally heterogeneous, rather biotite-rich metagranite-granodiorite. The volumetrical most important rock type in KFM08B, as well as the upper 780 metres of KFM08A (within the tectonic lens), is a medium-grained metagranite-granodiorite. Other frequent rock units within the two boreholes include various amphibolites, fine-grained metagranitoids, pegmatitic granite and leucogranite. Virtually all rocks have experienced Svecofennian metamorphism under amphibolite facies conditions.

Structurally, KFM08A and KFM08B is characterised by composite L-S fabrics, with a varying intensity of the two components. Totally 96 minor zones of more intense ductile and brittle-ductile deformation have been registered in KFM08A and the lower half of KFM08B. The widths of individual zones are typically up to few decimetres. A faint to weak oxidation of feldspars is generally associated with more intensely fractured intervals. The most intense oxidation is associated with an occurrence of vuggy, quartz-deficient granite at 409.85–412.04 metres length in KFM08A.

The total number of fractures registered during the boremap-logging of KFM08A and KFM08B amounts to 5,008. Of these are 839 open, 73 partly open and 4,096 sealed. Four fracture sets can be distinguished in the boreholes. (1) Vertical to sub-vertical fractures, striking NE-SW. Most of these fractures are inferred to be sealed. Breccias and sealed networks normally belong to this set. Typical infilling minerals are laumontite, calcite, chlorite, hematite, adularia, quartz and pyrite. (2) Mainly open, flat-lying fractures, generally encountered in KFM08B and the upper half of KFM08A. Several of the fractures have apertures that are clearly visible in the BIPS-image (i.e. > 1 millimetre). The most frequent infilling minerals are calcite, chlorite and clay minerals. (3) Mainly sealed, vertical to sub-vertical fractures, striking NW-SE. They are preferentially found below ~ 750 metres length in KFM08A. (4) Open and sealed fractures, parallel with the tectonic foliation. The orientation of these fractures tends to change gradually towards depth, as the boreholes enters the hinge of the large-scale fold structure.

Sammanfattning

Föreliggande rapport redovisar resultaten från boremapkarteringen av teleskopborrhål KFM08A och kärnborrhål KFM08B. Borrhålen är belägna på västra stranden av Asphällsfjärden, i norra delen av undersökningsområde Forsmark, och stupar 60° mot nordväst respektive väst. De huvudsakliga syftena med borrhålen var att (1) definiera den norra begränsningen av den tektoniska lins som i hög grad sammanfaller med undersökningsområdet och (2) undersöka den möjliga förekomsten av mindre deformationszoner i området. Den totala längden av KFM08A är 1 001,19 meter och den BIPS-bild som är användbar för kartering täcker intervallet 102,46–950 meter, efter längdjustering. De understa 51,19 metrarna av borrhålet, för vilka det saknas BIPS-bild, är konventionellt karterade. KFM08B har en total längd på 200,54 meter och BIPS-bilden omfattar intervallet mellan 5,72 och 200,06 meter efter justering. Alla strukturer och litologier i de Boremapkarterade intervallen har dokumenterats i detalj genom att integrera information från borrkärnorna och BIPS-bilderna.

De två borrhålen är lokaliserade i veckomböjningen på en förmodad större veckstruktur, som antas stupa måttligt åt sydost. KFM08A är borrad mer eller mindre vinkelrät mot veckaxeln, från den tektoniska linsen in i ett bälte av aplitisk metagranit på 780–876 meters längd och en efterföljande sekvens av metavulkaniter med förekomster av amfibolit på 876–925 meters längd. Därefter tränger borrhålet in i en strukturellt heterogen, relativt biotitrik metagranit-granodiorit. Den volymmässigt viktigaste bergarten i KFM08B och de övre 780 metrarna av KFM08A (i den tektoniska linsen), är en medelkornig metagranit-granodiorit. Andra vanligt förekommande bergarter i de två borrhålen inkluderar olika amfiboliter, finkorniga granitoider, pegmatitisk granit och leucogranit. Största delen av berggrunden i området har genomgått Svekofennisk amfibolitfacies-metamorfos.

KFM08A och KFM08B karaktäriseras vidare av en sammansatt L-S-struktur, med en varierande intensitet av de två komponenterna. Totalt 96 mindre zoner med plastisk och spröd-plastisk deformation har registrerats i KFM08A och den undre hälften av KFM08B. Bredden på enskilda zoner är generellt upp till några decimeter. En svag till mycket svag oxidation av fältspater uppträder normalt i längdintervall som är mer kraftigt uppspruckna. Den kraftigaste oxidationen uppträder i anslutning till en förekomst av hålrumsförande, kvartsfattig granit på 409,85–412,04 meters längd i KFM08A.

Det totala antalet sprickor som registrerats vid boremapkarteringen av KFM08A och KFM08B uppgår till 5 008. Av dessa är 839 öppna, 73 partiellt öppna och 4 096 läkta. Fyra sprickgrupper kan urskiljas i borrhålen. (1) Vertikala till subvertikala sprickor som stryker NO-SV. De flesta av dessa sprickor är registrerade som läkta. Breccior och läkta nätverk tillhör normalt denna grupp. Typiska sprickmineral inkluderar laumontit, kalcit, klorit, hematit, adularia, kvarts och pyrit. (2) Huvudsakligen öppna, flacka sprickor som framför allt påträffas i KFM08B och övre hälften av KFM08A. Flera av dem har aperturer som är klart synliga i BIPS-bilden (dvs > 1 millimeter). De vanligast förekommande sprickfyllnadsmineralen är kalcit, klorit och lermineral. (3) Ofta läkta, vertikala till subvertikala sprickor som stryker NV-SO. De uppträder främst under ~ 750 meters längd i KFM08A. (4) Både öppna och läkta sprickor som är parallella med den tektoniska foliationen. Orienteringen av dessa sprickor tenderar att ändras successivt mot djupet, då borrhålet penetrerar omböjningen i den storskaliga veckstrukturen.

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1 Introduction

Since 2002, SKB investigates two potential sites at Forsmark and Oskarshamn, for a deep repository in the Swedish Precambrian basement. In order to characterise the bedrock down to a depth of about 1 km in the central part of the Forsmark site investigation area, three deep telescopic boreholes were drilled. Each borehole starts with 100 metres of percussion drilling, followed by core drilling down to about 1,000 metres depth. To obtain drill cores for the upper 100 metres, additional boreholes were drilled adjacent to telescopic boreholes at drilling site (DS) 1 and 3. After completion of these initial drillings, SKB launched a more extensive, complementary drilling programme, aiming to solve more specific geological issues. An important aspect is to define the northern margin of rock domain 29 (RFM029; /SKB 2004/), which largely coincides with the boundary of the site investigation area. Therefore, borehole KFM08A was drilled at the western shore of Asphällsfjärden with 60° inclination towards northwest (319°) (Figure 1-1). KFM08A is a telescopic borehole (cf SKB MD 620.004), identical with the seven previous deep boreholes in the area, with a total length of about 1,000 metres. An additional borehole, KFM08B, was drilled at DS8 to obtain a complementary drill core for the upper, percussion drilled part of KFM08A. This borehole is 200 metres long and plunges 59° westward (270°) to investigate the possible existence of minor deformation zones.

The drilling activities in KFM08A and KFM08B were finished 31 March and 26 January 2005, respectively. The geological logging of KFM08A started 11 May and ended 21 June 2005, whereas KFM08B was mapped during the period 2 May to 4 June 2005.

A detailed geological logging of the drill cores obtained through the drilling programs is essential for subsequent sampling and borehole investigations, and consequently, for the three-dimensional modelling of the site geology. For this purpose, the so-called Boremap system has been developed. The system integrates results from geological drill core logging, or alternatively, the drill cuttings when a core is not available, with information from BIPS-logging (Borehole Image Processing System) and calculates the absolute position and orientation of fractures and various planar lithological features (SKB MD 143.006 and 146.005).

This document reports the results gained by the geological logging of KFM08A and KFM08B, which is one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan AP PF 400-05-044. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

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

Activity plan	Number	Version
Boremapkartering av teleskopborrhål KFM08A och kärnborrhål KFM08B	AP PF 400-05-044	1.0
Method documents	**Number**	**Version**
Metodbeskrivning för Boremap-kartering	SKB MD 143.006	2.0
Nomenklatur vid Boremap-kartering	SKB MD 143.008	1.0
Mätsystembeskrivning för Boremapkartering, Boremap v 3.0	SKB MD 146.005	1.0

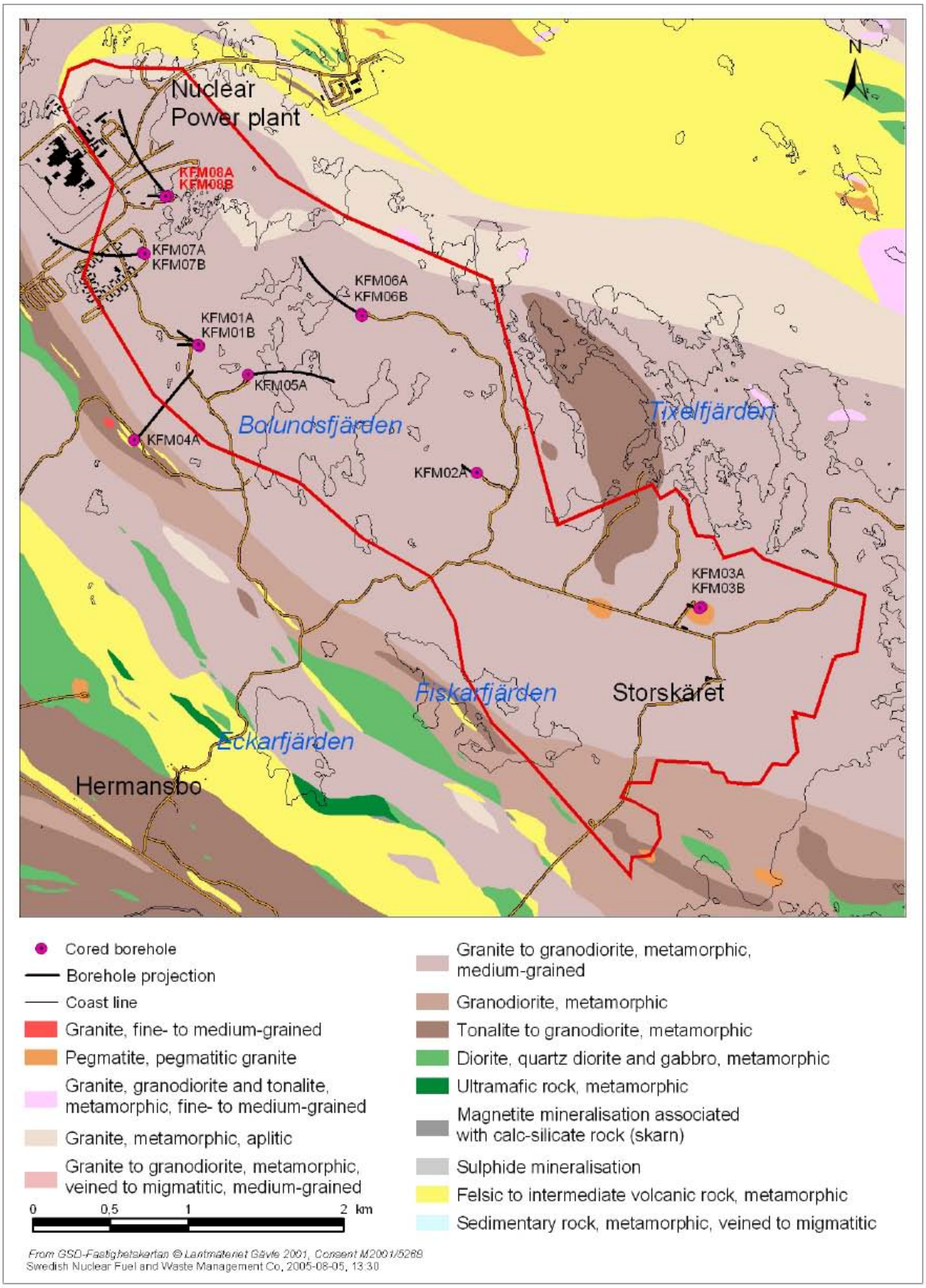

Figure 1-1. *Generalized geological map over Forsmark site investigation area and the projections of KFM08A and KFM08B in relation to other cored boreholes from the drilling programme.*

2 Objective and scope

Borehole KFM08A starts with percussion drilling (Ø = 251 millimetres) to a length of 100.55 metres, followed by core drilling at Ø = 77 millimetres down to full borehole length at 1,001.19 metres. The diameter of the drill core is 51 millimetres under ideal conditions. The soil cover is 5.60 metres. Material from the percussion-drilled part is *not* included in the mapping engagement. The available BIPS-image of KFM08A covers the length interval 102.45–980.45 metres (after adjustment 102.46–984.34 metres). However, the BIPS-image usable for geological logging ends at an adjusted length of about 950 metres, and the last 51.19 metres was hence mapped conventionally.

KFM08B is a traditional cored borehole (Ø = 77 millimetres) with a total length of 200.54 metres. The recovered drill core has a diameter of 51 millimetres under ideal conditions, and the soil cover is 4.92 metres. The BIPS-image used for the geological logging covers the length interval 5.74–199.068 metres (after adjustment 5.72–200.06 metres).

The aim of the geological logging is to obtain a detailed documentation of *all* structures and lithologies intersected by the BIPS-logged intervals of borehole KFM08A and KFM08B. These data will serve as a platform for forthcoming analyses of the drill cores, aimed at investigating geological, petrophysical and mechanical aspects of the rock volume, as well as site descriptive three-dimensional modelling.

3 Equipment

3.1 Description of equipment/interpretation tools

All BIPS-based mapping was performed in Boremap v 3.6. This software contains the bedrock and mineral standard used by the Geological Survey of Sweden (SGU) for geological mapping of the surface at the Forsmark site investigation area, to enable correlation with the surface geology. Additional software used during the course of the geological logging was BIPS Viewer v 1.10 and Microsoft Access. The final data presentation was made by Geoplot and WellCAD v 3.2.

The following equipment was used to facilitate the core logging: folding rule, concentrated hydrochloric acid diluted with three parts of water, unglazed porcelain plate, knife, hand lens, paintbrush and tap water.

4 Execution

4.1 General

During the core logging, the 1,100 metres drill core obtained from the interval 4.92–200.54 metres of KFM08B and 100.55–1,001.19 metres of KFM08A was available in its full length on roller tables in the core-mapping accommodation at Forsmark (the Llentab hall, near the SKB/SFR-office). The BIPS-based mapping of KFM08A was preceded by an overview mapping made by Kenneth Åkerström. No thin-sections were available from the drill cores, and all lithological descriptions are based on ocular inspection. Five geologists from SwedPower AB, Johan Berglund, Peter Danielsson, Jesper Petersson, Göran Skogsmo and Anders Wängnerud, were involved in the BIPS-based mapping. Most of the mapping was done by two geologists at a time, forming a core logging team. However, to speed up the mapping at the prospect of a single-hole interpretation meeting in the end of June 2005, two teams were working parallel part of the time.

The core logging of KFM08A and KFM08B was performed in Boremap v 3.6 according to activity plan AP PF 400-05-044 (SKB internal document) following the SKB method description/instruction for Boremap mapping, SKB MD 143.006 (v 2.0) and 143.008 (v 1.0). An exception is that no geophysical logs were available for KFM08B, and that interpretations of the geophysical logging data for KFM08A arrived when the mapping reached a borehole length of about 350 metres. A WellCAD summary of the mapping is presented in Appendices 1A and 1B.

4.2 Preparations

The length registered in the BIPS-image deviates from the true borehole length with increasing depth, and the difference at the bottom of KFM08A is about 5 metres. It was, therefore, necessary to adjust the length in KFM08A with reference to groove millings cut into the borehole wall at every 50 metres, with the deepest slot at a length of 981 metres. The precise level of each reference mark can be found in SKB's database SICADA (Appendix 4). However, the adjusted length is still not completely identical with the one given in the drill core boxes, as the core recovery may yield erroneous lengths. The difference at every 50 metres is given in Table 4-1, and may locally exceed 2 decimetres. KFM08B lacks groove millings. However, to facilitate the mapping, we adjusted the length in the BIPS-image with reference to more or less orthogonal rock contacts or fractures at six levels (6, 9, 76, 119, 171 and 199 metres). The difference between the drill core and the BIPS-image is, therefore, very small.

Data necessary for calculations of absolute orientation of structures in the borehole includes borehole diameter, azimuth and inclination, and these data were imported directly from SKB's database SICADA (Appendices 2 and 3).

Table 4-1. Differences between adjusted length in the BIPS-image and the length given in the drill core boxes.

Adjusted length in BIPS (m)	Approximate length in the drill core boxes (m)	Difference (m)
111.73	111.70	+0.03
151.09	151.11	–0.02
200.25	200.30	–0.05
250.19	250.39	–0.20
299.92	299.75	+0.17
349.99	350.00	–0.01
399.92	399.96	–0.04
449.97	450.03	–0.06
499.91	500.00	–0.09
599.91	600.00	–0.09
649.94	650.00	–0.06
701.05	701.17	–0.12
750.09	750.21	–0.12
800.06	800.23	–0.17
850.50	850.65	–0.15
899.91	900.13	–0.22
949.68	949.93	–0.25

4.3 Data handling

To obtain the best possible data security, the mapping was performed on the SKB intranet, with regular back-ups on the local drives. However, the intranet was closed for service between 17 July (17.00) and 19 July (23.00). During this time we were obligated to map on the local hard drives.

To avoid that some broken fractures become unregistered, the number of broken fractures in the drill core was regularly checked against the number of registered fractures. The quality routines include also daily controls of the mapping by detailed examination of Boremap generated variable/summary reports and WellCad log to match. The final quality check of the mapping was done by a routine in the Boremap software. The primary data were subsequently exported to the SKB database SICADA, where they are traceable by the activity plan number.

4.4 Analyses and interpretations

The Boremap system has obviously some limitations, since all geological features must be represented by intersecting planar surfaces. Non-planar structures, such as small scale folding, linear objects (e.g. mineral lineation) and curved fractures can, therefore, not be correctly documented. The major problem is curved structures (e.g. fractures), which run almost parallel with the borehole axis. During the mapping sessions of KFM08A and KFM08B such features were normally approximated by fitting the plane after one of their ends in the borehole. The fact that some of these structures do not actually intersect the borehole is only noted in the attached comments.

Another problem with the core logging system is related to geological features (mainly fractures) that can be observed only in the drill core. This problem usually arises from poor resolution in the BIPS-image, which in the present case often is caused by the occurrence of suspension from drilling and/or brownish black coating from the drilling rods on the borehole walls. However, even in the most perfect BIPS-image, it is sometimes difficult to distinguish a thin fracture, sealed by a low contrast mineral. All fractures observed in the drill core, but not recognized in the BIPS-image, have been registered as 'not visible in BIPS' in Boremap, to prevent them from being used in forthcoming fracture orientation analysis. Fractures supposed to be induced by the drilling activities fall within this category. Obviously drilling-induced fractures are not included in the mapping.

The resolution of the BIPS-image does generally make it possible to estimate the width of fractures with an error of ± 0.5 millimetres. Thus, reliable measurements of fracture widths/apertures less than 1 millimetre are possible to obtain in the drill core, and the minimum width/aperture given is therefore 0.5 millimetre. However, if the fracture width measured in the drill core is much less than 0.5 millimetre, it is normally noted in the attached comment.

The fracture mapping focuses on the division into broken and unbroken fractures, depending on whether they are parting the core or not. Broken fractures include both open fractures and originally sealed fractures, which were broken during the drilling. To decide if a fracture was open, partly open or sealed in the rock volume (i.e. in situ), SKB has developed a confidence classification expressed at three levels, 'possible', 'probable' and 'certain', on the basis of the weathering of the fracture surface and fit of the fracture planes. The criteria for this classification are given in SKB method description for Boremap mapping, SKB MD 143.006 (v 2.0).

Up to four infilling minerals can be registered in the database for each fracture. As far as possible, they are given in order of decreasing abundance in the fracture. Additional minerals (i.e. five or more), which occur in a few fractures, are noted in the attached comment. However, it must be emphasized that this provides no information of the volumetric amount of individual minerals. In a fracture with two minerals, the mineral registered as 'second mineral' may range from sub-microscopic staining up to amounts equal to that of the mineral registered as 'first mineral'. Hematite, for example, which is found in more than 10% of the registered fractures in the cored interval of KFM08A, occur consistently as extremely thin coatings or impurities in other fracture minerals, such as adularia and laumontite.

4.5 Nonconformities

A large amount of the fractures intersected by KFM08A and KFM08B are sealed by laumontite (Ca-zeolite). These fractures occur as both broken and unbroken, but dehydration of laumontite tends to produce volumetric changes, and the sealing will eventually crackle and break the drill core. Thus, all laumontite-bearing fractures suspected to have been sealed originally are registered as unbroken.

Some fracture filling minerals are more conspicuous than other. For example, the distinct red tinting shown by sub-microscopic hematite reveals extremely low concentrations of the mineral. Also the use of diluted hydrochloric acid for identification of calcite makes it possible to detect amounts that are macroscopically invisible. The amount of fractures filled with other less conspicuous minerals may, on the other hand, be underestimated. Pyrite, which typically forms up to millimetre-sized, isolated crystals, might for example be under-represented in unbroken fractures.

As in previous cored boreholes, the mapping of KFM08A was locally hampered by suspended drill cuttings, brownish black coatings on the borehole walls as well as mechanical turning of the borehole walls. The amount of suspended material is highest in the last 100 metres of KFM08A, where the plunge of the borehole is less than 43° (Appendix 3A), and up to metre-long, opaque accumulations may, locally, cover the entire borehole wall. Orientations registered for geological structures (e.g. fractures) in these intervals may, consequently, differ greatly from the actual orientations. Because of this suspension, the BIPS-image usable for geological logging ends at an adjusted length of ~ 950 metres, and the last 51.19 metres was, therefore, mapped conventionally. The results are reported in Appendix 5, and include rock type, occurrences, alterations and a separation of fractures into unbroken, broken, sealed and open. The dark coating is ubiquitous below ~ 360 metres of KFM08A, where it typically forms a spiral pattern or a single band along the borehole axis. In the worst cases it obscures more than half of the borehole wall. This coating phenomenon is obviously drill induced, and the explanation proposed by /Askling and Odén 2004/ is that the coatings originate from metal fragments abraded from the drill rods.

A drill induced crush has been noted at 922.55–922.88 metres of KFM8A. Several pieces of the crushed material have fracture coatings. However, it has not been possible to register these fractures due to the poor quality of the BIPS-image.

Both during the mapping and the subsequent work with the mapping data, we noted a few inexplicable errors in the database. These were all corrected, though there might still be unnoticed errors. We disclaim the responsibility for all such errors caused by the shortcomings in the software.

5 Results

5.1 General

Borehole KFM08A is located in the hinge area of a major fold structure /cf Bergman et al. 2003/ and plunges 60° northwestwardly, towards a belt of aplitic metagranite and felsic to intermediate metavolcanic rocks (rock domain 32; SKB 2004). Also this belt is part of the fold structure. Since the fold axis of the proposed structure is inferred to plunge moderately towards the southeast /Stephens et al. 2003/, KFM08A was expected to enter rock domain 32 at repository level. At 780–876 metres length (i.e. a true depth of ca 590–670 metres), the borehole intersects an aplitic metagranite (rock code 101058), and subsequently a sequence of metavolcanic rocks (rock code 103076) with intercalated amphibolite (102017) at 876–925 metres length. At 925 metres length, the borehole enters a structurally heterogeneous, rather biotite-rich metagranite-granodiorite (rock code 101057), which belongs to rock domain 34 /cf SKB 2004/. The remaining part of KFM08A, above 780 metres length, is dominated by the typical metagranite(-granodiorite) (rock code 101057), which also prevails in the previously drilled deep boreholes located in the tectonic lens of the Forsmark area (i.e. rock domain 29; /cf SKB 2004/) /Petersson and Wängnerud 2003, Petersson et al. 2003ab, 2004ab, 2005bc/. This is also the volumetrically most important rock type in KFM08B. Other frequent rock units within the two boreholes, none forming occurrences more than a few metres in length, include various amphibolites, fine- to finely medium-grained metagranitoids and dykes or veins of pegmatite, pegmatitic granite and leucogranite. Except for some late veins or dykes, all rocks have experienced Svecofennian metamorphism under amphibolite facies conditions.

5.2 Core lithology

The medium-grained metagranite(-granodiorite) (rock code 101057) occupies about 62% of the logged interval of KFM08A, and 81% of KFM08B. Above 780 metres length in KFM08A (i.e. in rock domain 29) as well as in the entire KFM08B, it is typically granitic with a tendency to be slightly granodioritic. Texturally, the rock is rather equigranular with elongated quartz domains, alternating with feldspar-dominated domains and thin streaks of biotite. The colour of the rock varieties ranges from greyish red to grey, whereas completely grey varieties, lacking the reddish tint, are sparse and typically associated with amphibolites. Minor sections variably speckled by fine-grained, whitish plagioclase occur sporadically throughout the borehole. Microscopic examination of similar rocks from KFM01A and KFM03A suggests that the feature is a result of retrograde sericitization /Petersson et al 2004c/. The metagranite-granodiorite that occurs below 925 metres length in KFM08A (i.e. in rock domain 34) differs markedly from the prevalent variety in the tectonic lens. The mineral distribution is here typically more heterogeneous, and the characteristic texture with alternating domains, as described above, is only vaguely distinguishable. Most conspicuous, however, is the high, but variable biotite content, which locally reaches up to about 30–35 vol %. Moreover, the rock often contains subordinate, but yet significant amounts of muscovite. The presence of muscovite has been recorded by using 'sericitization' and the intensity reflects the amount of muscovite in the rock.

Aplitic metagranite (rock code 101058) is generally restricted to a more or less continuous length interval between 780 and 877 metres of KFM08A. Only two of the occurrences outside this interval exceed one metre in length (203.08–204.40 and 908.26–911.40 metres).

Totally, the rock occupies about 9% of the boremap-logged interval of KFM08A, and 1.5% of KFM08B. Generally, the rock is equigranular and greyish red to reddish grey in colour. A significant amount is variably bleached and characterized by flecks of stretched biotite aggregates. The overall appearance of this variety is highly reminiscent of the albitized rock in the lower part of KFM06A and outcrops along the northeastern margin of the investigation site /cf Petersson et al. 2005ab/. Bleached intervals were, therefore, mapped as 'albitized'. However, defining the relative intensity of the albitization is more difficult, but the majority has been mapped as 'weak' to 'medium'.

The fine-grained, intermediate rock of inferred volcanic origin (rock code 103076) occupies about 4% of the boremap-logged interval of KFM08A, and less than 1% of KFM08B. Most of it is found in the length interval between 880 and 925 metres in KFM08A, where the rock forms an almost continuous sequence with intercalations of amphibolite (rock code 102017). A second continuous occurrence occurs at 943.6–947.1 metres length. Other occurrences, which rarely exceed one metre in length, are limited to the following length intervals: 425–452, 479–500, 811–848, 927–938, 966–971 metres in KFM08A and 143–145 metres in KFM08B. The rock is generally equigranular, dark grey in colour and all contacts are parallel with the tectonic foliation (Figure 5-1). The most prominent occurrence in the length interval 880–925 metres of KFM08A is locally aphanitic and displays mostly a fine-scaled compositional banding. Other occurrences are typically more structureless, and except for the grain-size, there is no textural or structural macroscopic feature that unambiguously points towards a volcanic origin of the rocks. All extensions and contacts are more or less parallel with the tectonic foliation (Figure 5-1).

Dykes, veins and segregations of pegmatite, pegmatitic granite, aplite and leucogranitic material are frequent throughout the borehole, and the rock types occupy about 15% of the drill cores logged in Boremap. Most occurrences are some decimetre or less, but several pegmatites/pegmatitic granites reach up to a few metres in width. The pegmatitic granites are generally texturally heterogeneous, often with a highly variable grain-size, and some occurrences include intervals of finely medium-grained, equigranular granite. Rather coarse magnetite, and subordinately hematite, has been identified in some pegmatites. A few also contain accessory amounts of sulphides, such as pyrite, pyrrhotite, and probable molybdenite. Despite the textural variability and temporal span within this unit, most of these rocks were grouped as 'pegmatite, pegmatitic granite' (rock code 101061). Considering the orientation of the pegmatites and pegmatitic granites, the vast majority are oriented parallel with the tectonic foliation (Figure 5-1). Rocks related to the pegmatitic material, such as fine to finely medium-grained leucogranite (111058) and some minor aplites, constitute less than 1% of the drill cores logged in Boremap. Some of the leucogranites are highly reminiscent of the more granitic varieties of the fine- to finely medium-grained metagranitoids, as discussed below. A distinctive criterion apart from their late-tectonic character is, however, their anomalously high natural gamma radiation /cf Mattsson and Keisu, 2005/. The aplites (rock code 1062), on the other hand, were distinguished from the previously described aplitic metagranite (rock code 101058) by the fact that they are more massive. Quartz-dominated segregations or veins were coded as 8021. Some of them are sulphide bearing with scattered grains of pyrite and pyrrhotite.

Amphibolites (rock code 102017) and related rocks occupy 6.5% of the total cored interval of KFM08A and KFM08B. All extensions and contacts are more or less parallel with the tectonic foliation (Figure 5-1). Generally, the amphibolites are fine-grained, equigranular with a large proportion of biotite. Disseminations of pyrite and/or pyrrhotite are macroscopically visible in some of the occurrences. None of the amphibolites form occurrences that exceed a few metres in core-length, and some are surrounded by up to one decimetre wide rims of whitish, leucogranitic material, similar to the whitened, 'albite rock' described above.

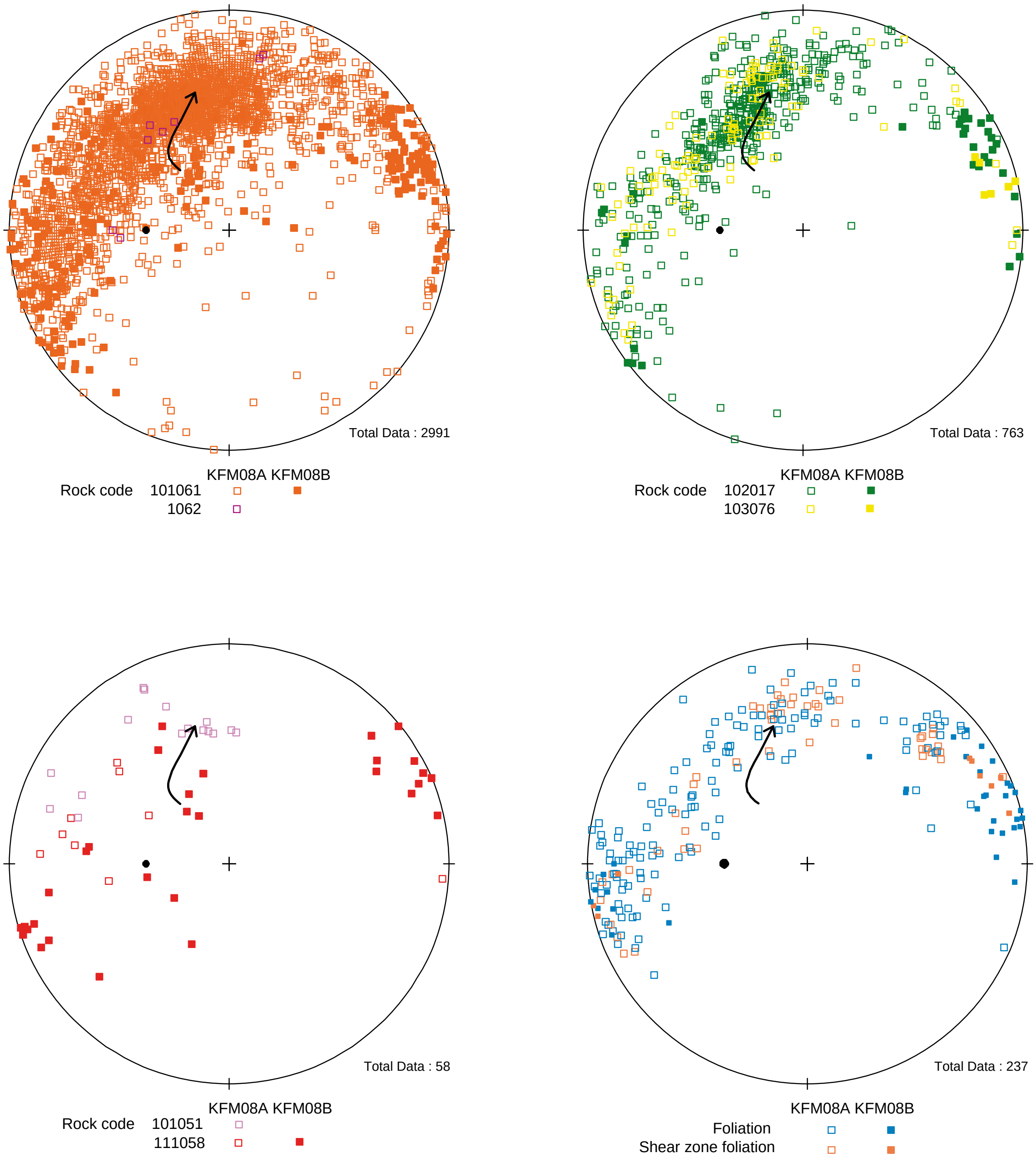

Figure 5-1. *(a–c) Lower hemisphere, equal-area stereographic projection showing poles to upper and lower rock contacts for the following rock groups in KFM08A and KFM08B: pegmatitic granites (101061), aplite (1062), amphibolites (102017), fine-grained intermediate metavolcanic rock (103076), fine- to medium-grained metagranitoids (101051) and granites (111058). (d) Lower hemisphere, equal-area stereographic projection showing poles to ductile foliation planes as well as ductile and brittle-ductile shear zones mapped as "structural features" in KFM08A and KFM08B. Arrows mark the orientation of the borehole axis of KFM08A towards depth. A filled, black circles mark the orientation of KFM08B at the surface.*

Some minor occurrences of skarn-like material (rock code 108019) sporadically occur in both KFM08A and KFM08B. These are mainly concentrated into three length intervals of KFM08A: 623–644, 674–699 and 718–725 metres. They are all vaguely defined and distinguished by their visible content of epidote and/or prehnite. Other components are feldspars, quartz, magnetite and probable garnet. None of the occurrences exceed six decimetres in core-length, though the majority are less than two decimetres. All of them occur in intervals, variably affected by albitization.

Fine- to finely medium-grained metagranitoids (rock code 101051) of mostly granodioritic composition occupy about 1% of KFM08A. Except for three minor (< 2 decimetres) occurrences, these rocks are all restricted to the length interval 420–463 metres. Three of the occurrences in this interval exceed one metre in length (420.35–422.26, 425.72–427.72 and 457.41–462.88 metres).

In addition, there are a few minor occurrences of granite, granodiorite and tonalite in KFM08A and KFM08B. None of them appears to fit into the bedrock nomenclature defined by SKB ('Regler för bergarters benämningar vid platsundersökningarna i Simpevarp och Forsmark', v 1.0). Instead they were coded as 1058 (unspecified granite), 1056 (unspecified granodiorite) and 1053 (unspecified tonalite). Some of the tonalities are surrounded by up to 1 decimetre wide rims of whitened (i.e. albitized) wall rock.

5.3 Ductile structures

The rocks in KFM08A and KFM08B are characterised by composite L-S fabrics, with a slight predominance of linear mineral fabrics. However, the relative intensity of the two components is locally highly variable. The intensity of the deformational fabric is mostly weak to medium, and more rarely faint. It must, however, be emphasized that it often is difficult to distinguish tectonic fabric visually in the pegmatites and some of the fine-grained mafic rocks. The fact that they may appear massive does not necessarily implicate that they actually are post-kinematic. The foliation in KFM08B and the uppermost part of KFM08A is generally steep with a NNW trending strike. The orientation in KFM08A changes, however, gradually towards depth, and the strike turns eastward as the dip becomes less steep (Figure 5-2). The general pattern in the two boreholes is that the poles to the foliations tend to fall along a great circle in a stereographic projection (the pole to which plunges moderately towards southeast; Figure 5-1d), as can be expected considering their location in the hinge zone of a major fold structure. None of the linear fabrics have been possible to register with the present methodology, but the general impression is that they are gently to moderately dipping.

Totally 96 narrow zones of more intense ductile and brittle-ductile deformation have been registered in KFM08A and KFM08B. The 19 zones in KFM08B are all found in the lower half of the borehole, whereas the 79 zones in KFM08A occurs more sporadically throughout the borehole. The widths of individual zones in this interval range up to 1.77 metres. However, the typical width is less than a few decimetres. The protolith in the zones seems mainly to be a highly deformed and grain-size reduced variety of the metagranite (101057). Some of the zones are intimately associated with occurrences of amphibolite. All shear zones are rather steep with a NNW-SSE trending strike, i.e. they are more or less parallel with the local tectonic foliation (Figure 5-1d).

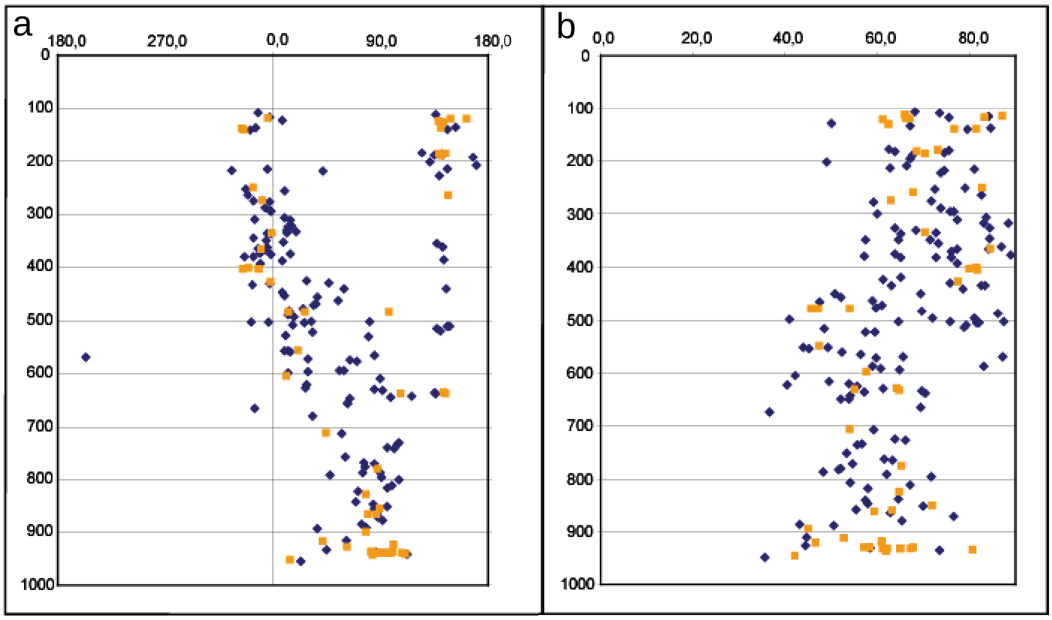

Figure 5-2. *Bivariate plots of (a) strike and (b) dip versus length for ductile foliation planes (blue symbols) as well as ductile and brittle-ductile shear zones (red symbols) mapped as "structural features" in KFM08A.*

5.4 Alteration

Except for the pre- or possibly syn-metamorphic albitization as discussed in section 5.1, the most common alteration encountered in KFM08A and KFM08B is varying degrees of oxidation or red pigmentation of feldspars by sub-microscopic hematite. It is generally associated with more intensely fractured intervals, most frequent in the length interval 258–310 metres of KFM08A. Less than 8% of the total BIPS-logged interval of KFM08A and KFM08B has been affected by oxidation. Normally this oxidation is faint to weak in intensity, and more rarely medium to strong. The most intense oxidation is associated with a conspicuous occurrence of vuggy, syenitic rock at a length interval of 409.85–412.04 metres in KFM08A. It is more or less identical to the rock found in borehole KFM02A /Möller et al. 2003, Petersson et al. 2003a/, and according to the IUGS recommendations /Le Maitre 2002/ it should be denoted 'episyenite' as it apparently was formed by hydrothermal processes involving the selective removal of quartz. The occurrence was, therefore, mapped as 'quartz dissolution', though other types of alteration have also affected it. The alteration is clearly not bound to any specific lithology or ductile structure, and the following rock types have been affected: the medium-grained metagranite-granodiorite (rock code 101057), the pegmatitic granite (rock code 101061) and probably also the aplitic metagranite (rock code 101058).

Other types of alterations within KFM08A and KFM08B include chloritization, muscovitization, epidotization, probable illitization and an occurrence of silicification. Individual occurrences are generally less than a few decimetres in length. The chloritization is mainly restricted to amphibolites (rock code 102017), whereas the epidotization typically occurs in the medium-grained metagranite (rock code 101057). Also the skarn-like occurrences (rock code 108019) found in the length interval 623–682 metres have been registered as 'weakly albitized'. The muscovitization (registered as 'sericitization' in Boremap) is generally restricted to the last 50 metres of KFM08A, where biotite-rich variety of the medium-grained metagranite-granodiorite (rock code 101057) prevails. However, this muscovitization appears to be pre- or possibly syn-metamorphic, and is hence unrelated to brittle structures. An interval rich in a greenish mineral with greasy feel was encountered at 953.90–954.85 metres in KFM08A. The mineral was inferred to be illite, and is also frequent in associated fractures. A quartz-dominated variety of the medium-grained metagranite (rock code 101057), inferred to be the result of alteration, occurs at the length interval 597.92–598.72 metres of KFM08A. The interval is mapped as ‘silicification’.

5.5 Fractures

5.5.1 Fracture frequencies and orientations

Excluding crush zones and sealed networks, the total number of open (broken fractures with aperture > 0), partly open (unbroken fractures with aperture > 0) and sealed fractures (broken and unbroken fractures with aperture = 0) registered during the boremap-logging of KFM08A and KFM08B amounts to 5,008, i.e. about 4.8 fractures/metre. Of these are 839 open, 73 partly open and 4,096 sealed. It should be emphasized that there is a certain degree of uncertainty in whether a fracture actually is open or sealed. Throughout the boreholes, the frequency of open and sealed fractures varies rather coherently, with an increased number of open fractures in intervals with concentrations of sealed fractures (Appendices 1A and 1B). In contrast to most other core drilled boreholes in the area, there is no unambiguous increase in the open fracture frequency towards the surface. There are several major intervals with anomalously high fracture frequencies throughout both boreholes, though none of them are especially well-defined, and all are dominated by sealed fractures. The most extensive intervals occur at about 170–340 and 775–975 metres of KFM08A. Other, less extensive intervals, occur at the following levels: 479–496, 528–557 and 672–693 metres in KFM08A and 133–185 metres in KFM08B.

The fracture orientations vary considerably throughout KFM08A and KFM08B, though the stereographic projections in Figure 5-3 reveal at least three distinct fracture sets in KFM08B and four distinct fracture sets in KFM08A. All these sets include both open and sealed fractures, though the proportions differ significantly. The *first* fracture set, which is well-defined in both KFM08A and KFM08B, consists of vertical to sub-vertical fractures with NE-SW strike. Fractures of this set are found throughout both boreholes (Figure 5-3). Most of these fractures are inferred to be sealed, and a considerable proportion of the fracture orientations registered in the sealed networks belong to this set. A *second* fracture set, also conspicuous and mainly encountered in KFM08B and the upper half of KFM08A, consists of flat-lying fractures (Figure 5-3). A majority of these fractures are mapped as open and several have apertures that are clearly visible in the BIPS-image (i.e. more than one millimetre), especially in the length interval between about 170–340 metres. A few have apertures up to 5–8 millimetres. A *third* fracture set, mainly restricted to the length interval below ca 750 metres in KFM08A, consists of vertical to sub-vertical fractures with NW-SE strike. The vast majority of these fractures are generally inferred to be sealed. In addition, there is a *fourth* set that comprises fractures that are parallel with the tectonic foliation. These fractures are found throughout the boreholes, and are inferred to be both sealed and open. In KFM08B, this set includes vertical to sub-vertical, westerly dipping fractures with SSE trending strikes. In KFM08A, on the other hand, the dips are overturned towards east, and the strikes become thus NNW trending. The orientation changes gradually towards depth, as discussed in section 5.3, and more moderately dipping fractures with ENE to E-W trending strikes predominates below ca 780 metres length in KFM08A.

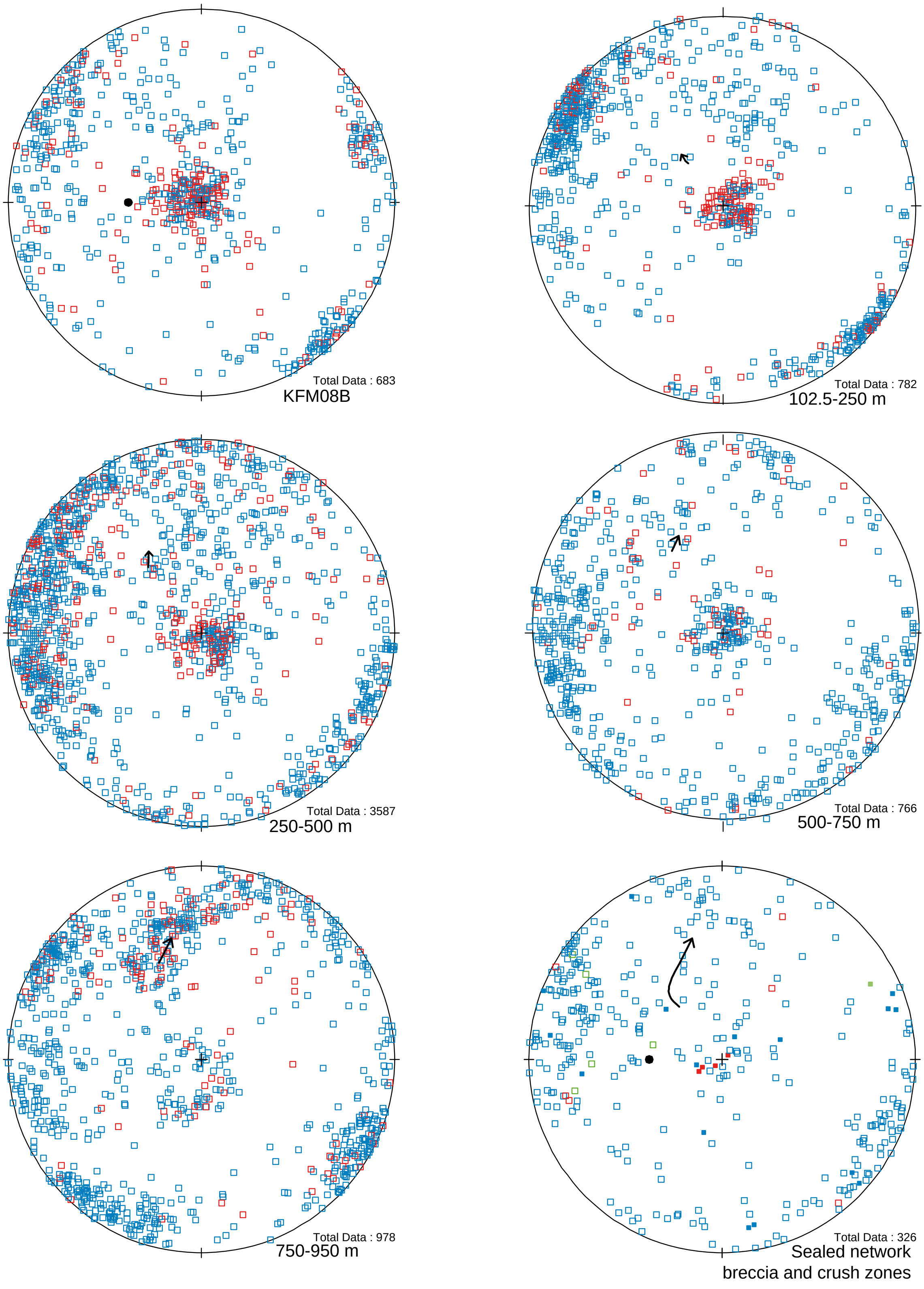

Figure 5-3. *Lower hemisphere, equal-area stereographic projections showing the poles to all sealed (blue squares) and open (red squares) fractures, as well as the orientation of breccias (green squares) and prevailing fracture orientations in sealed networks (blue squares) and crush zones (red squares) in borehole KFM08A and KFM08B. The fracture data for KFM08A have been divided into four length intervals (102.5–250, 250–500, 500–750 and 750–950 metres). The arrow mark the orientation of the borehole axis of KFM08A towards depth, whereas the filled, black circle in the stereographic projections with data for KFM08A mark the orientation of the borehole axis at the surface. Filled, small squares in the lower right stereographic projection are data from KFM08B, whereas larger, open squares are from KFM08A.*

It is reasonable to expect that mechanical discontinuities, such as lithological contacts, should be the locus of fracture formation more frequently than in a homogeneous rock. For this reason we have noted the proportion of fractured amphibolite contacts. About 32% of the contacts in the mapped interval of KFM06A and KFM06B are fractured. This can be compared with other cored boreholes from the Forsmark drilling programme, in which 22–35% of the contacts are fractured /Petersson et al. 2003ab, 2004ab, 2005bc/. However, the relative amount of fractured contacts in the sequence of intermediate rock of inferred volcanic origin (rock code 103076) is only about 12%.

Totally five crush zones have been observed, two in KFM08B and three in the cored interval of KFM08A. The two crush zones in KFM08B are almost horizontal, and occur at 21.36–21.39 and 30.95–30.99 metres length. The orientations of the three crush zones in KFM08A are more variable, with the following approximate strikes/dips: 340°/70°, 30°/85° and 110°/60° (see Figure 5-3). The widest of them occurs at 918.85–919.28 metres length, whereas the two other occur at 339.82–339.83 and 495.26–495.31 metres length.

Five breccia zones and 155 sealed networks have been registered in the cored interval of KFM08A. Corresponding numbers for KFM08B are one and eight, respectively. The distinction between breccia and sealed network is not straight forward, but normally zones with none or minor rotation of individual rock fragments has been mapped as sealed network. The width of individual breccia zones ranges up to seven centimetres. In KFM08A, they all occur in the length interval 274–605 metres, whereas the breccia in KFM08B occurs at 162.23–162.30 metres. The sealed networks, on the other hand, occur throughout KFM08A, with major concentrations at 684–692 and 915–922 metres. All sealed networks in KFM08B are found in the length interval 135–182 metres. Although there is a considerable scatter in the orientation, most breccias and sealed networks belong to the NE-SW striking fracture group (Figure 5-3). Except for the registered breccia zones, fractures with measurable displacements, indicating that they have been initiated or reactivated as shear fractures, are found at one and 14 levels in KFM08B and KFM08A, respectively. Nine of the fractures that show macroscopic displacements in KFM08A occur in the length interval at 253–264 metres. Most of these fractures belong to the NE-SW striking fracture set.

Inferred core discing occurs sporadically in the length interval 169–190 metres of KFM08B and at about 480 metres in KFM08A. Some intervals include also what appears to be initial core discing that not actually breaks the core. None of the intervals exceed 5 decimetres in width, and the typical dimension of individual discs range between 1 and 2 centimetres. The fractures are all planar to slightly saddle-shaped.

5.5.2 Fracture mineralogy

Chlorite and/or calcite are found in about 80% of the total number of the registered fractures in KFM08A and KFM08B.They are found in all fracture sets discussed above (Figure 5-4 and 5-5). Other infilling minerals, in order of decreasing abundance, include adularia, submicroscopic hematite, laumontite, quartz, pyrite, clay minerals, prehnite, epidote, biotite, asphalt, amphibole, pyrrhotite, iron hydroxide, zeolite, unspecified sulphides, muscovite, white feldspar and chalcopyrite. In addition, there are a few fractures with unknown mineral filling. Analyses by XRD of similar material from the previously mapped cored boreholes in the area have revealed that most such filling are mineral mixtures, or in some cases, feldspars, apophyllite or analcime /Sandström et al. 2004/. There are also 189 fractures that are virtually free from visible mineral coatings. These are mostly open, and the majority belong to the horizontal to sub-horizontal fracture set (Figure 5-4 and 5-5).

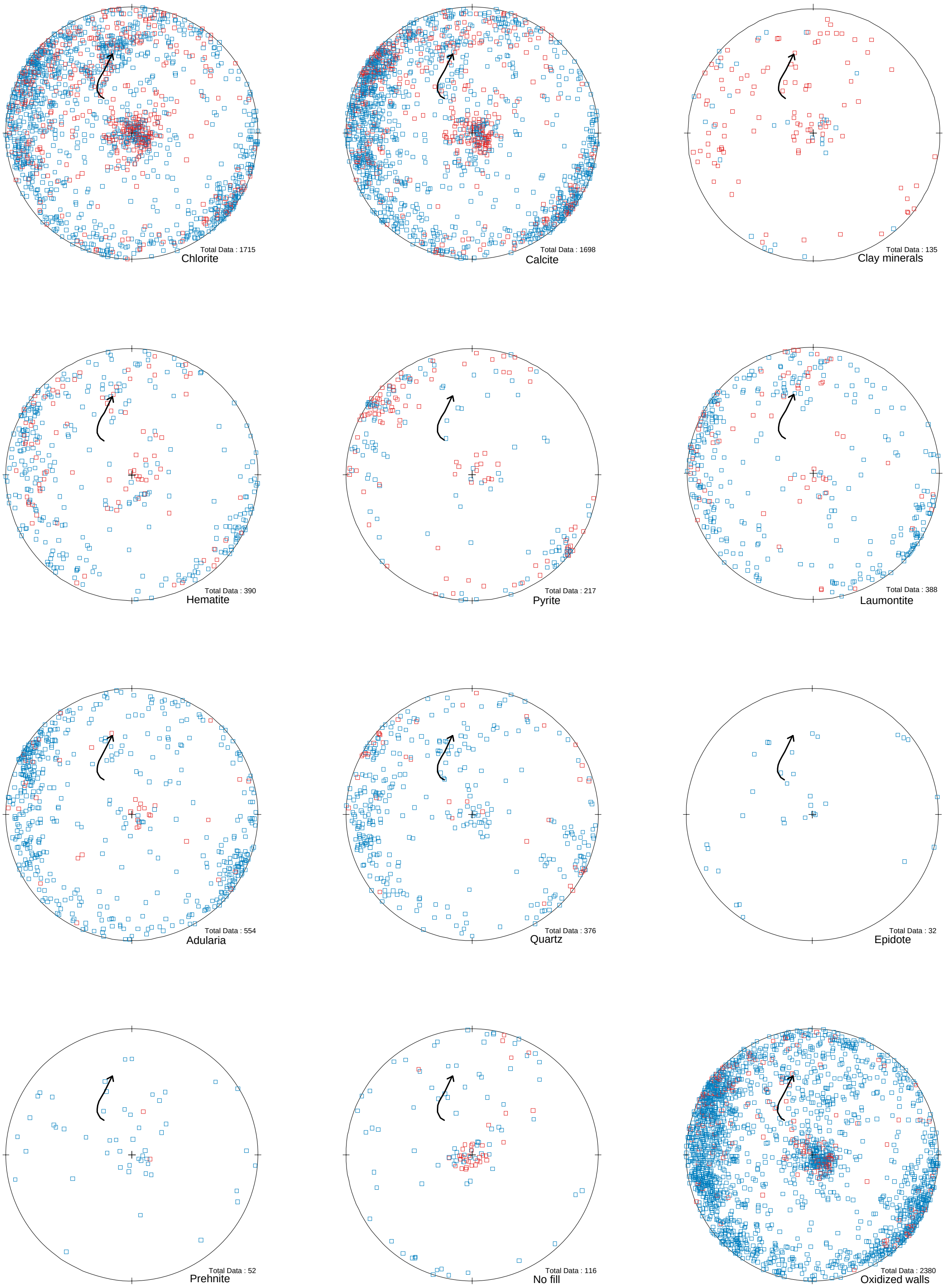

Figure 5-4. *Lower hemisphere, equal-area stereographic projections showing the poles to sealed (blue squares) and open (red squares) fractures with different mineral fillings in KFM08A. Also shown are those that are free from visible filling and those surrounded by oxidized walls. Arrows mark the orientation of the borehole axis towards depth.*

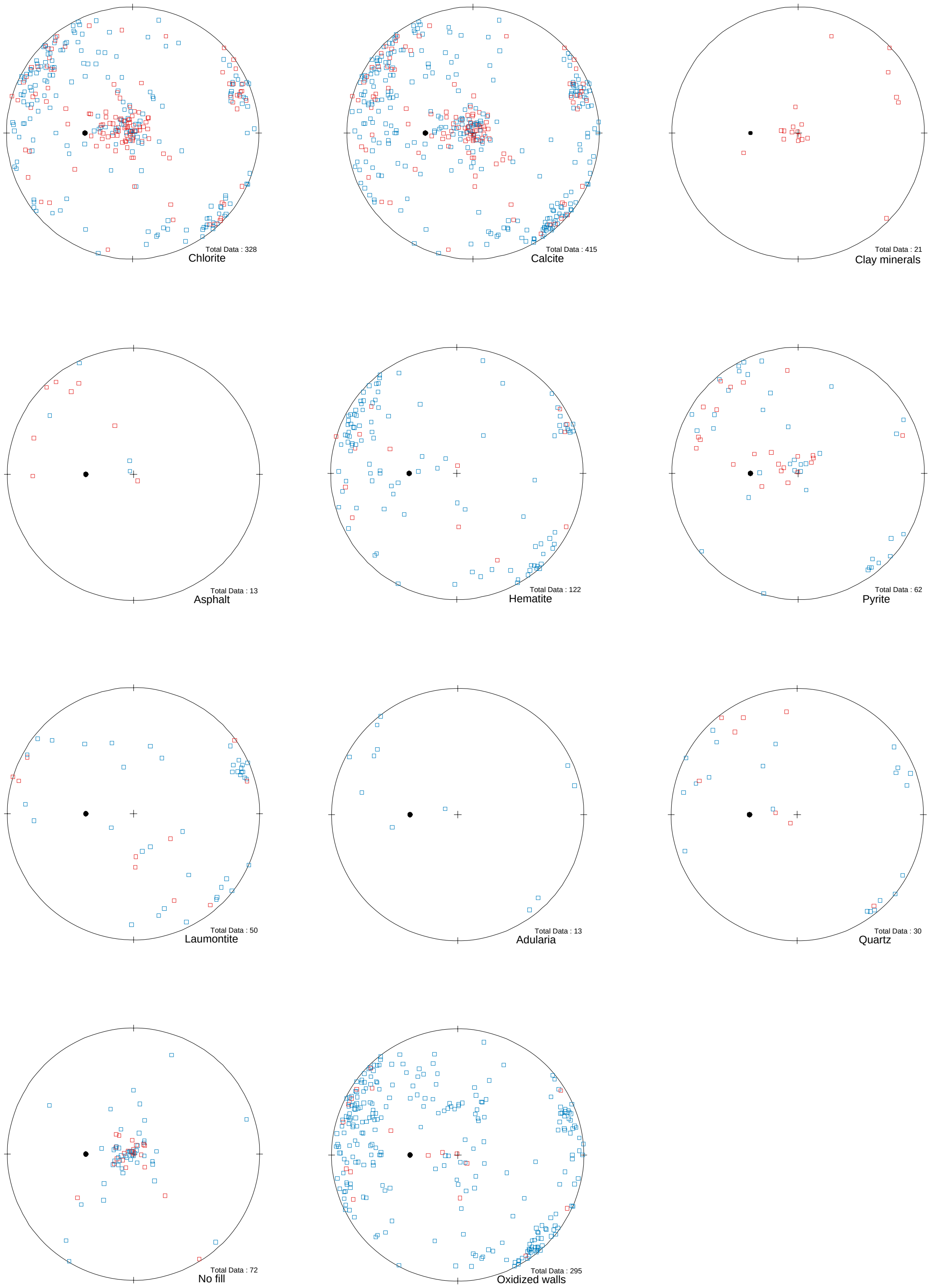

Figure 5-5. *Lower hemisphere, equal-area stereographic projections showing the poles to sealed (blue squares) and open (red squares) fractures with different mineral fillings in KFM08B. Also shown are those that are free from visible filling and those surrounded by oxidized walls. The filled, black circle in the stereographic projections with data for KFM08B mark the orientation of the borehole axis at the surface.*

The various clay minerals are more or less restricted to open fractures (Figure 5-4 and 5-5). In KFM08B, most clay minerals are found in flat-lying fractures in the uppermost 70 metres of the borehole, whereas the orientation of the clay-bearing fractures in KFM08A are more varying and mainly occur in two length intervals: 200–500 metres and the lowermost 100 metres. Clay minerals registered in fractures at greater depths are typically corrensite and illite (Figure 5-6a), often intimately associated with chlorite. Another mineral limited to open fractures are the few findings of a zeolite, which most certainly is analcime (Figure 5-6b).

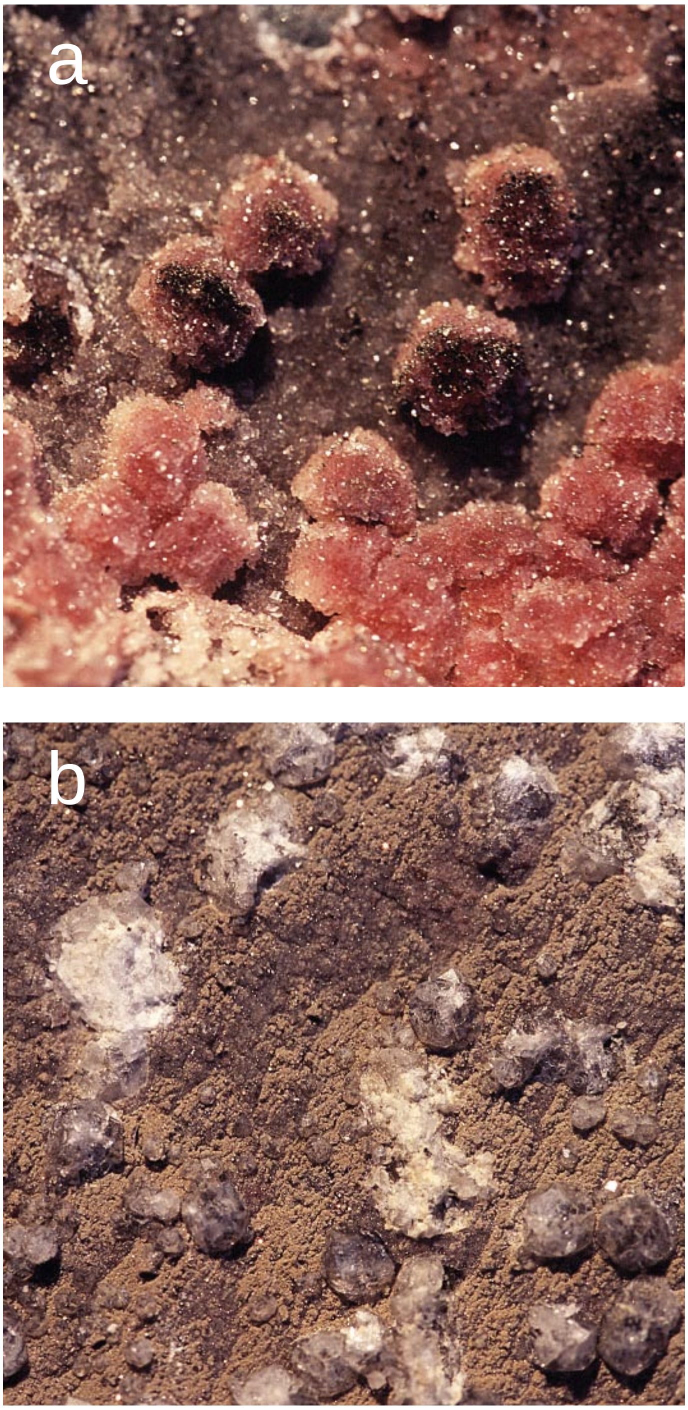

Figure 5-6. *(a) Fracture filling of euhedral quartz with thin coating of hematite and corrensite. 278.99 metres length in KFM08A. (b) Fracture filling of clay minerals and euhedral analcime. 246.27 metres length in KFM08A.*

Asphalt occurs in both sealed and open fractures in KFM08B, but is absent in KFM08A. Most of the asphalt occurs in the NE-SW trending fracture set but there are also a few occurrences in sub-horizontal fractures (Figure 5-5). Pyrite also occurs in both sealed and open fractures. Minerals mapped as sulphides are chalcopyrite and/or pyrite.

Fe-hydroxide, typically expected in shallow fractures if water with low pH and high O_2-content circulated in the bedrock /cf Tullborg 1989/, was encountered in three fractures in KFM08B and at the following borehole lengths: 35.79, 49.89 and 52.15 metres. No Fe-hydroxide was found in KFM08A. It is, moreover, expected that pyrite would increase at the expense of Fe-hydroxide towards depth. However, no such relationship was recognized, and the increased frequency of pyrite from about 180 metres length reflects a general increase in the fracture frequency below that level.

All other minerals, as well as the presence of oxidized walls, are preferentially associated with sealed fractures. A typical mineral assemblage found in the NE-SW striking fracture set is laumontite + calcite + chlorite + hematite stained adularia ± pyrite (Figure 5-4 and 5-5). Several of these fractures occur in the length interval 170–340 metres of KFM08A. A number of very thin (<< 1 millimetre), sealed fractures are typically only revealed by their oxidized walls. Several of these thin fractures are sealed by a mineral inferred to be hematite, but it might well be hematite-stained laumontite or adularia. Laumontite tends to contract, and eventually crackle in the drill core. Thus, some laumontite-bearing fractures that are broken in the drill core may in fact represent originally unbroken fractures. Other minerals that tend to concentrate in the NE-SW fracture set are adularia, hematite, quartz and pyrite. However, the exact assemblage varies locally. One typical mineral assemblage is adularia + quartz + chlorite + hematite. Hematite occurs in two main varieties: (1) thin, reddish coatings, preferentially found in flat lying fractures, and (2) staining of various silicates, such as adularia and laumontite.

Epidote only occurs in sealed fractures in KFM08A and is nearly absent in the NNE-SSW to NE-SW trending steeply dipping set in contrast to most other minerals. Prehnite mostly occur in sealed fractures with varying orientation in KFM08A. Some of the light greenish mineral mapped as prehnite might well be adularia.

Quartz and amphibole occur together in six fractures in KFM08A. They are inferred to be late-metamorphic and restricted to the length interval 729.1–731.8 metres.

In this context it is also worth to mention that two, up to 2 centimetre wide length intervals, recorded as "cataclastic rocks" (rock code 8003), occurs at 30.28–30.30 and 30.89–30.91 metres in KFM08B and one, 1 millimetre wide interval, occurs at 478.96 metres in KFM08A. The occurrences are inferred to consist of lithified fault gauge with up to 3 millimetres large clasts of the wall rock. In KFM08B, the occurrences follow the horizontal to sub-horizontal set, whereas it follows the steeply dipping, NE-SW trending set in KFM08A.

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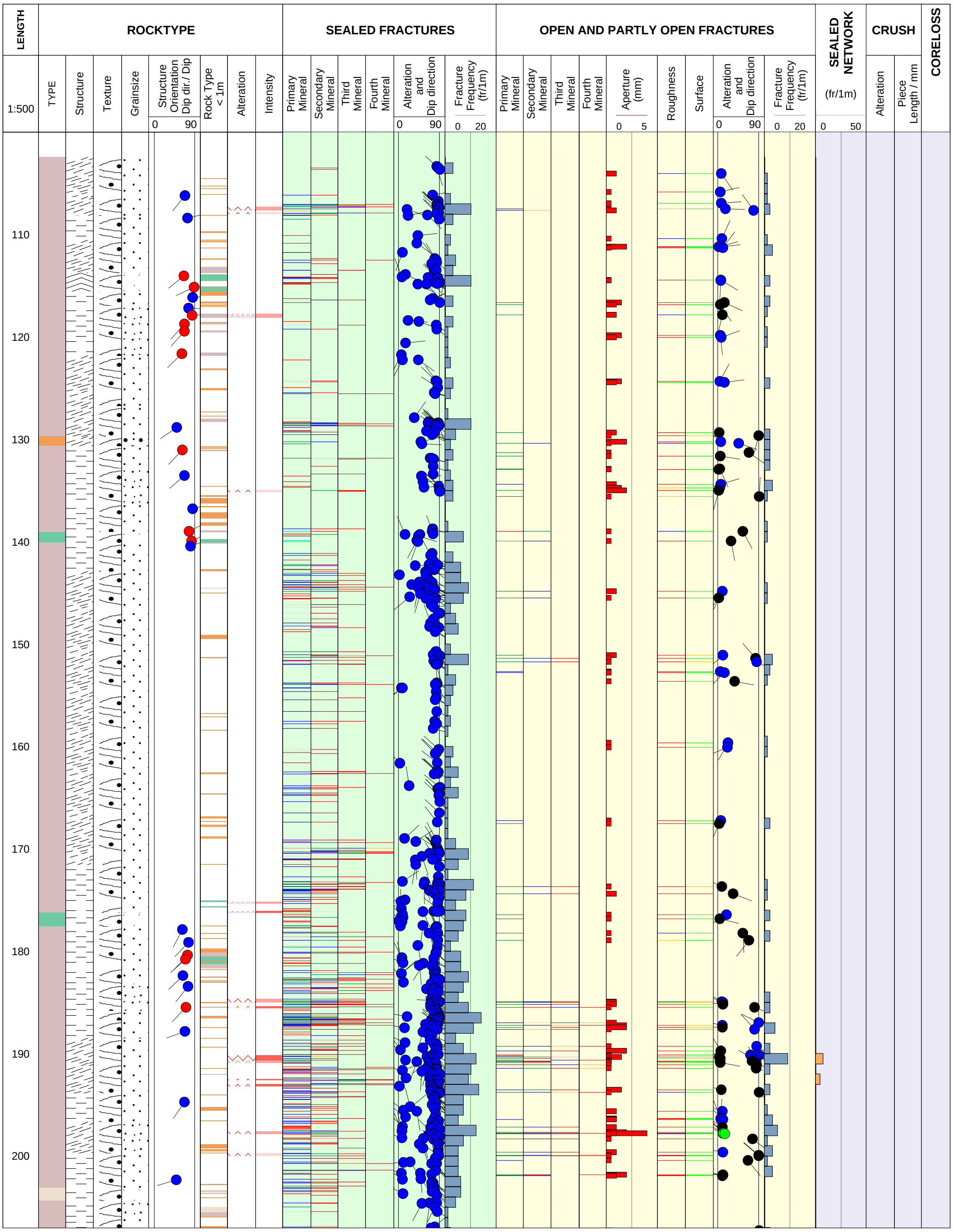
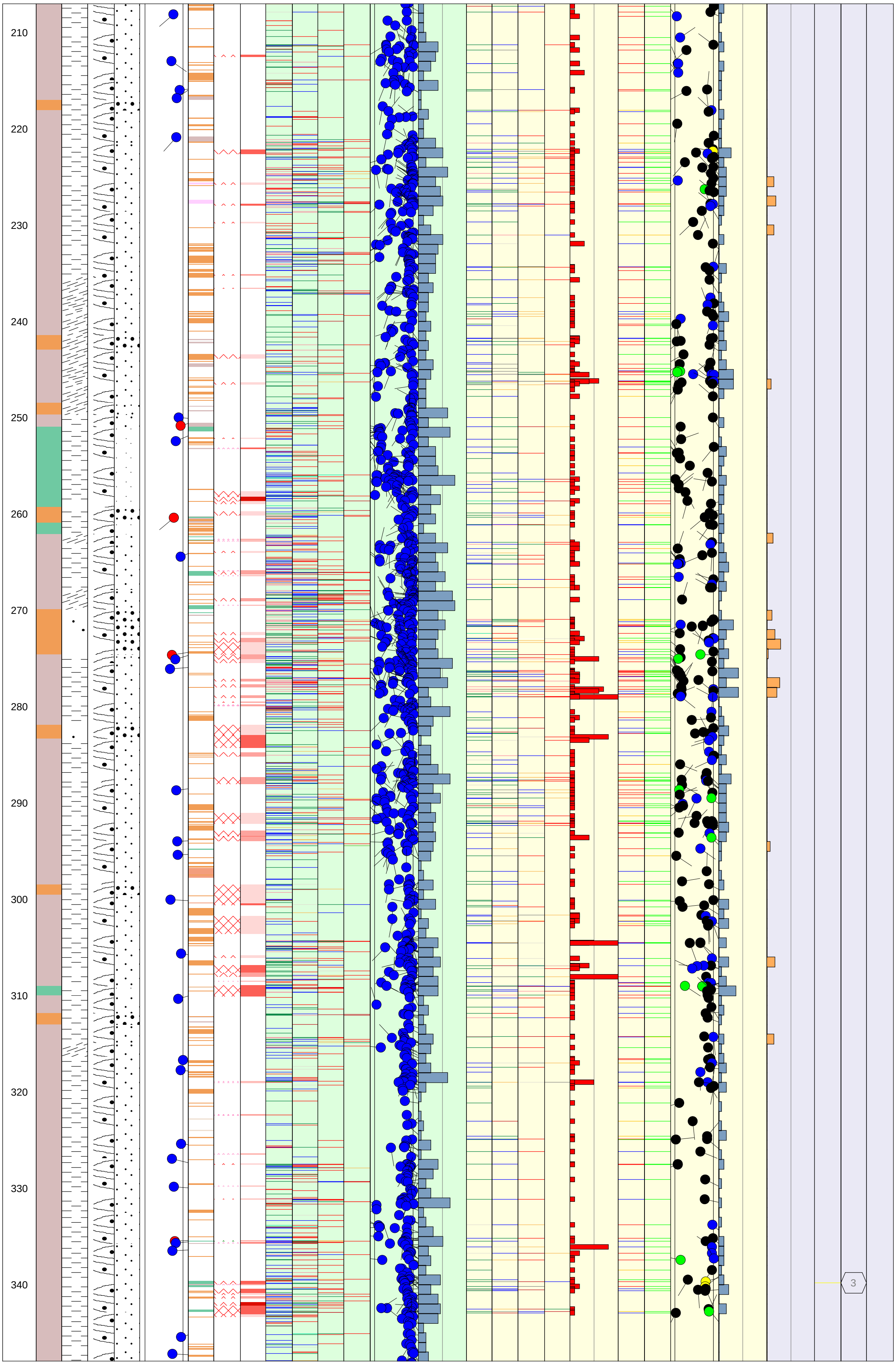
WellCAD images KFM08A

Title GEOLOGY IN KFM08A **Appendix:** 1

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	KFM08A	**Northing [m]**	6700494.49
Diameter [mm]	77	**Easting [m]**	1631197.06
Length [m]	1001.190	**Elevation [m.a.s.l.]**	2.49
Bearing [°]	321.00	**Drilling Start Date**	2004-09-13 11:03:00
Inclination [°]	-60.88	**Drilling Stop Date**	2005-03-31 10:40:00
Date of coremapping	2005-05-11 10:43:00	**Plot Date**	2005-08-16 23:30:14
Rocktype data from	p_rock_XXXXX	**Fracture data from**	p_fract_core

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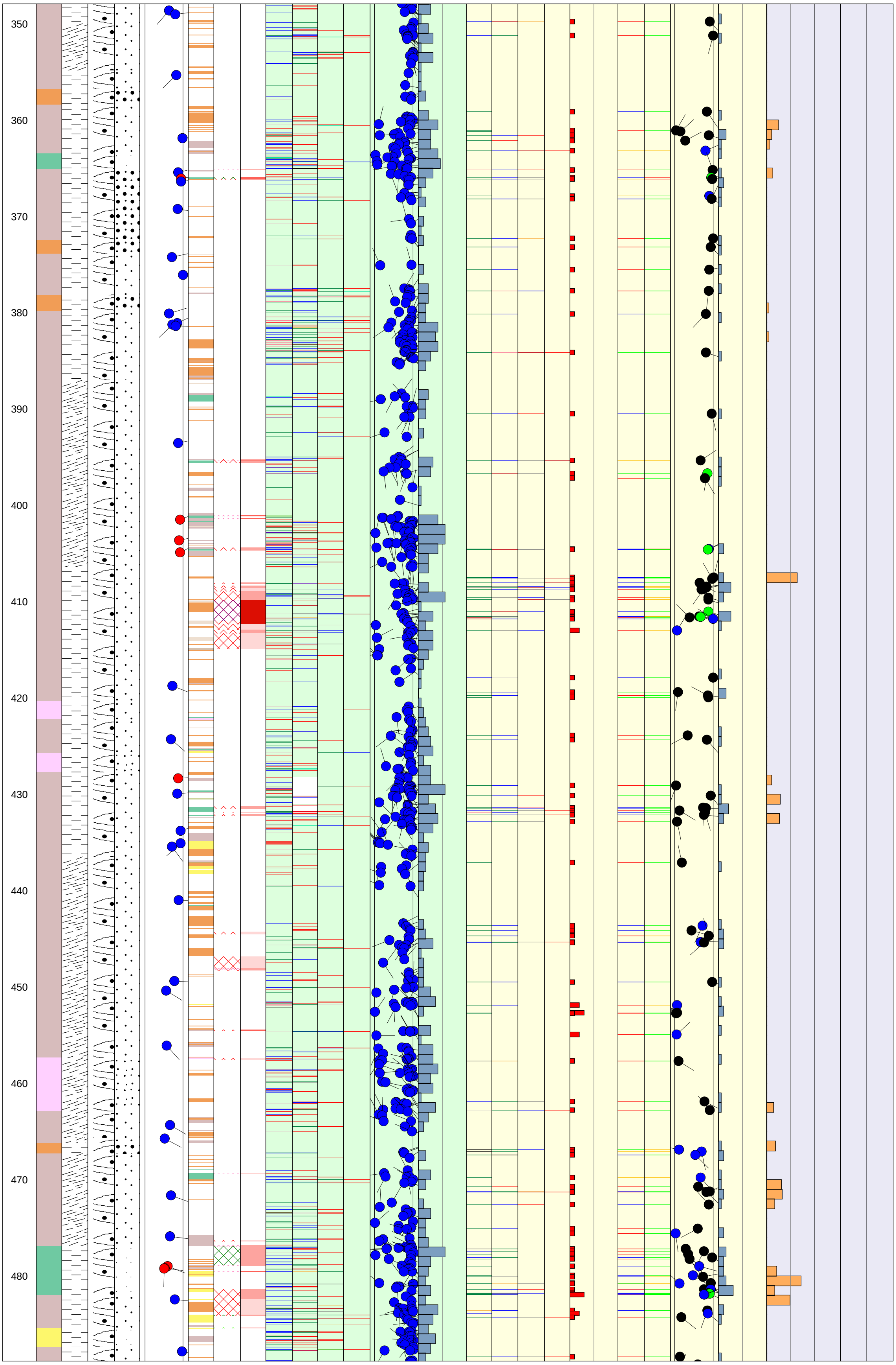
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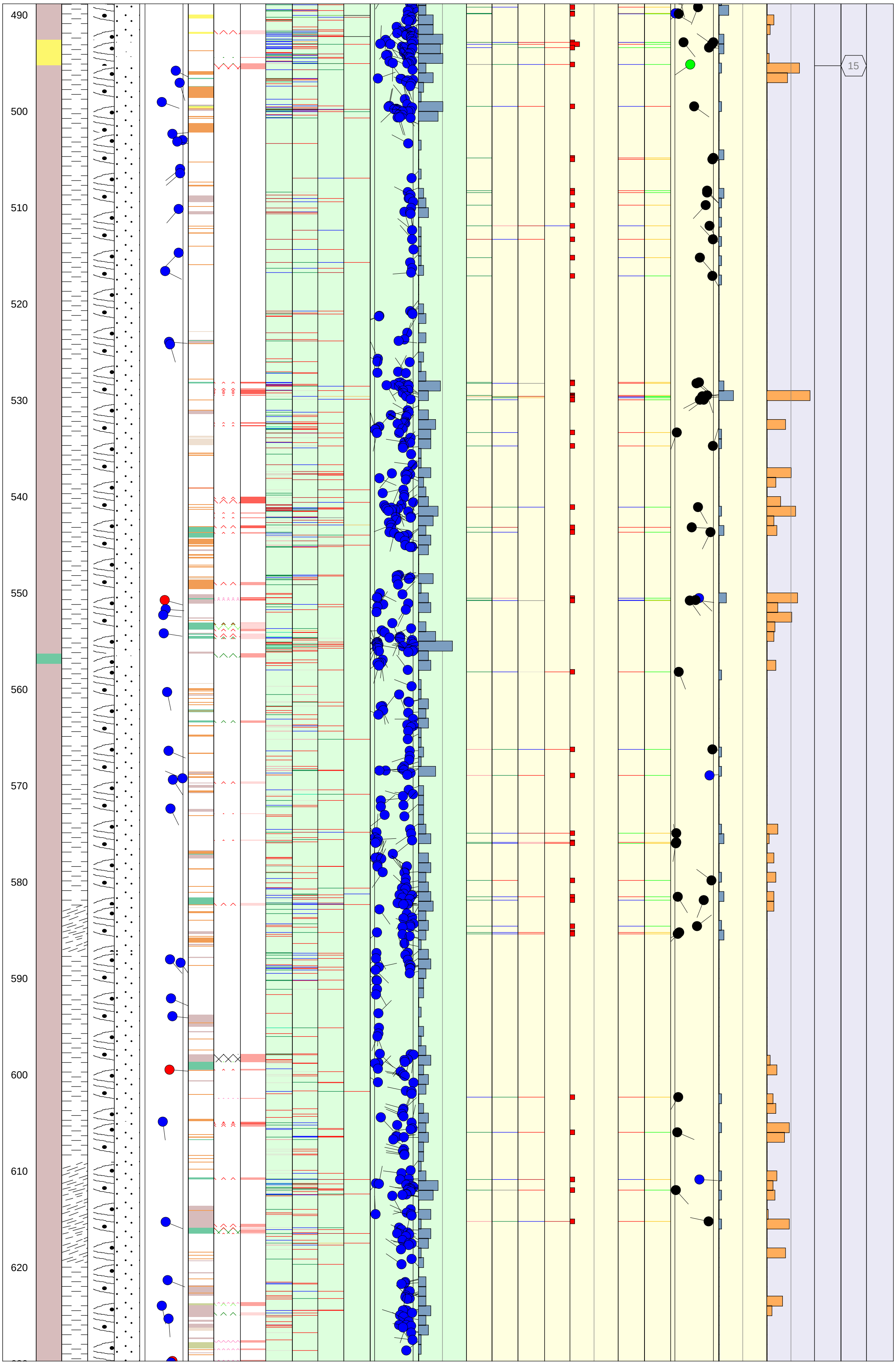
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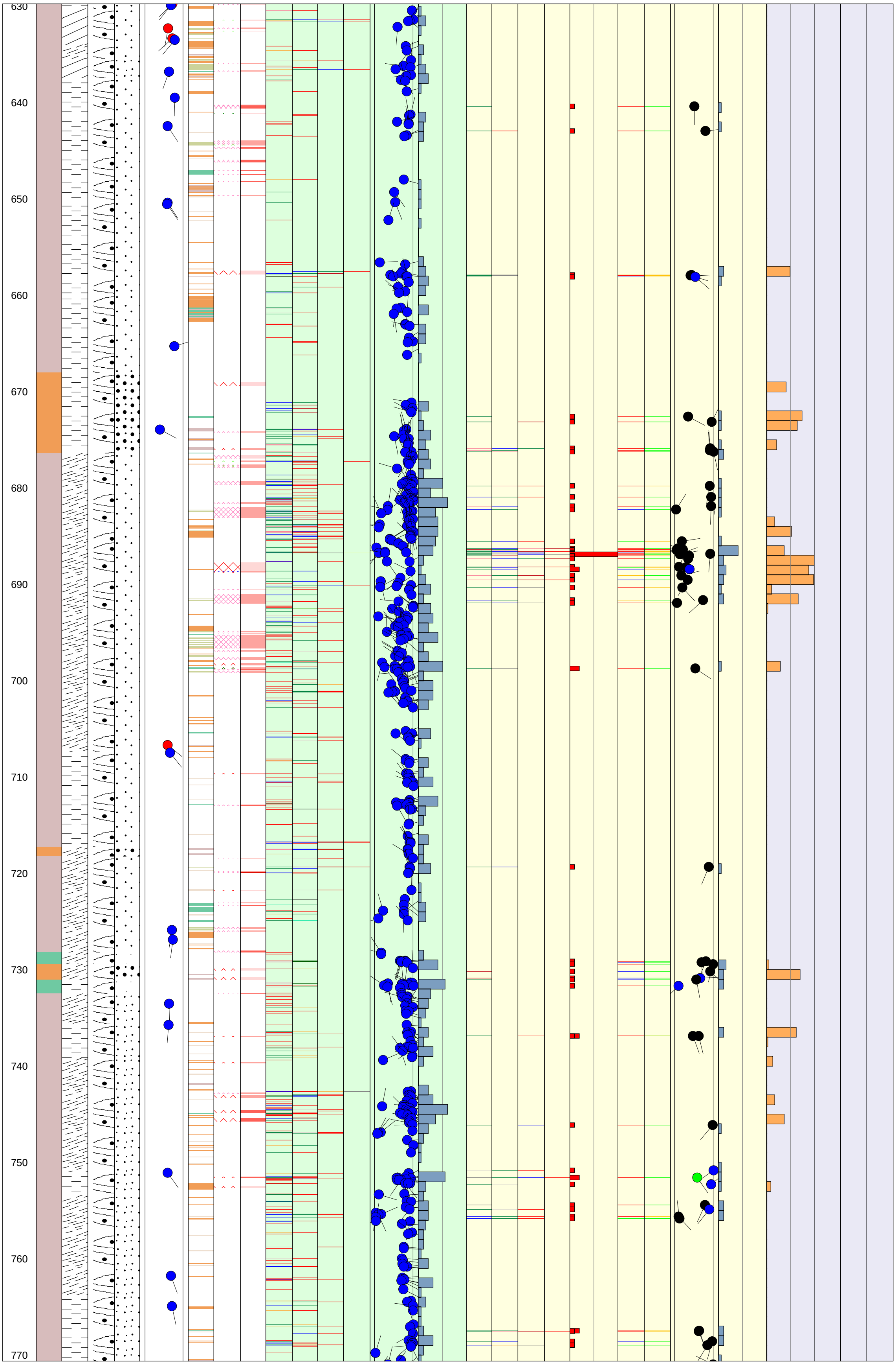
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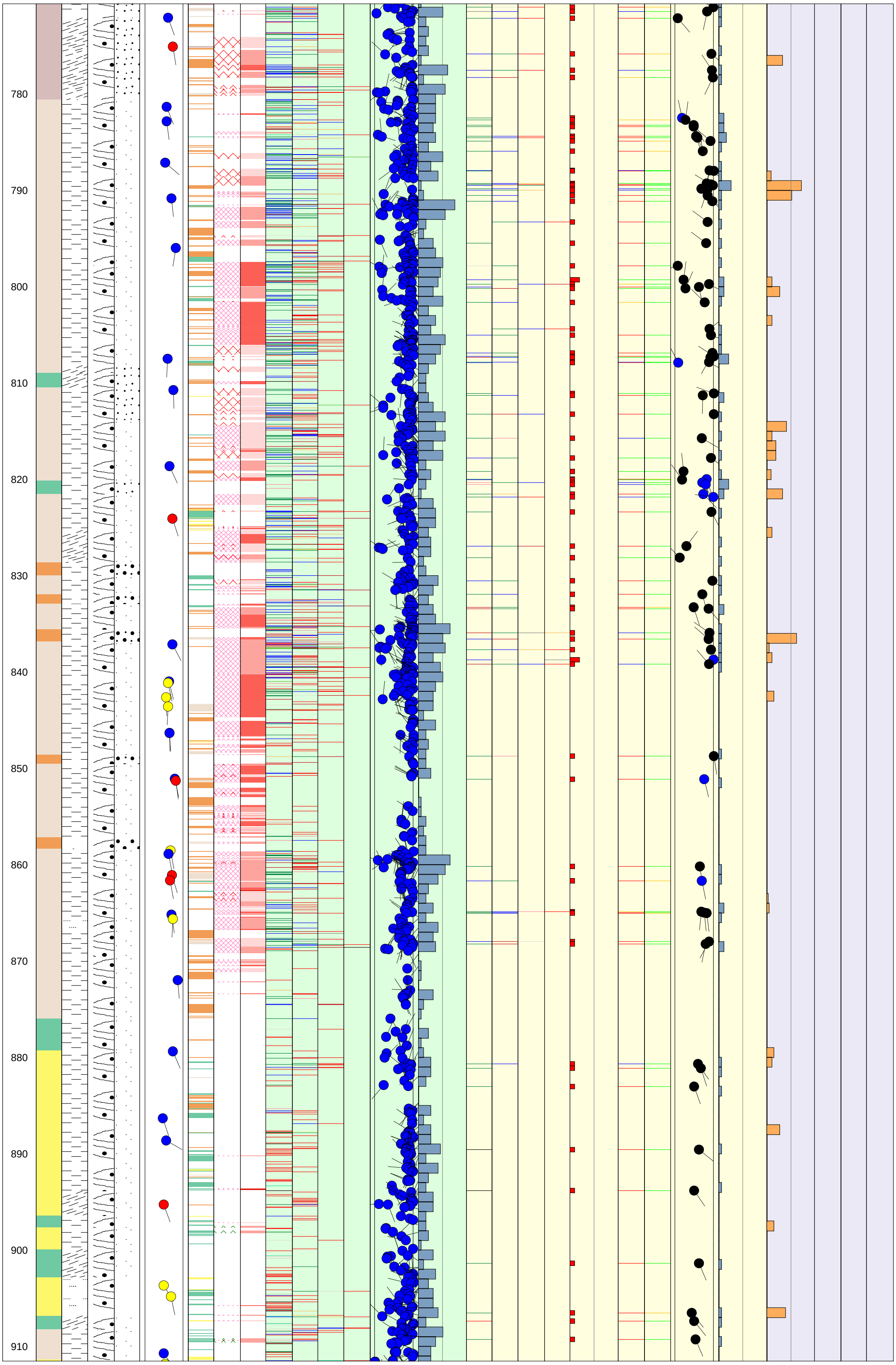
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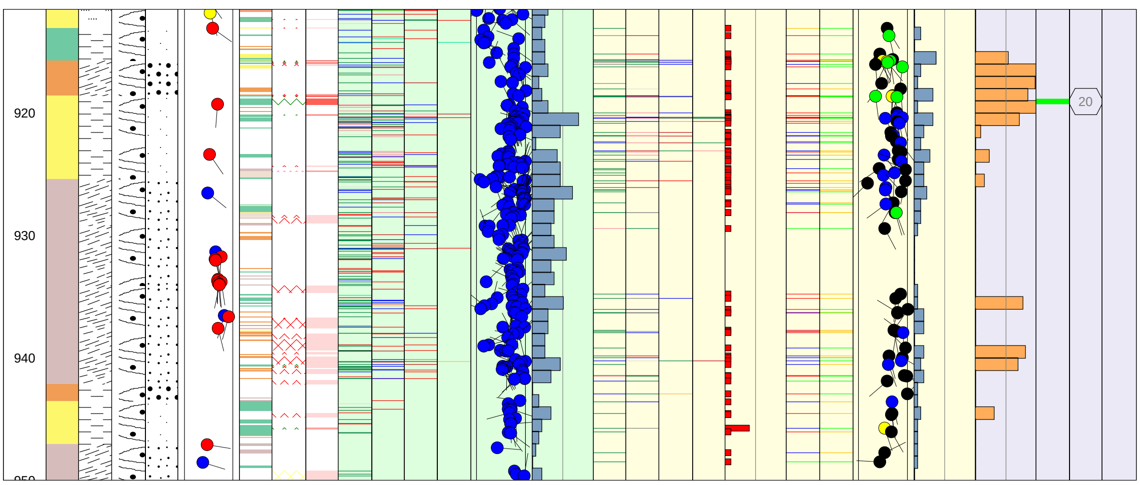

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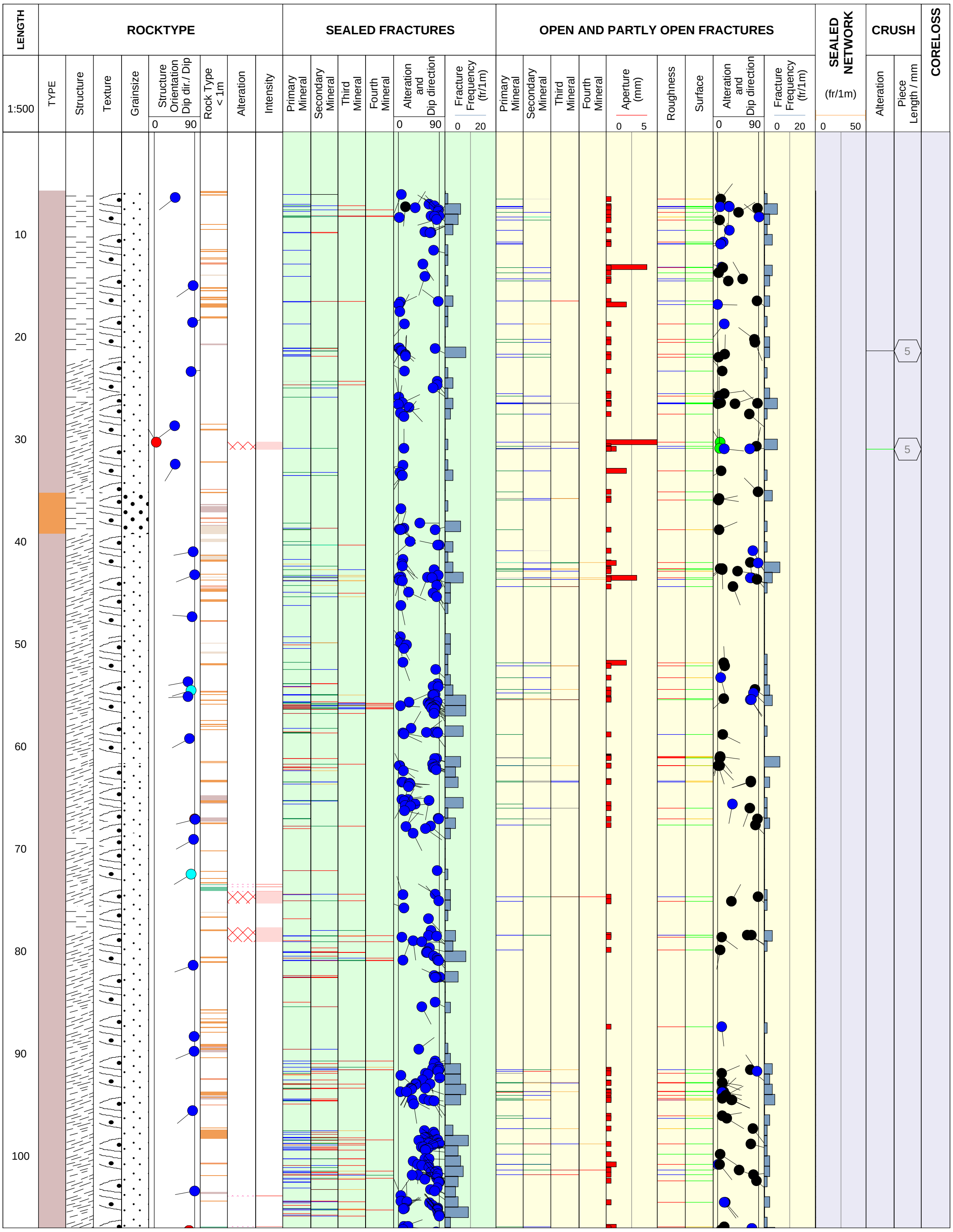
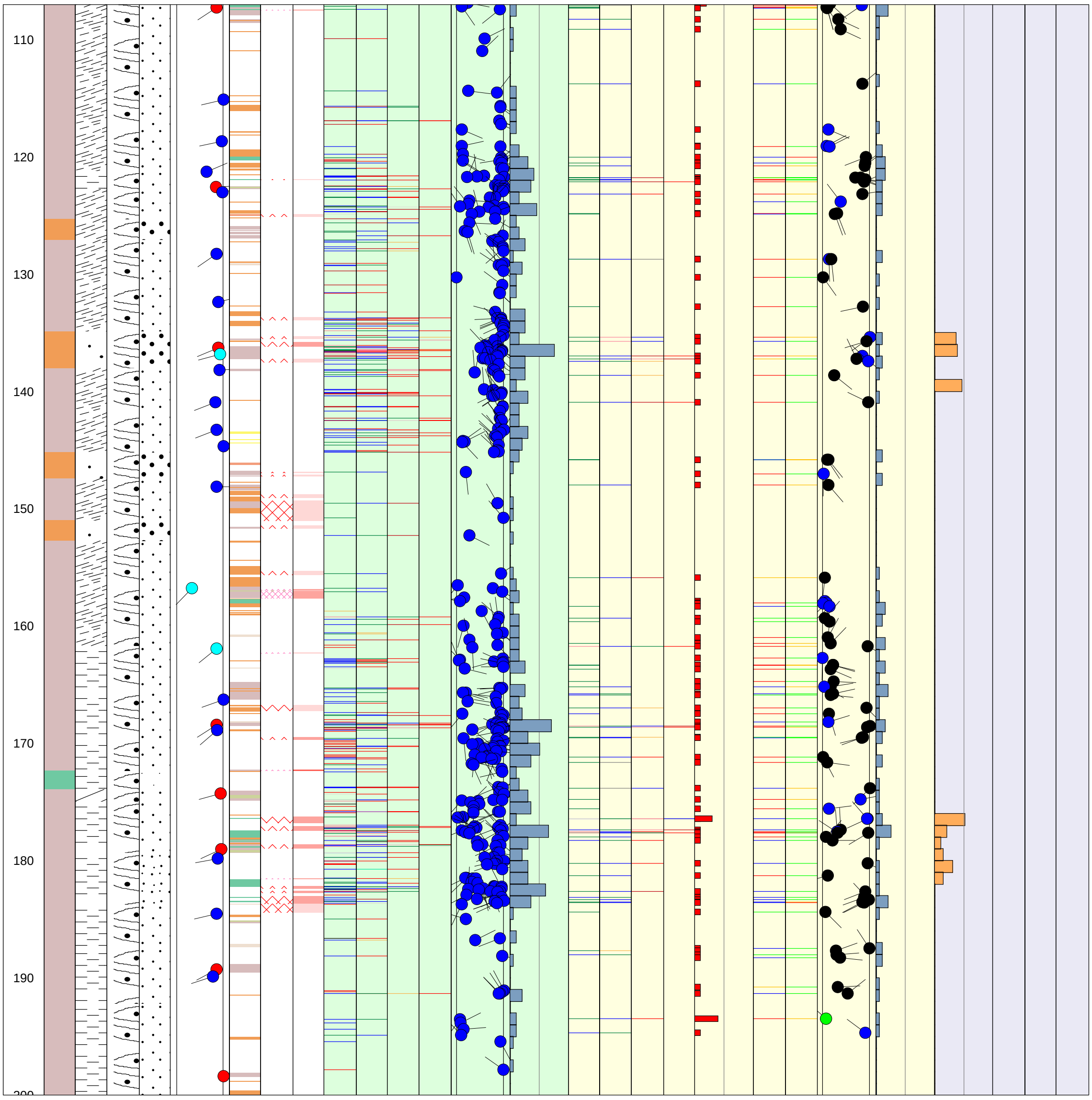
WellCAD images KFM08B

Title	GEOLOGY IN KFM08B		Appendix: 1
Site	FORSMARK	Coordinate System	RT90-RHB70
Borehole	KFM08B	Northing [m]	6700492.75
Diameter [mm]	76	Easting [m]	1631173.27
Length [m]	200.540	Elevation [m.a.s.l.]	2.25
Bearing [°]	270.45	Drilling Start Date	2005-01-11 16:04:00
Inclination [°]	-58.84	Drilling Stop Date	2005-01-26 14:51:00
Date of coremapping	2005-05-02 14:49:00	Plot Date	2005-08-16 23:30:14
Rocktype data from	p_rock_XXXXX	Fracture data from	p_fract_core

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Appendix 2

Borehole diameters

Hole Diam T - Drilling: Borehole diameter

KFM08A, 2005-01-25 01:00:00 - 2005-01-25 10:00:00 (97.140 - 100.550 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	9.140	0.343	
9.140	97.140	0.249	
97.140	102.400	0.086	drilled in cement 97.14 m - 100.55m.
104.400	1001.190	0.077	

Printout from SICADA 2005-06-22 08:33:41.

Hole Diam T - Drilling: Borehole diameter

KFM08B, 2005-01-11 16:04:00 - 2005-01-26 14:51:00 (0.000 - 200.540 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
0.000	5.580	0.093	casing shoe at lower limit
5.580	200.540	0.076	

Printout from SICADA 2005-05-09 17:22:16.

Downhole deviation measurements KFM08A

Maxibor T - Borehole deviation: Maxibor

KFM08A, 2005-04-06 10:20:00 - 2005-04-06 15:00:00 (0.000 - 999.000 m)

Length (m)	Northing (m)	Easting (m)	Elevation (m)	Coord System	Inclination (degrees)	Bearing (degrees)	Local A (m)	Local B (m)	Local C (m)	Extrapol Flag
0.00	6700494.68	1631197.03	-2.50	RT90-RHB70	-60.11	319.42	0.0000	0.0000	0.0000	
3.00	6700495.82	1631196.06	0.10	RT90-RHB70	-59.77	319.61	1.5000	0.0000	0.0000	
6.00	6700496.97	1631195.08	2.69	RT90-RHB70	-59.46	319.43	3.0100	0.0100	0.0200	
9.00	6700498.12	1631194.09	5.28	RT90-RHB70	-59.49	319.10	4.5300	0.0100	0.0500	
12.00	6700499.28	1631193.09	7.86	RT90-RHB70	-59.56	318.93	6.0500	0.0000	0.0800	
15.00	6700500.42	1631192.09	10.45	RT90-RHB70	-59.59	318.92	7.5700	-0.0200	0.1100	
18.00	6700501.57	1631191.09	13.04	RT90-RHB70	-59.60	318.84	9.0900	-0.0300	0.1400	
21.00	6700502.71	1631190.09	15.62	RT90-RHB70	-59.56	318.70	10.6100	-0.0400	0.1700	
24.00	6700503.85	1631189.09	18.21	RT90-RHB70	-59.52	318.54	12.1300	-0.0600	0.2000	
27.00	6700504.99	1631188.08	20.79	RT90-RHB70	-59.48	318.36	13.6500	-0.0900	0.2300	
30.00	6700506.13	1631187.07	23.38	RT90-RHB70	-59.41	317.96	15.1700	-0.1200	0.2600	
33.00	6700507.26	1631186.05	25.96	RT90-RHB70	-59.29	317.69	16.7000	-0.1500	0.3000	
36.00	6700508.40	1631185.02	28.54	RT90-RHB70	-59.19	317.57	18.2300	-0.2000	0.3400	
39.00	6700509.53	1631183.98	31.12	RT90-RHB70	-59.10	317.50	19.7700	-0.2500	0.3900	
42.00	6700510.67	1631182.94	33.69	RT90-RHB70	-58.99	317.55	21.3100	-0.3000	0.4400	
45.00	6700511.81	1631181.90	36.26	RT90-RHB70	-58.88	317.52	22.8500	-0.3500	0.5000	
48.00	6700512.95	1631180.85	38.83	RT90-RHB70	-58.78	317.35	24.4000	-0.4000	0.5600	
51.00	6700514.09	1631179.80	41.40	RT90-RHB70	-58.67	317.22	25.9600	-0.4600	0.6300	
54.00	6700515.24	1631178.74	43.96	RT90-RHB70	-58.52	317.17	27.5100	-0.5200	0.7000	
57.00	6700516.39	1631177.67	46.52	RT90-RHB70	-58.40	317.15	29.0800	-0.5800	0.7800	
60.00	6700517.54	1631176.60	49.07	RT90-RHB70	-58.34	316.97	30.6500	-0.6400	0.8700	
63.00	6700518.69	1631175.53	51.63	RT90-RHB70	-58.30	316.69	32.2200	-0.7100	0.9600	
66.00	6700519.84	1631174.45	54.18	RT90-RHB70	-58.18	316.45	33.8000	-0.7900	1.0600	

69.00	6700520.99	1631173.36	56.73	RT90-RHB70	-58.05	316.33	35.3800	-0.8700	1.1600
72.00	6700522.13	1631172.26	59.27	RT90-RHB70	-57.91	316.31	36.9600	-0.9500	1.2600
75.00	6700523.29	1631171.16	61.81	RT90-RHB70	-57.81	316.21	38.5500	-1.0400	1.3800
78.00	6700524.44	1631170.05	64.35	RT90-RHB70	-57.75	316.10	40.1500	-1.1300	1.4900
81.00	6700525.59	1631168.94	66.89	RT90-RHB70	-57.73	315.89	41.7500	-1.2200	1.6100
84.00	6700526.74	1631167.83	69.43	RT90-RHB70	-57.67	315.67	43.3500	-1.3200	1.7400
87.00	6700527.89	1631166.71	71.96	RT90-RHB70	-57.60	315.55	44.9500	-1.4300	1.8600
90.00	6700529.04	1631165.58	74.50	RT90-RHB70	-57.47	315.55	46.5500	-1.5300	1.9900
93.00	6700530.19	1631164.45	77.02	RT90-RHB70	-57.31	315.55	48.1600	-1.6400	2.1300
96.00	6700531.35	1631163.32	79.55	RT90-RHB70	-57.27	315.49	49.7800	-1.7500	2.2700
99.00	6700532.50	1631162.18	82.07	RT90-RHB70	-57.31	315.43	51.4000	-1.8600	2.4100
102.00	6700533.66	1631161.04	84.60	RT90-RHB70	-57.26	315.54	53.0100	-1.9800	2.5600
105.00	6700534.82	1631159.91	87.12	RT90-RHB70	-57.20	315.72	54.6300	-2.0900	2.7000
108.00	6700535.98	1631158.77	89.64	RT90-RHB70	-57.16	315.88	56.2500	-2.1900	2.8500
111.00	6700537.15	1631157.64	92.16	RT90-RHB70	-57.10	316.02	57.8800	-2.2900	3.0000
114.00	6700538.32	1631156.51	94.68	RT90-RHB70	-57.06	316.12	59.5000	-2.3900	3.1600
117.00	6700539.50	1631155.38	97.20	RT90-RHB70	-57.01	316.23	61.1300	-2.4800	3.3200
120.00	6700540.68	1631154.25	99.72	RT90-RHB70	-56.95	316.39	62.7600	-2.5700	3.4800
123.00	6700541.86	1631153.12	102.23	RT90-RHB70	-56.87	316.51	64.4000	-2.6600	3.6400
126.00	6700543.05	1631151.99	104.74	RT90-RHB70	-56.81	316.65	66.0300	-2.7400	3.8100
129.00	6700544.24	1631150.86	107.25	RT90-RHB70	-56.75	316.76	67.6800	-2.8200	3.9800
132.00	6700545.44	1631149.74	109.76	RT90-RHB70	-56.70	316.89	69.3200	-2.9000	4.1500
135.00	6700546.64	1631148.61	112.27	RT90-RHB70	-56.67	317.02	70.9600	-2.9700	4.3300
138.00	6700547.85	1631147.49	114.78	RT90-RHB70	-56.62	317.13	72.6100	-3.0400	4.5100
141.00	6700549.06	1631146.36	117.28	RT90-RHB70	-56.57	317.22	74.2600	-3.1100	4.6900
144.00	6700550.27	1631145.24	119.79	RT90-RHB70	-56.51	317.31	75.9100	-3.1700	4.8700
147.00	6700551.49	1631144.12	122.29	RT90-RHB70	-56.45	317.35	77.5700	-3.2300	5.0600
150.00	6700552.71	1631143.00	124.79	RT90-RHB70	-56.37	317.42	79.2200	-3.2900	5.2500
153.00	6700553.93	1631141.87	127.29	RT90-RHB70	-56.28	317.50	80.8800	-3.3500	5.4500
156.00	6700555.16	1631140.75	129.78	RT90-RHB70	-56.18	317.56	82.5500	-3.4000	5.6500
159.00	6700556.39	1631139.62	132.27	RT90-RHB70	-56.09	317.60	84.2200	-3.4600	5.8500
162.00	6700557.63	1631138.49	134.76	RT90-RHB70	-56.02	317.68	85.8900	-3.5100	6.0600
165.00	6700558.87	1631137.36	137.25	RT90-RHB70	-55.97	317.79	87.5700	-3.5600	6.2800
168.00	6700560.11	1631136.23	139.74	RT90-RHB70	-55.95	317.89	89.2400	-3.6100	6.4900
171.00	6700561.36	1631135.11	142.22	RT90-RHB70	-55.96	317.99	90.9200	-3.6500	6.7100
174.00	6700562.61	1631133.98	144.71	RT90-RHB70	-55.96	318.10	92.6000	-3.7000	6.9200
177.00	6700563.86	1631132.86	147.19	RT90-RHB70	-55.97	318.21	94.2800	-3.7400	7.1400
180.00	6700565.11	1631131.74	149.68	RT90-RHB70	-55.95	318.31	95.9600	-3.7700	7.3600
183.00	6700566.36	1631130.63	152.17	RT90-RHB70	-55.93	318.38	97.6400	-3.8000	7.5800
186.00	6700567.62	1631129.51	154.65	RT90-RHB70	-55.91	318.45	99.3200	-3.8300	7.7900
189.00	6700568.88	1631128.40	157.14	RT90-RHB70	-55.89	318.51	101.0000	-3.8600	8.0100

192.00	6700570.14	1631127.28	159.62	RT90-RHB70	-55.85	318.55	102.6800	-3.8900	8.2300
195.00	6700571.40	1631126.17	162.10	RT90-RHB70	-55.81	318.60	104.3700	-3.9100	8.4600
198.00	6700572.66	1631125.05	164.58	RT90-RHB70	-55.77	318.62	106.0500	-3.9400	8.6800
201.00	6700573.93	1631123.94	167.06	RT90-RHB70	-55.74	318.66	107.7400	-3.9600	8.9100
204.00	6700575.20	1631122.82	169.54	RT90-RHB70	-55.67	318.77	109.4300	-3.9800	9.1400
207.00	6700576.47	1631121.70	172.02	RT90-RHB70	-55.58	318.85	111.1200	-4.0000	9.3700
210.00	6700577.75	1631120.59	174.50	RT90-RHB70	-55.49	318.90	112.8200	-4.0200	9.6100
213.00	6700579.03	1631119.47	176.97	RT90-RHB70	-55.39	318.97	114.5200	-4.0400	9.8500
216.00	6700580.31	1631118.35	179.44	RT90-RHB70	-55.33	319.01	116.2200	-4.0500	10.0900
219.00	6700581.60	1631117.23	181.90	RT90-RHB70	-55.27	319.05	117.9300	-4.0600	10.3400
222.00	6700582.89	1631116.11	184.37	RT90-RHB70	-55.19	319.14	119.6300	-4.0700	10.6000
225.00	6700584.19	1631114.99	186.83	RT90-RHB70	-55.09	319.21	121.3500	-4.0800	10.8500
228.00	6700585.49	1631113.87	189.29	RT90-RHB70	-55.00	319.25	123.0600	-4.0900	11.1200
231.00	6700586.79	1631112.75	191.75	RT90-RHB70	-54.93	319.29	124.7900	-4.0900	11.3800
234.00	6700588.10	1631111.62	194.21	RT90-RHB70	-54.85	319.32	126.5100	-4.1000	11.6600
237.00	6700589.41	1631110.50	196.66	RT90-RHB70	-54.78	319.38	128.2400	-4.1000	11.9300
240.00	6700590.72	1631109.37	199.11	RT90-RHB70	-54.69	319.46	129.9700	-4.1000	12.2100
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246.00	6700593.36	1631107.12	204.00	RT90-RHB70	-54.53	319.58	133.4400	-4.1000	12.7800
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255.00	6700597.35	1631103.73	211.33	RT90-RHB70	-54.28	319.98	138.6700	-4.0700	13.6700
258.00	6700598.69	1631102.60	213.76	RT90-RHB70	-54.21	320.09	140.4200	-4.0600	13.9700
261.00	6700600.04	1631101.48	216.20	RT90-RHB70	-54.16	320.15	142.1700	-4.0400	14.2800
264.00	6700601.38	1631100.35	218.63	RT90-RHB70	-54.11	320.14	143.9300	-4.0100	14.5900
267.00	6700602.73	1631099.23	221.06	RT90-RHB70	-54.07	320.13	145.6900	-3.9900	14.9000
270.00	6700604.09	1631098.10	223.49	RT90-RHB70	-54.03	320.18	147.4500	-3.9700	15.2200
273.00	6700605.44	1631096.97	225.92	RT90-RHB70	-53.99	320.23	149.2100	-3.9500	15.5400
276.00	6700606.79	1631095.84	228.34	RT90-RHB70	-53.92	320.25	150.9700	-3.9200	15.8600
279.00	6700608.15	1631094.71	230.77	RT90-RHB70	-53.84	320.25	152.7400	-3.9000	16.1800
282.00	6700609.51	1631093.58	233.19	RT90-RHB70	-53.77	320.25	154.5100	-3.8700	16.5100
285.00	6700610.88	1631092.45	235.61	RT90-RHB70	-53.73	320.29	156.2800	-3.8400	16.8400
288.00	6700612.24	1631091.31	238.03	RT90-RHB70	-53.70	320.36	158.0600	-3.8200	17.1700
291.00	6700613.61	1631090.18	240.45	RT90-RHB70	-53.67	320.42	159.8300	-3.7900	17.5100
294.00	6700614.98	1631089.05	242.86	RT90-RHB70	-53.62	320.47	161.6100	-3.7600	17.8400
297.00	6700616.35	1631087.91	245.28	RT90-RHB70	-53.59	320.54	163.3900	-3.7300	18.1800
300.00	6700617.73	1631086.78	247.69	RT90-RHB70	-53.57	320.60	165.1700	-3.6900	18.5200
303.00	6700619.10	1631085.65	250.11	RT90-RHB70	-53.54	320.65	166.9500	-3.6500	18.8600
306.00	6700620.48	1631084.52	252.52	RT90-RHB70	-53.49	320.71	168.7400	-3.6200	19.2100
309.00	6700621.86	1631083.39	254.93	RT90-RHB70	-53.44	320.75	170.5200	-3.5700	19.5500
312.00	6700623.25	1631082.26	257.34	RT90-RHB70	-53.37	320.78	172.3100	-3.5300	19.9000

315.00	6700624.63	1631081.13	259.75	RT90-RHB70	-53.31	320.80	174.1000	-3.4900	20.2500
318.00	6700626.02	1631079.99	262.15	RT90-RHB70	-53.25	320.82	175.8900	-3.4500	20.6100
321.00	6700627.41	1631078.86	264.56	RT90-RHB70	-53.19	320.82	177.6800	-3.4000	20.9600
324.00	6700628.81	1631077.73	266.96	RT90-RHB70	-53.11	320.87	179.4800	-3.3600	21.3200
327.00	6700630.20	1631076.59	269.36	RT90-RHB70	-53.00	320.89	181.2800	-3.3100	21.6900
330.00	6700631.61	1631075.45	271.75	RT90-RHB70	-52.89	320.91	183.0800	-3.2700	22.0600
333.00	6700633.01	1631074.31	274.15	RT90-RHB70	-52.78	320.94	184.8900	-3.2200	22.4400
336.00	6700634.42	1631073.17	276.54	RT90-RHB70	-52.69	320.96	186.7100	-3.1700	22.8200
339.00	6700635.83	1631072.02	278.92	RT90-RHB70	-52.62	321.02	188.5200	-3.1200	23.2100
342.00	6700637.25	1631070.87	281.31	RT90-RHB70	-52.58	321.09	190.3500	-3.0700	23.6000
345.00	6700638.67	1631069.73	283.69	RT90-RHB70	-52.52	321.14	192.1700	-3.0200	23.9900
348.00	6700640.09	1631068.58	286.07	RT90-RHB70	-52.46	321.17	193.9900	-2.9700	24.3800
351.00	6700641.51	1631067.44	288.45	RT90-RHB70	-52.42	321.21	195.8200	-2.9100	24.7800
354.00	6700642.94	1631066.29	290.82	RT90-RHB70	-52.38	321.29	197.6500	-2.8500	25.1800
357.00	6700644.37	1631065.15	293.20	RT90-RHB70	-52.35	321.33	199.4800	-2.7900	25.5800
360.00	6700645.80	1631064.00	295.58	RT90-RHB70	-52.31	321.35	201.3100	-2.7300	25.9900
363.00	6700647.23	1631062.86	297.95	RT90-RHB70	-52.27	321.40	203.1400	-2.6700	26.4000
366.00	6700648.66	1631061.71	300.32	RT90-RHB70	-52.22	321.49	204.9800	-2.6100	26.8000
369.00	6700650.10	1631060.57	302.69	RT90-RHB70	-52.16	321.54	206.8100	-2.5400	27.2100
372.00	6700651.54	1631059.42	305.06	RT90-RHB70	-52.10	321.58	208.6500	-2.4700	27.6300
375.00	6700652.99	1631058.28	307.43	RT90-RHB70	-52.06	321.64	210.4900	-2.4000	28.0400
378.00	6700654.43	1631057.13	309.80	RT90-RHB70	-52.01	321.70	212.3400	-2.3300	28.4600
381.00	6700655.88	1631055.99	312.16	RT90-RHB70	-51.96	321.75	214.1800	-2.2600	28.8800
384.00	6700657.33	1631054.84	314.52	RT90-RHB70	-51.91	321.83	216.0300	-2.1800	29.3100
387.00	6700658.79	1631053.70	316.89	RT90-RHB70	-51.85	321.90	217.8800	-2.1100	29.7400
390.00	6700660.25	1631052.56	319.24	RT90-RHB70	-51.80	321.95	219.7300	-2.0200	30.1600
393.00	6700661.71	1631051.41	321.60	RT90-RHB70	-51.73	322.02	221.5800	-1.9400	30.6000
396.00	6700663.17	1631050.27	323.96	RT90-RHB70	-51.67	322.07	223.4400	-1.8600	31.0300
399.00	6700664.64	1631049.13	326.31	RT90-RHB70	-51.60	322.08	225.3000	-1.7700	31.4700
402.00	6700666.11	1631047.98	328.66	RT90-RHB70	-51.50	322.10	227.1600	-1.6900	31.9100
405.00	6700667.58	1631046.83	331.01	RT90-RHB70	-51.39	322.08	229.0200	-1.6000	32.3600
408.00	6700669.06	1631045.68	333.35	RT90-RHB70	-51.31	322.09	230.8900	-1.5100	32.8100
411.00	6700670.54	1631044.53	335.70	RT90-RHB70	-51.25	322.15	232.7700	-1.4200	33.2700
414.00	6700672.02	1631043.38	338.04	RT90-RHB70	-51.21	322.20	234.6400	-1.3400	33.7300
417.00	6700673.51	1631042.23	340.37	RT90-RHB70	-51.15	322.26	236.5200	-1.2400	34.1900
420.00	6700675.00	1631041.07	342.71	RT90-RHB70	-51.10	322.29	238.4000	-1.1500	34.6600
423.00	6700676.49	1631039.92	345.04	RT90-RHB70	-51.06	322.34	240.2800	-1.0600	35.1300
426.00	6700677.98	1631038.77	347.38	RT90-RHB70	-51.03	322.39	242.1600	-0.9600	35.6000
429.00	6700679.47	1631037.62	349.71	RT90-RHB70	-51.00	322.44	244.0500	-0.8600	36.0700
432.00	6700680.97	1631036.47	352.04	RT90-RHB70	-50.98	322.53	245.9300	-0.7600	36.5400
435.00	6700682.47	1631035.32	354.37	RT90-RHB70	-50.93	322.65	247.8200	-0.6600	37.0100

438.00	6700683.97	1631034.17	356.70	RT90-RHB70	-50.86	322.77	249.7100	-0.5500	37.4900
441.00	6700685.48	1631033.03	359.03	RT90-RHB70	-50.80	322.85	251.6000	-0.4400	37.9700
444.00	6700686.99	1631031.88	361.35	RT90-RHB70	-50.75	322.94	253.4900	-0.3300	38.4500
447.00	6700688.51	1631030.74	363.68	RT90-RHB70	-50.70	323.02	255.3900	-0.2100	38.9400
450.00	6700690.02	1631029.59	366.00	RT90-RHB70	-50.62	323.08	257.2800	-0.0900	39.4200
453.00	6700691.55	1631028.45	368.32	RT90-RHB70	-50.54	323.16	259.1800	0.0300	39.9100
456.00	6700693.07	1631027.31	370.63	RT90-RHB70	-50.47	323.30	261.0800	0.1500	40.4100
459.00	6700694.60	1631026.17	372.95	RT90-RHB70	-50.38	323.46	262.9900	0.2800	40.9100
462.00	6700696.14	1631025.03	375.26	RT90-RHB70	-50.30	323.61	264.9000	0.4200	41.4100
465.00	6700697.68	1631023.89	377.57	RT90-RHB70	-50.22	323.75	266.8100	0.5600	41.9200
468.00	6700699.23	1631022.76	379.87	RT90-RHB70	-50.15	323.89	268.7200	0.7000	42.4300
471.00	6700700.78	1631021.62	382.17	RT90-RHB70	-50.09	324.04	270.6400	0.8500	42.9400
474.00	6700702.34	1631020.49	384.48	RT90-RHB70	-50.03	324.20	272.5600	1.0100	43.4600
477.00	6700703.90	1631019.36	386.77	RT90-RHB70	-49.95	324.38	274.4800	1.1700	43.9800
480.00	6700705.47	1631018.24	389.07	RT90-RHB70	-49.88	324.57	276.4000	1.3300	44.5000
483.00	6700707.05	1631017.12	391.37	RT90-RHB70	-49.78	324.69	278.3300	1.5100	45.0300
486.00	6700708.63	1631016.00	393.66	RT90-RHB70	-49.68	324.82	280.2600	1.6800	45.5600
489.00	6700710.22	1631014.88	395.94	RT90-RHB70	-49.56	324.96	282.1900	1.8700	46.0900
492.00	6700711.81	1631013.76	398.23	RT90-RHB70	-49.46	325.11	284.1300	2.0500	46.6400
495.00	6700713.41	1631012.65	400.51	RT90-RHB70	-49.33	325.30	286.0700	2.2500	47.1800
498.00	6700715.02	1631011.54	402.78	RT90-RHB70	-49.22	325.45	288.0100	2.4500	47.7300
501.00	6700716.63	1631010.42	405.05	RT90-RHB70	-49.11	325.57	289.9600	2.6500	48.2900
504.00	6700718.25	1631009.31	407.32	RT90-RHB70	-49.02	325.73	291.9100	2.8600	48.8500
507.00	6700719.88	1631008.21	409.59	RT90-RHB70	-48.93	325.90	293.8700	3.0800	49.4200
510.00	6700721.51	1631007.10	411.85	RT90-RHB70	-48.82	326.09	295.8300	3.3000	49.9900
513.00	6700723.15	1631006.00	414.11	RT90-RHB70	-48.72	326.25	297.7900	3.5300	50.5700
516.00	6700724.79	1631004.90	416.36	RT90-RHB70	-48.66	326.43	299.7500	3.7700	51.1500
519.00	6700726.44	1631003.80	418.61	RT90-RHB70	-48.62	326.60	301.7200	4.0100	51.7300
522.00	6700728.10	1631002.71	420.86	RT90-RHB70	-48.56	326.78	303.6900	4.2600	52.3100
525.00	6700729.76	1631001.62	423.11	RT90-RHB70	-48.51	326.94	305.6600	4.5100	52.9000
528.00	6700731.43	1631000.54	425.36	RT90-RHB70	-48.44	327.08	307.6300	4.7700	53.4900
531.00	6700733.10	1630999.46	427.60	RT90-RHB70	-48.36	327.22	309.6000	5.0400	54.0800
534.00	6700734.77	1630998.38	429.85	RT90-RHB70	-48.29	327.34	311.5700	5.3100	54.6800
537.00	6700736.45	1630997.30	432.09	RT90-RHB70	-48.19	327.45	313.5500	5.5800	55.2700
540.00	6700738.14	1630996.23	434.32	RT90-RHB70	-48.13	327.57	315.5300	5.8600	55.8800
543.00	6700739.83	1630995.15	436.56	RT90-RHB70	-48.05	327.65	317.5100	6.1500	56.4800
546.00	6700741.52	1630994.08	438.79	RT90-RHB70	-47.97	327.74	319.5000	6.4300	57.0900
549.00	6700743.22	1630993.01	441.02	RT90-RHB70	-47.92	327.82	321.4900	6.7200	57.7000
552.00	6700744.92	1630991.94	443.24	RT90-RHB70	-47.87	327.93	323.4800	7.0200	58.3200
555.00	6700746.63	1630990.87	445.47	RT90-RHB70	-47.77	328.01	325.4700	7.3200	58.9400
558.00	6700748.34	1630989.80	447.69	RT90-RHB70	-47.67	328.12	327.4600	7.6200	59.5600

561.00	6700750.06	1630988.73	449.91	RT90-RHB70	-47.61	328.25	329.4600	7.9200	60.1800
564.00	6700751.78	1630987.67	452.12	RT90-RHB70	-47.57	328.43	331.4500	8.2300	60.8100
567.00	6700753.50	1630986.61	454.34	RT90-RHB70	-47.50	328.57	333.4500	8.5500	61.4400
570.00	6700755.23	1630985.55	456.55	RT90-RHB70	-47.40	328.66	335.4600	8.8700	62.0700
573.00	6700756.96	1630984.50	458.76	RT90-RHB70	-47.30	328.69	337.4600	9.2000	62.7100
576.00	6700758.70	1630983.44	460.96	RT90-RHB70	-47.22	328.76	339.4700	9.5300	63.3500
579.00	6700760.44	1630982.38	463.16	RT90-RHB70	-47.16	328.88	341.4800	9.8600	64.0000
582.00	6700762.19	1630981.33	465.36	RT90-RHB70	-47.08	329.02	343.4900	10.1900	64.6500
585.00	6700763.94	1630980.28	467.56	RT90-RHB70	-46.98	329.12	345.5000	10.5300	65.3000
588.00	6700765.70	1630979.23	469.75	RT90-RHB70	-46.91	329.21	347.5200	10.8800	65.9600
591.00	6700767.46	1630978.18	471.94	RT90-RHB70	-46.87	329.27	349.5400	11.2300	66.6100
594.00	6700769.22	1630977.13	474.13	RT90-RHB70	-46.84	329.34	351.5600	11.5800	67.2800
597.00	6700770.99	1630976.08	476.32	RT90-RHB70	-46.80	329.41	353.5800	11.9300	67.9400
600.00	6700772.76	1630975.04	478.51	RT90-RHB70	-46.74	329.51	355.6100	12.2900	68.6000
603.00	6700774.53	1630973.99	480.69	RT90-RHB70	-46.64	329.60	357.6300	12.6500	69.2700
606.00	6700776.30	1630972.95	482.87	RT90-RHB70	-46.55	329.71	359.6600	13.0100	69.9400
609.00	6700778.09	1630971.91	485.05	RT90-RHB70	-46.46	329.81	361.6900	13.3800	70.6100
612.00	6700779.87	1630970.87	487.23	RT90-RHB70	-46.35	329.91	363.7200	13.7500	71.2900
615.00	6700781.66	1630969.83	489.40	RT90-RHB70	-46.26	330.02	365.7600	14.1300	71.9800
618.00	6700783.46	1630968.80	491.56	RT90-RHB70	-46.18	330.13	367.8000	14.5100	72.6600
621.00	6700785.26	1630967.76	493.73	RT90-RHB70	-46.11	330.26	369.8400	14.9000	73.3500
624.00	6700787.07	1630966.73	495.89	RT90-RHB70	-46.02	330.37	371.8800	15.2900	74.0500
627.00	6700788.88	1630965.70	498.05	RT90-RHB70	-45.94	330.49	373.9300	15.6800	74.7400
630.00	6700790.69	1630964.67	500.21	RT90-RHB70	-45.90	330.62	375.9700	16.0800	75.4500
633.00	6700792.51	1630963.65	502.36	RT90-RHB70	-45.86	330.73	378.0200	16.4900	76.1500
636.00	6700794.34	1630962.63	504.51	RT90-RHB70	-45.82	330.82	380.0700	16.9000	76.8500
639.00	6700796.16	1630961.61	506.66	RT90-RHB70	-45.76	330.92	382.1200	17.3100	77.5600
642.00	6700797.99	1630960.59	508.81	RT90-RHB70	-45.67	331.02	384.1700	17.7300	78.2600
645.00	6700799.82	1630959.57	510.96	RT90-RHB70	-45.58	331.12	386.2200	18.1500	78.9700
648.00	6700801.66	1630958.56	513.10	RT90-RHB70	-45.49	331.21	388.2800	18.5800	79.6900
651.00	6700803.51	1630957.55	515.24	RT90-RHB70	-45.42	331.31	390.3400	19.0100	80.4100
654.00	6700805.35	1630956.54	517.38	RT90-RHB70	-45.35	331.44	392.4000	19.4400	81.1300
657.00	6700807.20	1630955.53	519.51	RT90-RHB70	-45.28	331.55	394.4600	19.8800	81.8500
660.00	6700809.06	1630954.52	521.64	RT90-RHB70	-45.25	331.67	396.5200	20.3200	82.5800
663.00	6700810.92	1630953.52	523.77	RT90-RHB70	-45.20	331.77	398.5900	20.7700	83.3100
666.00	6700812.78	1630952.52	525.90	RT90-RHB70	-45.14	331.88	400.6500	21.2200	84.0400
669.00	6700814.65	1630951.52	528.03	RT90-RHB70	-45.08	331.99	402.7200	21.6800	84.7700
672.00	6700816.52	1630950.53	530.15	RT90-RHB70	-45.03	332.09	404.7900	22.1400	85.5000
675.00	6700818.39	1630949.54	532.28	RT90-RHB70	-45.00	332.18	406.8600	22.6100	86.2400
678.00	6700820.27	1630948.55	534.40	RT90-RHB70	-44.94	332.28	408.9300	23.0800	86.9800
681.00	6700822.15	1630947.56	536.52	RT90-RHB70	-44.87	332.38	411.0000	23.5500	87.7100

684.00	6700824.03	1630946.57	538.63	RT90-RHB70	-44.79	332.48	413.0700	24.0200	88.4600
687.00	6700825.92	1630945.59	540.75	RT90-RHB70	-44.74	332.60	415.1400	24.5100	89.2000
690.00	6700827.81	1630944.61	542.86	RT90-RHB70	-44.69	332.70	417.2200	24.9900	89.9500
693.00	6700829.71	1630943.63	544.97	RT90-RHB70	-44.64	332.79	419.2900	25.4800	90.7000
696.00	6700831.61	1630942.65	547.08	RT90-RHB70	-44.60	332.89	421.3700	25.9800	91.4500
699.00	6700833.51	1630941.68	549.18	RT90-RHB70	-44.52	333.00	423.4500	26.4700	92.2000
702.00	6700835.41	1630940.71	551.29	RT90-RHB70	-44.45	333.11	425.5300	26.9800	92.9500
705.00	6700837.32	1630939.74	553.39	RT90-RHB70	-44.40	333.17	427.6100	27.4800	93.7100
708.00	6700839.24	1630938.77	555.49	RT90-RHB70	-44.33	333.24	429.6900	27.9900	94.4700
711.00	6700841.15	1630937.81	557.58	RT90-RHB70	-44.24	333.32	431.7700	28.5000	95.2300
714.00	6700843.07	1630936.84	559.68	RT90-RHB70	-44.13	333.39	433.8600	29.0200	96.0000
717.00	6700845.00	1630935.88	561.76	RT90-RHB70	-44.03	333.46	435.9500	29.5400	96.7700
720.00	6700846.93	1630934.91	563.85	RT90-RHB70	-43.92	333.54	438.0400	30.0600	97.5400
723.00	6700848.86	1630933.95	565.93	RT90-RHB70	-43.82	333.65	440.1400	30.5900	98.3200
726.00	6700850.80	1630932.99	568.01	RT90-RHB70	-43.74	333.77	442.2300	31.1200	99.1100
729.00	6700852.75	1630932.03	570.08	RT90-RHB70	-43.67	333.85	444.3300	31.6600	99.8900
732.00	6700854.69	1630931.08	572.15	RT90-RHB70	-43.55	333.94	446.4400	32.2000	100.6800
735.00	6700856.65	1630930.12	574.22	RT90-RHB70	-43.46	334.08	448.5400	32.7500	101.4800
738.00	6700858.61	1630929.17	576.28	RT90-RHB70	-43.41	334.27	450.6500	33.3000	102.2800
741.00	6700860.57	1630928.22	578.34	RT90-RHB70	-43.37	334.47	452.7500	33.8600	103.0700
744.00	6700862.54	1630927.28	580.40	RT90-RHB70	-43.27	334.62	454.8600	34.4200	103.8700
747.00	6700864.51	1630926.35	582.46	RT90-RHB70	-43.17	334.77	456.9700	34.9900	104.6800
750.00	6700866.49	1630925.41	584.51	RT90-RHB70	-43.10	334.94	459.0800	35.5700	105.4800
753.00	6700868.47	1630924.49	586.56	RT90-RHB70	-43.02	335.12	461.1900	36.1600	106.2900
756.00	6700870.46	1630923.56	588.61	RT90-RHB70	-42.95	335.28	463.3000	36.7500	107.1000
759.00	6700872.46	1630922.64	590.65	RT90-RHB70	-42.86	335.43	465.4100	37.3500	107.9100
762.00	6700874.46	1630921.73	592.69	RT90-RHB70	-42.78	335.59	467.5300	37.9600	108.7300
765.00	6700876.46	1630920.82	594.73	RT90-RHB70	-42.71	335.75	469.6400	38.5700	109.5500
768.00	6700878.47	1630919.91	596.77	RT90-RHB70	-42.64	335.91	471.7600	39.1900	110.3700
771.00	6700880.49	1630919.01	598.80	RT90-RHB70	-42.56	336.07	473.8700	39.8200	111.1900
774.00	6700882.51	1630918.12	600.83	RT90-RHB70	-42.49	336.21	475.9900	40.4500	112.0100
777.00	6700884.53	1630917.23	602.85	RT90-RHB70	-42.42	336.36	478.1100	41.0900	112.8400
780.00	6700886.56	1630916.34	604.88	RT90-RHB70	-42.35	336.52	480.2300	41.7400	113.6700
783.00	6700888.59	1630915.45	606.90	RT90-RHB70	-42.24	336.71	482.3500	42.3900	114.5000
786.00	6700890.63	1630914.58	608.92	RT90-RHB70	-42.15	336.89	484.4700	43.0500	115.3300
789.00	6700892.68	1630913.70	610.93	RT90-RHB70	-42.05	337.09	486.5900	43.7200	116.1700
792.00	6700894.73	1630912.84	612.94	RT90-RHB70	-41.95	337.27	488.7100	44.3900	117.0100
795.00	6700896.79	1630911.97	614.94	RT90-RHB70	-41.90	337.43	490.8300	45.0800	117.8500
798.00	6700898.85	1630911.12	616.95	RT90-RHB70	-41.83	337.58	492.9600	45.7700	118.6900
801.00	6700900.92	1630910.26	618.95	RT90-RHB70	-41.75	337.69	495.0800	46.4600	119.5400
804.00	6700902.99	1630909.41	620.95	RT90-RHB70	-41.64	337.79	497.2100	47.1700	120.3800

807.00	6700905.06	1630908.57	622.94	RT90-RHB70	-41.51	337.91	499.3300	47.8700	121.2400
810.00	6700907.15	1630907.72	624.93	RT90-RHB70	-41.39	338.02	501.4600	48.5800	122.0900
813.00	6700909.23	1630906.88	626.91	RT90-RHB70	-41.26	338.13	503.6000	49.3000	122.9500
816.00	6700911.33	1630906.04	628.89	RT90-RHB70	-41.14	338.26	505.7300	50.0300	123.8200
819.00	6700913.43	1630905.20	630.86	RT90-RHB70	-41.02	338.38	507.8700	50.7600	124.6900
822.00	6700915.53	1630904.37	632.83	RT90-RHB70	-40.89	338.48	510.0100	51.4900	125.5600
825.00	6700917.64	1630903.54	634.80	RT90-RHB70	-40.76	338.57	512.1600	52.2300	126.4400
828.00	6700919.75	1630902.71	636.75	RT90-RHB70	-40.66	338.68	514.3000	52.9800	127.3300
831.00	6700921.87	1630901.88	638.71	RT90-RHB70	-40.56	338.79	516.4500	53.7300	128.2200
834.00	6700924.00	1630901.05	640.66	RT90-RHB70	-40.47	338.92	518.6000	54.4800	129.1100
837.00	6700926.13	1630900.23	642.61	RT90-RHB70	-40.38	339.05	520.7500	55.2500	130.0000
840.00	6700928.26	1630899.42	644.55	RT90-RHB70	-40.28	339.20	522.9100	56.0100	130.9000
843.00	6700930.40	1630898.60	646.49	RT90-RHB70	-40.20	339.37	525.0600	56.7900	131.8000
846.00	6700932.55	1630897.80	648.43	RT90-RHB70	-40.13	339.54	527.2100	57.5700	132.7000
849.00	6700934.70	1630897.00	650.36	RT90-RHB70	-40.09	339.71	529.3700	58.3600	133.6100
852.00	6700936.85	1630896.20	652.29	RT90-RHB70	-40.01	339.87	531.5200	59.1500	134.5100
855.00	6700939.01	1630895.41	654.22	RT90-RHB70	-39.93	339.96	533.6700	59.9600	135.4200
858.00	6700941.17	1630894.62	656.15	RT90-RHB70	-39.80	340.02	535.8300	60.7600	136.3300
861.00	6700943.33	1630893.83	658.07	RT90-RHB70	-39.72	340.05	537.9800	61.5800	137.2400
864.00	6700945.50	1630893.05	659.98	RT90-RHB70	-39.72	340.03	540.1400	62.3900	138.1600
867.00	6700947.67	1630892.26	661.90	RT90-RHB70	-39.63	339.98	542.3000	63.2000	139.0700
870.00	6700949.84	1630891.47	663.81	RT90-RHB70	-39.52	340.04	544.4700	64.0100	139.9900
873.00	6700952.02	1630890.68	665.72	RT90-RHB70	-39.42	340.10	546.6300	64.8300	140.9200
876.00	6700954.20	1630889.89	667.63	RT90-RHB70	-39.33	340.16	548.8000	65.6500	141.8500
879.00	6700956.38	1630889.10	669.53	RT90-RHB70	-39.21	340.21	550.9700	66.4700	142.7900
882.00	6700958.57	1630888.31	671.43	RT90-RHB70	-39.08	340.30	553.1400	67.2900	143.7200
885.00	6700960.76	1630887.53	673.32	RT90-RHB70	-38.97	340.38	555.3200	68.1200	144.6700
888.00	6700962.96	1630886.74	675.20	RT90-RHB70	-38.88	340.41	557.5000	68.9600	145.6200
891.00	6700965.16	1630885.96	677.09	RT90-RHB70	-38.79	340.43	559.6800	69.7900	146.5700
894.00	6700967.36	1630885.18	678.97	RT90-RHB70	-38.68	340.46	561.8600	70.6300	147.5200
897.00	6700969.57	1630884.39	680.84	RT90-RHB70	-38.57	340.53	564.0500	71.4700	148.4900
900.00	6700971.78	1630883.61	682.71	RT90-RHB70	-38.47	340.58	566.2400	72.3200	149.4500
903.00	6700973.99	1630882.83	684.58	RT90-RHB70	-38.37	340.64	568.4300	73.1600	150.4200
906.00	6700976.21	1630882.05	686.44	RT90-RHB70	-38.26	340.72	570.6200	74.0200	151.3900
909.00	6700978.44	1630881.27	688.30	RT90-RHB70	-38.17	340.78	572.8100	74.8700	152.3700
912.00	6700980.66	1630880.50	690.15	RT90-RHB70	-38.10	340.84	575.0100	75.7300	153.3500
915.00	6700982.89	1630879.72	692.00	RT90-RHB70	-38.04	340.90	577.2100	76.5900	154.3300
918.00	6700985.13	1630878.95	693.85	RT90-RHB70	-37.96	341.03	579.4100	77.4600	155.3200
921.00	6700987.36	1630878.18	695.70	RT90-RHB70	-37.85	341.16	581.6100	78.3300	156.3000
924.00	6700989.60	1630877.42	697.54	RT90-RHB70	-37.74	341.28	583.8100	79.2100	157.2900
927.00	6700991.85	1630876.66	699.37	RT90-RHB70	-37.63	341.42	586.0100	80.0900	158.2900

930.00	6700994.10	1630875.90	701.21	RT90-RHB70	-37.58	341.56	588.2100	80.9800	159.2900
933.00	6700996.36	1630875.15	703.04	RT90-RHB70	-37.54	341.71	590.4100	81.8800	160.2800
936.00	6700998.62	1630874.40	704.86	RT90-RHB70	-37.49	341.87	592.6100	82.7800	161.2800
939.00	6701000.88	1630873.66	706.69	RT90-RHB70	-37.45	342.03	594.8100	83.6900	162.2800
942.00	6701003.14	1630872.92	708.51	RT90-RHB70	-37.41	342.20	597.0100	84.6000	163.2700
945.00	6701005.41	1630872.20	710.34	RT90-RHB70	-37.33	342.34	599.2100	85.5300	164.2700
948.00	6701007.69	1630871.47	712.16	RT90-RHB70	-37.26	342.45	601.4100	86.4500	165.2700
951.00	6701009.96	1630870.75	713.97	RT90-RHB70	-37.17	342.58	603.6000	87.3900	166.2700
954.00	6701012.24	1630870.04	715.79	RT90-RHB70	-37.07	342.70	605.8000	88.3300	167.2700
957.00	6701014.53	1630869.32	717.59	RT90-RHB70	-36.97	342.82	608.0000	89.2800	168.2800
960.00	6701016.82	1630868.62	719.40	RT90-RHB70	-36.88	342.95	610.2000	90.2300	169.2900
963.00	6701019.11	1630867.91	721.20	RT90-RHB70	-36.78	343.02	612.4000	91.1900	170.3000
966.00	6701021.41	1630867.21	722.99	RT90-RHB70	-36.69	343.08	614.6000	92.1500	171.3100
969.00	6701023.71	1630866.51	724.79	RT90-RHB70	-36.58	343.14	616.8100	93.1100	172.3300
972.00	6701026.02	1630865.81	726.57	RT90-RHB70	-36.44	343.17	619.0100	94.0800	173.3500
975.00	6701028.33	1630865.11	728.36	RT90-RHB70	-36.35	343.20	621.2200	95.0500	174.3800
978.00	6701030.64	1630864.42	730.13	RT90-RHB70	-36.26	343.26	623.4300	96.0300	175.4100
981.00	6701032.96	1630863.72	731.91	RT90-RHB70	-36.16	343.39	625.6400	97.0100	176.4400
984.00	6701035.28	1630863.03	733.68	RT90-RHB70	-36.09	343.49	627.8600	97.9900	177.4800
987.00	6701037.60	1630862.34	735.45	RT90-RHB70	-36.00	343.57	630.0700	98.9800	178.5200
990.00	6701039.93	1630861.65	737.21	RT90-RHB70	-35.90	343.66	632.2800	99.9700	179.5600
993.00	6701042.26	1630860.97	738.97	RT90-RHB70	-35.79	343.76	634.5000	100.9700	180.6000
999.00	6701046.94	1630859.61	742.47	RT90-RHB70	-35.61	343.84	638.9400	102.9800	182.7100

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Downhole deviation measurements KFM08B

Maxibor T - Borehole deviation: Maxibor

KFM08B, 2005-03-08 15:28:00 - 2005-03-08 17:15:00 (0.000 - 195.000 m)

Length (m)	Northing (m)	Easting (m)	Elevation (m)	Coord System	Inclination (degrees)	Bearing (degrees)	Local A (m)	Local B (m)	Local C (m)	Extrapol Flag
0.00	6700492.75	1631173.27	-2.25	RT90-RHB70	-58.85	270.45				
3.00	6700492.76	1631171.72	0.32	RT90-RHB70	-58.67	270.62				
6.00	6700492.78	1631170.16	2.88	RT90-RHB70	-58.68	270.72				
9.00	6700492.80	1631168.60	5.44	RT90-RHB70	-58.67	270.76				
12.00	6700492.82	1631167.04	8.01	RT90-RHB70	-58.64	270.79				
15.00	6700492.84	1631165.48	10.57	RT90-RHB70	-58.62	270.83				
18.00	6700492.86	1631163.92	13.13	RT90-RHB70	-58.59	270.89				
21.00	6700492.89	1631162.35	15.69	RT90-RHB70	-58.57	270.96				
24.00	6700492.91	1631160.79	18.25	RT90-RHB70	-58.55	271.02				
27.00	6700492.94	1631159.22	20.81	RT90-RHB70	-58.53	271.09				
30.00	6700492.97	1631157.66	23.37	RT90-RHB70	-58.50	271.17				
33.00	6700493.00	1631156.09	25.92	RT90-RHB70	-58.46	271.23				
36.00	6700493.04	1631154.52	28.48	RT90-RHB70	-58.43	271.30				
39.00	6700493.07	1631152.95	31.04	RT90-RHB70	-58.40	271.38				
42.00	6700493.11	1631151.38	33.59	RT90-RHB70	-58.38	271.45				
45.00	6700493.15	1631149.81	36.15	RT90-RHB70	-58.36	271.51				
48.00	6700493.19	1631148.24	38.70	RT90-RHB70	-58.35	271.58				
51.00	6700493.24	1631146.66	41.26	RT90-RHB70	-58.34	271.65				
54.00	6700493.28	1631145.09	43.81	RT90-RHB70	-58.34	271.71				
57.00	6700493.33	1631143.51	46.36	RT90-RHB70	-58.33	271.77				
60.00	6700493.38	1631141.94	48.92	RT90-RHB70	-58.32	271.85				
63.00	6700493.43	1631140.37	51.47	RT90-RHB70	-58.32	271.93				
66.00	6700493.48	1631138.79	54.02	RT90-RHB70	-58.30	271.99				
69.00	6700493.53	1631137.22	56.57	RT90-RHB70	-58.26	272.03				
72.00	6700493.59	1631135.64	59.13	RT90-RHB70	-58.22	272.06				
75.00	6700493.65	1631134.06	61.68	RT90-RHB70	-58.18	272.12				

78.00	6700493.71	1631132.48	64.23	RT90-RHB70	-58.13	272.19
81.00	6700493.77	1631130.90	66.77	RT90-RHB70	-58.09	272.26
84.00	6700493.83	1631129.31	69.32	RT90-RHB70	-58.05	272.34
87.00	6700493.89	1631127.72	71.87	RT90-RHB70	-58.01	272.43
90.00	6700493.96	1631126.14	74.41	RT90-RHB70	-57.98	272.51
93.00	6700494.03	1631124.55	76.95	RT90-RHB70	-57.94	272.61
96.00	6700494.10	1631122.96	79.50	RT90-RHB70	-57.87	272.73
99.00	6700494.18	1631121.36	82.04	RT90-RHB70	-57.81	272.83
102.00	6700494.26	1631119.77	84.58	RT90-RHB70	-57.77	272.89
105.00	6700494.34	1631118.17	87.11	RT90-RHB70	-57.75	272.98
108.00	6700494.42	1631116.57	89.65	RT90-RHB70	-57.71	273.08
111.00	6700494.51	1631114.97	92.19	RT90-RHB70	-57.67	273.16
114.00	6700494.60	1631113.37	94.72	RT90-RHB70	-57.65	273.24
117.00	6700494.69	1631111.77	97.26	RT90-RHB70	-57.61	273.33
120.00	6700494.78	1631110.16	99.79	RT90-RHB70	-57.57	273.41
123.00	6700494.88	1631108.56	102.32	RT90-RHB70	-57.51	273.47
126.00	6700494.97	1631106.95	104.85	RT90-RHB70	-57.46	273.55
129.00	6700495.07	1631105.34	107.38	RT90-RHB70	-57.40	273.64
132.00	6700495.18	1631103.72	109.91	RT90-RHB70	-57.33	273.72
135.00	6700495.28	1631102.11	112.43	RT90-RHB70	-57.27	273.79
138.00	6700495.39	1631100.49	114.96	RT90-RHB70	-57.17	273.86
141.00	6700495.50	1631098.87	117.48	RT90-RHB70	-57.08	273.93
144.00	6700495.61	1631097.24	120.00	RT90-RHB70	-57.01	274.02
147.00	6700495.72	1631095.61	122.51	RT90-RHB70	-56.92	274.08
150.00	6700495.84	1631093.98	125.03	RT90-RHB70	-56.85	274.14
153.00	6700495.96	1631092.34	127.54	RT90-RHB70	-56.80	274.24
156.00	6700496.08	1631090.70	130.05	RT90-RHB70	-56.74	274.35
159.00	6700496.21	1631089.06	132.56	RT90-RHB70	-56.64	274.41
162.00	6700496.33	1631087.42	135.06	RT90-RHB70	-56.53	274.46
165.00	6700496.46	1631085.77	137.56	RT90-RHB70	-56.43	274.51
168.00	6700496.59	1631084.11	140.06	RT90-RHB70	-56.36	274.58
171.00	6700496.72	1631082.46	142.56	RT90-RHB70	-56.30	274.65
174.00	6700496.86	1631080.80	145.06	RT90-RHB70	-56.24	274.72
177.00	6700497.00	1631079.14	147.55	RT90-RHB70	-56.19	274.77
180.00	6700497.14	1631077.47	150.04	RT90-RHB70	-56.18	274.83
183.00	6700497.28	1631075.81	152.54	RT90-RHB70	-56.16	274.90
186.00	6700497.42	1631074.14	155.03	RT90-RHB70	-56.14	274.98
189.00	6700497.56	1631072.48	157.52	RT90-RHB70	-56.11	275.08
195.00	6700497.87	1631069.15	162.50	RT90-RHB70	-56.08	275.23

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Appendix 4

Length reference marks

Reference Mark T - Reference mark in drillhole

KFM08A, 2005-04-05 09:00:00 - 2005-04-05 17:00:00 (151.000 - 981.000 m)

Bhlen (m)	Rotation Speed (rpm)	Start Flow (l/min)	Stop Flow (l/min)	Stop Pressure (bar)	Cutter Time (s)	Trace Detectable	Cutter Diameter (mm)	Comment
151.00	400.00	300	400	25.0	40	Ja		151m
200.00	400.00	300	450	30.0	50	Ja		
250.00	400.00	300	450	35.0	60	Ja		
300.00	400.00	300	450	35.0	40	Ja		The mark is located at 299.8 m
350.00	400.00	300	450	35.0	60	Ja		
400.00	400.00	300	500	35.0	45	Ja		
450.00	400.00	250	500	35.0	45	Ja		
500.00	400.00	350	550	35.0	50	Ja		
552.00	400.00	300	550	35.0	45	Ja		
600.00	400.00	300	550	35.0	50	Ja		
650.00	400.00	250	550	35.0	40	Ja		
700.00	400.00	250	550	35.0	40	Ja		
750.00	400.00	300	550	35.0	40	Ja		
800.00	400.00	250	550	35.0	40	Ja		
850.00	400.00	250	550	35.0	50	Ja		
900.00	400.00	300	550	35.0	40	Ja		
950.00	400.00	300	550	40.0	30	Ja		
981.00	400.00	300	600	35.0	30	Ja		

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Appendix 5

Detailed overview mapping of 950.0–1,001.19 metres of KFM08A